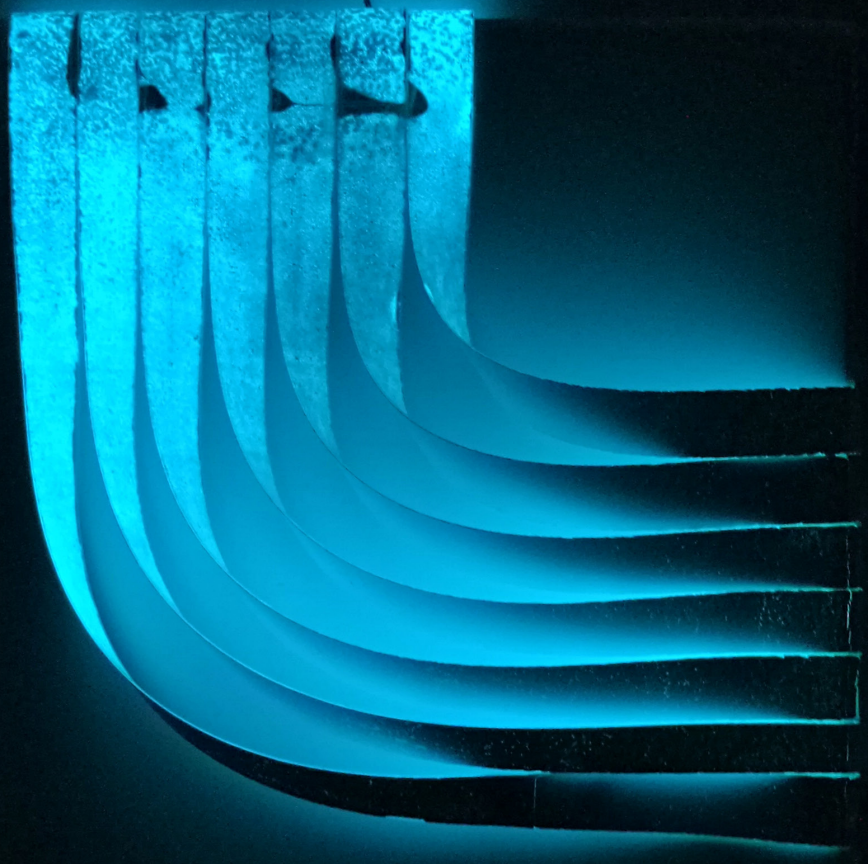
MASTER THESIS



June 2020

MATERIALIZING LIGHT:

using electroluminescent material in surface design

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1.1

ACKNOWLEDGEMENTS

I would like to say thank you to some people that made this project possible or helped me along the way. Firstly I would like to thank Kaspar Jansen for giving me this opportunity and being a great supportive chair along the way. His ideas and enthusiasm made my research phase much easier. My mentor, Sylvia Pont, always knew what to say to get me out of a funk or push me towards a new solution. I learned a lot about just going for it and trusting my own intuition from my clients, Alissa van Asseldonk and Nienke Bongers.

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I did not only get help from my supervisory team or the university. I would also like to say thank you to my friends who were so willing participate in all my researches, even if it took hours of playing with poorly insulated samples. Special shout-out to Emma Govan for proof reading my thesis and catching all the times I typed an instead of and.

fig. 1.1 close-up photo of **demonstrator**

1.2 executive

SUMMARY

This graduation project follows the process of researching, developing and creating a demonstrator for a surface design using the electroluminescent material - EL for short - a sandwich structured composite that emits light when alternating current flows through it.

The important parties in this project are the client (Alissa + Nienke, A+N for short), whose style the working methods and the final design should match; and the Emerging Materials Lab at TU Delft, who provides the equipment and materials needed to produce the electroluminescent samples.

The project kicks-off with an analysis phase where the electroluminescent material and relevant client products are introduced. This includes a detailed description of the EL material from working principle to pre-fabricated versions possible to purchase from online stores. Moreover a library has been made from various EL applications which serves as a benchmark and a source of inspiration.

In the next phase the EL materials themselves and A+N products were tinkered with. New DIY techniques are introduced which can help to create quick prototypes. A list of EL material characteristics have been collected that are possible to change during the making process. This phase closes with three mini researches, an experiential characterisation (exploring what people do with or think about the EL material), a luminescence measurement (seeing how certain parameters affect the brightness) and connecting a sample to an oscilloscope to see how frequency effects the colour output.

After the EL characteristics have been synthesized into possible directions approved by the supervisory team and the client, a new phase begun - surface design. It started with rapid prototyping many ideas from paper to see how a 2D sheet can be formed into a fascinating 3D object. A few selected ideas were iterated on and turned into phosphor models covered with black vinyl in order to make life-like photographs under UV light. Based on the opinion of the client, a concept direction is chosen, a set of twisted stripe designs that can be organised into a large pattern on a wall. The chapter closes with the description of elements that must be included in the finished concept.

The following chapter contains the concept development; starting with creating all the elements of the twist set and some possible large patterns, then refining the design together with the client. After that a proof of concept was made; they are the first working prototypes using most of the envisioned materials. Not every aspect of the first prototypes were liked by the client, thus some changes in the design had to be made. Those changes were worked out during a long iteration phase, ending up with the final version of the concept - a simple tile set with two different twist designs (straight and curved).

The last chapter describes the production of the demonstrators (one was made for each tile design); the making of the EL sheets and then the assembly steps. The chapter also provides a detailed description of the created demonstrators and a summary of the final design. A detailed evaluation walks through the possible light conditions where the tile installation could be placed and gives recommendations for certain options. The conclusions contain the strengths and limitations of the demonstrator. A list of recommendations for the client or for further development is also included.

The main body of the thesis closes with a personal evaluation of the project. However the document does not end there, a lengthy Appendix contains all the descriptions of experiments and samples made during the project.

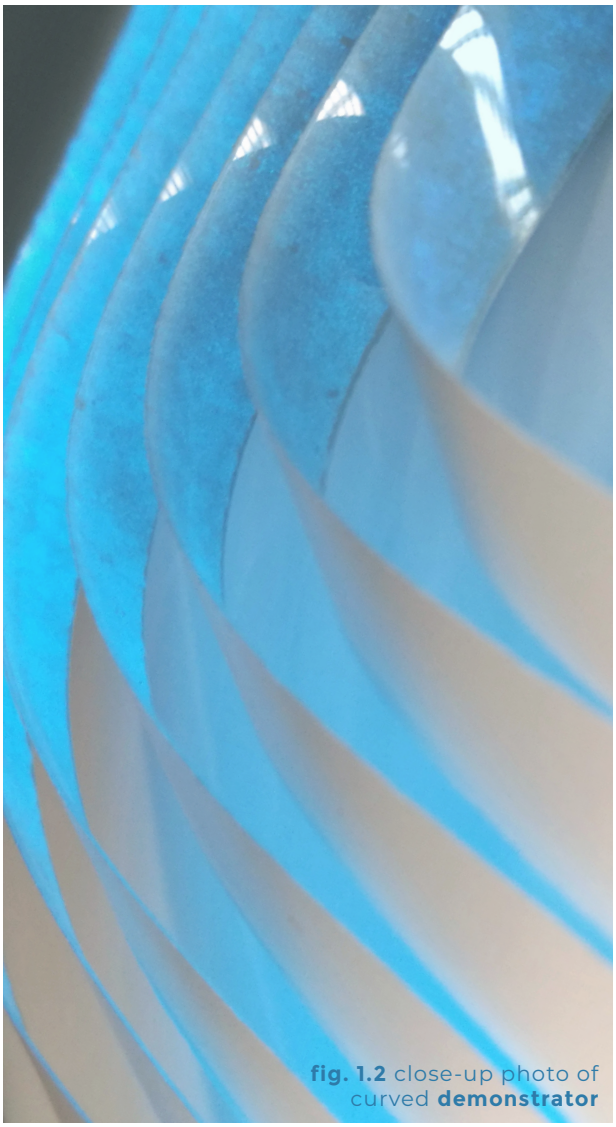

fig. 1.2 close-up photo of curved **demonstrator**

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1.3 project
BRIEF

The development and fast change of products and technological practices are accompanied by the rise of a new generation of materials: the smart materials. Smart materials have properties which may be controlled by external stimuli, such as stress, temperature, moisture, pH, and electric or magnetic fields (Badami & Ahuja, 2014, p. 4). The electroluminescent materials are one of these upcoming smart materials (controlled by electrical current). They have the potential to reinvent how we think about and use light.

Alissa + Nienke studio has a vision to put human experience in the centre of their design, together with triggering curiosity and interaction. Their main line, surface design, creates an opportunity to use the electroluminescent materials in practice (Alissa + Nienke, 2019). Electroluminescent materials are relatively unused in surface design (see chapter 2.6 Applications), even though they are highly suited for that due to their versatile nature (lightweight, thin, bendable, energy efficient, etc.).

The EL materials can bring a new aspect into surface design: light, produced by the embodied material. Furthermore, the material has potential for (triggering) interaction, which fits well into the profile of the studio. It is possible to connect the material with sensors, “animate” it (with dimming or switching on and off certain parts), or to make it touch or water responsive.

All in all this project explores how to implement electroluminescent material into surface design by following the development of one design from concept to a functional prototype. The process takes a look at how to trigger curiosity and interaction with the embodied material and what types of interactions are feasible with a surface installation.

fig. 1.3 CC FLO by Alissa + Nienke

1.4 design
APPROACH

In the analyses and material chapters Alissa + Nienke products and the EL materials themselves will be analysed and tinkered with. This exploration includes a benchmark on EL applications and luminous measurements of various EL samples. Moreover the research phase includes an Experiential characterisation (Camera & Karana, 2018) where the participants can explore, interact, “play” with the material. This can help gather input on how people react and interact with the material.

The next chapter focuses on the ideation and concept design. This phase aligns a lot with the exploration phase, as I imagine, they will trigger each other. The envisioned installation should be in the field of interior architecture, made for a clientele expecting a unique outcome, incorporating interaction by humans or natural forces. The installation is for semi-public places (office halls, museums, hospitals), where there is a chance to put them in semi-shaded areas.

The last part is a long embodiment phase, where (technical) details of the design can be worked out. The plan is to create a lot of prototypes to reach a refined and feasible design. The design should be tested in a fitting environment (light conditions) to evaluate the effect and looks of the design. The last step of the project is to make a functional demonstrator or scale model (and to finish the graduation deliverables).

ANALYSIS
EL working principle
used materials
types of EL
applications of EL
technical benchmark

MATERIAL
tinkering summary
material attributes
experiential characterisation
luminance measurements
design vision

CONCEPT
rapid prototyping with paper
prototyping with UV light
opinion survey on concepts
concept directions
design elements
developing the concept
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PROTOTYPE
making of the material
assembly steps
final design description
demonstrator evaluation
recommendations

We design materials that build intriguing and enriched spaces for those who live or work in them.
// Alissa + Nienke (2019)

1.5 the client
ALISSA + NIENKE

Alissa + Nienke (A+N), using their own words, is a small material research and design studio with a unique interpretation on surface design. Their work puts the human experience at the centre; they create installations that trigger curiosity and interaction. Their installations are characterised by tactility, simplicity and the use of natural forces like wind or light (Alissa + Nienke, 2019).

Most of their projects are in the field of interior design and architecture. They work on self-initiated projects or develop commissioned pieces (for Fendi, Dior, etc.). Their products in the line of interior design include wallpapers, wall-mounted decoration pieces, small art pieces, dividers and sliding doors. They showed interest in working with the electroluminescent material.

fig. 1.4 CC FLO by Alissa + Nienke

1.6 Emerging
MATERIALS LAB

The Emerging Materials lab has an ongoing research project about designing (with) electroluminescent materials. The project is expected to create product demonstrators that stretch the norms of how lighting (as a material) can improve and change everyday experiences and practices.

During that research the lab fabricated flexible and stretchable samples. This is a new area of research, which creates an opportunity to explore the possibilities of lighting as technology moves from rigid to flexible to stretchable substrates.

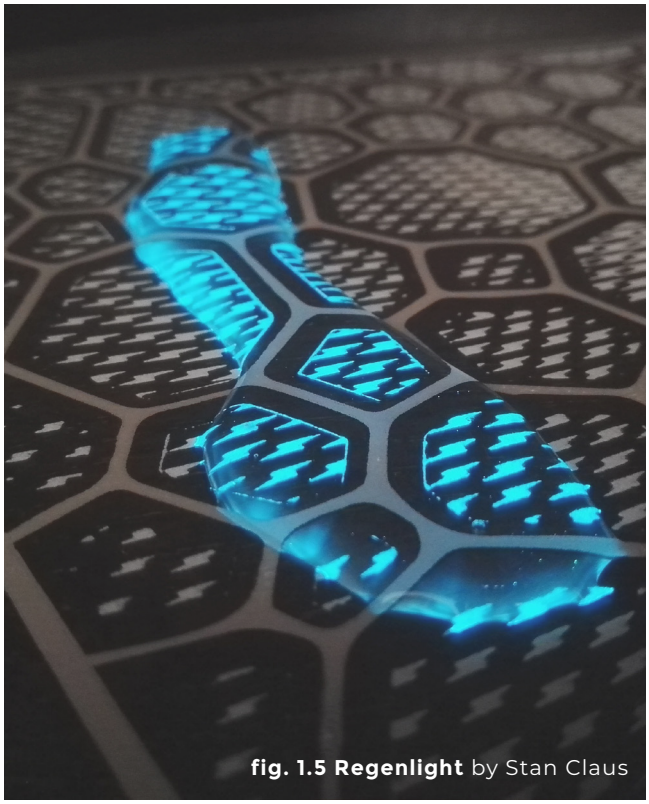


fig. 1.5 Regenlight by Stan Claus

INTRIGUING AND ENRICHED SPACES

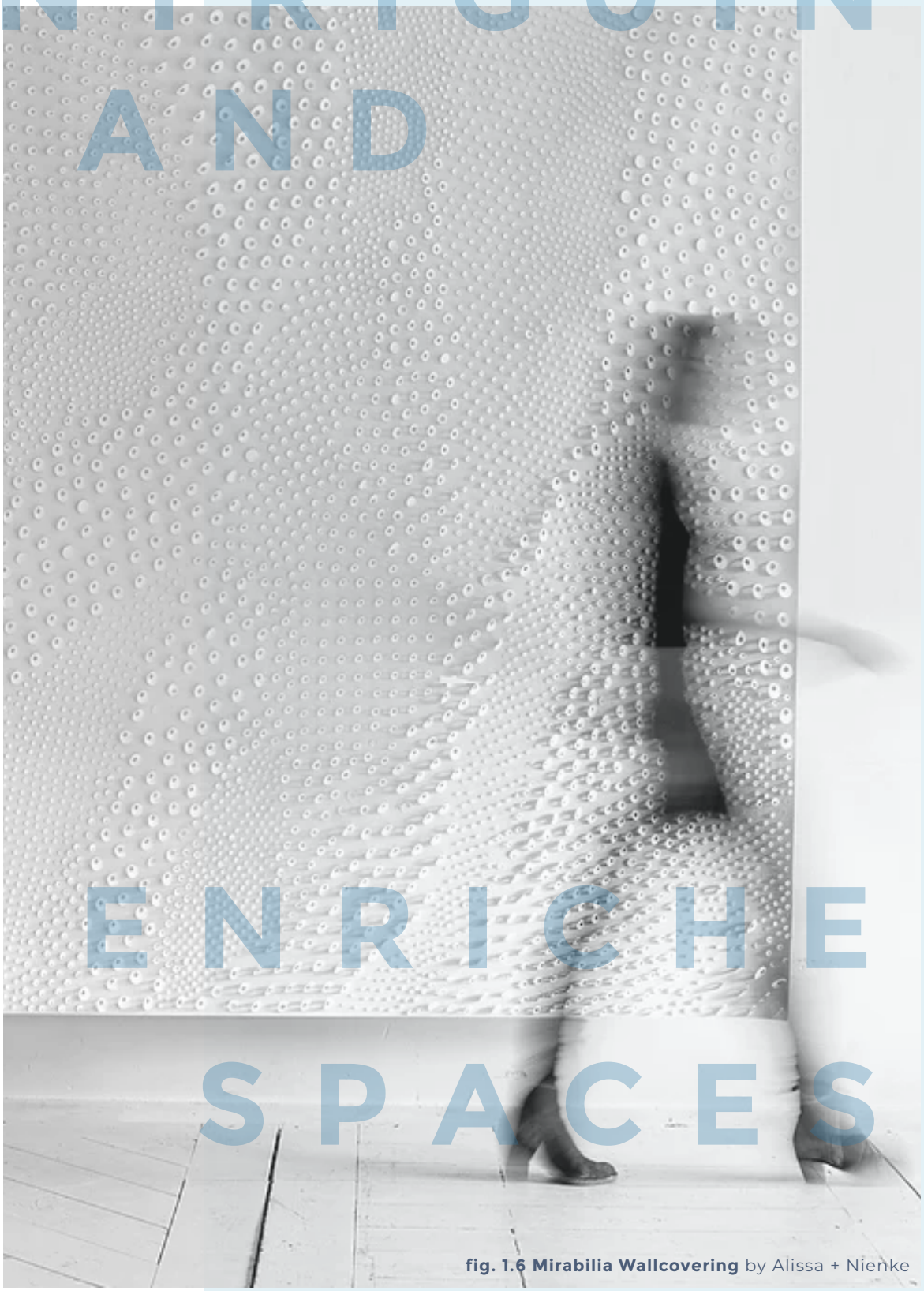


fig. 1.6 Mirabilia Wallcovering by Alissa + Nienke

ANALYS PHASE

basics of
ELECTROLUMINESCENCE

fig

This chapter contains an introduction to the electroluminescent materials, how they work and how they are made. It has a library of EL applications that can serve as an overview of what has been done and an inspiration for what could be possible. Furthermore, an overview of relevant Alissa + Nienke products are introduced. Last but not least a summary table of the strengths and weaknesses of EL materials has been presented.

IS 2

. 2.1 **DUNE** by Studio Roosegaarde

what is EL?

Electroluminescence is a characteristic of a material which enables it to **emit light when an electric current** or an electric field **is applied to** or around **it**.

Electroluminescent materials are smart materials with electroluminescence as a characteristic.

They are characterised by soft light, sharp colours and a futuristic look. The light produced by electroluminescence is **not enough to use as a primary light source ("lamp")**, it is closer to enhancement or decorational light.

Also interesting to mention it that the electroluminescent materials are often only used to enhance a design, they are not integrated in a more meaningful way.

fig. 2.2 Glowing Nature
by Studio Roosegaarde

2.1 working
PRINCIPLE

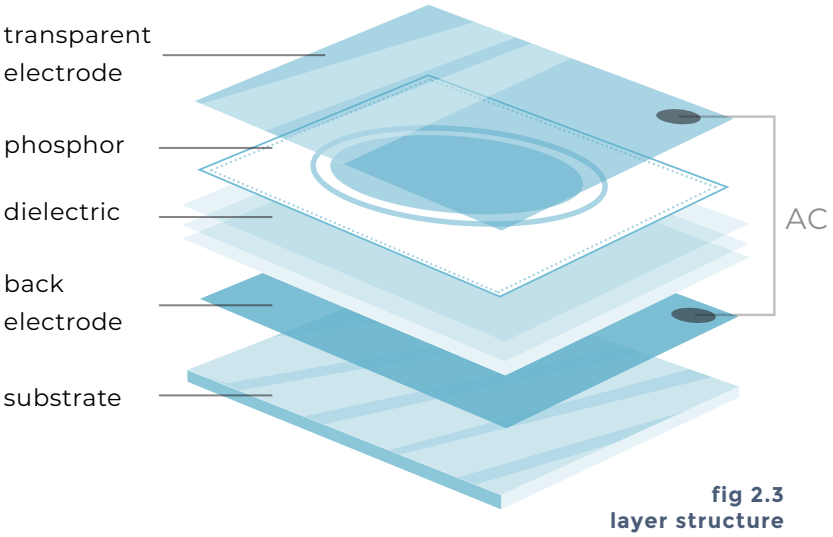


fig 2.3
layer structure
of basic EL devices

Electroluminecents are layered composites using multiple materials in between two electrodes, creating a 'sandwich-like' structure. The layer that emits light is created from phosphor. As Claus phrased in his graduation report *"When an alternating current passes through the composite the phosphor gets electrically charged and then loses its energy in the form light. The current allows energy to build up within the phosphor layer and during each half cycle of the alternating current the energy is released."* (Claus, 2016)

According to an Adafruit instructional video (2014) "*All EL materials need to be powered by an inverter. An inverter translates the DC voltage coming from the batteries into high voltage alternating current (or AC) required to excite the phosphor. Although its high voltage EL uses very little current so* [after insulation] *it is safe to wear* [or touch]." This means EL devices cannot be directly connected to most power sources, like batteries or power banks, or just plugged into a socket, they need one step in between - the inverter. The type of necessary inverter depends on the desired brightness output, the surface size of the EL device and portability.

2.2

MATERIALS

transparent electrode

The top layer is one of the two electrodes. It is essential that this layer lets the light through. A popular option is Indium Tin Oxide (ITO) coating on a transparent substrate, like a PET sheet. Another option is PEDOT, widely used for creating paintable electrodes, it is visually dark blue, but lets the light through.

phosphor

Phosphor is the luminescent compound, which means this layer emits the light and determines the colour. Phosphor also 'lights up' under UV light with a similar colour, making phosphor paste ideal for rapid prototyping on aesthetics.

dielectric

The dielectric layer makes sure no short circuit is created in between the two electrodes. The thicker this layer is, the less chance for a short circuit, but a too thick layer can decrease the light output. Therefore the layer should be as thin as possible without failing. Technically any non-conductive material can serve as dielectric. It is even possible to combine the phosphor and dielectric layers using a UV curable resin and phosphor powder without losing functionally.

back electrode

The rear electrode can be looked at as the "back" of the sample, it does not need to be transparent, unless a double-sided solution is needed. When a thin, opaque layer is required silver ink is a good option, however it is quite expensive. In case of double-sided illumination PEDOT can be used.

substrate

Nearly any material can become the substrate, depending on the layer structure. Usually it should be unable to absorb water, thus paint can be dried in a controlled way.

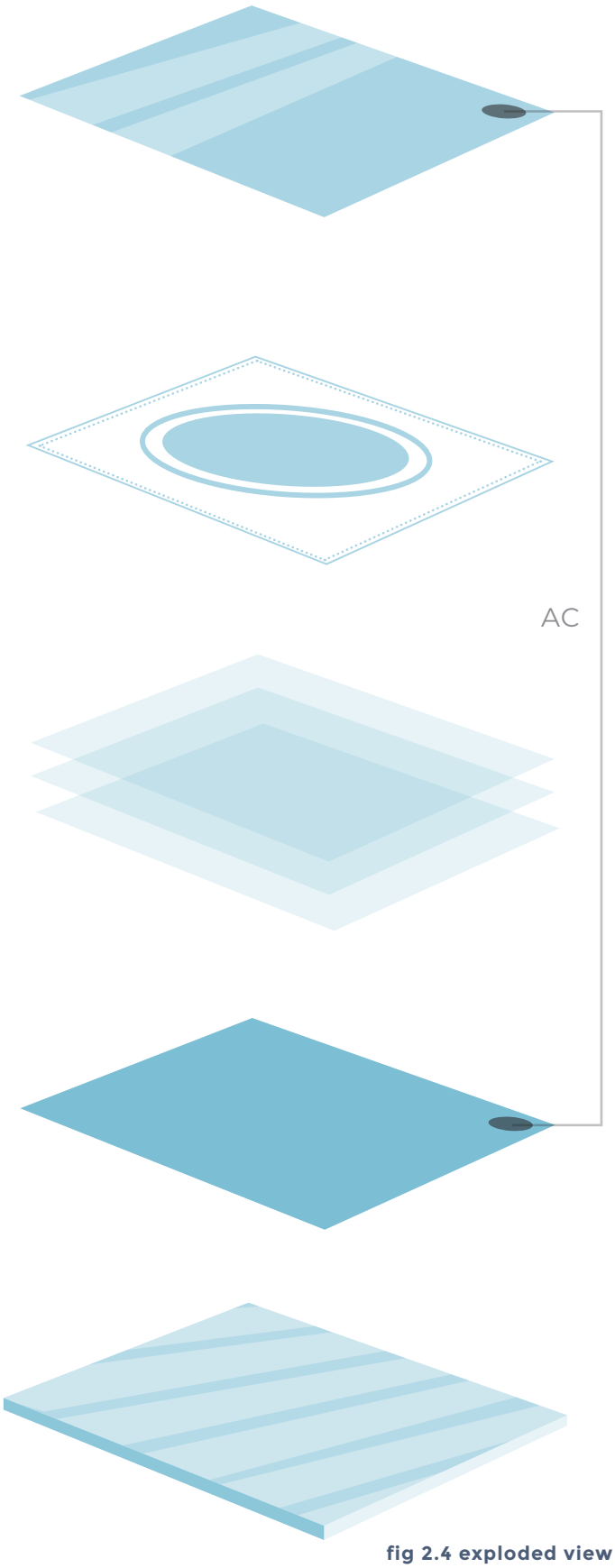


fig 2.4 exploded view
of the layer structure

2.3
TECHNICAL
specifications

non-directional

When electricity charges the phosphor particles they emit photons in every direction and the light scatters through the composite layers. This means the photons leave the surface with no specific direction, making it possible to view the samples from a wide angle (more than 160°) without losing brightness.

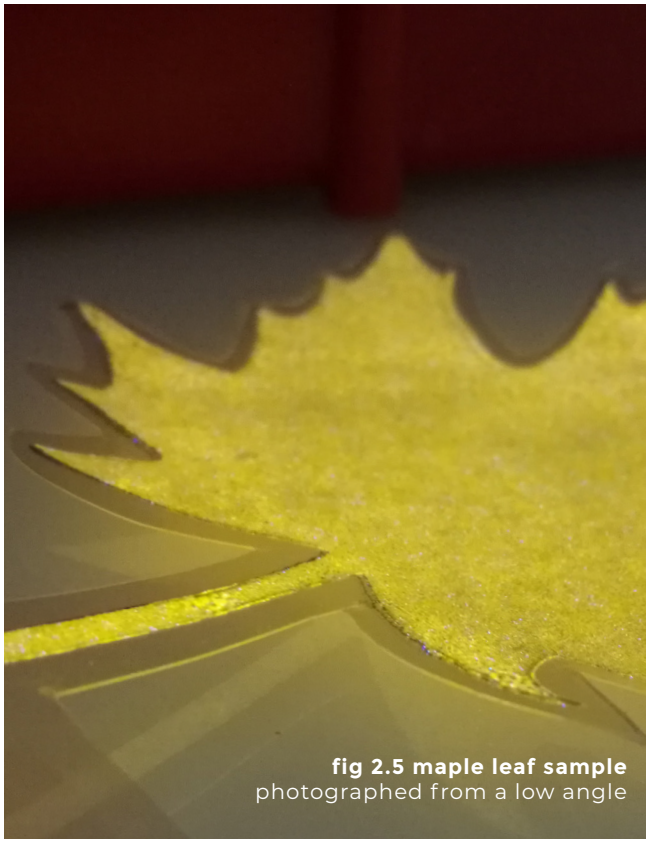


fig 2.5 maple leaf sample
photographed from a low angle

lightweight

EL panels are paper thin and lightweight, which is possible because they are composites consisting of extremely thin paint or ink layers. That means the weight is mostly determined by the substrate (leather or thin plastic).

cold light source

Many light sources use heat to generate photons (like a the simple light bulb or LEDs). On the other hand EL materials are cold light sources, because the luminescent compound is not heated to create photons. This means they can operate in warm temperatures and need no cooling system.

sound

A lot of DIY EL devices produce a high pitched beeping sound. The pitch and volume can be effected with pressure and frequency. The most likely reason for this is that the slightly loose layers vibrate on the frequency of the inverter that powers the device. This means touch sensitive samples can become disturbingly loud.

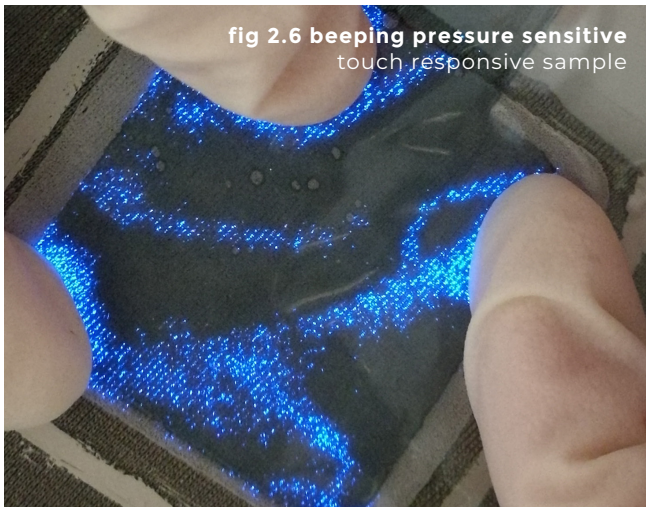


fig 2.6 beeping pressure sensitive
touch responsive sample

colour

The currently available colours are blue, aqua, orange, red and white. It is possible to mix these colours to create shades in between. For example white is a mixture of blue and orange. Using coloured coatings (that are at least translucent) it is possible to create other colour variations.

thickness

The main parameter in the thickness is the substrate, then the amount of applied layers. Standard, store bought panels have a thickness of 0.4mm, but using DIY methods panels can become half that thickness.

double-sided

It is possible to create EL devices that emit lights on both sides of the panel using transparent electrodes on both sides.

flexibility

The chosen substrate has a high influence on flexibility, then the adhesion of the layers to the substrate is also important. The elasticity of the layers themselves is another factor. Flexibility is an uncommon characteristic for light sources. This could give the EL materials a competitive edge above other types of light sources.

complex shape & geometry

Due to the nature of EL materials they provide a large degree of freedom for creating complex shapes and geometry. The possible 2D shapes and patterns are nearly limitless. With bendable or flexible samples it is even possible to create complex 3D geometry.

fig 2.7
Material Driven design project
by Pekarik & Boers (2018)

2.4 different
TYPES OF EL

EL panel

"This is a big sheet of flexible plastic coated with EL material so its like one big glowing square. It emits an even aqua glow over the entire shape [...]" (Adafruit, n.d.).

These pre-fabricated EL panels use the classic sandwich structure described in chapter 2.2 under working principle with one key difference, they are coated with a thick transparent insulation layer, like PVC.

EL panels come with an attachment point to a driver/inverter, which makes it very easy and quick to get them to work. It is possible to cut some versions into any desired shape as long as the attachment point of the inverter is still connected to the shape. The pieces that are cut off cannot be used anymore, thus an elaborate shape can come with a lot of waste. (Adafruit Industries, 2014)

fig. 2.8 EL Panel - Aqua by Adafruit (n.d.)

EL tape

EL tapes are quite similar to EL panels, both are flat, flexible, sheet-like devices using the same layer structure. The main difference is that the tapes are usually pre-assembled into an commonly used working length (1m) and can be directly attached to the desired surface with the adhesive at the back. There is a possibility to cut them in parts and attach a inverter to one of the new end with soldering (Adafruit, 2020).

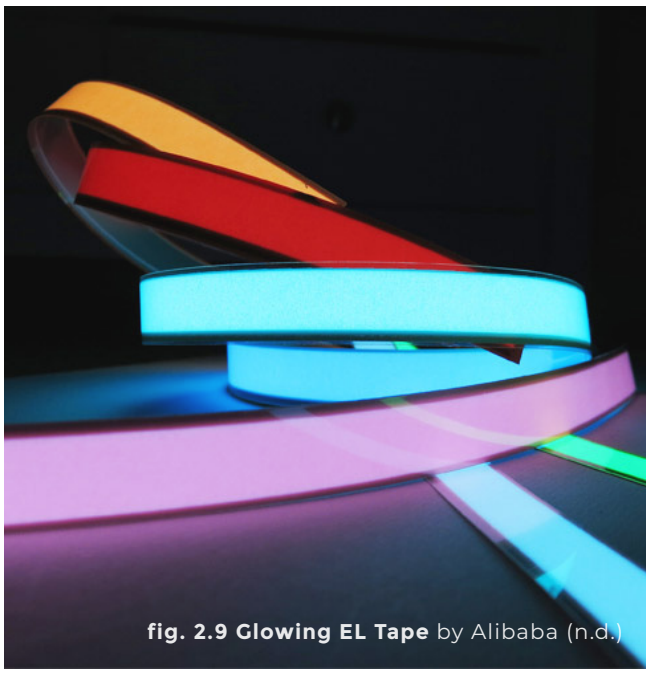


fig. 2.9 Glowing EL Tape by Alibaba (n.d.)

EL wire

The basic structure of the EL wire is essentially the same as of the panel, just in a cylinder form instead of sheets. It starts with a copper core, which is then wrapped in a layer of phosphor. Those together are covered with very thin insulated copper wires, acting as insulation and electrode at the same time. All those layers are covered with a protective PVC sheath, so the wires are safe to touch.

The construction of the wires allow for an effect called "chasing" - when the thin outside copper wires are switched on and off individually with a small time gap - it looks like small light spots are running through the wire. The wires are often used to customize wearables. (Adafruit Industries, 2014)

fig. 2.10 EL Wire by LED4Pin (n.d.)

EL spray paint

The principle of electroluminescence can also be applied in paint format. The basic structure is the same as the other EL types, in this case the different layers are applied with spray painting.

The most common applications of spray painted EL can be found in the automotive and aviation business, and in theme parks. It is also used to create customized illuminating items in home décor and sports. (LumiLor, 2019)

fig. 2.11 Light Paint by LumiLor (2019)

2.5 methods of
PRODUCTION

There is no 'works for all' production method when it comes to electro-luminescence; some methods are way more suitable for certain size, geometry, or quality. The chosen technique should highly depend on the required characteristics and the final application.

UV curing

In 2017 a graduate student created a new technique optimizing the production time from 2 hours to 15 minutes using UV curing (Wajwakana, 2017). This method can create complex designs with less tools and cleaning using aluminium foil as the back electrode.

spray painting

An easier option to apply EL to a curved surface is to use spray painting. This application method requires skills about spray painting and proper equipment (like a spray gun), which are relatively expensive, thus it is less optimal for DIY use. One small sample package is around $79 at the time of writing, painting a custom design on a larger surface is somewhere in the hundreds to thousands, depending on the number of different colours and the size of the surface. (LumiLor, 2019).

fig. 2.12 Applying EL paint (LumiLor, n.d.)

screen printing

One of the most popular techniques to create electroluminescent designs is screen printing. Screen-printing is a traditional printing technique where paint is applied through a fine mesh to the required flat surface to create an even and lasting layer. To have a certain design appear, a part of the mesh is blocked with vinyl (or any other material that doesn't let the paint through), leaving the needed shapes open.

One of the main limitations of screen printing is that it can only be done on a flat surface since the mesh itself is flat. One possibility is to use a plastic substrate, heat it up with a heat gun then bend it around a heat-resistant object and let it cool down on it.

First, start with a clean mesh, apply the vinyl sticker onto the surface, then make sure the mesh is correctly fixed down. Place the substrate under the mesh. The next step is to apply the needed paint or ink you want to use onto the vinyl sticker. Use a squeegee to push the paint through the mesh at a 45° angle and medium pressure. Make sure the mesh does not lift up during or after applying the paint. When done with the printing quickly lift up the mesh, take out the substrate and dry the paint according to its needs. Clean the mesh thoroughly before the used paint or ink dries on it. Repeat this process for all layers.

fig. 2.13 Material Driven design project
by Pekarik & Boers (2018)

2.6 electroluminescence

APPLICATIONS

Although this project focuses mainly on surface design it is essential to explore how electroluminescent lighting can be applied in other fields. Mapping the already existing applications can serve as a library of possibilities and inspiration. It collects what has been done before, which can help identify new directions or point toward new, unexplored directions.

fig. 2.14 The Cloud by Kenny Hong (2016)

fig. 2.15 Phototropia
by Responsive design studio (2012)

architecture

There are varied applications of EL in architecture, mainly using the standard sheets and wires to create large and complex installations. This is where the low energy consumption can come into play, making it possible to power large installations for very little cost. Most of the time these are temporary and function more as decor then anything else.

fig. 2.16 All the time in the world by Troika
(Heathrow airport, 2008)

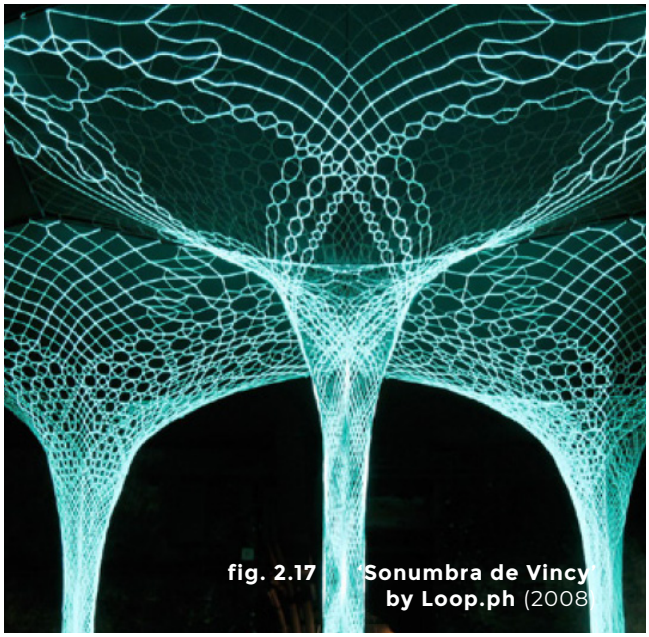


fig. 2.17 Sonumbra de Vincy by Loop.ph (2008)

art

The nature and unique properties of EL (DIY, flexible, lightweight, mobile) make it a suitable material for artistic use. There is a huge freedom in the shape and pattern of EL devices, which opens up the possibility to not be limited by flexibility or light quality. The weight and mobility of EL makes it a great option for dynamic situations, like a dance performance.

fig. 2.18 Homage to Burle Marx by Dan Corson (2012)

fig. 2.19 The Illuminated Mummy by Micheal taylor (2011)

fig. 2.20 Field of organic light by Carlo Bernardini (n.d.)

ambience

In interior design EL devices are commonly used for creating a specific ambient or feel. EL has a unique glow that is distinctly different from regular light bulbs or LED. Using a unique light can transform the experience of regular environments to something unusual and special. Some interior design applications also utilize specific characteristics of EL. The Swedish Ice hotel creating a TRON Legacy inspired room is a good example for this, using uniformity and cold resistance to their advantage.

fig. 2.21 Time Curtain by Soner Ozenc (2009)

fig. 2.22 TRON ice hotel suite by Ben Rousseau and Ian Douglas –Jones (Sweden, 2010)

fig. 2.23 Disco Chair by Kiwi & Pom (n.d.)

product design

Electroluminescence is often used for enhancement or decor, not to add extra functionality. The products below defy these standards, both are great examples on how EL can be used to communicate with the user. The tablecloth attempts to visualise product history by lighting up under items placed onto it even after they have been moved away. The praying mat has EL wires woven into it. When the mat is turned towards the right direction they light up. This can simplify the process of finding East without a compass or preliminary knowledge.

fig. 2.24 History Tablecloth by Royal College of Art's research program

fig. 2.25 El Sajjadah Prayer Mat by Soner Ozenc (2012)

fashion & clothing

Due to being a cold light, and also the light and flexible nature of EL materials, they can be applied onto or built into clothing; even woven together with fabric. The wires are quite commonly used on dance costumes, the sheets are used in fashion design to enhance the shape of the dresses or add an animated effect.

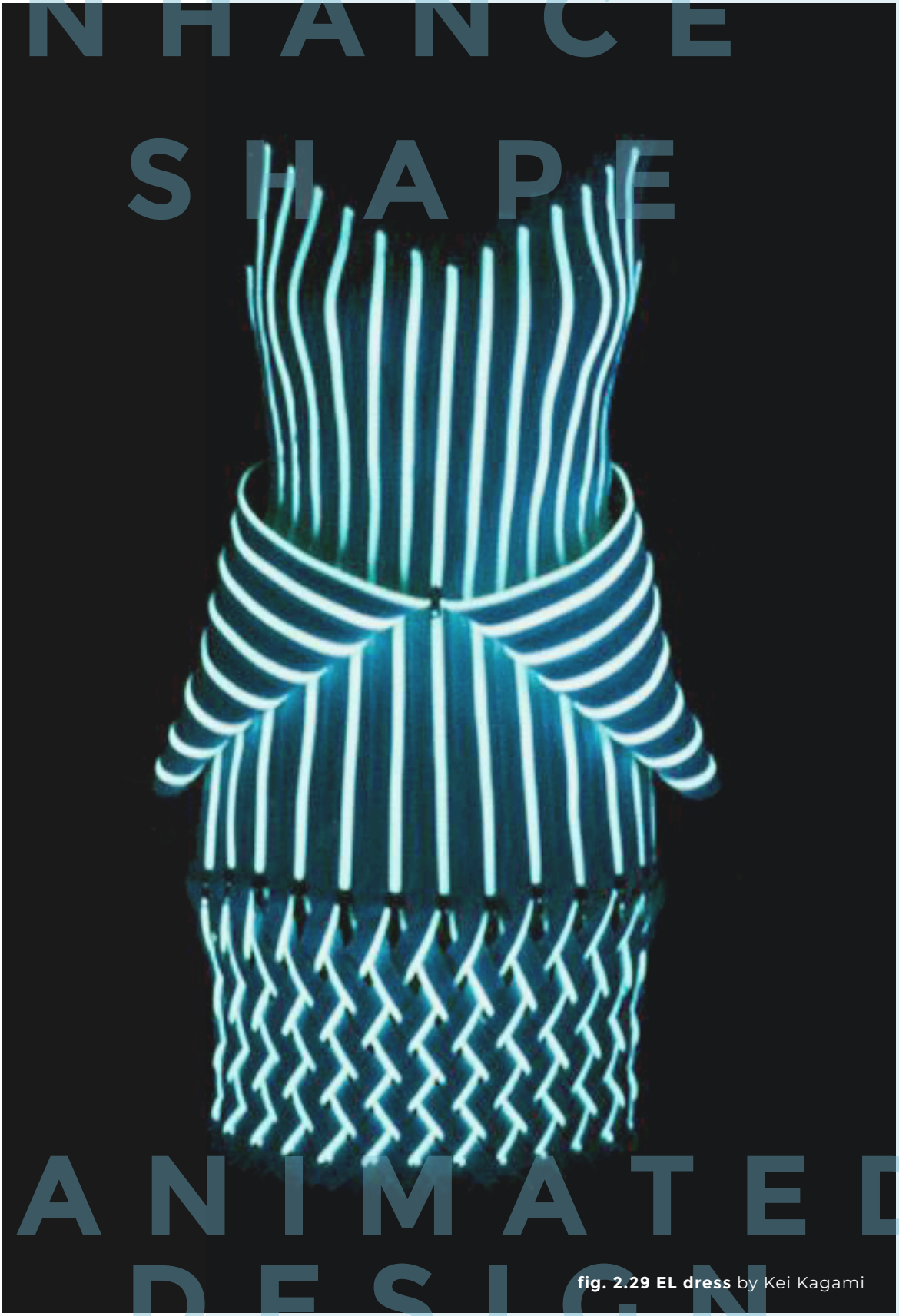
fig. 2.26 The Light Muses by ShockBlast (2011)

fig. 2.27 Alpha Lyrae by Vega Zaishi Wang (2012)

fig. 2.28 Alpha Lyrae by Vega Zaishi Wang (2012)

ENHANCE

SHAPE



ANIMATED

DESIGN

fig. 2.29 EL dress by Kei Kagami

2.7 surface designs from

ALISSA + NIENKE

It is important to become familiar with the portfolio and style of Alissa + Nienke in order to be able to create something that fits their style and available production methods. Their designs often utilize flat materials that are lasercut into the 2D design which is then transformed to 3D by bending or hanging. They often use movement or optical illusions to take their designs to the next level.

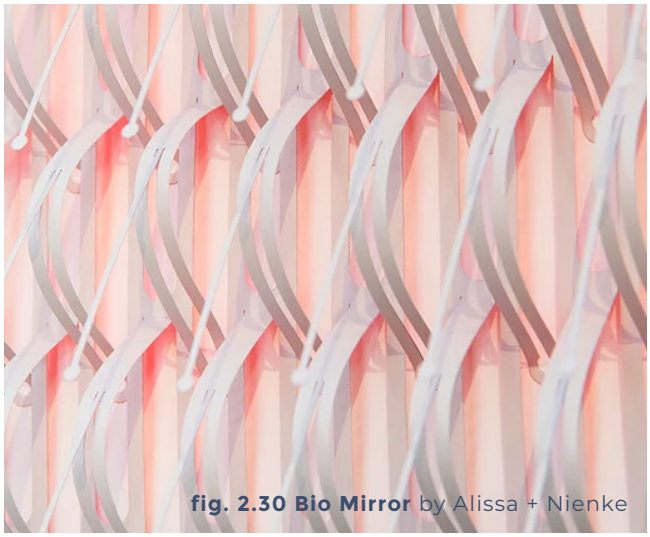


fig. 2.30 Bio Mirror by Alissa + Nienke

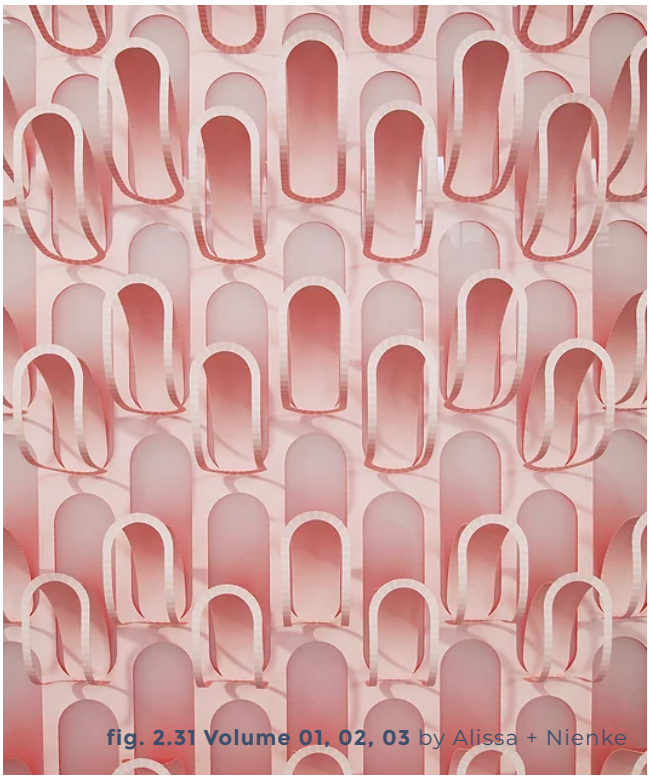


fig. 2.31 Volume 01, 02, 03 by Alissa + Nienke

fig. 2.32 Interstice by Alissa + Nienke

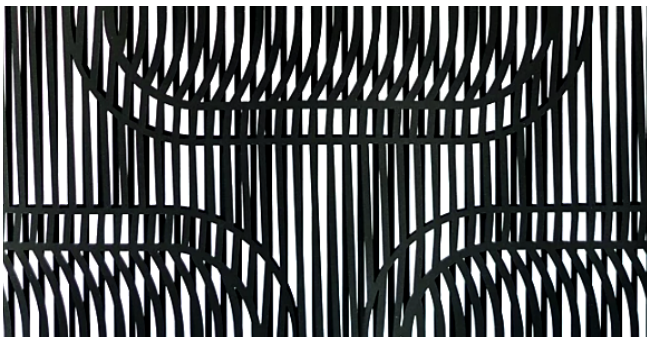


fig. 2.33 Bio Mirror by Alissa + Nienke

fig. 2.34 Mirabilia Wallcovering by Alissa + Nienke

2.8

SUMMARY & CONCLUSIONS

strength & weaknesses

The ELs are quite unique, being a thin and bendable light sources, but they also have downsides, including low luminance and no folding (see the full list below). They are commonly used for unique items or for small batch production, it is important to see what stops it from entering bigger market or mainstream use.

—	+
Degrading light during lifetime	Freedom of shape
Limited colours	Can be printed on nearly anything
Low luminance	Flexible and bendable
No folding	Double-sided illumination
Power consumption	Homogeneous and uniform
Expensive materials	Heat and water resistant
Fragile material	Possible to control the electronics with coding
	Transparency
	Cold light
	Lightweight
	Paper thin

what has already been done?

There are some examples of EL used as spatial or interior lighting, but all in all it is a more common choice in art and fashion. One of the most innovative and versatile uses of EL is in the Alpha Lyrae collection from Vega Wang. It highlights the unique properties of EL, including thinness and flexibility. It uses both front- and back light, an overlay to create a galaxy pattern and animated light. This can serve as an inspiration for how far a design can go if it utilises the characteristics of EL.

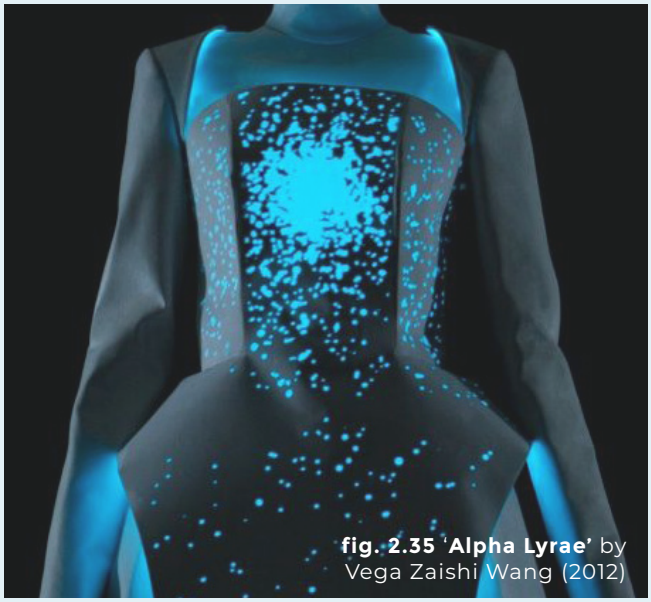


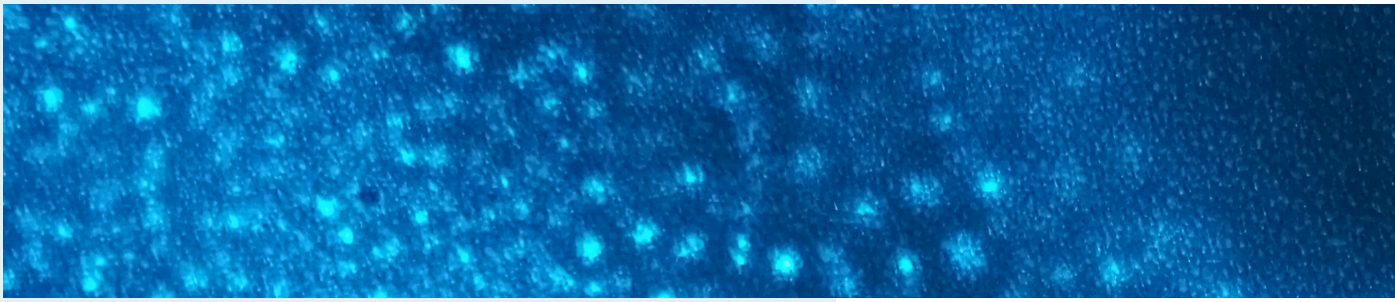
fig. 2.35 '**Alpha Lyrae'** by Vega Zaishi Wang (2012)

what is still an open market?

The benchmark has found no options where patterns are created within the material (during the production of the material level), not from it. Most designs use solid light (maybe letting it shine through a pre-cut pattern) or wires. In a previous project (Pekarik & Boers, 2018) multiple patterned samples and a gradient was created which proves there is a real possibility to create mixed colours and patterns inside the phosphor layer.

MATERI PHASE

the best of the best, **TINKERING SUMMARY**



This chapter contains tinkering with A+N products and with the EL material, technical findings, a list of EL characteristics that are possible to change, experiential characterisation, luminescence measurements and the design vision. The chapter is closed with a decision-making point giving a more precise direction for the upcoming design phase.

3

RECAP

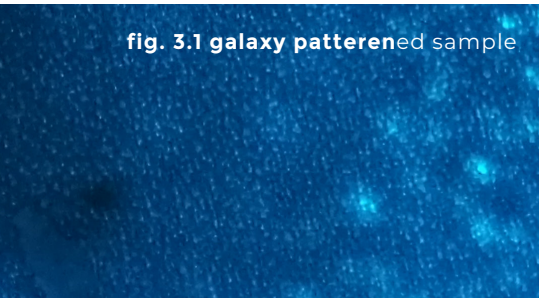
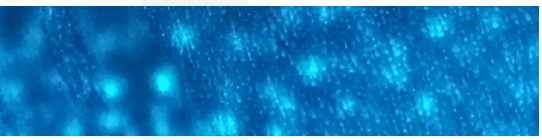


fig. 3.1 galaxy patterened sample



I started this journey with an existing knowledge of EL, but still it felt like half restarting. All the materials had to be tried and tested again before I could go and start changing characteristics or layer structure. I wanted to push further, create things that have not been done before or if so improve on them.

The end of my previous experience with EL resulted in some nature-inspired samples, a double-sided blue-orange gradient with transparent dielectric and a blue leaf which has been bent into a more organic shape with a heat-gun. I used some picture of these samples as examples, I did not recreate them to save time.

fig. 3.2 Material Driven design project by Pekarik & Boers (2018)

3.1 'lighting up'

A+N PRODUCTS

These samples are painted with phosphor paint on their front or back surface to test out the light effect under UV light.

MIRABILIA WALLCOVERING

circle

When painting the whole surface the sample becomes obnoxious. If only the circles themselves are painted the effect is completely different.

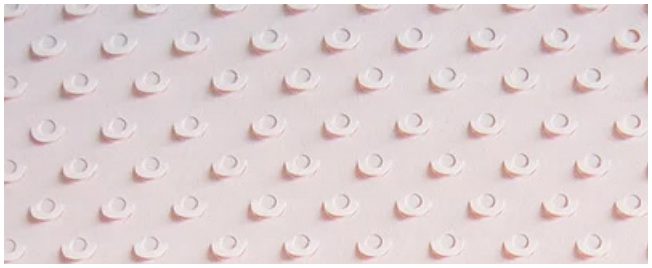
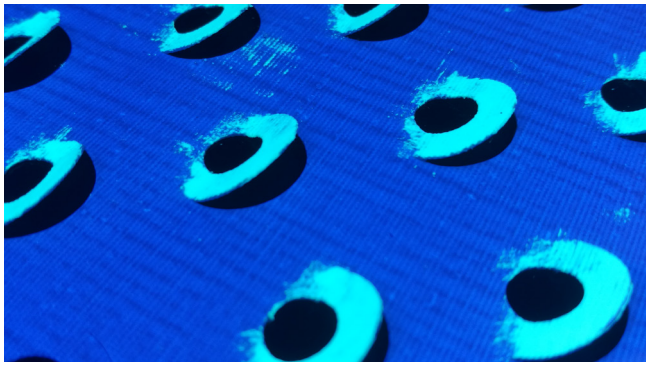


fig. 3.3 Mirabilia - circle by Alissa + Nienke



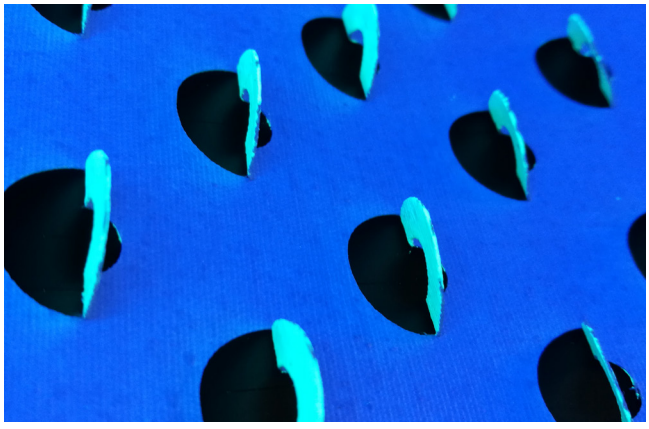
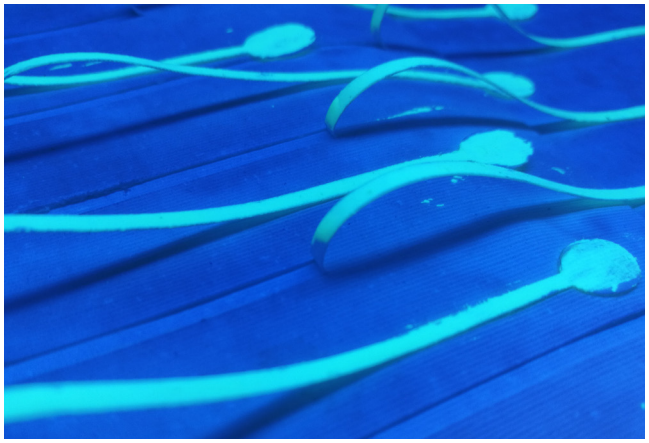


fig. 3.4 & 3.5 circle painted with phosphor

twig

The same is true for the twigs; when the background is painted too the twigs loose the 3D effect. While only the twigs are painted a colour difference similar to the original is created.

fig. 3.6 Mirabilia - twig by Alissa + Nienke



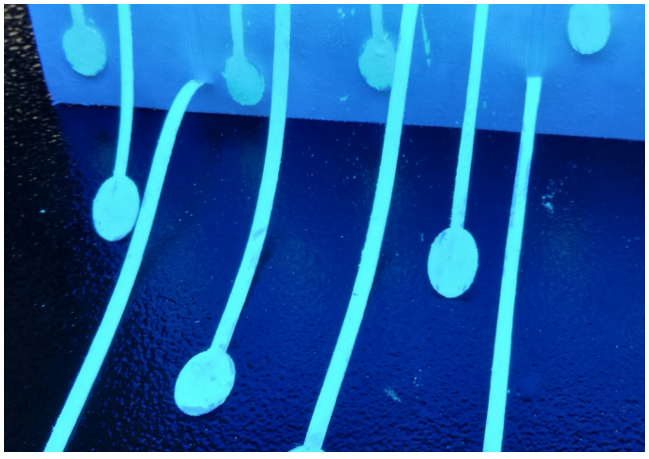


fig. 3.7 & 3.8 twig painted with phosphor

See the **detailed list of used materials** (full name, company, product code) **in Appendix B**.

BIOMIRROR

These samples are an evolution towards creating a back light version of the Biomirror. As a first step only the large parts are cut and let loose, which creates a grass-like field, it moved with touch or the wind. Black vinyl is used to create the negative space.

fig. 3.9 Bio Mirror by Alissa + Nienke

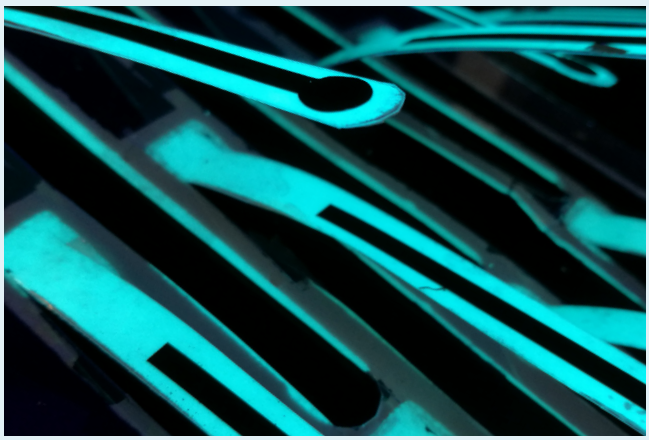


fig. 3.10 & 3.11 simplified Bio Mirror painted with phosphor

The next sample uses phosphor on its front surface, which feels a bit too much without the sufficient negative space to balance it out, especially when it is closed.

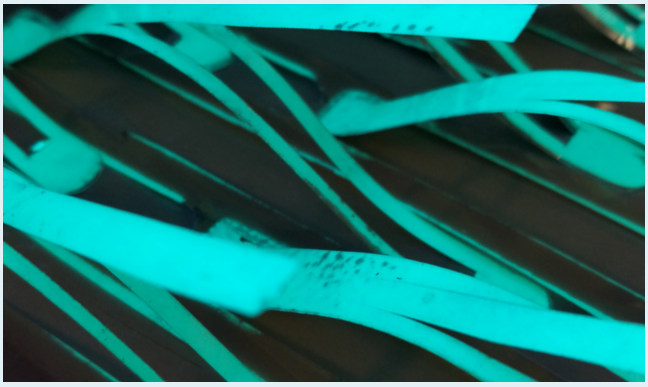
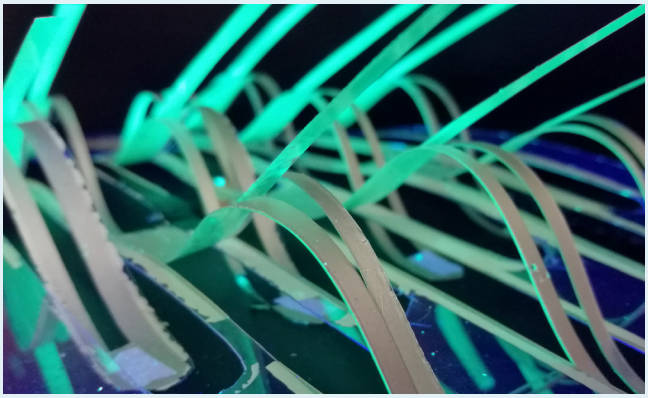


fig. 3.12 front of Bio Mirror painted with phosphor

The original piece uses shadows and colours to enhance its own shape, which can also be done by back lighting. These samples look intriguing and elegant, their movement is mesmerising.



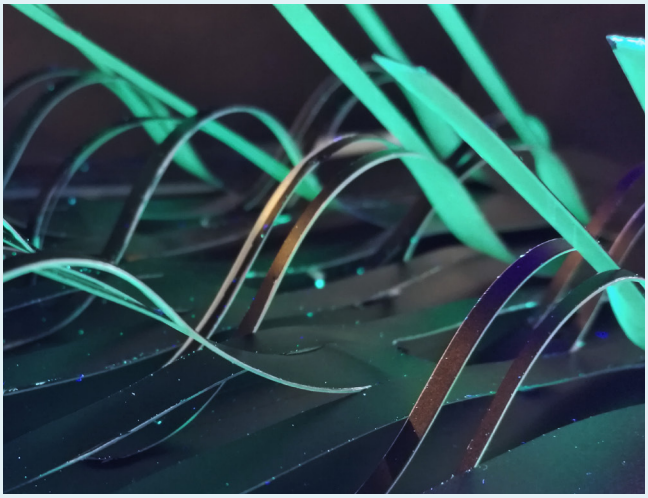


fig. 3.13 & 3.14 back of BioMirror painted with phosphor - uncovered & covered silver layer

3.2 TECHNICAL FINDINGS

the ‘new’ dielectric

The dielectric layer is very important, as it seals the two sides of the current from each other. With screen printing three layers of dielectric is needed, which takes a lot of time and effort. Furthermore the available dielectric can be a 'difficult' material to work with. If it is slightly old the end result will be thick and brittle.

After some iterating a simple insulation spray works perfectly for any sample type. For small samples 1 or 2 thin layers of spray is enough insulation, for more complex design 3 medium layer are needed.

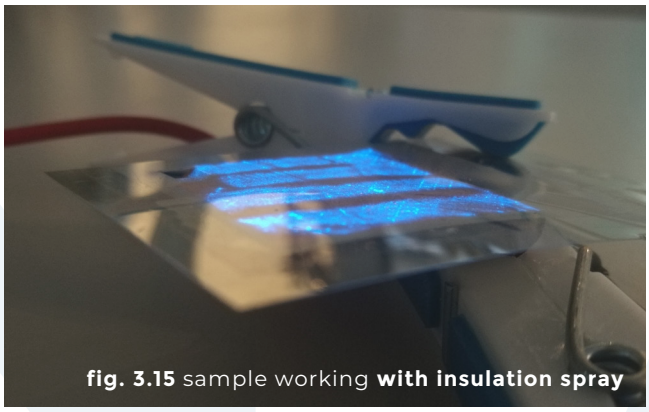


fig. 3.15 sample working **with insulation spray**

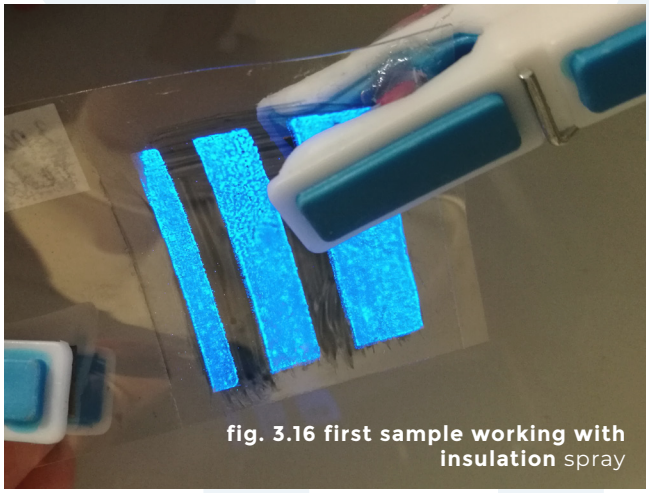


fig. 3.16 first sample working with insulation spray

lasercutting

One of the exciting discoveries is that the fully finished samples are possible to lasercut. This includes all materials and substrates, technically all of them can be lasercut. As the material is quite reflective a layer of paper tape is needed on both sides so it does not spark while being cut. The tape also protects the edges from being burnt. See some recommendations in Appendix A - Experiment 14.

Further research has to be done into knowing that all the materials are safe to cut, that they do not contain chloride (for example PVC based plastic substrates) or produce harmful gases while lasercut. This was outside of the scope of the project. The test samples were possible to cut safely due to their very small size (only a couple mm^2).

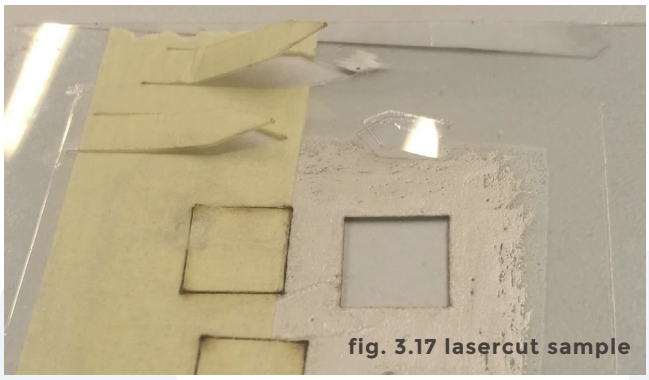


fig. 3.17 lasercut sample

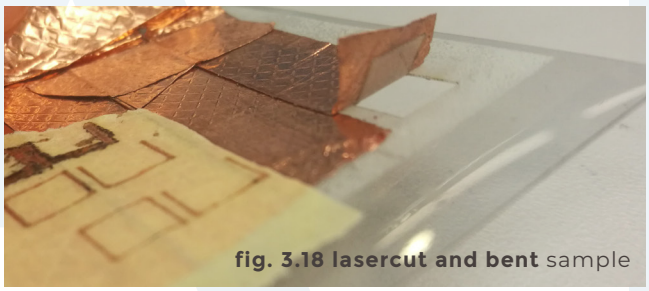


fig. 3.18 lasercut and bent sample

fig. 3.19 lasercut and bent sample switched on

See the **detailed list of used materials** (full name, company, product code) **in Appendix B**.

3.3

SAMPLE ATTRIBUTES

Sample attributes include everything that can be changed by the maker, from sample colour to the surface quality. These of course can be mixed and matched together to create a unique effect. This holds infinite variety.

SURFACE QUALITY

Depending on how a sample was made the quality of surface can change a lot; if it is screen printed (and done well) the surface can be extremely smooth and uniform. On the other hand, painting with a brush will leave a completely different effect behind; a less controlled surface with visible brush direction strokes, and less homogeneous light as well.

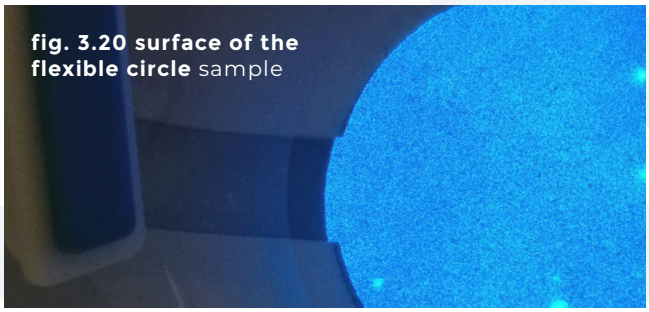


fig. 3.20 surface of the flexible circle sample

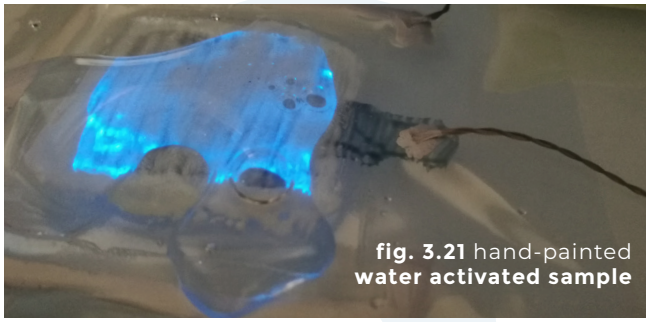


fig. 3.21 hand-painted **water activated sample**

PATTERNS

The patterns here only contain single material versions, the ones with colour are under the Colour section. Most material based patterns have been discovered due to the errors in the screen printing process (uneven layers, spray paint can running out and dripping, etc.).

dots / stars

The stars or dotty pattern on the samples are created by an extra scattered layer of spray, which did not dry evenly or together with the other spray layers. The smaller ones are invisible while the sample is not on electricity. The bigger ones appear to be dimples on the surface.

fig. 3.22 surface of the dotted flexible circle sample

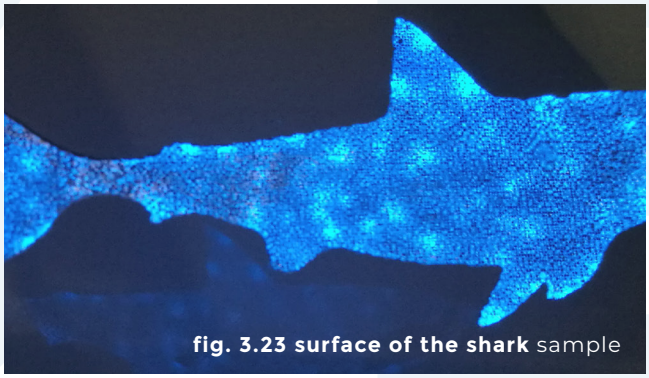


fig. 3.23 surface of the shark sample

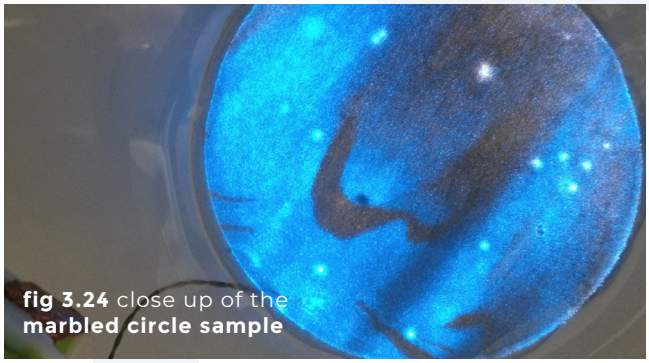


fig 3.24 close up of the **marbled circle sample**

COLOUR

The easily available colours are blue, orange and white, but sadly the store-bought whites usually came across quite disappointingly. Although if you mix together blue and orange and create your own version a whiter white can be created.

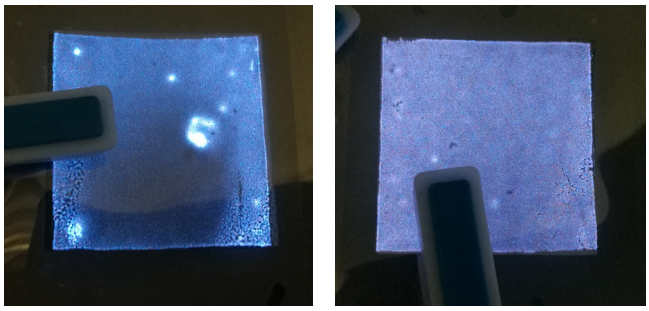


fig. 3.25 store-bought & hand-mixed white samples

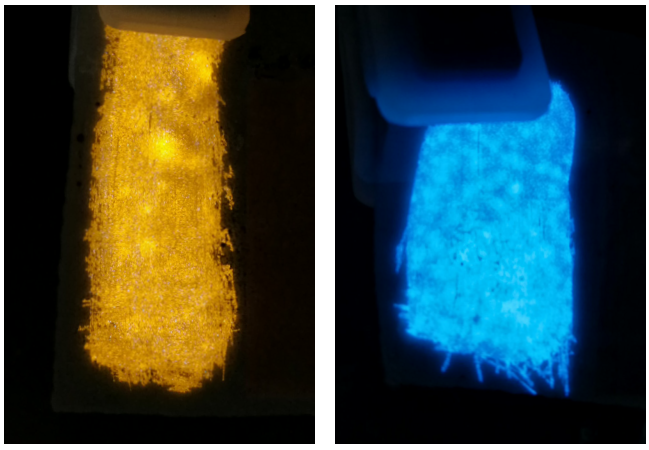


fig. 3.26 orange & blue coloured sample

gradient

A gradient can be created from orange to blue with screen printing by putting the two colours next to each other and mixing together the two in the middle. If mixed well the middle will become slightly white.

fig. 3.27 Material Driven Design project by Pekarik & Boers (2018)

marbling

These marble patterns have been created by lining blue and orange phosphor horizontally after each other on the vinyl stencil, pushing and mixing them together with a small tool, then screen printed as usual. They look natural, hand-painted.

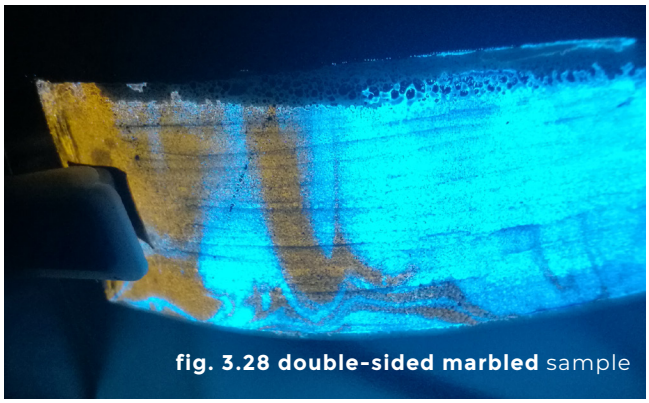


fig. 3.28 double-sided marbled sample

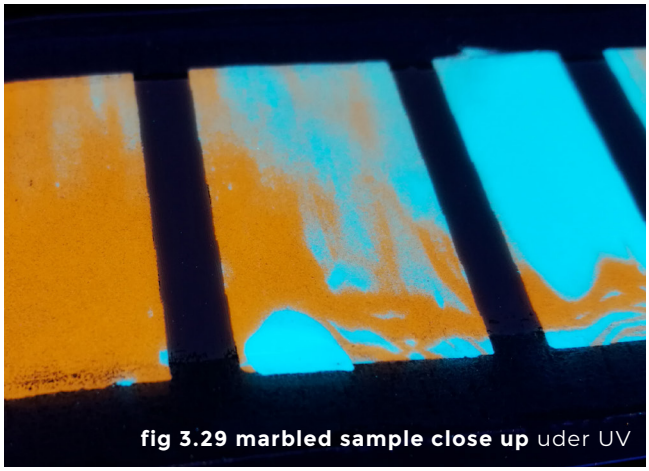


fig 3.29 marbled sample close up uder UV

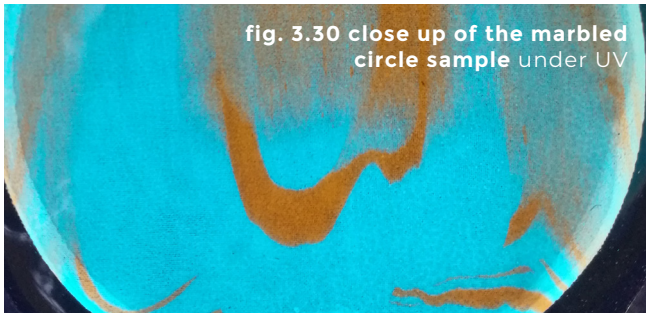


fig. 3.30 close up of the marbled circle sample under UV

SHAPE

2D shape

The 2D shape is a very important and noticeable factor of every sample, as a good structure and well aligned layers are essential for a working EL device.

The shapes of the samples can be very detailed and intricate, even replicate existing shapes and forms of our surroundings. The more difficult a shape is generally the more time-consuming it is to make it.

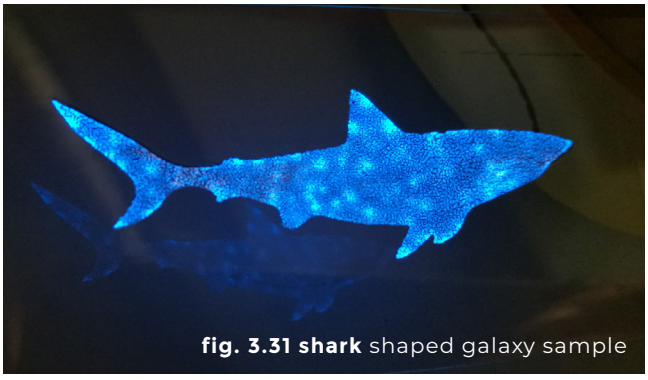


fig. 3.31 shark shaped galaxy sample

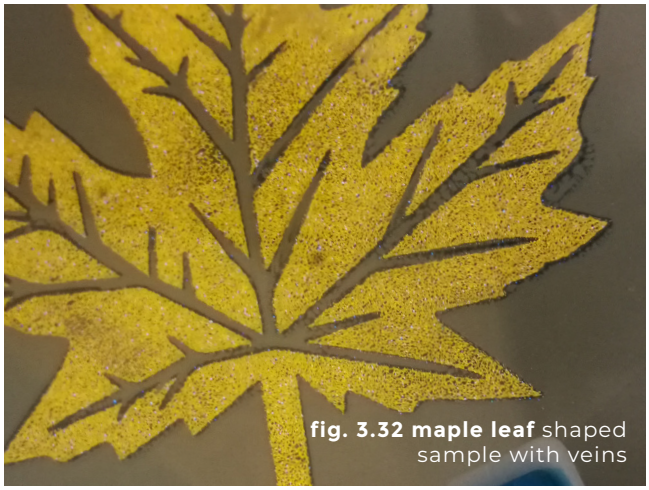


fig. 3.32 maple leaf shaped sample with veins

3D shape

The 3D shape describes the spacial characteristics of a sample, if it is completely flat, bent or curved. With a heat-gun it is possible to curve up the edges of the samples, roll or push them on a chosen surface to create a lasting deformation.

fig. 3.33 Material Driven Design project by Pekarik & Boers (2018)

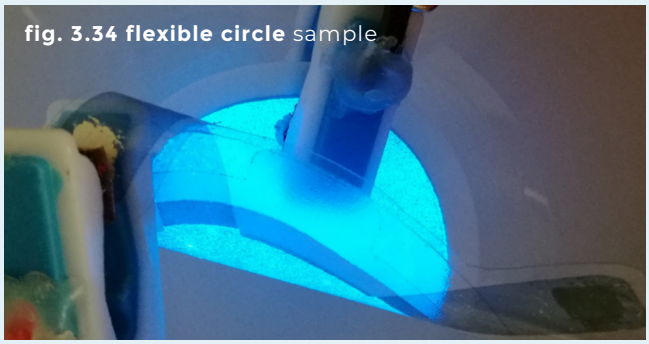


fig. 3.34 flexible circle sample

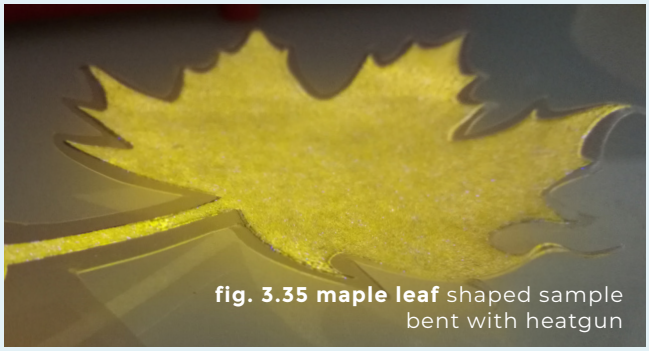


fig. 3.35 maple leaf shaped sample bent with heatgun

2D to 3D ‘pop-up’ shape

Using back lights and possibly an opening closing mechanism the light dims up and down while the sample is moved.

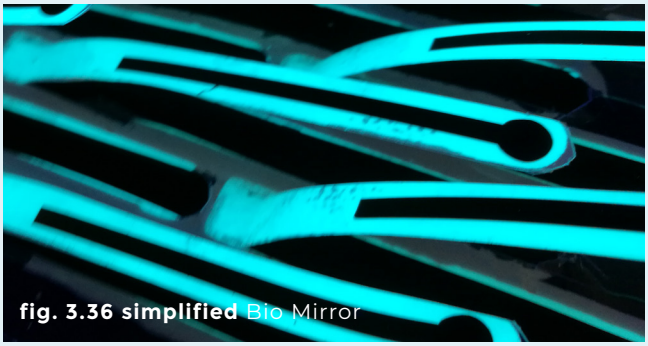


fig. 3.36 simplified Bio Mirror

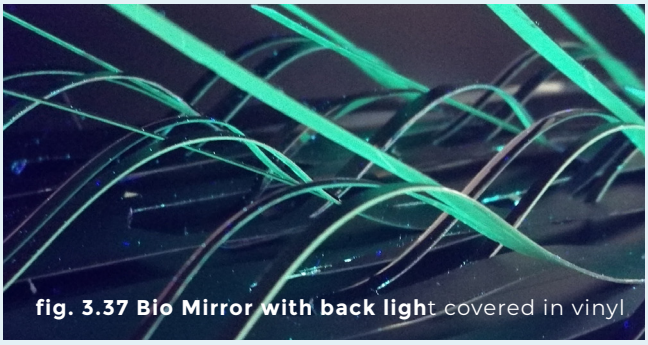


fig. 3.37 Bio Mirror with back light covered in vinyl

ILLUMINATION

SINGLE SIDED

Single sided samples have a transparent conductor (and substrate in certain cases) on one side only, which means there is light on one side. This is mostly done with PEDOT as a top layer, or a bottom emitting structure using ITO coated PET sheets.

light on the front

These are straight up samples with light on one side that is featured on the front.

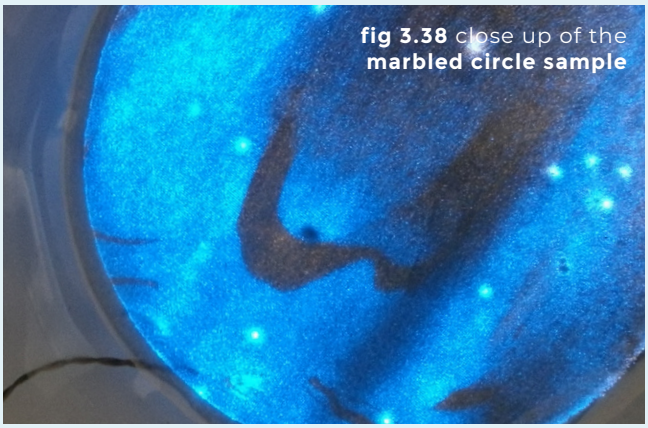


fig 3.38 close up of the **marbled circle sample**

light on the back

These samples also emit light on one side, but that is not on the front. It is hidden on the back side of the sample, which can be revealed with a 3D opening structure, opened up or bent out. The light can be reflected on the other surfaces for an interesting, more lit up effect.

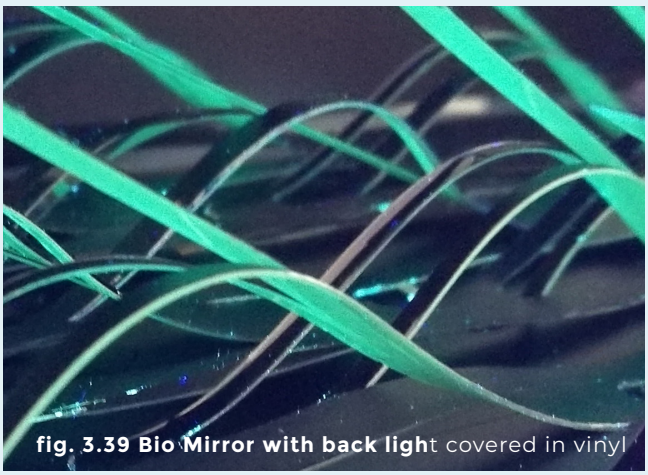


fig. 3.39 Bio Mirror with back light covered in vinyl

DOUBLE-SIDED

Double sided samples have transparent conductors on the top and the bottom. This can be done two different ways, a sandwich structure with two ITO coated PET layers (see fig. 3.40 below) or one ITO PET layer on the bottom and PEDOT as a top layer (see fig. 3.41 and 3.42). It is essential to use a transparent dielectric in this case, so the light is not blocked in the middle. Another option is the transparent electrical insulation spray, mentioned in the chapter 'Technical findings'.

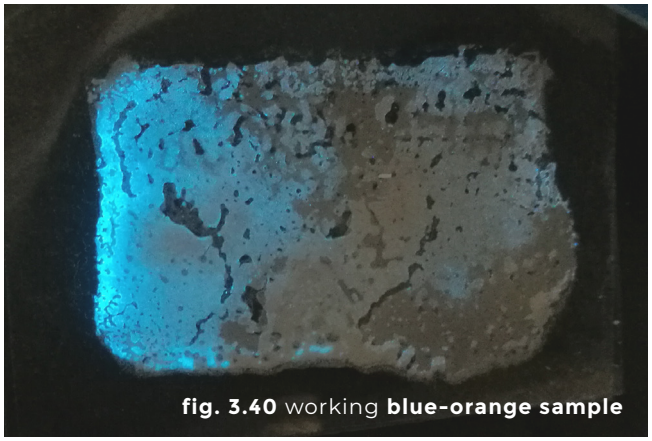


fig. 3.40 working **blue-orange sample**

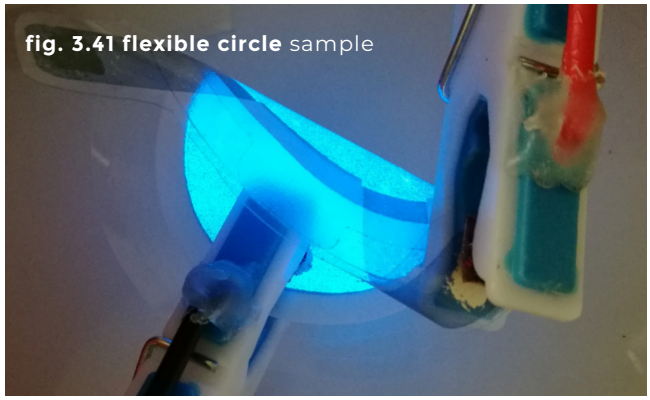


fig. 3.41 flexible circle sample

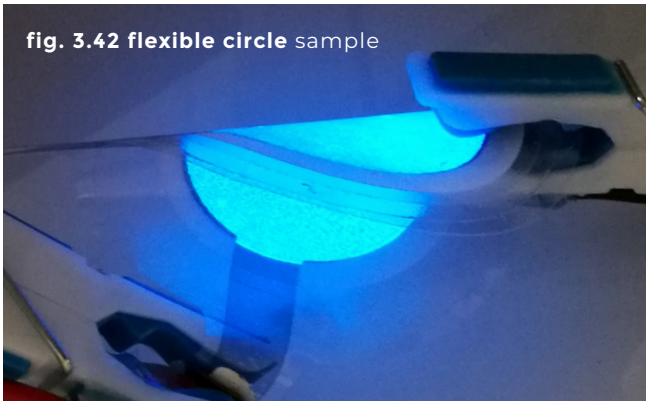


fig. 3.42 flexible circle sample

INTERACTION

INDIRECT

Interaction does not have to mean direct touch or contact. Catching the attention of the user, making them interested in or thinking about the sample is also a way of interaction. A short minute of standing captivated by the installation, stopping to take a photo, or walking back to figure out what it actually is or how it works are all valuable ways of interacting. Conveying emotion with the design or transporting the viewer into a fantasy land also falls into that category.

fig. 3.43 teamLab Borderless in MORI Building Digital Art Museum, Tokyo

fig. 3.44 Waterlight by Studio Roosegaarde

fig. 3.45 DUNE by Studio Roosegaarde

DIRECT
with the surroundings

With the help of **sensors** a product can react to the changes in its surroundings, for example by changing its shape or in case of luminous constructs, its brightness. Various sensors can be implemented to drive the change like light, humidity, temperature or a motion detector.

For example *The Sun Show* by Alissa + Nienke (2019) opens or closes depending on the light level in the room using a light sensor and a mechanical solution. As another option to drive the shape change instead shape memory alloys (SMAs) could be used. With SMAs by using electricity the shape of a sample can be changed between two states, it could for example open up like a flower.

fig. 3.46 the Sun Show by Alissa + Nienke

It is possible for a construct to directly interact with the **forces of nature**, like being moved by wind or lit up by rain (Claus, 2016). Wind could also be more like an airflow, created by people walking around or a door getting opened nearby. *CC Flow* created by Alissa + Nienke (2019) works with that principle.

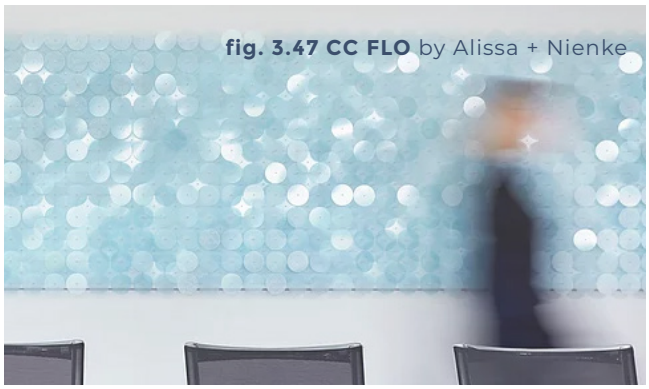


fig. 3.47 CC FLO by Alissa + Nienke

with the user

In this case the user can actively interact with the product by touching it, blowing on it or even influencing when and where it lights up. This can come in many forms, the important part is that the user can in a certain way directly manipulate what happens with the shape or light. Samples that react to outside input with the change in the output (light) - similar to how bioluminescent algae works, lighting up when it is disturbed by waves (National Geographic Society, 2012) - are considered responsive samples in this document.

fig. 3.48 interacting with the simplified Bio Mirror

fig. 3.49 DUNE by Studio Roosegaarde

fig. 3.50 **Glowing Nature** by Studio Roosegaarde

responsive samples

These are samples that are 'missing' a conductive layer, which means they need an outside element to connect the two electrodes. This can be water, conductive textile or a disassembled normal layer like ITO or a substrate covered with PEDOT. It could also mean that the sample is connected to sensors and reacts to outside effects.

by pressure / touch

This is the part where people really start to be able to do something with the material, which was a very welcomed part. It makes it way more interesting. It's loud but a lot of fun to play with, people kept poking it to change the sound and light, only problem was that the light comes from under your fingers.

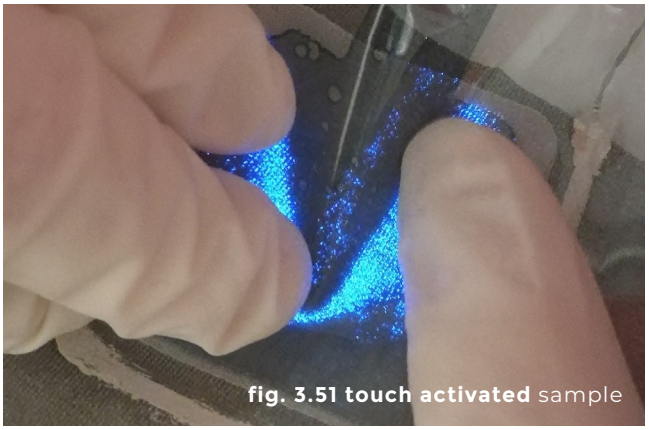


fig. 3.51 touch activated sample

fig. 3.52 touch activated sample

with water

The water with a pipette can be moved very precisely, added and also sucked back up. It's quite like panting with light, the amount of water to connection point ratio effects the brightness and the sounds too, and the shapes are easy to change by dragging or dropping the water to a different place.

People generally prefer this over the textile because it is less loud and they don't have to touch it with their bare hands. So far everyone loved playing with it.

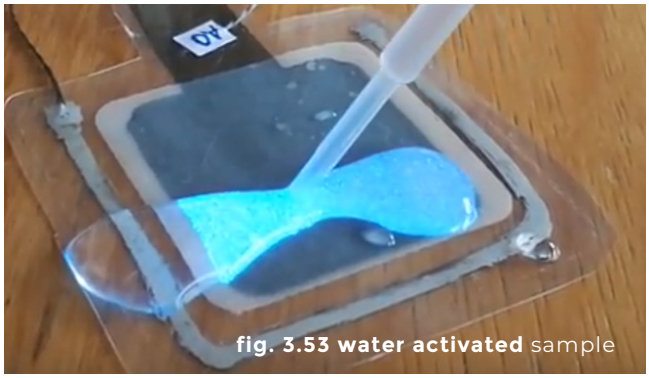


fig. 3.53 water activated sample

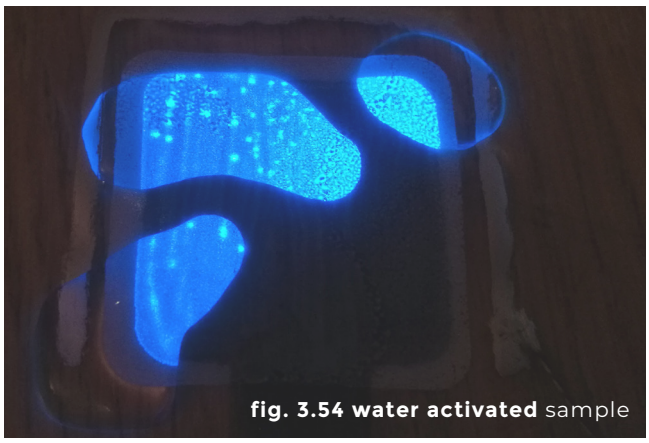


fig. 3.54 water activated sample

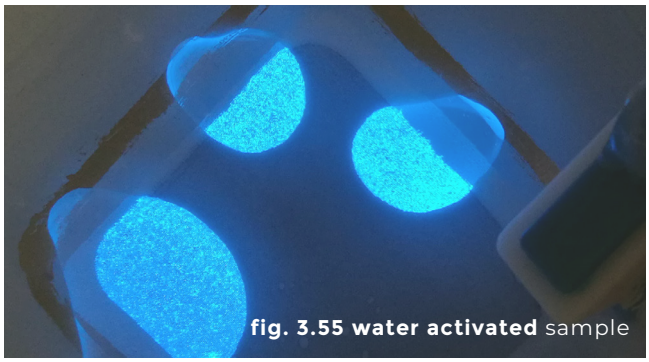


fig. 3.55 water activated sample

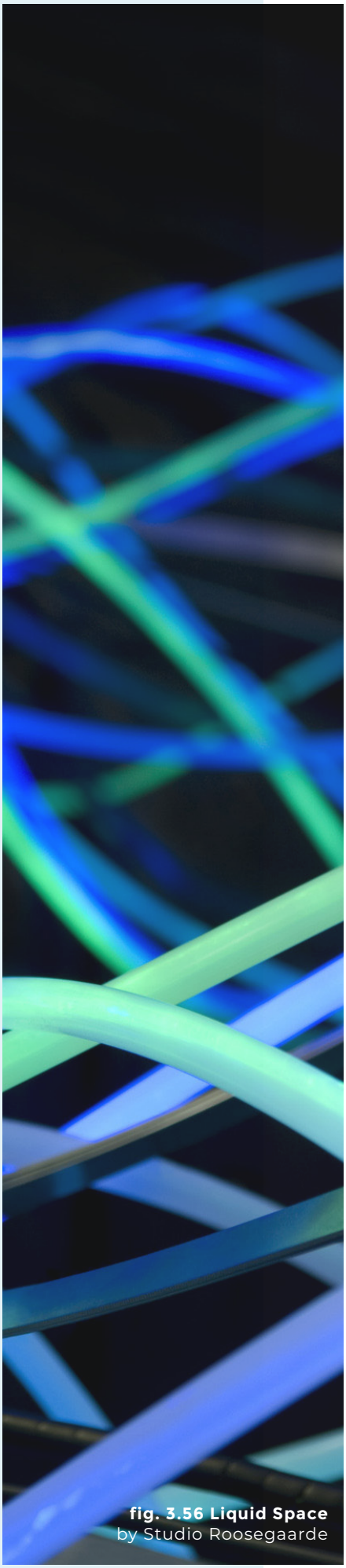


fig. 3.56 Liquid Space
by Studio Roosegaarde

3.4

EXPERIENTIAL CHARACTERISATION

This chapter contains a short research where the participants can explore, interact, “play” with the material. This can help gather input on how people react and interact with the material, what they think about it or associate it with and how they feel about this interaction.

These inputs are gathered via experiential qualities on three levels: sensorial, affective, performative and interpretive.

The Material Driven Design method presents a list of questions that helps the understanding of the four levels (Karana, Barati, Rognoli, & van der Laan, 2015):

- *"What are unique sensorial qualities and which are the most and least pleasing?*
- *Is the material associated with any other materials?*
- *Does the material evoke any meanings?*
- *Does the material elicit any emotions?*
- *How do people interact/behave with the material?"* (Karana, Barati, Rognoli, & van der Laan, 2015)

SETUP

participants

The 6 participants of the test are students of Technical University of Delft, most of them were Dutch, between 20-25 years old.

procedure

To conduct the test the Ma2E4 Tool kit developed by TUDelft and Politecnico Milano (Camera & Karana, 2018) was used. Every participant received an experiential characterisation map to fill in, while they examined the samples.

The facilitator guided them through the map, providing them with the needed materials and answers to the occasional questions about the test or the material (eg. safety) itself. The tests were conducted in the Technical University of Delft, in moderately shaded areas to be able to see the light created by the samples.

For the testing an extended version of the experiential characterisation map was used. The extension is about the light and its qualities, developed by the student together with Sylvia Pont (professor at TU Delf).

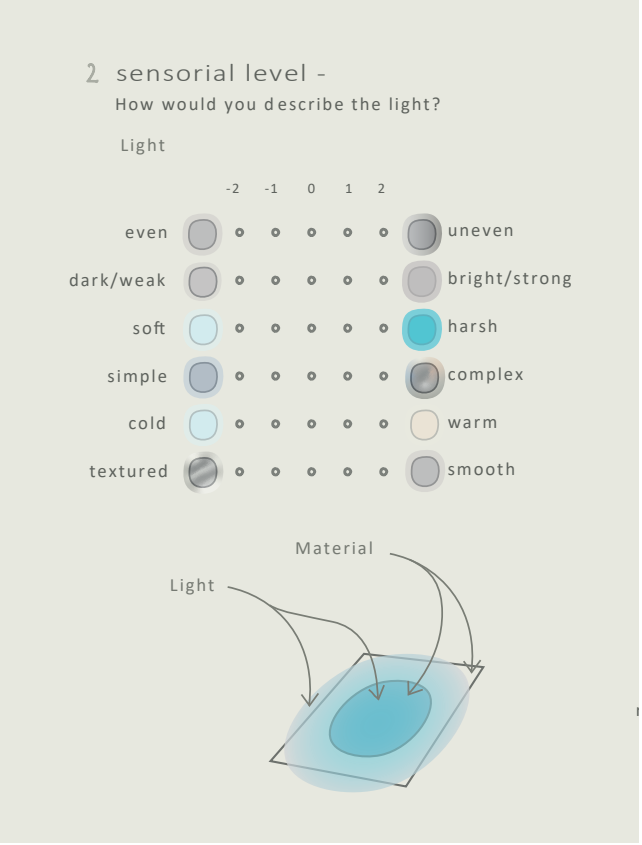


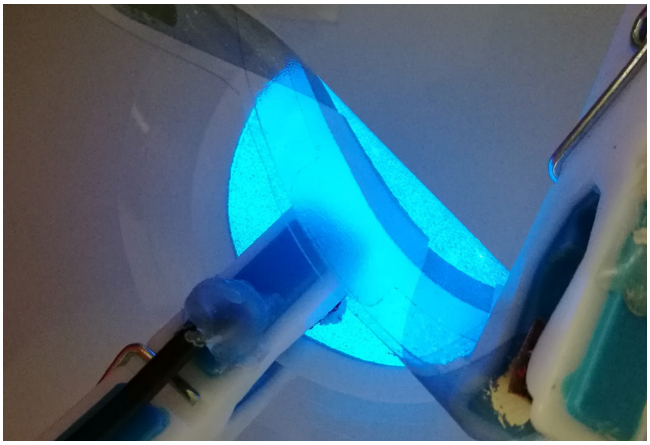
fig. 3.57 modified extra page in the research

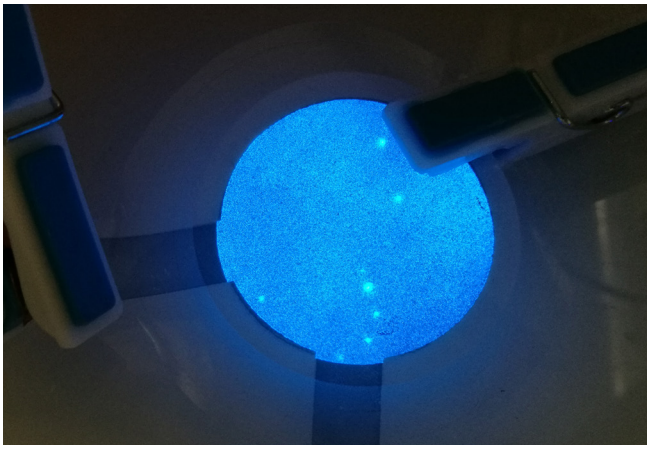
Four similar samples were analysed (thus more people could participate at the same time). The samples are flexible bright blue round samples with different dotted pattern (see fig. 3.58 - 3.62).

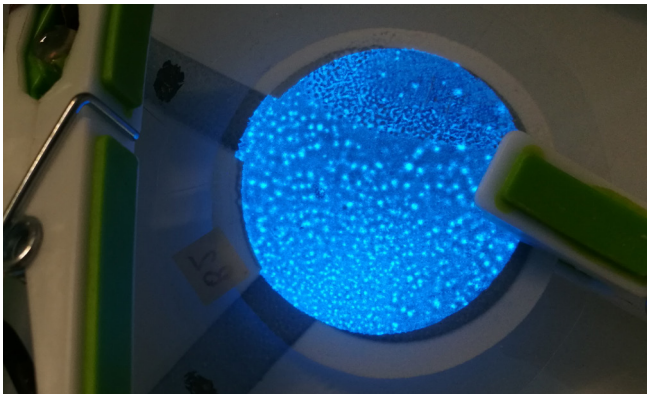
RESULTS

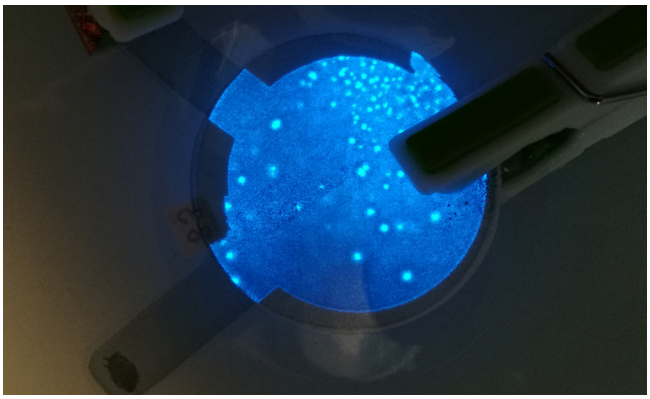
1: performative level

fig. 3.58 - 3.62 flexible samples
with different patterns









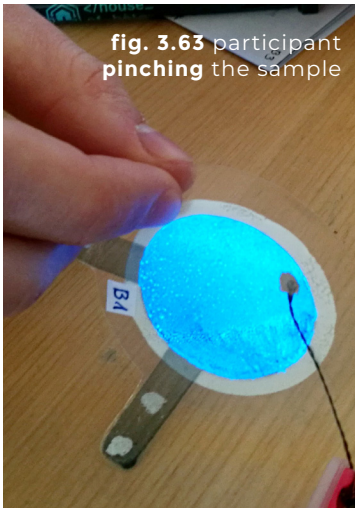


fig. 3.63 participant **pinching** the sample

TOUCH
rubbing (n=4/6)
poking (n=4/6)
pressing (n=2/6)

MOVE
folding (n=2/6)
flexing (n=2/6)
bending (n=4/6)

HOLD
pinching (n=4/6)
holding (n=3/6)

When the material was presented to the participants, most of them started to poke or rub it, maybe press it, fiddle with it. Some were slightly reluctant to touch it. Moving samples mainly happened by flexing, bending or folding it. Most of the participants found pinching (holding it in between two fingers) the best way to hold the material, or to just hold it in your palm.

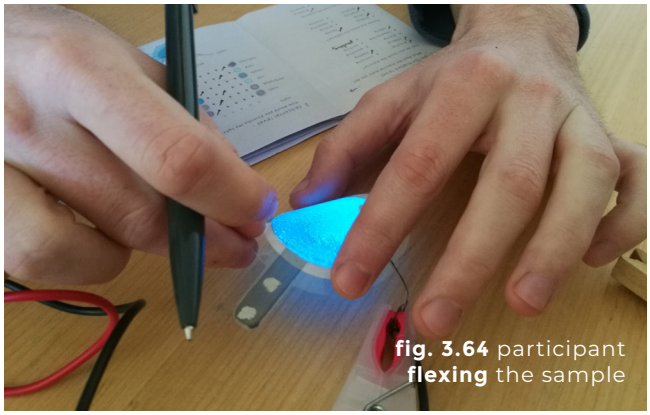


fig. 3.64 participant **flexing** the sample

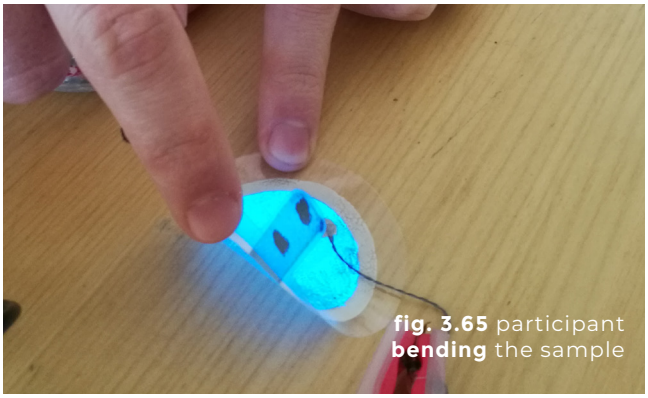


fig. 3.65 participant **bending** the sample

2: sensorial level

The participants generally had mixed ideas about the characteristics of the material, giving a high dispersion of answers. Therefore after tallying up the average, quite a few answers ended up in the middle of the scale. In some properties participants highly agreed, those are: weight, strength, and ductility. That means most of the participants consider the material really light, quite strong, ductile and non-fibred.

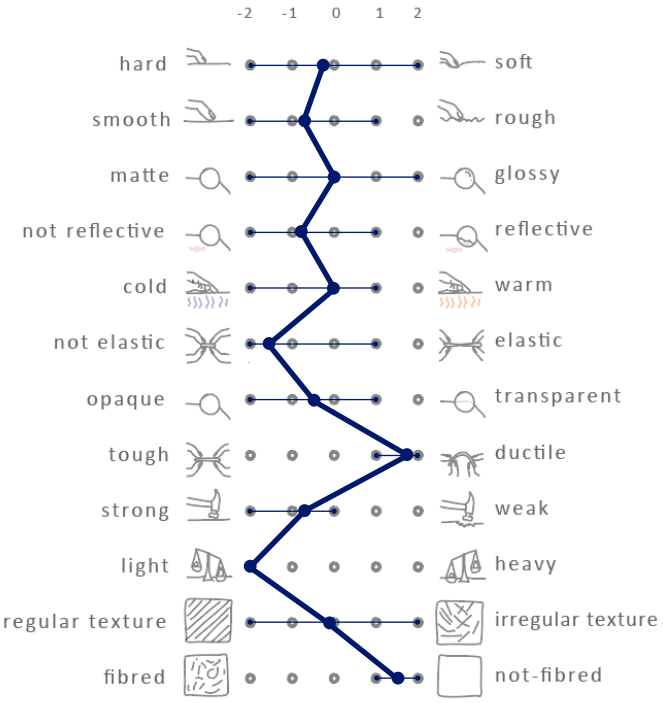


fig. 3.66 averaged material properties on sensorial level

In case of evaluating the light there was quite a strong agreement with all characteristics, the answers aligned a lot with each other. The participants consider the light uneven, medium harsh and bright, quite complex, really cold and highly textured.

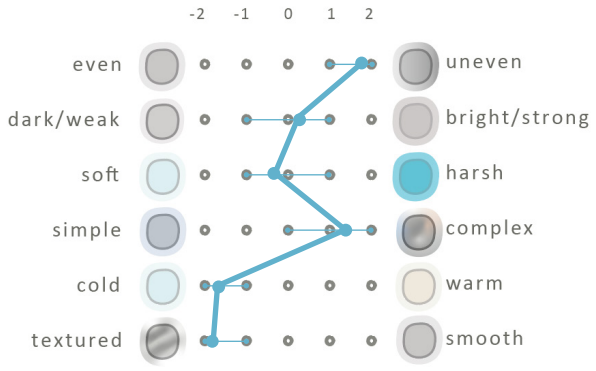


fig. 3.67 averaged light properties on sensorial level

3: affective level

The material evoked two main categories of emotions: intense and pleasant ones grouped around surprise and curiosity; and unpleasant ones, mainly distrust and doubt. For the light the participants used the words fascination, amusement, curiosity on the pleasant side, melancholy closer to the neutral levels, and confusion on the slightly unpleasant side.

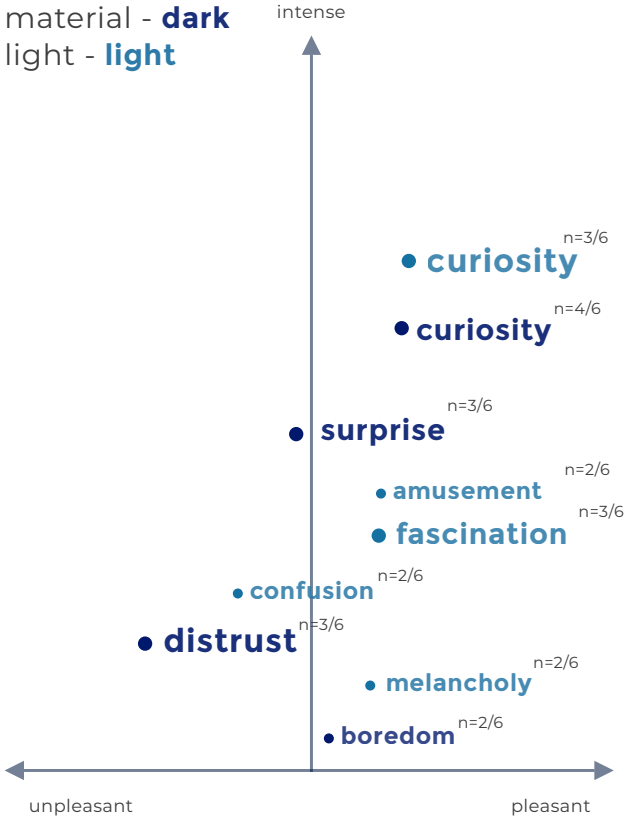


fig. 3.68 pleasantness - intensity diagram

4: interpretive level

The most frequently chosen meanings for the material in order were **manufactured, toy-like, futuristic, not-sexy and strange**. Besides those only a couple of other terms have been selected by the participants, unnatural, hand-crafted, vulgar, sober, calm, professional, aloof and cosy.

The most frequently chosen meanings for the light in order were **strange, hand-crafted, futuristic, manufactured and unnatural**. Besides those only a couple of other terms have been selected by the participants, unnatural, professional, frivolous, sexy, not-sexy, calm and cosy.

The choice of strange was explained by the following: *“bacteria-like”, “shouldn't be possible”, “weird texture”, "fluorescent"*.

The sample was considered futuristic and toy-like because it is *“light”, “bright”, “neon-like”, “paper thin”*.

The sample was considered manufactured and toy-like because it is *“round shape”, “plastic feel”, “texture looks deliberate”, “safe”*.

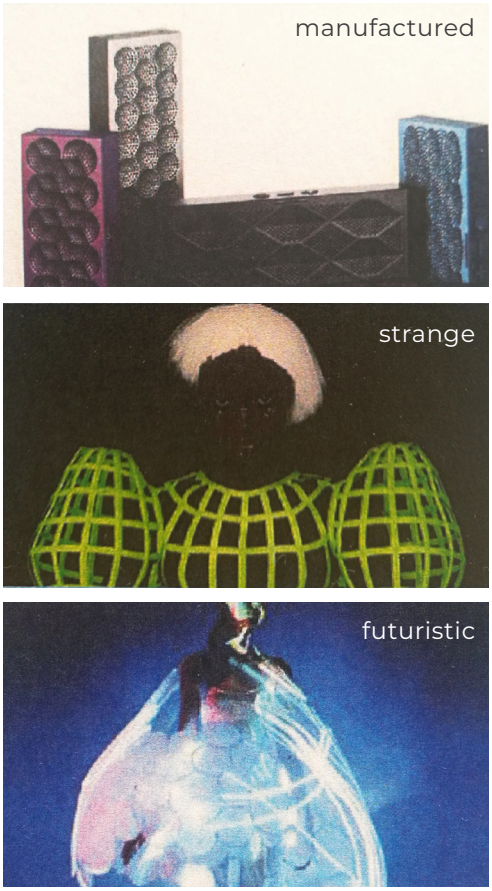


fig. 3.69 most commonly chosen pictures
for the most common meanings

material	**light**
manufactured (n=3/6)	strange (n=3/6)
toy-like (n=3/6)	hand-crafted(n=3/6)
futuristic (n=2/6)	futuristic (n=2/6)
not-sexy (n=2/6)	manufactured(n=2/6)
strange (n=2/6)	unnatural (n=2/6)

It is interesting to see that an opposite pair, manufactured and hand-crafted were both chosen frequently. According to the quotes, it comes from the DIY nature of the material paired with the plastic feel and round shape.

It is clearly visible in the results, that some of the characteristics of the material are hard to define. The electroluminescent sheet has several visible layers and materials. Furthermore some of the characteristics are also highly relative, depending on the point of view. This was less of an issue when describing the light, the data has significantly lower dispersion in that case.

The material evokes some distrust and confusion, mainly towards the electric nature of it. The data also shows that curiosity does overpower distrust in most cases and develops into fascination or boredom.

On the interpretive level some of the chosen terms turned out to be the opposites of each other (manufactured vs. hand-made). This shows that the different characteristics of the material can be interpreted in various ways.

The participants mostly saw strangeness in the pattern and texture of the samples, focusing on the small imperfections and unknown nature. The colour had various associations, the blue hue was considered futuristic, on the other hand the brightness and saturation made it look toy-like. The geometric shape made it feel more manufactured, the simpleness and plastic feel had the same association.

Several interrelations can be found between the different levels of the experimental characterisation. The emotions that were evoked in the participants by interacting with the samples align with the chosen meanings. Samples that were considered futuristic or strange, could be connected with the curiosity, also with the surprised and confused emotions. The careful interaction involving the fear of danger is visible on the affective level, where distrust emerged.

3.5 how frequency

INFLUENCES COLOUR

PREMISE

This research was conducted to **see what parameters influence the colour output** of an electroluminescent sheet. It is known that frequency can slightly alter the colour, but the scale of the difference with the used specific power supply and inverter combination (power bank + pocket inverter and EL wire inverter plugged into a socket) was unknown.

SETUP

A working blue **sample was connected to an oscilloscope**, then the **voltage and frequency was slowly** (and separately) **changed** to see what happens. Then the frequency and voltage output of the regularly used power supply and inverter combinations have been measured.

RESULTS

oscilloscope

When changing the voltage on the oscilloscope not much happened, on a lower voltage the samples went slightly dimmer. However **when the frequency was altered changes happened in the colour output** as well. With the oscilloscope it was possible to distinguish and measure the connected frequency values of 3 colours.

Voltage	Frequency
240V	Blue - 1.8 kHz
240V	Aqua - 1.0 kHz
240V	Turquoise - 0.72kHz

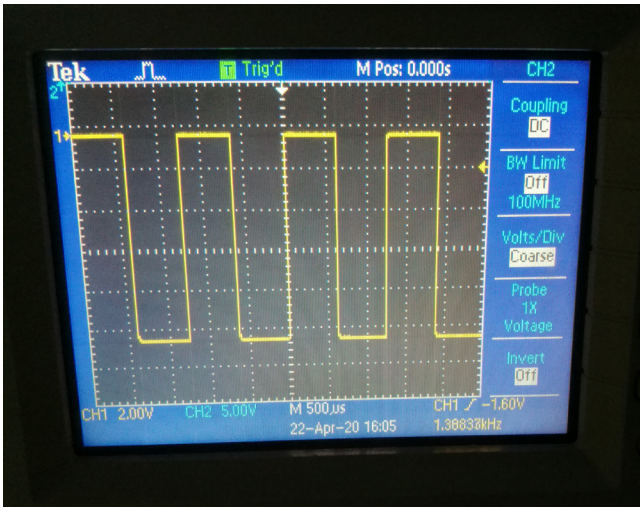


fig. 3.70 curve drawn by the **oscilloscope**

power bank & inverter

fig. 3.71 information of the **power bank**

The small power bank connected to a pocket inverter that is normally used to power the small samples has been connected to the oscilloscope so the frequency and voltage could be measured. The waves draw a sinus curve.

Voltage - 150 V Frequency - 2.76 kHz

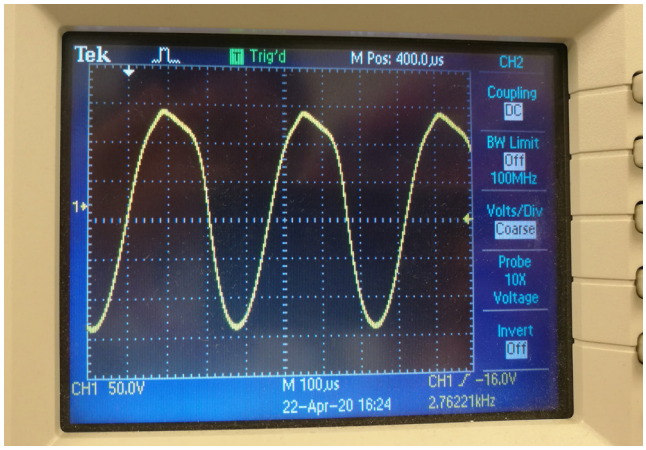


fig. 3.72 curve drawn by the **power bank + inverter**

EL wire inverter

fig. 3.73 photo of the **Inverter for EL WIre**

The inverter for electroluminescent wires can deliver a higher voltage than the small power bank, making it possible to power larger samples. It is, as the name says, intended for wires but frequently used for sheets as well.

Voltage - 270 V Frequency - 0.96 kHz

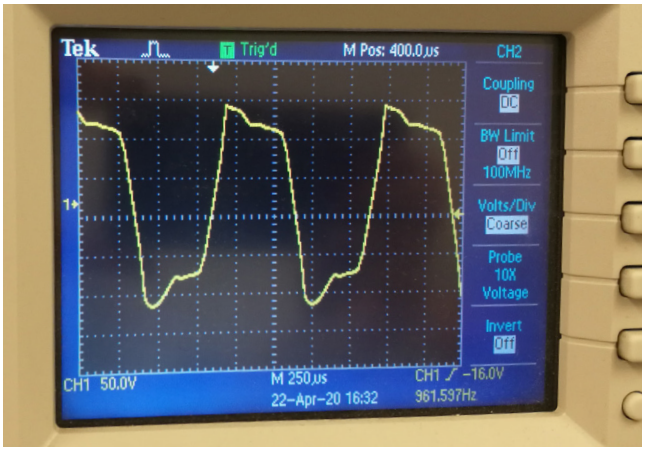


fig. 3.74 curve drawn by the **EL wire inverter**

CONCLUSIONS

Based on this small research it seems that the colour is mainly dependent on the used phosphor powder and the applied frequency. On a lower frequency the samples appear greener and 'less bright', **on a higher frequency they are 'brighter' and more blueish** , closer to the intended colour described on the phosphor packaging. This phenomenon points to the **importance of choosing the right inverter** for the EL sheet so it will appear as bright and with the exact colour as desired.

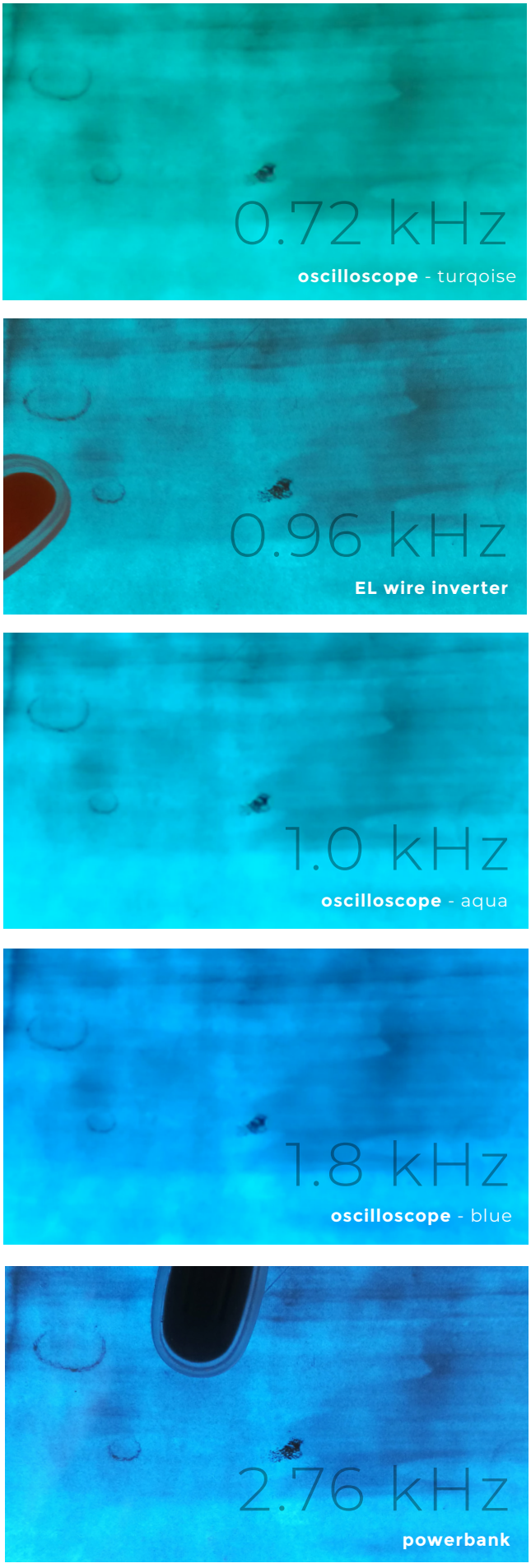


fig. 3.75 photos of the **different colour outputs**

3.6

LUMINANCE MEASUREMENTS

"Luminance is often used to characterize emission or reflection from flat, diffuse surfaces. Luminance levels indicate how much luminous power could be detected by the human eye looking at a particular surface from a particular angle of view. Luminance is thus an indicator of how bright the surface will appear." (Wikipedia contributors, 2020)

PREMISE

This research was conducted to **determine the maximum layer number** or thickness of the insulation spray **before the light quality starts to get diminished by too much insulation**. Different application methods have been considered in order to see how much the method (which mainly correlates to the thickness of the applied layers) matters. How even certain layers are is highly reflected in the outcome as well, as the light appears quite homogeneous on even samples and patchy on uneven ones.

METHODS

spray painting

These samples have been **spray painted** with the **insulation spray** from the recommended 30 cm, thus the layer thickness is quite even all over the surface. However by increasing the size of the samples spray painting even layers becomes exponentially more difficult.

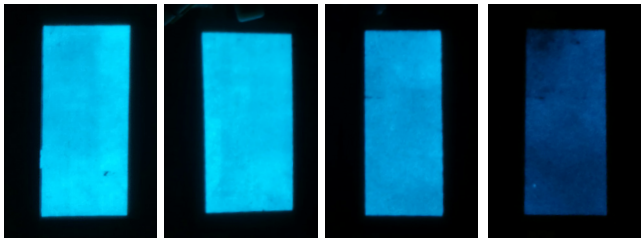


fig. 3.76 spray painted samples with 1, 3, 6 9 layers

using a squeegee

As evenly spray painting large samples is quite difficult a search for other application methods had begun. The insulation spray cannot be screen printed as it dries too quickly (thin layers dry within 10 seconds) and would cure the mesh and layers under it together.

This method uses a rubber **squeegee to press and spread the** material (**liquid sprayed out of the can**) from a vinyl stencil to all over the surface (see instructions for this method in Appendix A, Experiment 39 - How is it made?). If pressure is applied evenly the layers turn out quite even as well. With the increasing number of layers this can become quite difficult to achieve. The first sample has two layers instead of one, as that sample short-circuited.

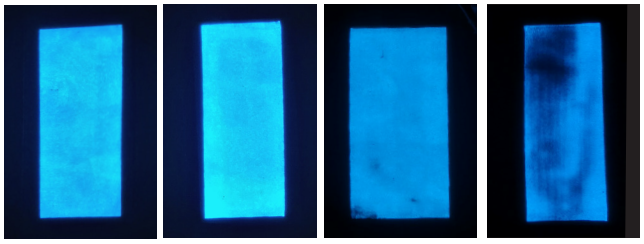


fig. 3.77 squeegee samples with 2, 3, 6 9 layers

spreading with a stick

The insulation material was **poured onto the edge of the surface** and a **stick was used to distribute it** over the whole area. This method was considered in order to increase the layer thickness and decrease the needed layer number, however it is quite difficult to create even layers with it. There are only 3 samples for this method as the samples with 1-2 layers short-circuited.

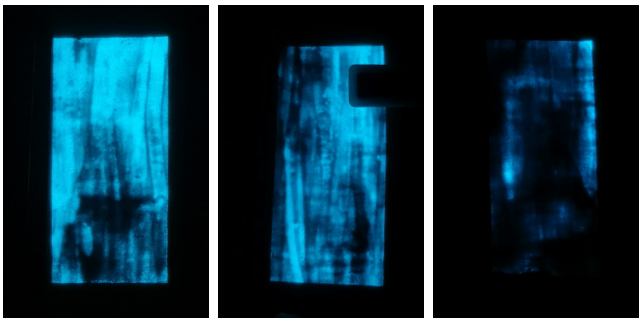


fig. 3.78 stick spreading samples with 3, 6 9 layers

SETUP

A **luminance meter** was used to take the measurements from the samples, the unit is cd/m². The luminance measurements had been taken in a dark room from one point with the first two methods, and from 2 points (brightest and darkest) on the last method.

The thickness was measured with a **digital thickness gauge**, and it is presented in µm. The insulation layer is so thin it is measured together with the phosphor layer (~40-45 µm). The precision is 5 µm, which means the thickness measurements are slightly unreliable.

RESULTS

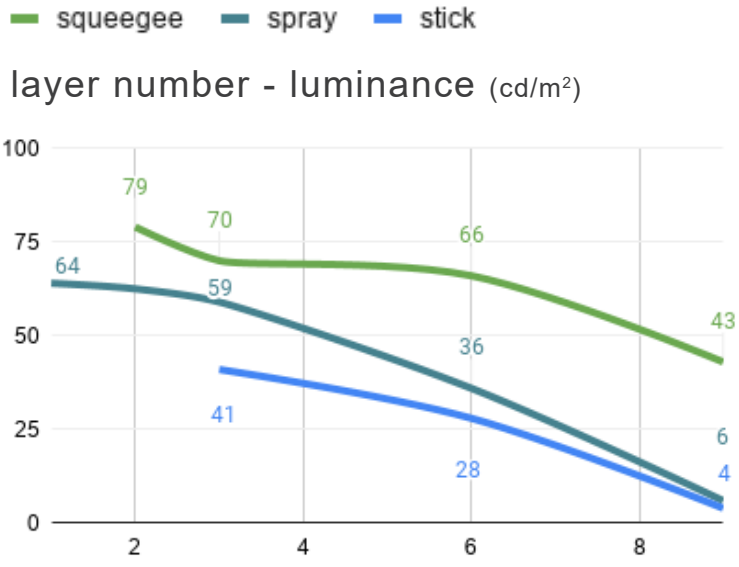


fig. 3.79 luminance correlation to layer number

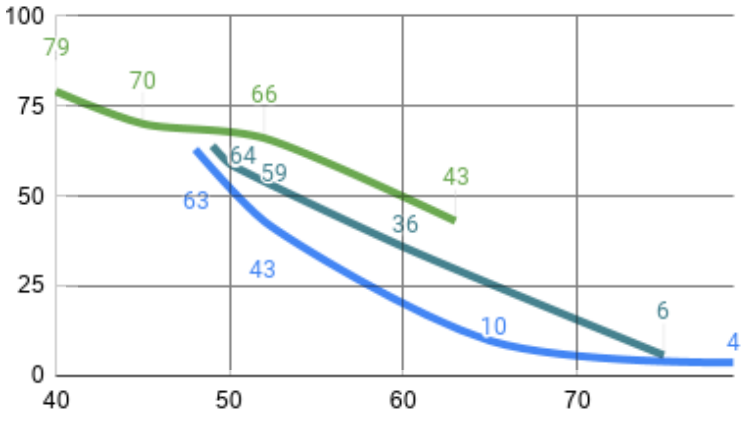


fig. 3.80 luminance correlation to thickness

CONCLUSIONS

For the spreading with a stick method on the layer number graph an average of all the measurements (both bright and dark) have been used, on the thickness graph the bright and dark measurements have been connected to the high and low thickness values to create a more refined graph. See the data tables in Appendix D.

Both the thickness and layer number show a connection to brightness. **All samples** in all methods **get consistently less bright with more layers**, creating a flat descending curve on the graphs. However there is a **notably small difference between 3 and 6 layers with the squeegee method**, only 4 cd/m², which is barely visible to the naked eye.

The individual layer thickness also seems to be connected to brightness. The layers produced by the squeegee method are thinner than the spray painted or spread with a stick methods. The first squeegee sample, even with 2 layers is brighter than the 1 layer spray painted one.

All in all the **squeegee method produces the brightest samples** and has the **smallest difference between 2 and 9 layers** in luminance. The spray painted ones look the most homogeneous, and work already with only one layer. The layer thickness with spreading with a stick is similar to spray painting, however it created a very uneven surface with a lot of dark patches. A **combination of spray painting and using a squeegee holds the possibility to create bright and very even samples**.

3.7
DECISION POINT

light on the **BACK SURFACE**

The tinkering showed that a large surface with solid light can become obnoxious. The samples need to be smaller, not solid light or need a negative space (covered part) to look their best. Thus a decision was made to the use light mainly on the back surface. It is more subtle and unique, gives opportunities to play with the 3D shapes and create a structure which reveals the light only on certain places.

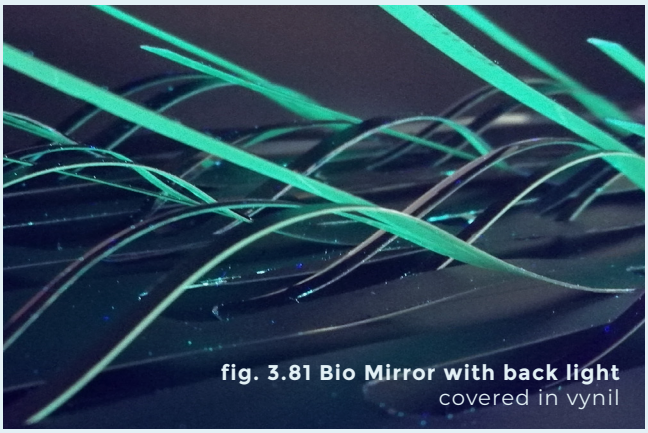


fig. 3.81 Bio Mirror with back light covered in vynil

INDIRECT interaction

Creating designs that trigger curiosity and interaction is important for Alissa +Nienke. Electroluminescence holds great opportunities for both direct and indirect interactions. The indirect interaction category includes illuminating surfaces that catch and/or hold the attention of the viewer. That can happen via representing a 'feel' or a captivating aesthetic. The intriguing aspect can be a unique shape, pattern, gradient or a changing design. It is possible to create changing shapes not by movement of the material but the movement of the viewer (3D shapes that look different from different angles).

movement by **WIND OR TOUCH**

The samples that are capable of moving can create intriguing and interesting surfaces. Movement with airflow or touch fits well with the profile and style of Alissa + Nienke. The idea to use sensors was disregarded, as it could be unnecessarily difficult for this specific project.

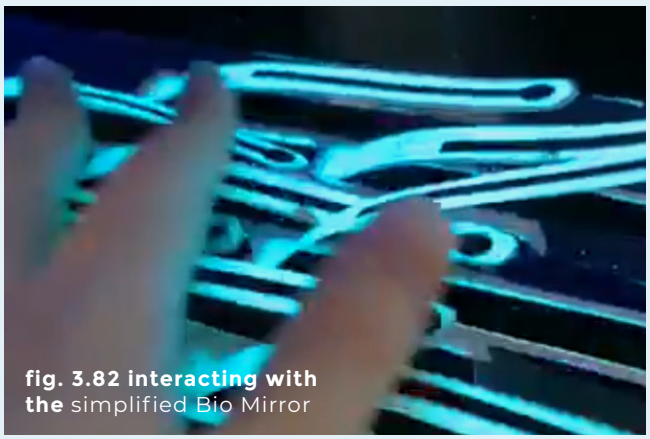


fig. 3.82 interacting with the simplified Bio Mirror

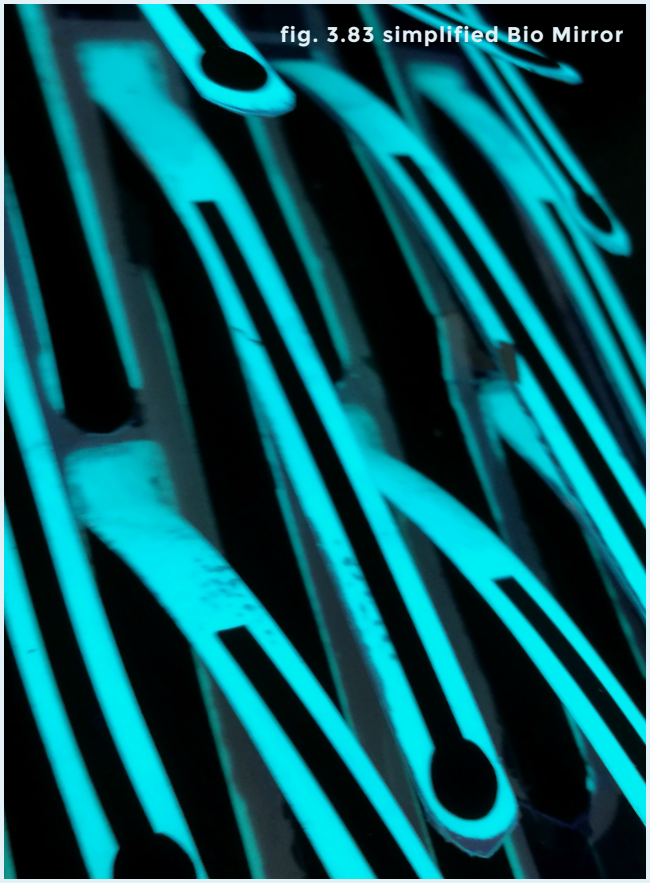


fig. 3.83 simplified Bio Mirror

HOSPITAL
environment

The assignment started as a really open challenge, which means a lot of freedom and very little requirements. To help the design phase a possible scenario was created, placing the product in a hospital environment. It could be decoration in waiting rooms to help people forget about the stress for a while.

This immediately creates restrictions:

- the movement of the samples cannot be fast, as people might be near them for a long time (no flashing),
- there will be all kinds of people around (including children and elderly) who might get curios and touch or fold parts not intended for it,
- a hospital is a busy environment, the decor cannot get in the way of function.

fig. 3.84 hospital where the Mirabilia was applied

fig. 3.85 Mirabilia Wallcovering in application by Alissa + Nienke

WHAT IS NEXT?

Designing a surface installation that fits with the chosen directions, the hospital environment, also the style and working methods of Alissa +Nienke.

Furthermore the following points need to be taken into account when creating concepts:

- possible ways to manipulate the material (bending, using a heat gun),
- possible production methods (screen printing, laser cutting, etc.),
- and the types of possible interaction in the environment (touching, with the airflow, catching the interest of people).

fig. 3.86 Mirabilia Wallcovering by Alissa + Nienke

3.8

DESIGN VISION

TRIGGERING
curiosity & interaction

At this point the vision is an empty canvas with many possible directions. The design in general will not be created to solve a specific problem, it is more in the exploration genre, searching for new and meaningful ways to incorporate the material in surface design. However the distinctive style of Alissa + Nienke and this verstile material does have an intersection. A+N takes 'simple' shapes and materials and turns them into enriched designs that trigger curiosity and interaction. This became the starting point of the vision.

I would like to create something that fits into the portfolio of Alissa + Nienke and at the same time it truly represents the uniqueness and beauty of the electroluminescent materials. Using the outstanding chracteristics of EL materials I imagine creating a surface design with 3D elements in it that invite people to interact with it, inspiring them to think about what they saw.

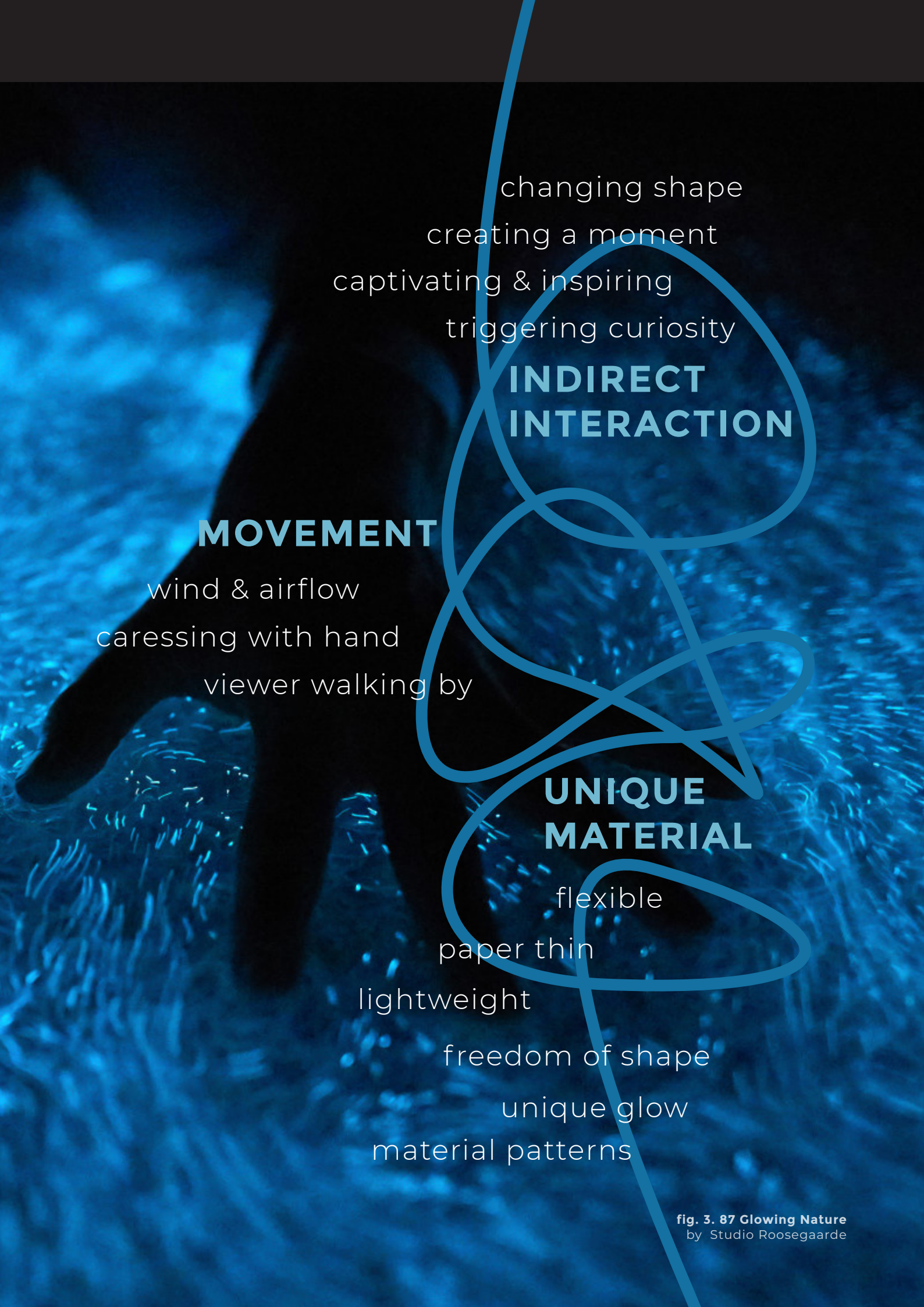
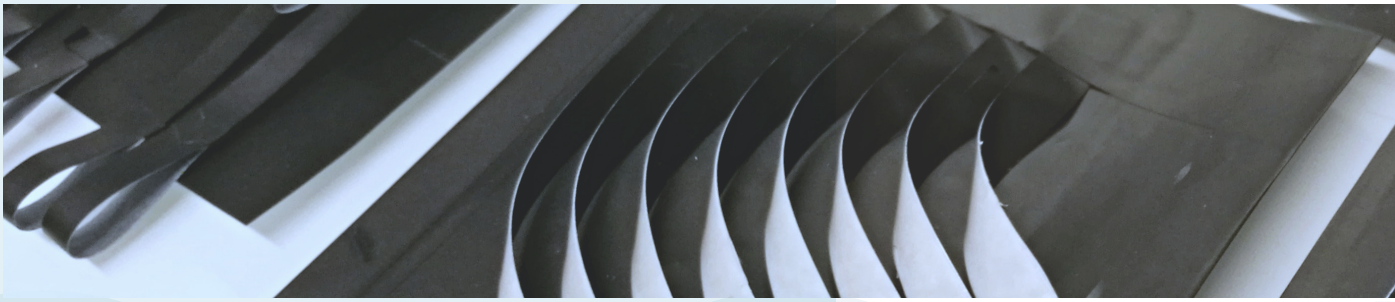


fig. 3. 87 Glowing Nature
by Studio Roosegaarde

CONCEP
PHASE

how we came to
THE PHYSICAL SHAPE



This chapter contains the concept development; starting with creating all the elements of the tile set and some possible large patterns. After that a proof of concept was made; they are the first working prototypes using most of the envisioned materials. Lastly, during a long iteration phase the final details of the design have been worked out.

T

4

SURFACE DESIGN

"Surface design is any type of artwork (pattern, illustration, hand lettering, etc.) made by a designer that is intended to be applied to a surface to enhance its visual appearance and/or functionality." (McNab, 2019)

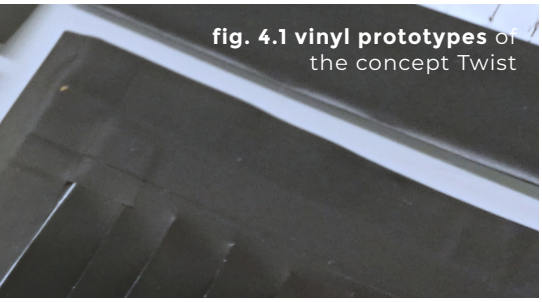


fig. 4.1 vinyl prototypes of the concept Twist

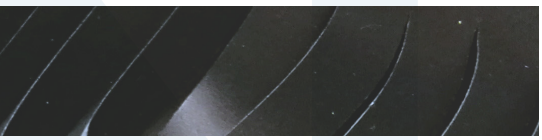


fig. 4.2 CC FLO by Alissa + Nienke

fig. 4.3 photos of selected **best paper concepts**

4.1 searching for **SHAPES**

Searching for simple shapes and patterns that can be made from a flat sheet with cutting, bending and glue. The models highlight the thinness and bendability of EL devices, using the possibility to laser-cut them.

The important choices for furthering the design was to create a simple solution with as little post-processing after laser-cutting as possible. That also means for connection points (like loops) a solution made from the material itself is preferable, like making a hole in the material and pulling it back through it. Furthermore a clean design from a single sheet fits the style of the client.

The two chosen directions are the bent lines and the hanging loops, they fit the requirements well while being a unique and interactive design.

LINES

fig. 4.4 photo of **concept Twist**

fig. 4.5 close up of **concept Twist**

LOOPS

fig. 4.6 photo of **concept Loops**

fig. 4.7 vinyl prototypes of the concept Loops

4.2 UV light
PROTOTYPES

Detailing the chosen physical shapes and patterns with paper and plastic models covered with black vinyl. Black vinyl does not shine or light up under UV light, so the phosphor layer is visible without interruption.

LOOP
stripes

The Loops have light on the back of the sheet which is exposed inside the loops. Most versions have the cut shapes hanging flipped backwards to create a more arched line. The individual lines can dangle and move around with the wind. The first version has thin stripes on the front side where the light is not covered.

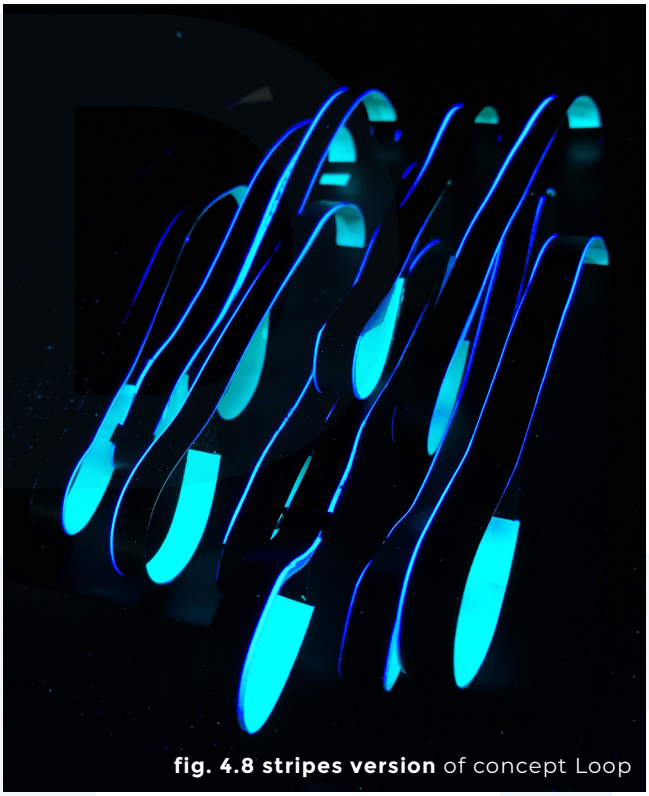


fig. 4.8 stripes version of concept Loop

thin lines

This version has thinner lines which is created by the light shining through the substrate itself. It creates a cleaner design, looking like falling raindrops.

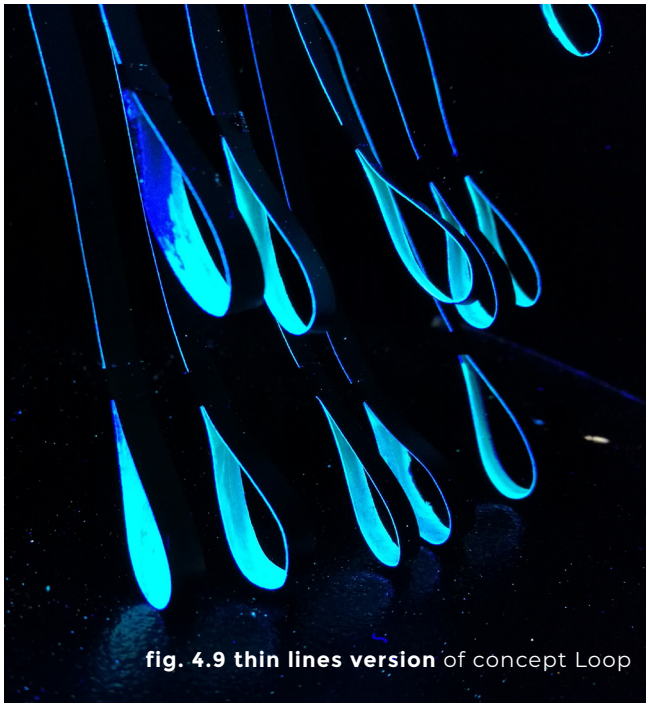


fig. 4.9 thin lines version of concept Loop

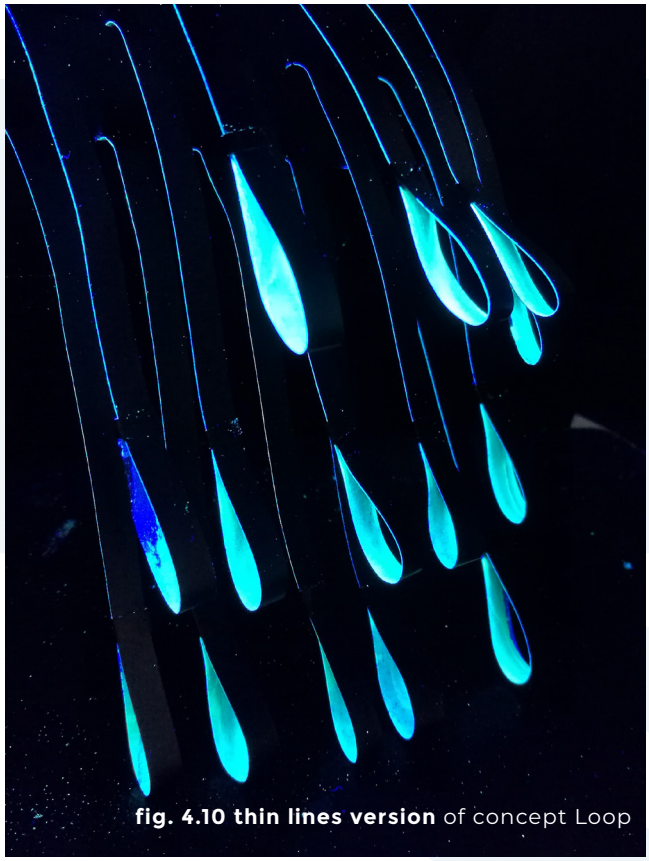


fig. 4.10 thin lines version of concept Loop

waves

In this case the cut shapes are curved and just hanging (without flipping) with an asymmetrical loop at the end. This means the light is more visible from one side.

fig. 4.11 waves version of concept Loop

squares

This model uses a connection made from the material itself by cutting the lines in half-way then just sliding them onto each other. This visually creates the squares.

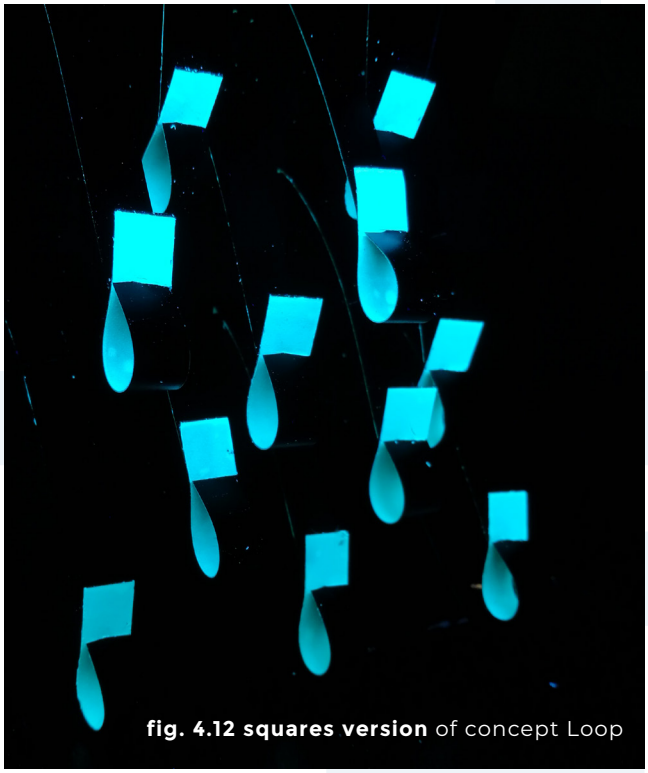


fig. 4.12 squares version of concept Loop

TWIST

This simple but effective concept is about twisting the thinly cut material revealing the light placed on the back side. This can happen in a straight line or with a curve to the side. Twisting the material once is possible, more than that could tear or damage the layers.

straight twist

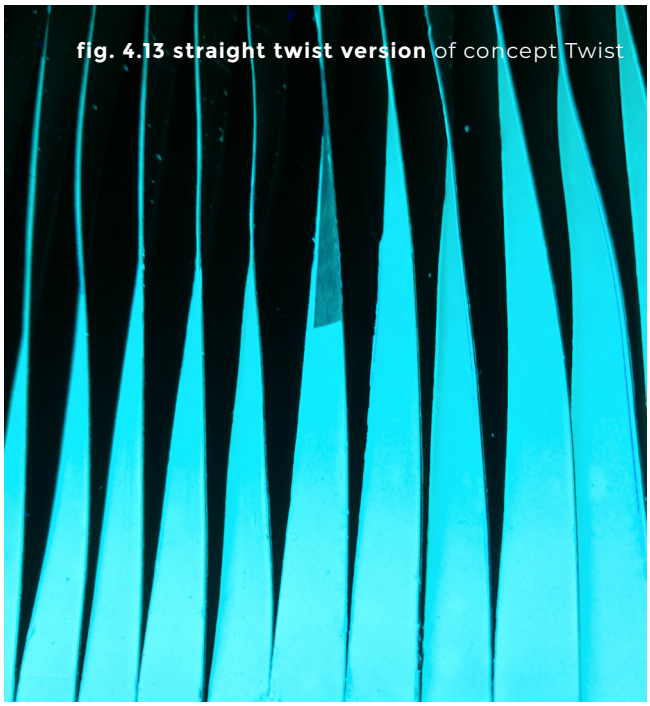


fig. 4.13 straight twist version of concept Twist

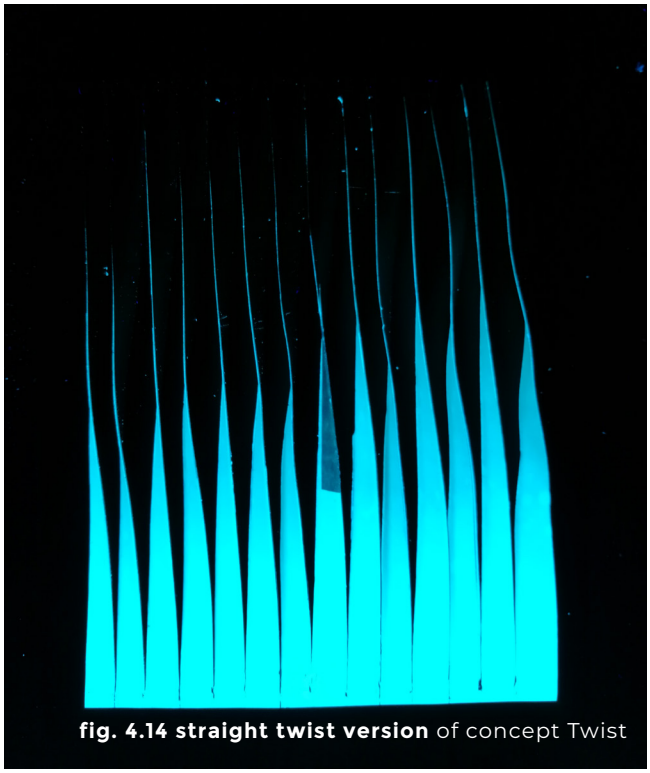


fig. 4.14 straight twist version of concept Twist

curves

The curved twist introduces a more 3D effect, if you walk by it from right to left, more and more light will be exposed. The curves can be subtle or more aggressive depending on how much of the surface should be lit.

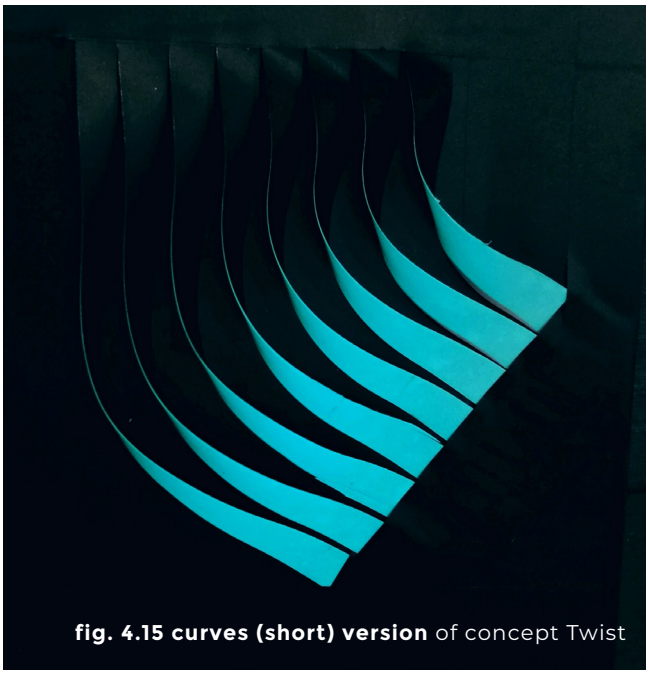


fig. 4.15 curves (short) version of concept Twist

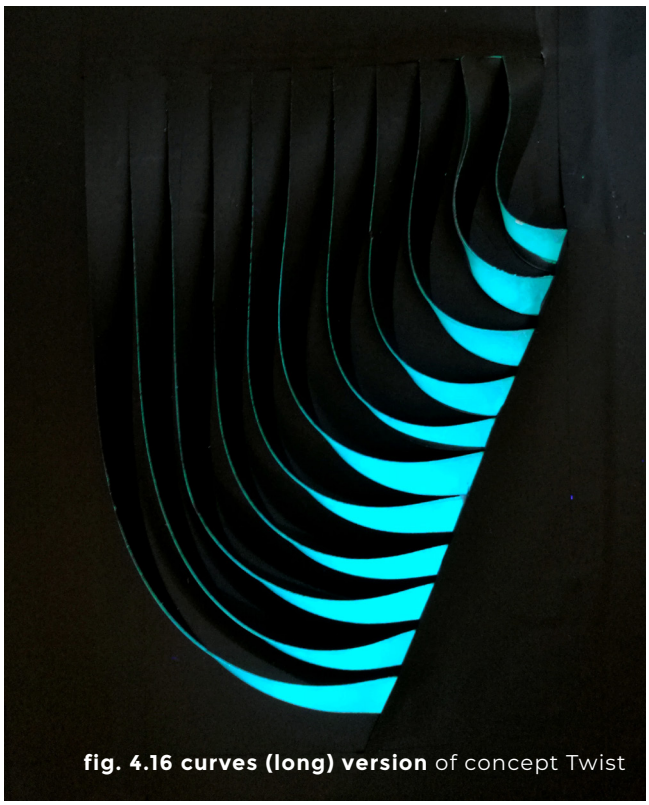


fig. 4.16 curves (long) version of concept Twist

braid

The other models do not have a connection to each other or a closed end, the light is just cut off. This model tries to solve that by adding another curved element without light, weaving them together like a simple braid.

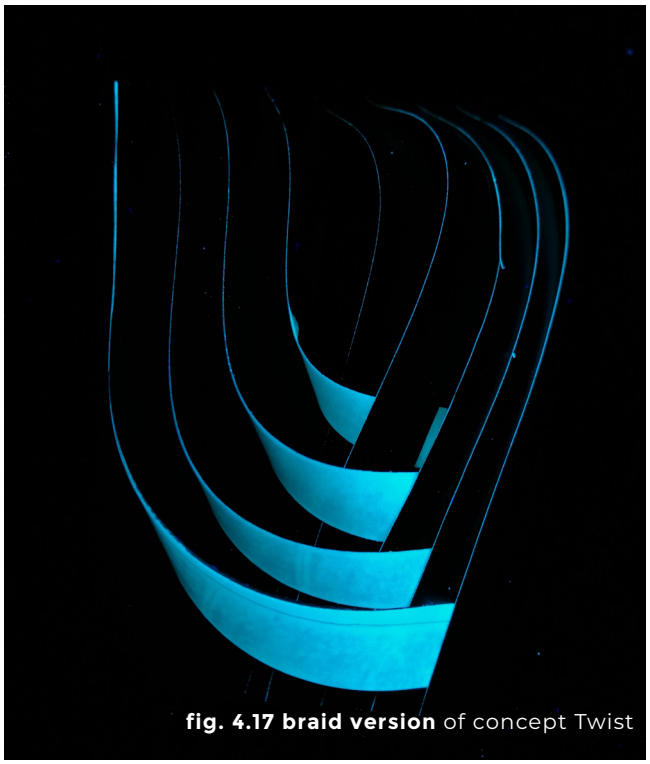


fig. 4.17 braid version of concept Twist

HOW IS IT MADE?

why the black vinyl?

fig. 4.18 photo of the **vinyl concepts**

These models are made with different bases (100g paper and PET sheets) and a layer of phosphor paint for UV light testing. As paper lights up under UV and the used plastic was transparent and highly reflective the places where the light should not appear was blocked out with black non-reflective vinyl sticker. It photographs well and acts as a blackout material as well. It is not the final colour or material and it was purely chosen for rapid prototyping.

All of the models were made with blue phosphor to make them comparable with each other. It is also the colour that gives the most realistic shade under UV light. The other colour options are photo edited together from real samples and patterns (see fig. 4.21). This solution saves a lot of time and material, as the needed colours and patterns for this have already been created at the tinkering phase.

4.3 what do
PEOPLE THINK?

24 students have filled in a Google Form to share their opinion about the presented samples. See all answers in Appendix E.

opinions & favourites

People thought that the stripes and thin lines looked really similar, but the **stripes** *"looks a bit more messy"*.

From the loop collection the simple one with a **thin line** was the most well-liked. *"I would want to touch it."* One student said they *"... look like a fish swarm swimming in the ocean. I get the feeling of watching Blue Planet. I wonder if the wind would make it seem like they are swimming."*

fig. 4.19 hanging thin lines version of concept Loop

People thought the **waves** looked really aesthetically pleasing, maybe could see it on a bigger wall. *"I like the curves that you can see. I looks like waves of water."*

The **squares** got a mixed review, saying that the light on the front is random and misplaced, *"they [...] feel uncomfortable for some reason"*.

The opinions about the **knot** were mostly positive, it is the most liked sample from the twist collection and all in all too. Someone said that the knot is *"simple but still interesting to look at and calming"*.

It was chosen most as the sample that people can imagine as a surface design on a wall: *"the knot one but then the knots need to be connected"*.

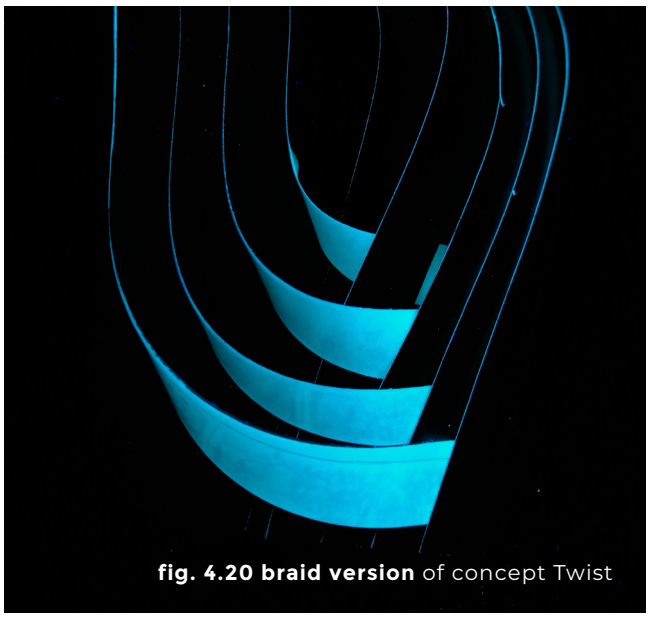


fig. 4.20 braid version of concept Twist

People thought the **short** version could also work on the wall: *"they wouldn't be too overwhelming and can combine into fun patterns."*

The **long** version was called a *"more abstract shape"*, that *"looks almost like a glowy logo design of some sort"*. The logo association came up multiple times.

The **straight** twist was the second favourite from the group, it still got some mixed reviews. *"More intense, more present than previous ones"*, but someone said *"it looks like shark teeth"*.

These reviews helped to see what people would like to see on a bigger scale. It also confirmed the chosen direction and the need for a large scale connecting pattern.

4.4

DECISION POINT

tile set from the **TWIST VERSIONS**

As the direction to continue with TWIST was chosen, with the idea to create a set of tiles with different designs on them (straight, turn and U shape). All of the tiles would incorporate the backlit style and a partially visible light.

From the tiles a large pattern could be created on the wall, for example with 'connecting' the open ends to each other or just simply repeating the same tile. It is important to consistently keep the look and dimensions through the tiles, thus the illusion of connection can be created.

All the electricity could be hidden in the back side of the tile with a simple plug in wire connection where the next tile lights up by connecting it to the previous one. It is important to use highly flexible wiring so it can be pulled to the backside without exposing it.

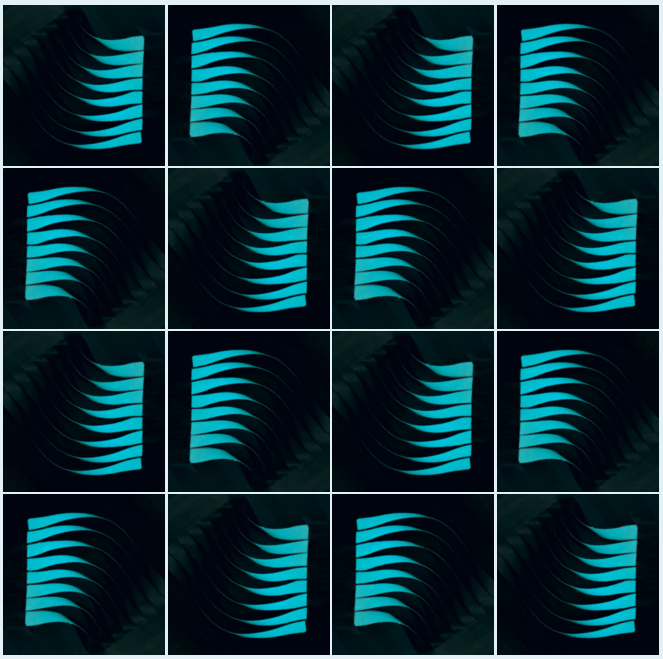


fig. 4.21 pattern made out of curves concept

COLOUR & PATTERN options

These are the colour and pattern options that can be created from the available materials. The **full white** and the **white galaxy** caught the attention of the client, as it is the most versatile and can be paired with more colours. It is also less futuristic and more neutral looking, which makes is fit different environments.

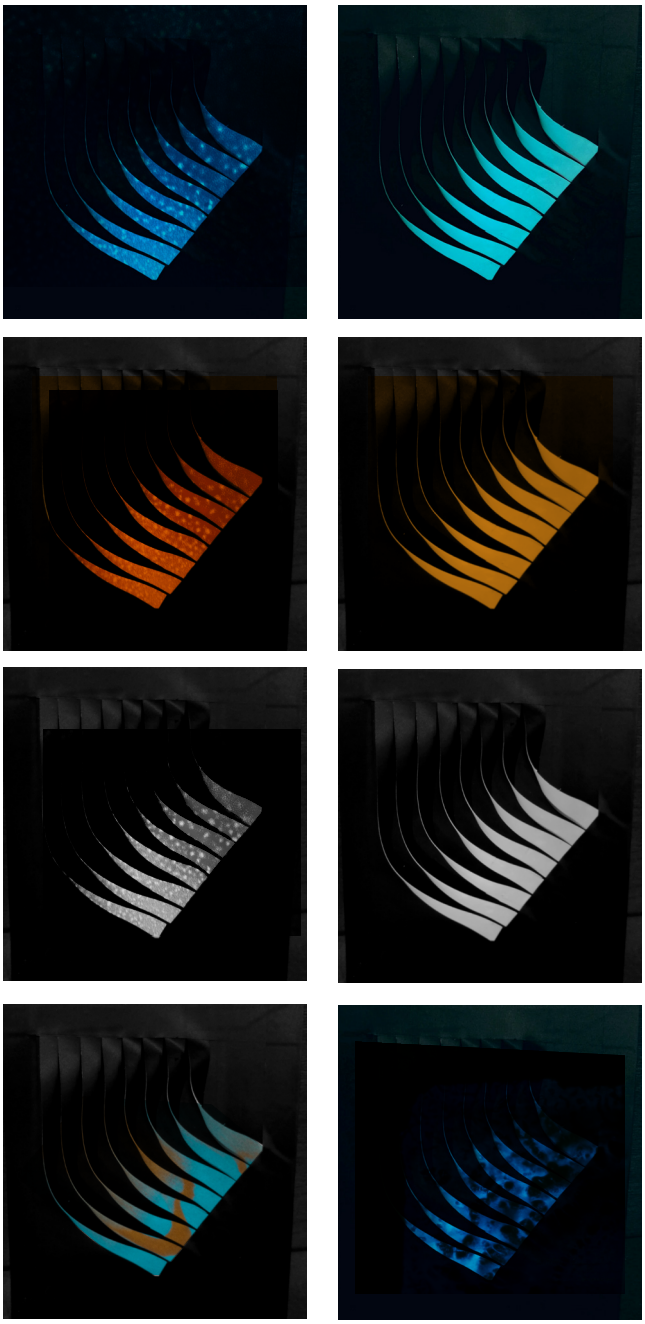


fig. 4.22 different colours of curves concept

4.5

DESIGN ELEMENTS

This is the summary of relevant findings and decisions that have been made with the supervisory team and the client brought together. They represent the elements that need to be incorporated into the concept design.

electroluminescence

'Although the material was already given, effort was put into making the best version of it that was possible. During the experimentation phase a brighter and 'whiter' white colour was created, a version that it is possible to use in a design without being too overpowered.

Furthermore patterns and gradients were created easily, but most of them are too busy to use in such a clean design. One of them did catch the attention of Alissa+Nienke, the starry, galaxy-like style. It is mono-colour and much more subtle then the colourful versions. It has an overall lower brightness than the solid light types, which means a more starry and less full on milky-way pattern might work better.

The paint colour it is paired with can help emphasize the light, if a matte and quite dark, maybe blueish toned colour is chosen, the whiteness of the white could come through better.

hospital environment

One location possibility - as it is a place the client already has connections with - is hospital environments, more specifically a lobby or waiting room. Hospitals come with certain restrictions, for example there will be all kinds of people around (including elderly and children) who might get curious and touch or fold parts not intended for it. Hospitals are busy places, the decoration cannot get in the way of function. If the installation is placed in a waiting room where people might spend more time the light cannot move or change fast, and most importantly cannot flash.

other possibilities

Hospitals present a lot of requirements, they are bright and busy, have high safety and hygienic restrictions. It is definitely a possibility, but other locations might present a more fitting environment. Semi public places with medium or low light levels, like a hotel lobby, a museum, an elegant bar, or a darker restaurant would fit into this category.

interaction

A decision was made that the viewers should not touch the product, but still have an indirect interaction with it. Catching the attention of the user, making them interested in or thinking about the sample is part of this. A short minute of standing captivated by the installation, stopping to take a photo, or walking back to figure out what it actually is or how it works are all valuable ways of interacting.

movement

The tiles themselves cannot move, but when the viewer walks by the shape and how much light is visible is changing. This creates a certain illusion of movement, which could be enhanced by animated light (dimming up and down or a light wave going through the connected tiles).

physical shape

A more closed shape was partially chosen because it is less invites less touching from viewers. The material is not stable enough for people to tug on it or fold it without damaging. Other reasons were the unique 3D structure with a partially exposed back light and the possibility to create connected super patterns with different tile designs.

super pattern

The created super pattern is inspired by geometric style ceramic tiles. The number of different tile designs should allow the creation of a wide variety of patterns. The best option is a set that can work both using only a few tiles, and also covering up a full wall.

materials

Based on the required properties and aesthetics ITO coated PET sheet was chosen as the substrate and transparent electrode. As in this case no double-sided illumination is needed the back electrode can be silver, an easier material to work with. As the silver colour does not fit the envisioned look and it is highly reflective it will be covered up with a layer of paint, matching the back board behind.

production methods

As was tried before EL materials are possible to lasercut, thus the design was created for this specific production method (together with screen printing). Simplicity is very important for the client, as little post-production as possible. It is possible to assemble the tiles in a few steps using a strong transparent double sided tape.

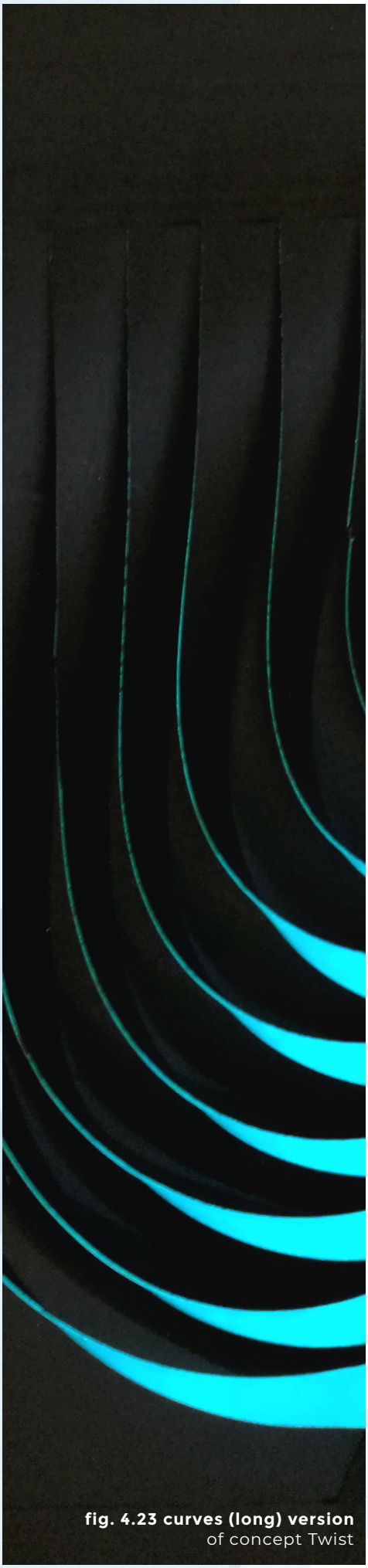


fig. 4.23 curves (long) version of concept Twist

4.6 developing the
TILE DESIGN

After a round of iterations - *on the ratio of the tile (1:1, 1:2, 2:3, 3:4), the number (6-8) and width (6mm - 10mm) of the stripes* - a **square shape** was chosen where the stripes cover up about a third from the tile width. The square shape is preferable over the rectangle due to the fact that turning it does not mess up the pattern grid.

The other parameters were chosen based on aesthetics and feasibility. Bending the stripes is only possible up to a certain extent before tearing, thus small turns are difficult to create. Paper represents that well enough, that is why the models are made out of it. However plastic (the chosen substrate is PET) has a higher surface tension so the curves will be smoother than from paper.

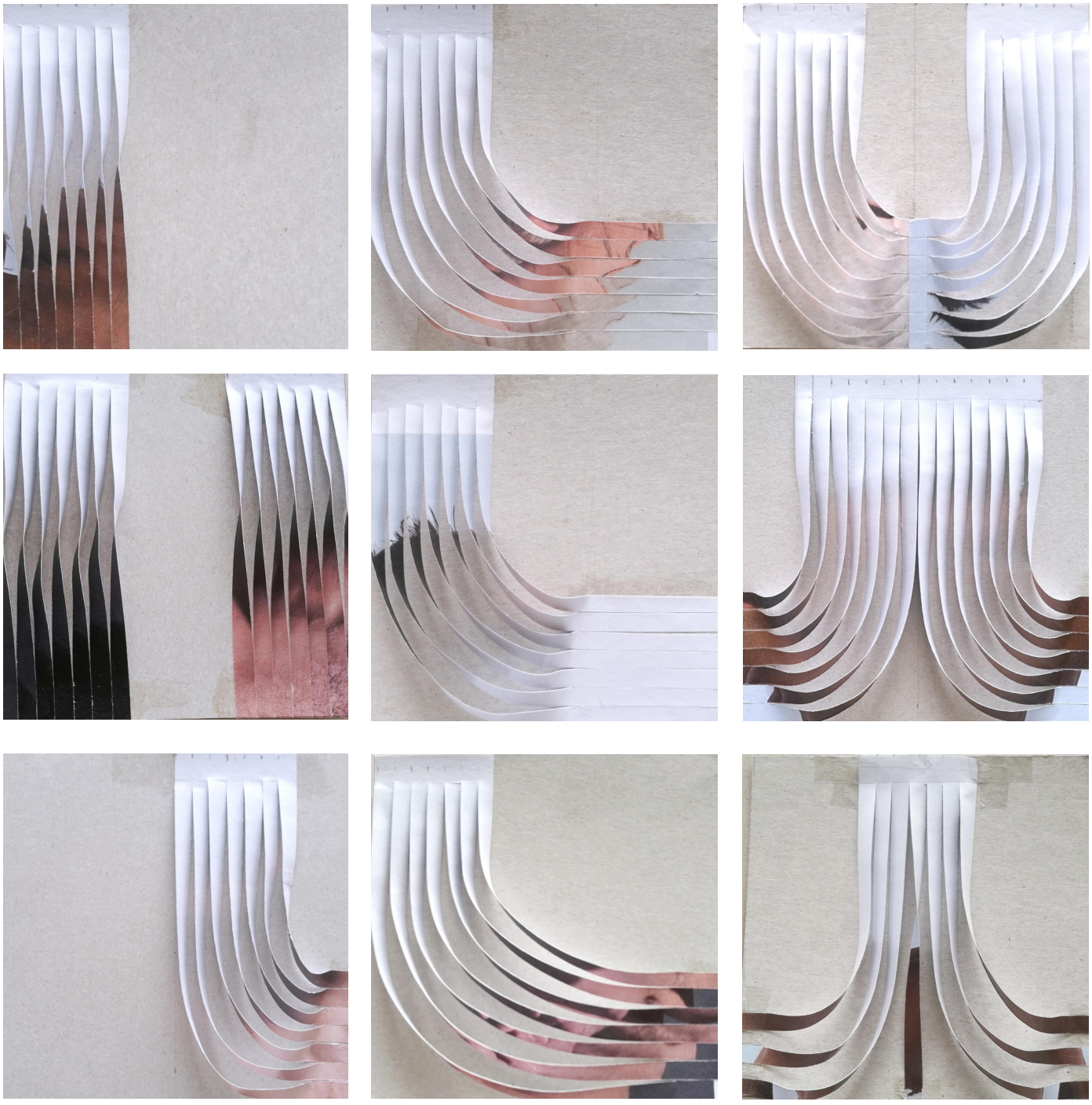


fig. 4.24 rapid prototypes of the **stripe patterns**

4.7 simplifying
THE DESIGN

The created tiles are quite varied and busy, often containing more than one shape on the square. A decision was made to break them down to their core, a simple straight shape, a quarter circle (arch) and an empty tile. With these all the more difficult shapes are possible to put together.

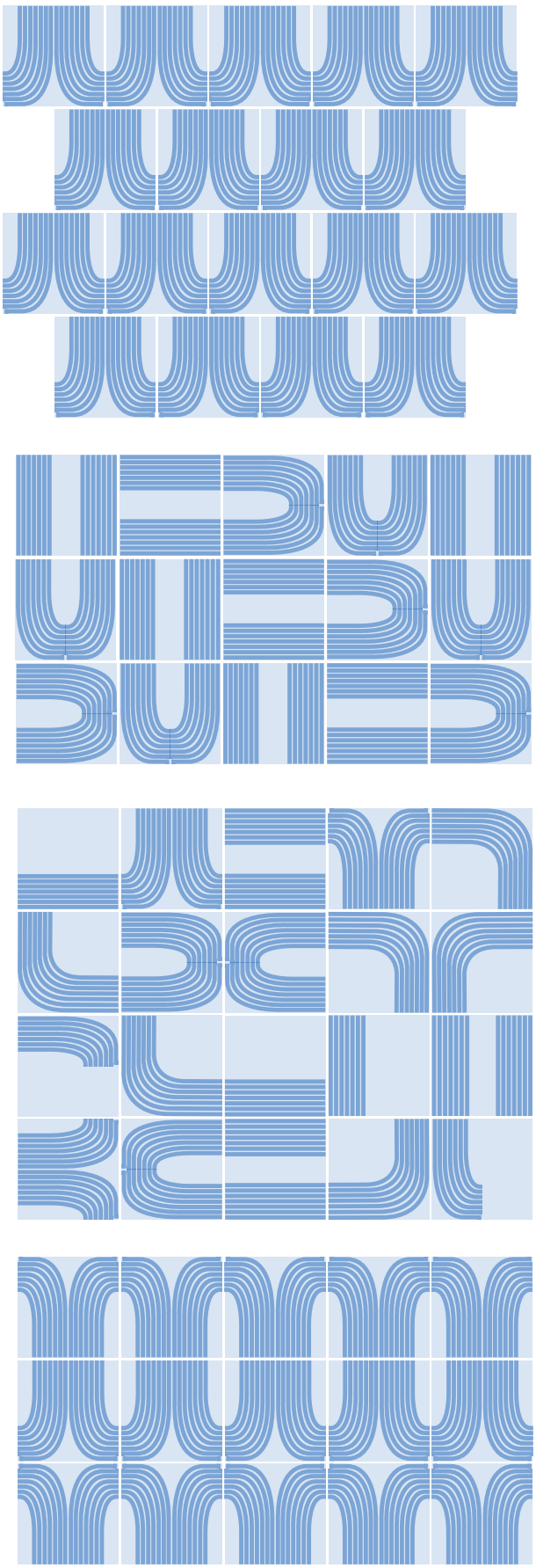


fig. 4.25 patterns created with the paper tiles

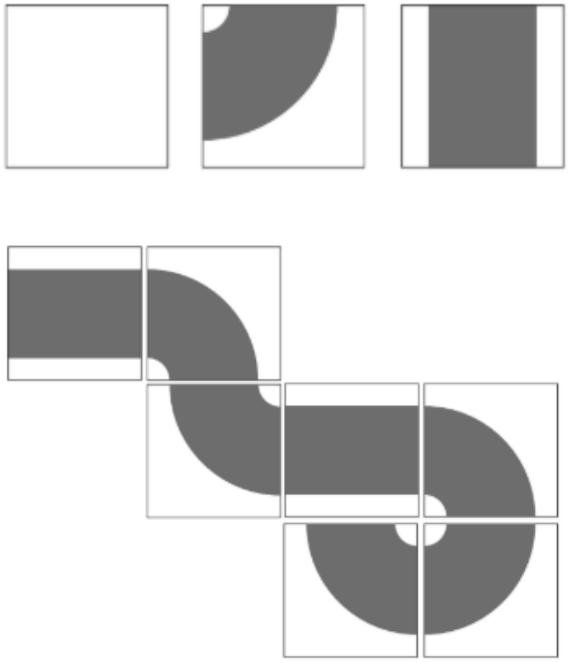


fig. 4.26 shape ideas by Alissa + Nienke

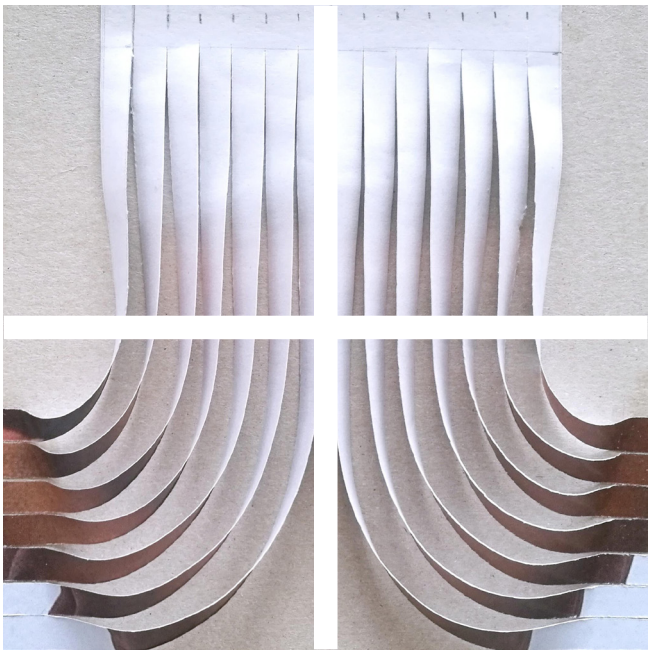


fig. 4.27 devisions to create the A+N shape ideas

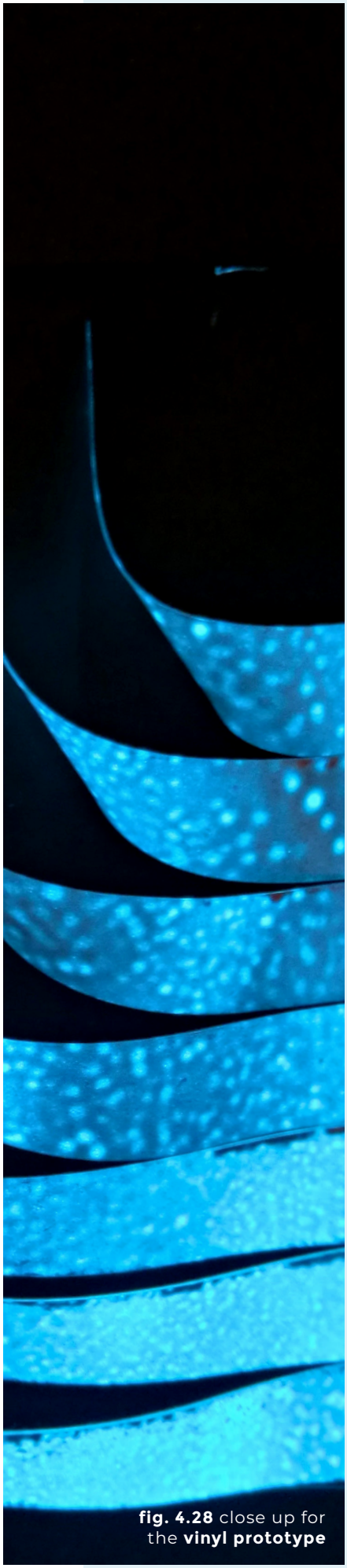


fig. 4.28 close up for the **vinyl prototype**

4.8 proof of **CONCEPT**

The first working prototypes - proof of concept - use the envisioned materials for the stripes (ITO PET with single-side illumination), however take a simplified option for the backdrop, cardboard covered with black vinyl. The design has a relatively large frame to hide the electrical connection points under, which in the prototype consists of flat non-connecting parts. When placing tiles next to each other the wide frame takes away the illusion of continuity, so it needs to be reconsidered in the next phase.

The prototypes use a blue dotted pattern for the strips, however that has a relatively lower brightness than a solid lit surface. The pattern is also difficult to create on purpose, making it another point to rethink for the final design.

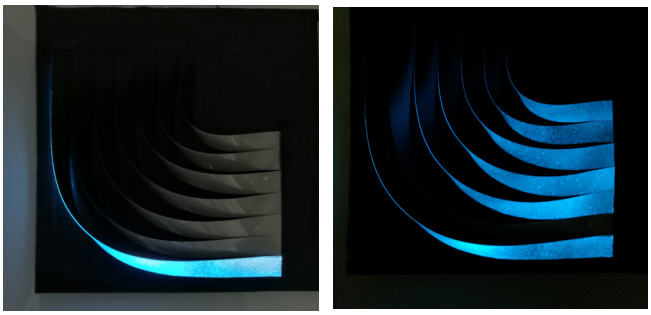


fig. 4.29 first tries of making a prototype

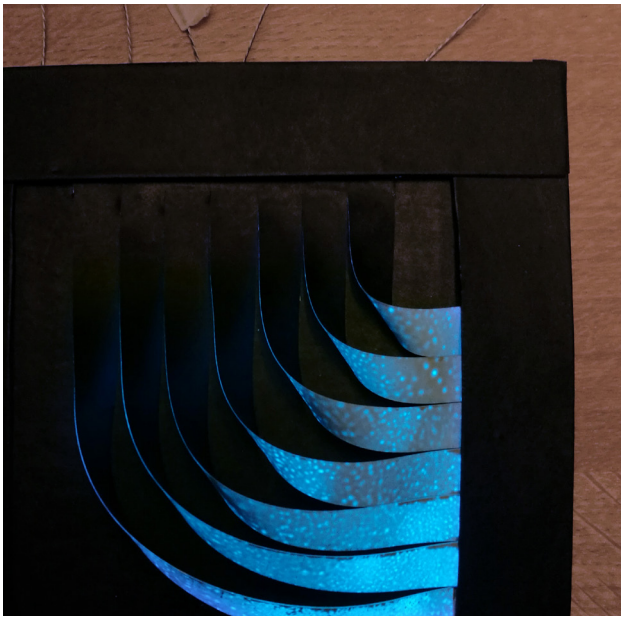


fig. 4.30 close up of the vinyl prototype frame

Instead of wires the prototype uses conductive thread made out of steel, as they are easy to attach (no need for soldering), and highly flexible, thus possible to pull to the back without breakage. The two designs were possible to connect with parallel connection via the conductive threads touching each other. This proves it is possible to create a large chain from the tiles having only one direct connection to electricity.

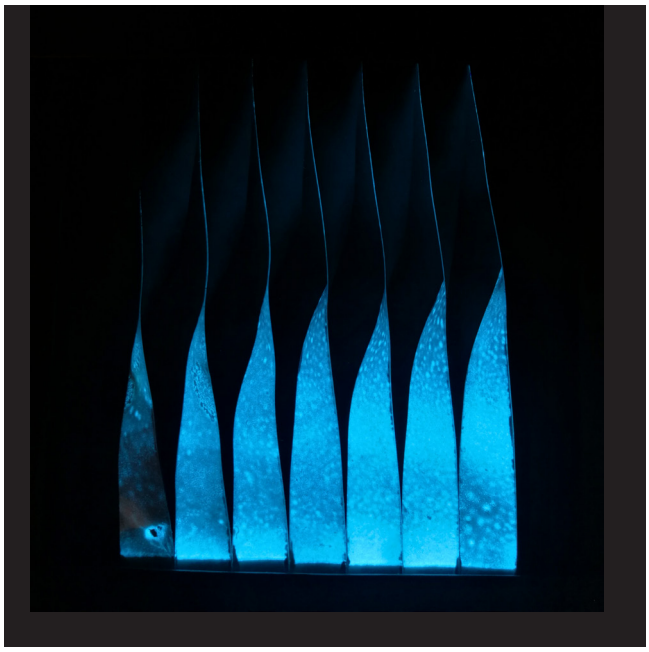


fig. 4.31 straight vinyl prototype

fig. 4.32 curved vinyl prototype

fig. 4.33 wiring of the straight vinyl prototype

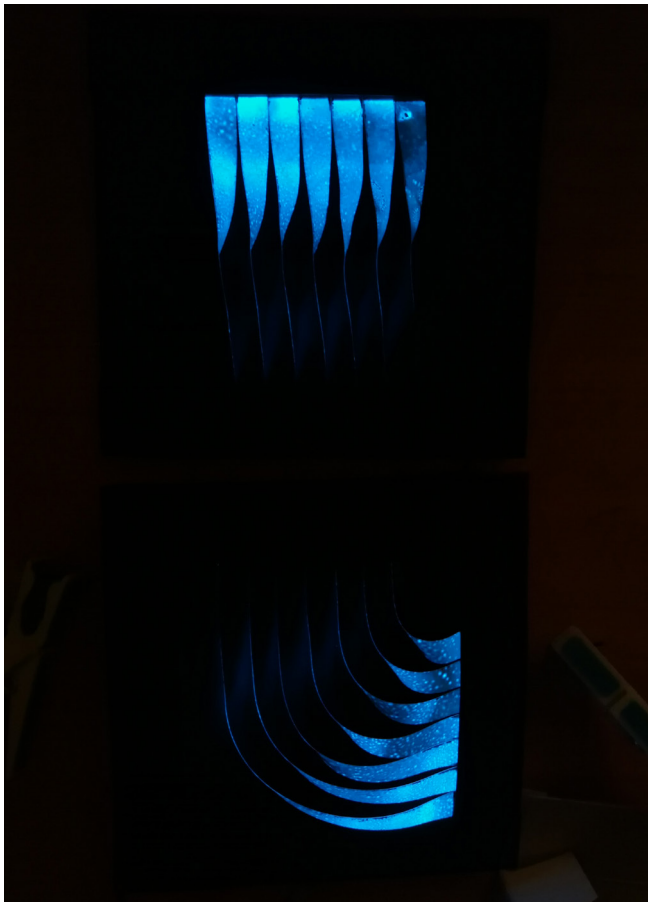


fig. 4.34 photo of the **connected prototypes**

4.9 finalising the **CONCEPT**

After creating the first working prototypes a discussion with the supervisory team and the client lead to some changes in the design.

bending the sample

The thick frame covering up the wire connection points on the front was disliked by the client. Even if the connections are on the backside of the material they make a slight dent on the strips making them noticeable on the front. Thus a solution was proposed to try to hide the connection points in between the side of the backdrop and a thin frame by bending the EL sheets with 90°. First experiments supported this solution, even proved that the material can be curved around a thick tile to hide the connections completely on the back. The material itself cannot be bent on such a short curvature easily, however **using a heat gun** to warm up the substrate plastic (PET) into an elastic state can help make that happen.

fig. 4.35 sample **curved around a pencil**

fig. 4.36 sample **bent with 90°**

searching for a frame

The large or wide frame was not desired by the client, thus a search for something thin and elegant began. Acoustic panels or really thin aluminium picture frames came up as a possible solution, but none was found with the exact needed size. There is another question about having a frame: how to attach or fasten the material to or with it. Acoustic panels usually have a thin textile layer on the front surface which is fastened in the sidebars (in some cases in between rubber insulation). A regular picture frame has less secure options and a smaller space for that. There's one problem with both, making sure they do not crack or scratch material.

The best option seemed to be to **have no frame** at all, which brings up some challenges of its own:

- how to "push down" the strips on the front to avoid curving up,
- have a perfect curvature on the edges to bend the strips around.

fig. 4.37 minimum size needed for a frame

white instead of black

In many prototypes a black background was used to create a large contrast with the lit up parts, also to make photographing easier. However a black or dark background does not fit with many environments seamlessly, a decision was made to use a completely **white backdrop** instead. With a sharp white colour the contrast is still there, furthermore by the use of silver as back electrode, the EL sheet has a light greyish colour when turned off, blending in better with a white (or off-white) background.

placement of the strips

The earlier prototypes have **placed the strips** to the geometrical middle, making more large pattern designs possible. However in that configuration the lit up surface looked awkwardly small compared to the empty background (see fig. 4.43). Thus a decision was made to move the curved design **to the 'optical middle'** of the tile, covering now about half of it.

fig. 4.38 placement in the **optical middle**

measurements

In order to make the strips smoothly bendable the individual width was reduced to 7 mm, making the full width 7x7=49 mm. With the quarter circle design the longest strip needs to be 180 mm long, each strip can be 15 mm shorter. From that about 160 mm has to be covered with the material, the rest is needed for attachment. In case of the straight design the strips need to be 140 mm long and covered with the material for about 125 mm. The size of the tile is **115 x 115 x 6 mm**, the edges are sanded down to a 6 mm diameter circle. To place the strips to the optical middle **they are attached starting 20 mm from the sides**.

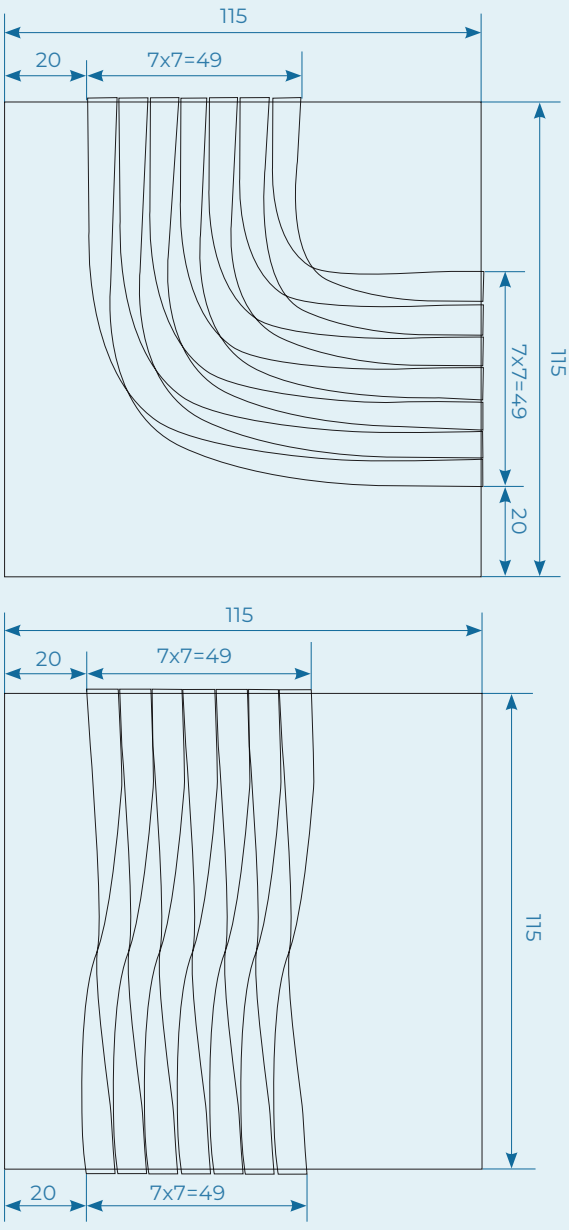


fig. 4.39 measurements of the designs

tile with sanded edges

In order to hide all the connections at the back and have no frame, the tile needs to have curved edges that the material can be pulled around. For the demonstrators an **MDF board** was chosen where the **edge**s had been **sanded down to quarter circles - ending with a** ~6 mm diameter half circle. Before painting to white it can be used for bending the material around it. The EL sheet can be taped to the back, slowly heated then pulled around the curve to create a perfectly fitting arch.

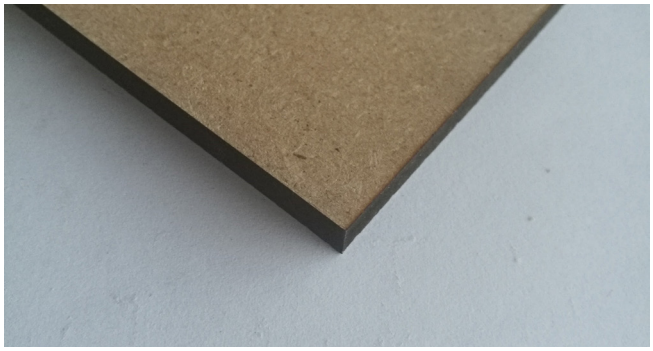


fig. 4.40 corner of the **lasercut MDF board**

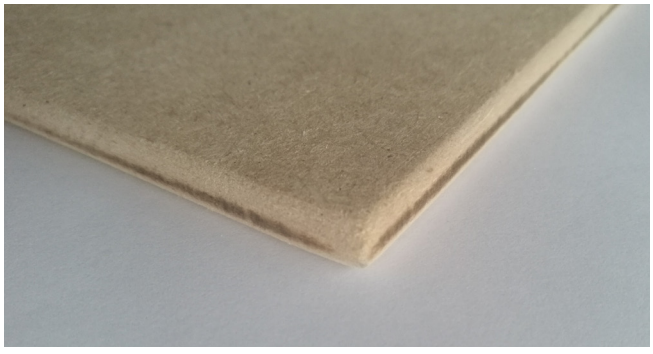


fig. 4.41 corner of the **sanded down MDF board**

fig. 4.42 corner of the **painted tile**

rounded square design

The initial design idea was to create a perfect quarter circle and a rectangle with the same width on the tiles, however that is not possible without the strips lifting up from the surface in a slightly odd curvature. It takes away from the simple and streamlined look. Thus a compromise was made to avoid the use of a frame; have a **quarter of a rounded square** instead of a quarter circle as the arched shape, meaning that the first and last **half centimetre of the strips on the front side of the tiles is taped down**. This does not effect the look of the straight design that much, as it was already a rectangle.

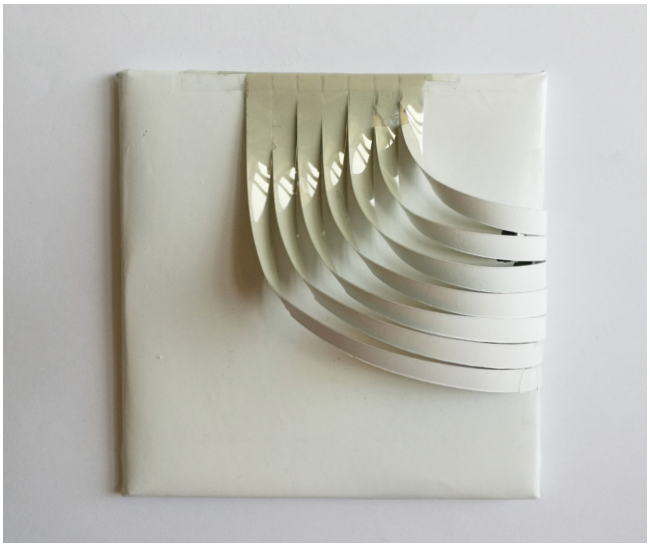


fig. 4.43 the strips **oddly curving** up

reason for using blue

The first prototypes are made with a blue galaxy-like dotted pattern, however that does not have the best brightness or quality. To increase the contrast between the white backdrop and the lit up surfaces the sample has to emit light **more homogeneous**ly; that increases the overall luminance. In order to achieve that the prototypes use an **aqua blue colour**, the **brightest** of the phosphor pastes, without a pattern.

During the project several decently bright white samples have been produced; the client even preferred a white light over the blue colour. However they never reach the same brightness as the blue ones, which is the reason behind using a blue phosphor for the demonstrators. The **concept is still envisioned with a white light**. The hand-mixed slightly blueish white could possible be developed into a brighter sample fitting the current design in the future.

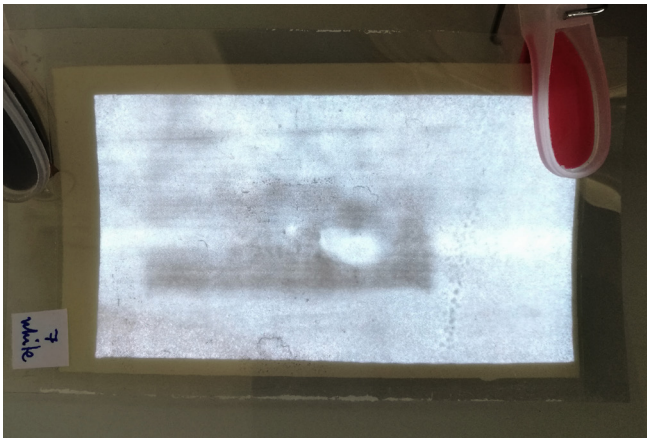


fig. 4.44 photo of a **bright white sample**

generic environment

Earlier in the report it was mentioned that a possible display environment could be hospitals. However hospitals come with a lot of requirements (they are more about the function than the decor) that would have effected the design too much, making it too specific. Thus a decision was made to drop the restricting hospital environment and design the installation in a way that it could fit many surroundings.

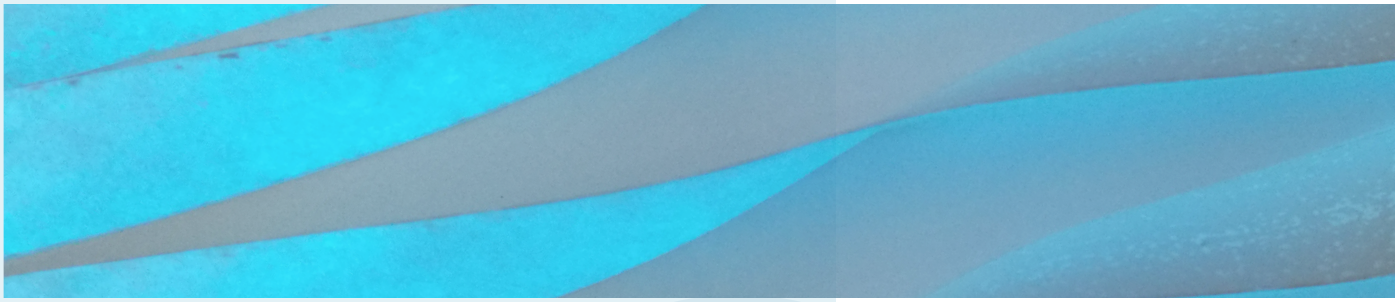
The modularity and the option to change the colour of the light and the backdrop quite easily, supports a flexible design more than a fixed one with many rules. A high customizability can make the installation desirable for more buyers.

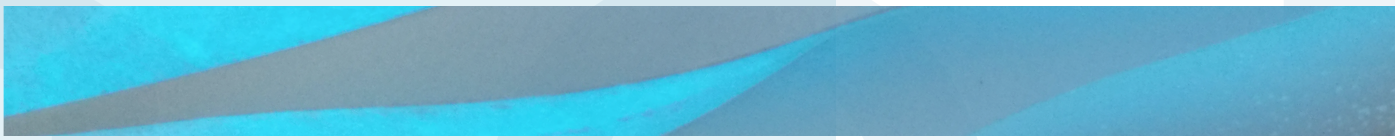
fig. 4.45 Mirabilia in a hospital by Alissa + Nienke

PROTOTYPE PHASE

how I created

THE FINAL DEMONSTRATOR





This chapter contains the production of the final demonstrator: the making of the EL sheets and the assembly steps. A detailed description of the demonstrators (including the influencing factors on each attribute) is also included. A detailed evaluation walks through the strengths and weaknesses of the demonstrator. Last, but not least, a list of recommendations for the client or for further development is also included.

TYPE 5

DEMONSTRATOR

Demonstrators are created to showcase the final designs using the intended materials for the EL sheet and a possible option for the tile. These models prove the validity of the last iterations, and give a chance to see what light conditions are the most fitting to install this surface design.

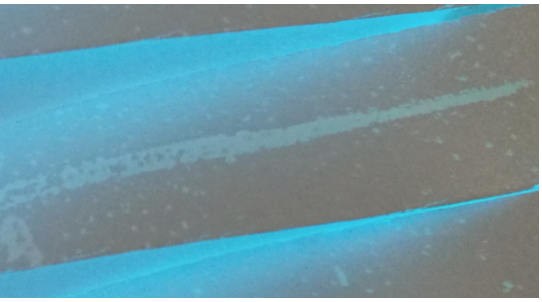


fig. 5.1 close-up photo of **straight design**

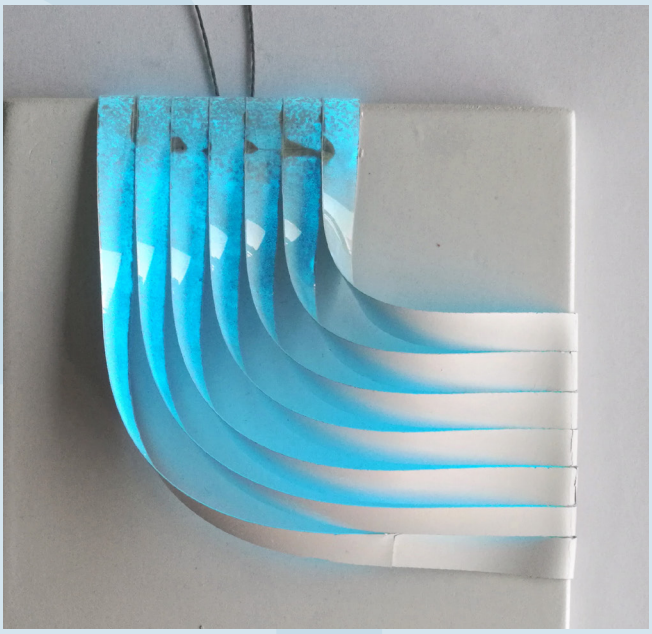


fig. 5.2 photo of the **demonstrator**

BUILDING THE DEMONSTRATORS

5.1 making of
THE EL SHEETS

1. materials

Only one side of the sample has to emit light, thus a simple single-sided structure was chosen with ITO as the clear conductive and silver ink as the rear electrode. Using silver will make the EL sheet have a warm grey colour on the light side when switched off. Due to the lack of availability an insulation spray was used instead of dielectric, which is recommended in general. Due to the bending of the material it is important to find an insulation material that is not brittle, like the used spray or the transparent dielectric mentioned below.

Silver Paste
Sun Chemical
C2120918P1

Transparent insulation spray
3M Vernis Isolant transparent 81042
Scotch 1601
DE-9999-5305-7
7100036939

Indium tin oxide coated (ITO) PET
Aldrich
PCode: 1003009077
639303-5EA

Phosphor paste - blue
GWENT Group
C2061027P13

Transparent dielectric - recommended
DuPont 8153
BaTiO3 dielectric

2. layer structure

As mentioned above the EL sheet uses a simple single-sided structure. Important to mention that the silver ink layer should never directly touch the ITO coated PET sheet. In order to achieve that both the phosphor and insulation layers need to be larger than the silver one. The phosphor and silver layers are screen-printed.

In the prototype - for the insulation layer - a combination of spraying and spreading with a squeegee is used (see more detailed descriptions of the methods in chapter 3.6 Luminescent measurements). After experimenting with various different combinations, the following created the most stable and bright samples: two layers sprayed, then ten applied with a squeegee, then the last one sprayed. The lowest layer number (for a working sample of this size) was 9, however most samples need at least 11-12 layers to not short-circuit after cutting. This could be exchanged to 3 layers of transparent dielectric.

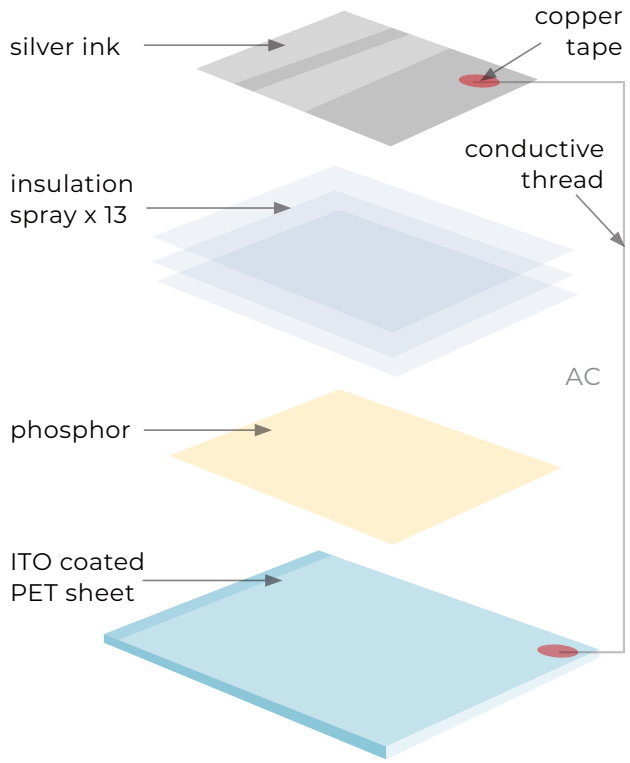


fig. 5.3 layer structure of the demonstrator

fig. 5.4 taping down the substrate

fig. 5.5
using a squeegee to
apply insulation spray

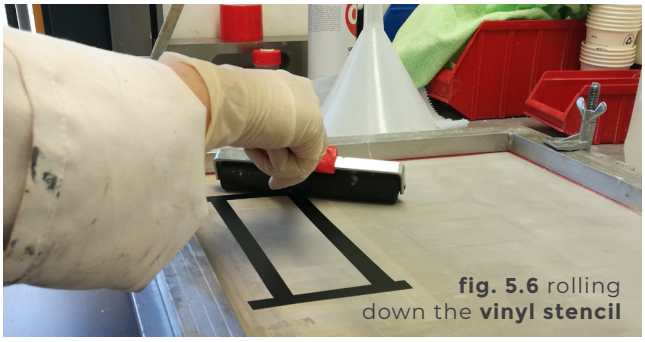


fig. 5.6 rolling
down the **vinyl stencil**

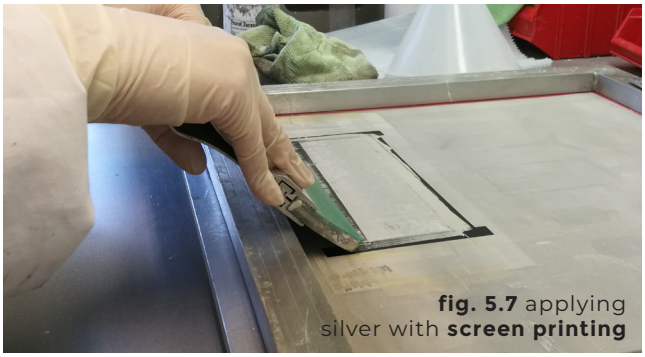


fig. 5.7 applying
silver with **screen printing**

fig. 5.8 applying **spray paint**

3. meshes

It is important to find the right thread count mesh for each material, as it ensures a clean and precise print. Under here is a short list with the materials, the recommended thread count (T) and the exact value used for the prototypes. The needed number varies depending on the viscosity and age of the material. Older materials tend to lose some moisture and become more viscous, thus needing a lower thread count.

material	**recommended T**	**used T**
phosphor	64T or lower	39T
dielectric	80T or lower	*77T*
silver ink	64T - 90T	68T

4. vinyl stencils

To make sure the layers are the right size vinyl stencils are used during screen printing. These can be cut with a vinyl cutter very precisely. After sticking them to the mesh it is important to make sure the board holding the substrate is placed there perfectly.

5. screen printing

See the description of how to apply the insulation layer in Appendix A, Experiment 39 - How is it made?. To recreate this sample follow the screen printing instructions from chapter 2.5 or use a detailed tutorial developed by Claus (2016).

6. applying paint

Make sure the parts of the sheet that need to remain not painted are covered with a vinyl stencil (about a 1 cm wide stripe on the silver layer and 2 cm on the ITO sheet). Paint is quite difficult to remove from the surface without damaging the sample if sprayed or splashed to the wrong place. During the painting the sample needs to be fixed to a solid ground so the backside cannot be splashed. The paint dries best in an oven on 50°, above 80° it starts bubbling up (unless a heat-resistant paint is chosen). The paint used is **OK White Matt Primer**.

5.2 steps of
ASSEMBLY

1. preparing the tile

The tile has to be very smooth on the front for the painting, and needs to have smooth curves on the side so it does not damage the bent material with sharp edges. A matt surface is preferred as it will not reflected the light back as much. This can be achieved by sanding or sandblasting the surface.

2. cutting of the sheet

The cutting needs to be precise, thus lasercutting is probably the optimal method, however it needs more research done (to make sure no harmful gases are produced while cutting). Another possibility is to cut it with punching, but that requires an investment into making a knife for it. The prototypes have been hand-cut, from the plastic side, which ensures less ripping in the material.

3. bending

After cutting, tape the strips together so they do not move during bending. Use a bending form to ensure the curvature is the same everywhere. Tape the material to the back of the form with the plastic side up (make sure the alignment is correct). Use a heat gun to warm up the surface for about 30-60 seconds, then carefully bend the material a bit. Repeat until it is possible to tape or clip the material to the other side of the bending form. Then heat the material lightly until it stays in the curved position without the tape on the back.

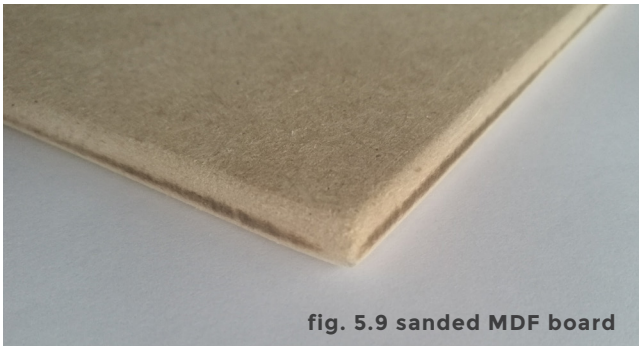


fig. 5.9 sanded MDF board

fig. 5.10 cutting the EL sheet

fig. 5.11 heating
the EL sheet

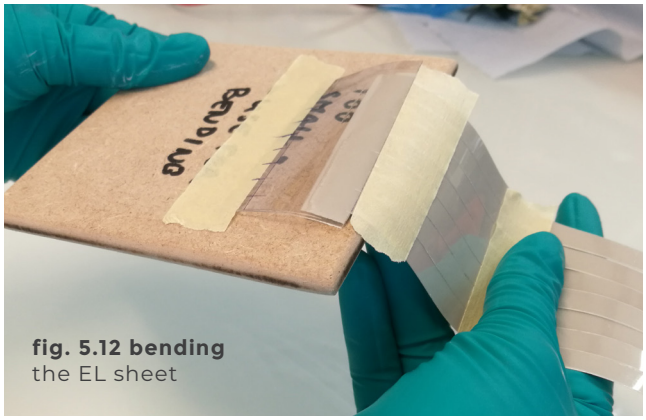


fig. 5.12 bending
the EL sheet

4. wiring

Can be done before the bending. Glue the conductive thread or flexible wires to the ITO sheet and silver surface with a piece of copper tape (2 to each). Make sure they do not cross and there is insulation on the ITO sheet where the thread/wire coming from the silver could touch it. The uncovered threads can be insulated with a spray if needed. To connect the tiles to each other use wire connectors, making sure the ITO sheet and silver wiring never directly connects.

5. attaching to the tile

The prototypes use a strong and thin double-sided tape on the back side and around the curved sides to attach the strips to the tile. On the plastic side this works well, on the other side it can rip the screen-printed layers if it is not attached correctly at the first try. Strong instant glue could be used instead of double-sided tape to avoid ripping layers off of the plastic.

6. bending to the back

After attaching the strips on both ends to the front of the tile the loose ends need to be carefully bended to the back. This requires no heating, and even if the material "shatters" it is not a problem as the strips do not need to light up on the back. Last step is to cover any parts that are conductive with insulation spray or tape. The painted layer and the plastic side are completely safe to touch.

7. wall attachment

I recommend using mirror tape or other simple adhesives to attach the tiles to the wall, minding to not pull or stretch the electrical connections. Attach one tile to the wall, then connect the wires to surrounding tiles or to electricity. With an inverter the installation can just be plugged in to any socket.

fig. 5.13 wires attached with copper tape

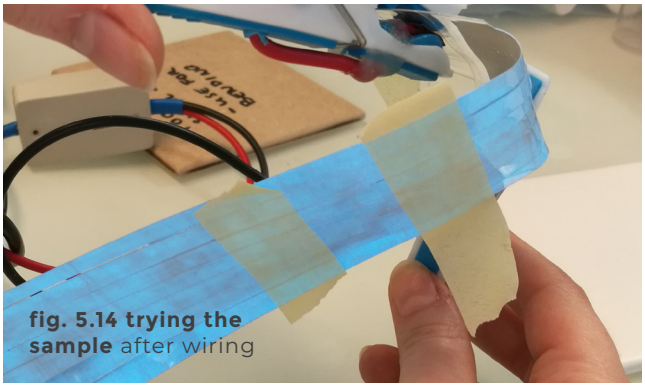


fig. 5.14 trying the sample after wiring

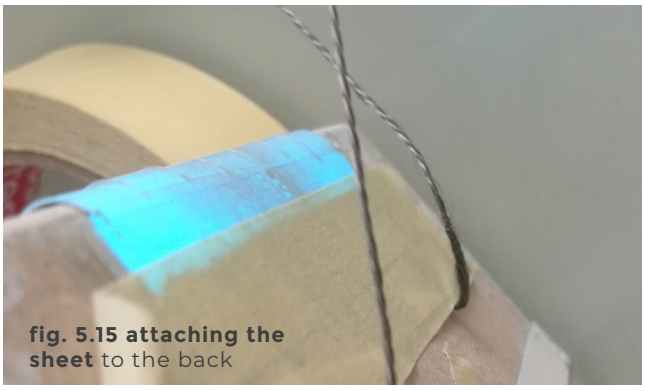


fig. 5.15 attaching the sheet to the back

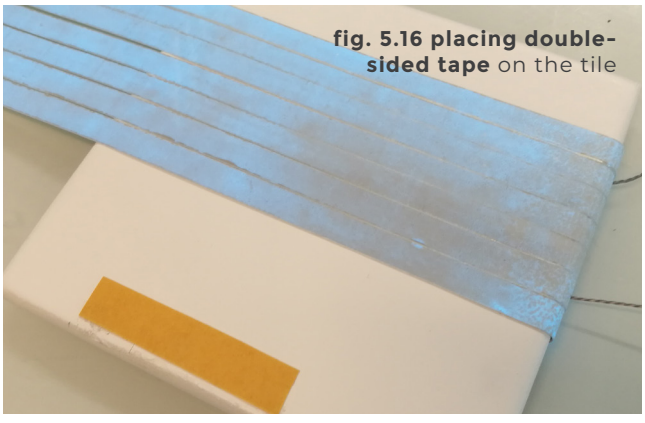


fig. 5.16 placing double-sided tape on the tile

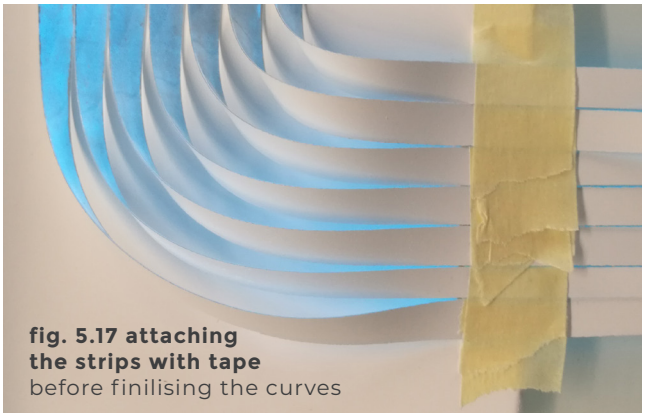


fig. 5.17 attaching the strips with tape before finilising the curves

5.3

CHARACTERISTICS

of the demonstrator

hidden connections

The first functional prototypes had electrical connections on the front, with only the wires going to the back; meaning they need a frame to hide behind. Thus a solution was proposed to **curve the strips around the edge** to be able to **hide the connections on the back of the tile**. The material itself cannot be bent on such a short curvature easily, however **using a heat gun** to warm up the substrate plastic (PET) into an elastic state can help make that happen.

no frame needed

A large or wide frame was not desired by the client, thus a search for a thin and elegant solution began. As the tile size is quite specific pre-fabricated or store bought solutions were quickly discarded. After the possibility of curving the material around the tile was discovered the best option seemed to be to **have no frame** at all, which **fits with the original wish of the client** (as small a frame as possible). Having no frame introduced some challenges during assembly, however nothing so unsolvable that would make the design return to the use of a frame.

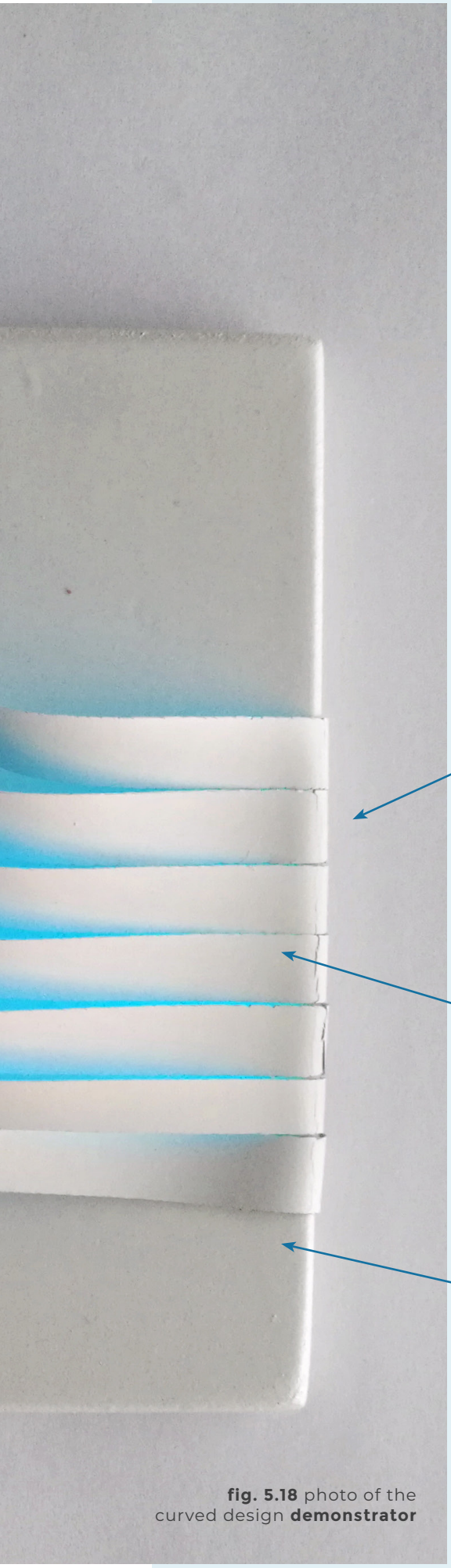


fig. 5.18 photo of the curved design **demonstrator**

curved edges

In order to hide all the connections at the back and have no frame, the backdrop needs to have curved edges that the material can be pulled around. For the demonstrators an **MDF board** was chosen where the **edges** had been **sanded down to quarter circles**. The material can be taped to the back, slowly heated then pulled around the half circle shaped sides.

covering the material

The strips only give out light on one side, which means the other side is an **open electrode**, in this case, silver. It is a colour not fitting into the design, thus it needs to be covered and **painted to the same colour as the backdro**p.

white tile

A simple **white** background **fits with many environments** seamlessly, it has a sophisticated and minimalist look, slightly resembling ceramics. With a sharp white colour the contrast in between the tile and the light is still there, furthermore **it blends in better with the warm greyish colour of the turned off EL sheet**.

rounded square design

The initial design idea was to create a perfect quarter circle on the tile as the arched shape, however that is not possible without the strips lifting up from the surface in a slightly odd curvature. It takes away from the simple and streamlined look. Thus a decision was made to have a **quarter of a rounded square** instead of a quarter circle; meaning that the first and last **half centimetre of the strips has to be taped to the front side of the tile**. This does not effect the straight design as much, however to make the curvature clean it also needs to be taped down on both ends.

light pattern & colour

The first prototypes are made with a galaxy-like dotted pattern, however that does not have the best quality. To increase the contrast between the white backdrop and the lit up surfaces the sample has to emit light **more homogeneous**ly, that increases the overall luminance. In order to achieve that the prototypes use the brightest phosphor paste, an **aqua blue colour**.

measurements

The width of each strip is 7 mm, making the full width of the EL sheet to 49 mm. With the curved design the longest strip needs to be 180 mm long, each strip can be 15 mm shorter. From that about 160 mm has to be covered with the material, the rest is needed for attachment. In case of the straight design the strips need to be 140 mm long and covered with the material for about 125 mm.

The size of the tiles is **115 x 115 mm**, **thickness is 6 mm**, sanded down to a 6 mm diameter circle. The **strips start 20 mm from the edge**.

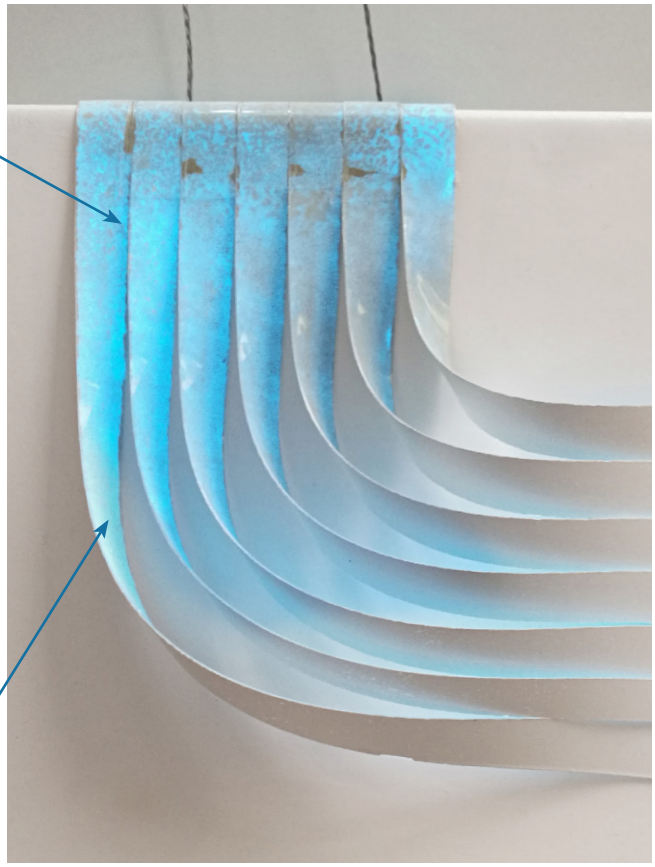


fig. 5.19 photo of the **curved design**

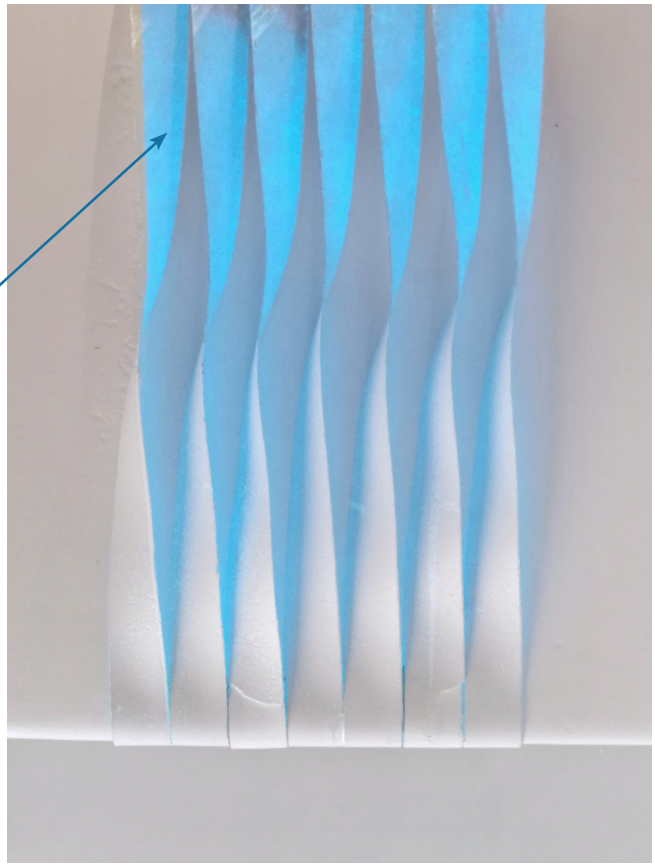
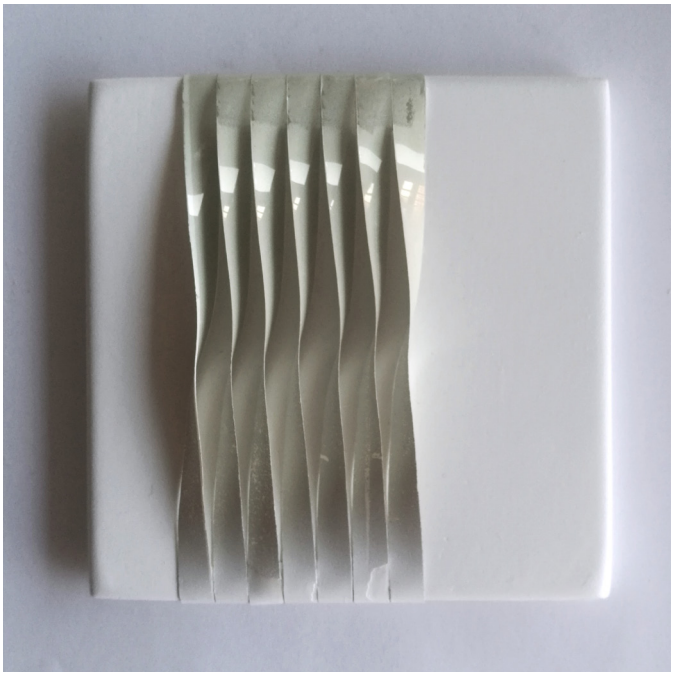


fig. 5.20 photo of the **straight design**

fig. 5.21 photos of the **demostrators turned off**



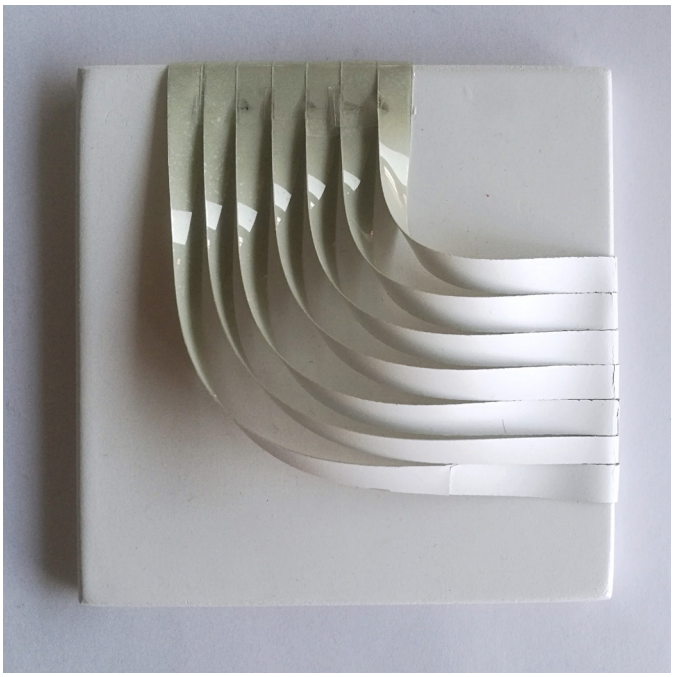
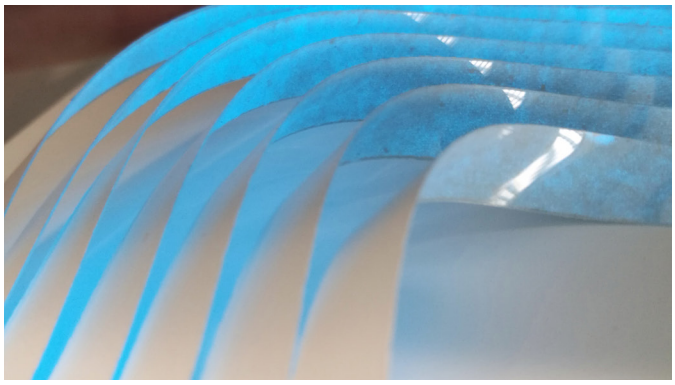
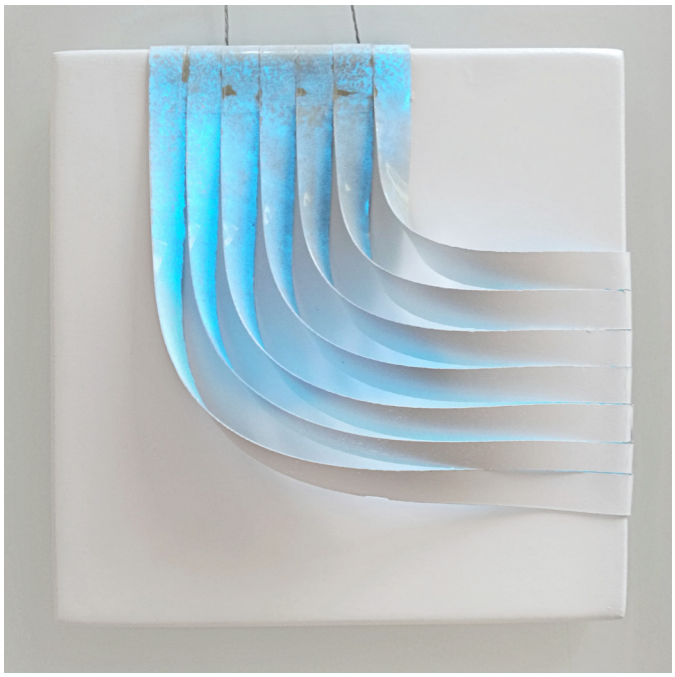


fig. 5.22 photos of the **demostrators turned on**





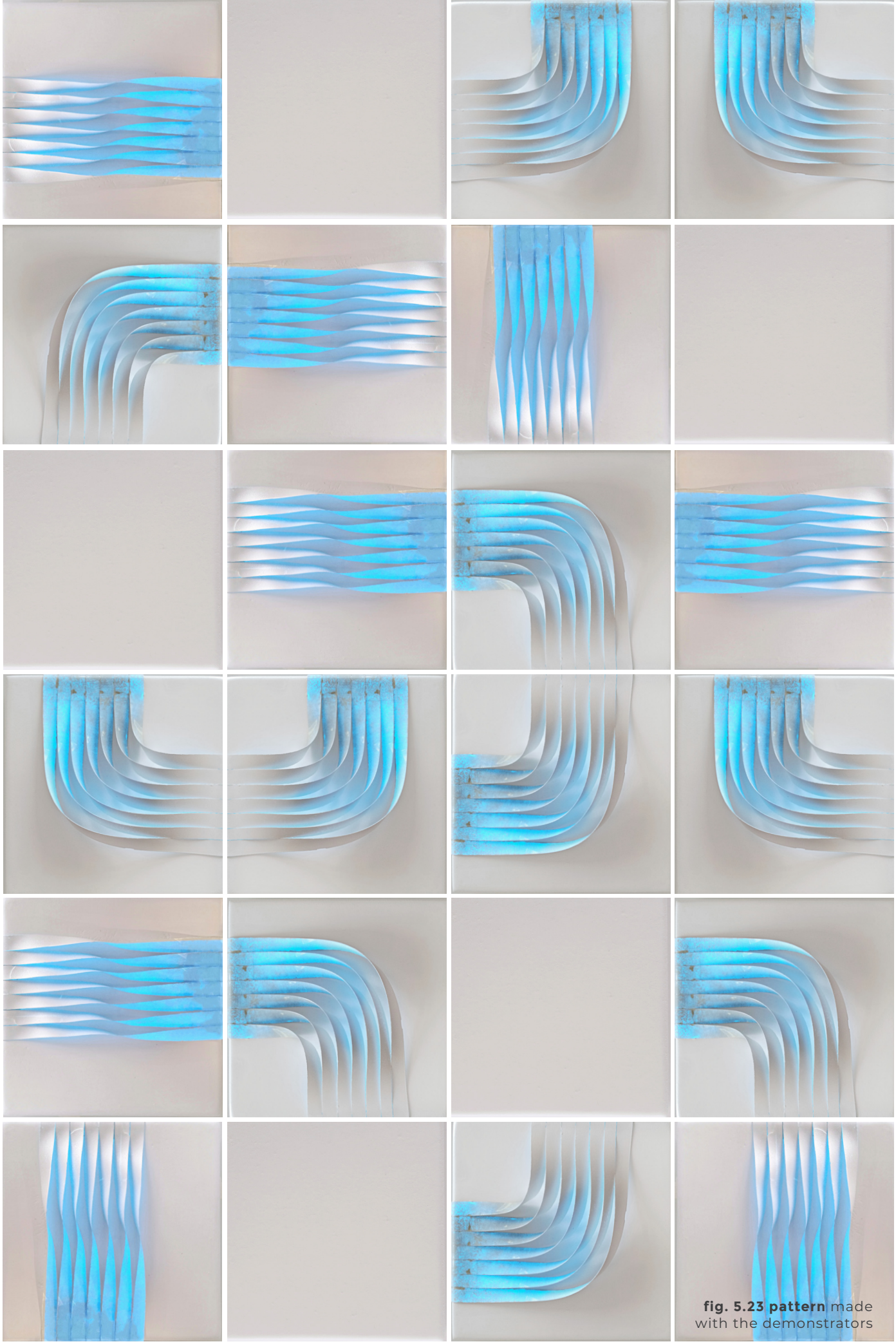


fig. 5.23 pattern made with the demonstrators

SUMMARY

5.4 introducing the
LUX TWIST TILE SET

The LUX Twist Tile set is a modular surface installation that uses electroluminescent (EL) material - a composite that emits light when an alternating current flows through it - to create an illuminated 3D pattern on a wall.

The base module of this product is a tile with twisted electroluminescent strips on it. The set consist of different tile designs, the featured twist comes in a curved and a straight option, available in left and right orientations. An empty tile is also part of the set to increase the variety of creatable patterns. The tiles can be connected with wire plugs at the back, which allows the current to flow from one to another. The last tile has to be connected to an inverter, then it can be plugged into a socket.

The size of the installation and the pattern created with the different tiles can be completely customized to fit a desired environment and lighting conditions. The light emitted by the material looks its best in slightly shaded or medium dark environments; it is also visible in well lit surroundings, the colour and brightness might appear less strong though. The emitted light is only enough to light up the immediate surroundings, thus the installation cannot function as a primary lighting source. The tiles were also designed in a way that they look attractive with or without the light, in case the installation is not switched on continuously.

One of the unique selling points of this installation is the EL material. Electroluminescence has a distinct neon glow that gives an unusual, maybe even futuristic character to the installation. The thinness and flexible nature of the material is what makes the twisting possible; furthermore the material (and the tiles as well) are surprisingly light, making it easy to hang on the wall with a strong adhesive tape.

As the strips have a twisted 3D design they look quite different from various angles; the light only fully appears if the tile is viewed from certain directions (from up front towards the twisting direction). This means a viewer walking by will see appearing and disappearing features, as if the installation was moving or changing. This can spark interest or curiosity in the viewer, maybe inspire them to stop for a second and examine the tiles up close. The paper thin strips are not obvious light sources, which might make them wonder how the installation actually works.

CONCLUSIONS

5.5 demonstrator
EVALUATION

One of the biggest challenges during production was to create homogeneous and bright EL sheets that do not short-circuit. This could highly likely be solved by changing the insulation material to a screen-printable transparent dielectric. The **insulation spray** is great for small prototypes or quick experimenting, but **falls short on larger surfaces needing precise layers**. It took many tries and experiments to figure out how the spray could work for the needed size, which took time away from perfecting the final design.

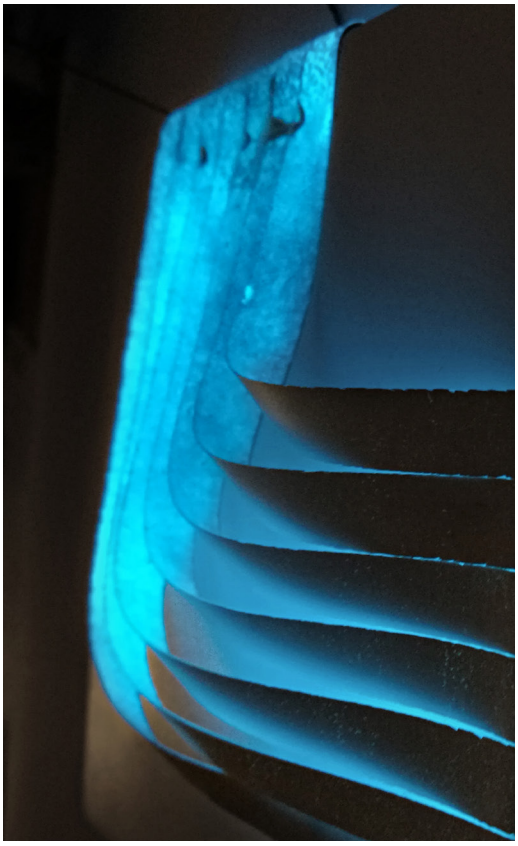
Sadly the used **paint** has its limitations too, it cracks when bent around the sides, also **bubbles up** or becomes patchy if heated **above 80°C** (seen on fig. 5.24). This heat-sensitivity in combination with a very hot heat gun caused partial breakage in many samples, making bending a fiddly and unpredictable process. A solution could be to paint after bending, but it is quite difficult to cover up the parts that should not be painted (as the material should not be bent after cooling down). Moreover the matt paint, even after sanding the surface down, is still **slightly too reflective**.

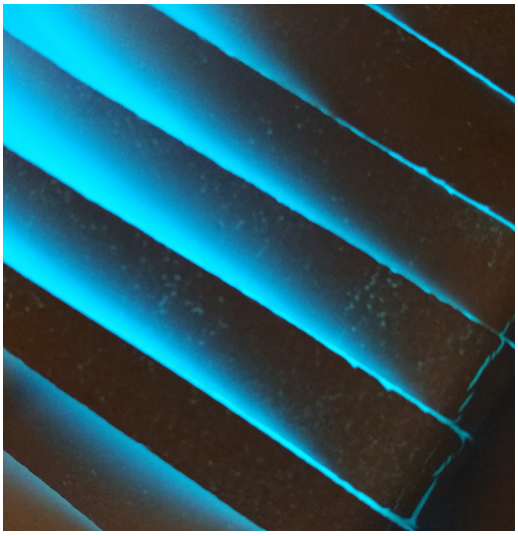
Lasercutting for this size of sheet without a deeper research into safety (seeing if it produces harmful gases during cutting) was highly discouraged during the project, thus the EL sheets have been hand cut using a sharp Stanley knife. **Hand cutting** has its downsides, first of all it is **quite slow and less precise**. The pressure under the knife can also **shatter the screen printed layers** (even if it is cut from the plastic side), or peel off small parts, leaving the edges of the strips quite rough.

Attaching the material to the tiles with a very strong and thin double-sided tape seemed like a good idea, however it turns out the **tape can** easily **peel the screen printed layers away from the ITO sheet**, slowly tearing up each strip. The opposite problem appears where the plastic side is held down, the tape is strong enough for a couple days, then slowly starts to let go. For prototyping it is a workable solution, but a better one is needed for the long run.

The decision to tape down the first and last centimetre of the strip and moving the strips to the optical middle of the tile ended up **influencing the possible pattern designs** quit a lot. An **S curve cannot be made anymore** in a regular grid, as the strips do not meet in the middle, they appear offset compared to each other, making some of the original pattern designs impossible.

All in all the final demonstrator looks quite close to how it supposed to, the light has a nice contrast with the white colour, the curves turned out very **smooth and elegant**. Placed on a wall in a lightly shaded area with no direct sunlight the tiles do have a **fascinating visual effect**.





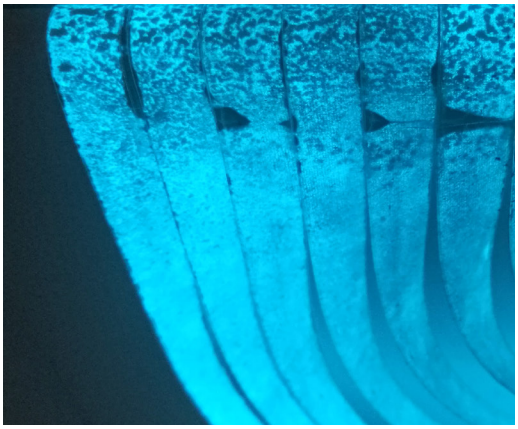
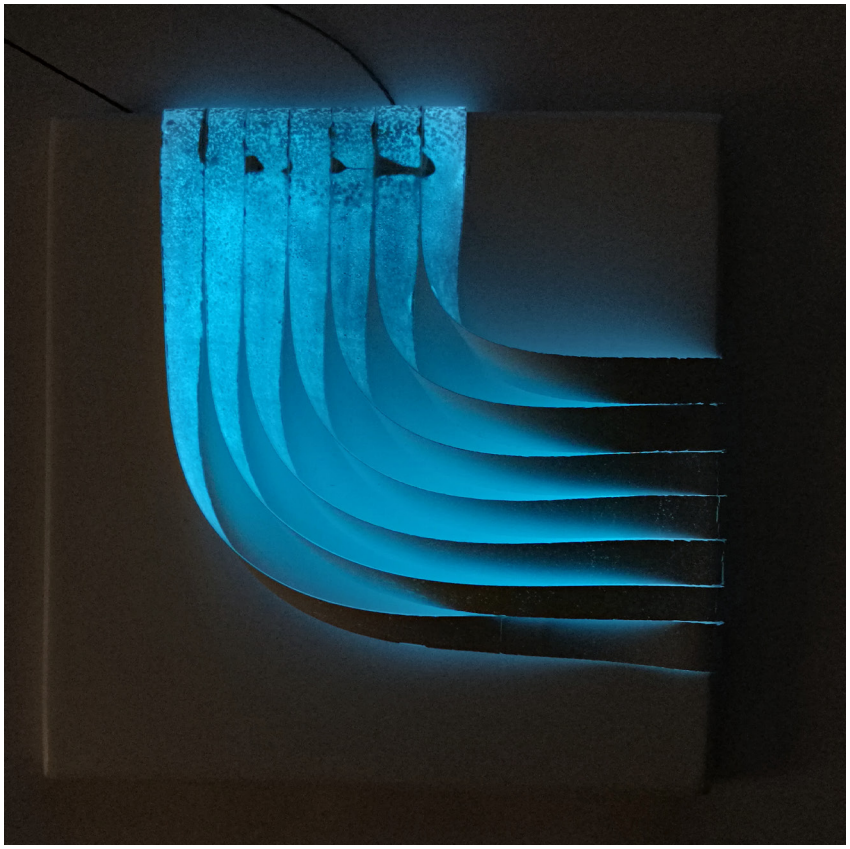
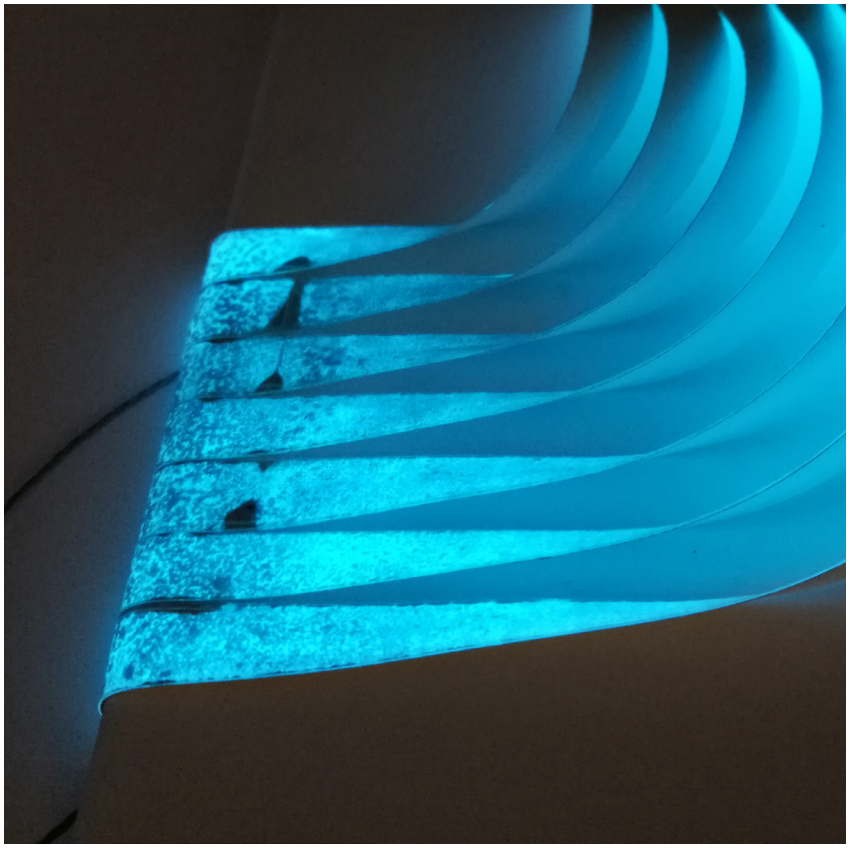


fig. 5.24 photos of the **curved design in a dark room**





5.6

EVALUATION OF

light situations for installation placement

The tiles have been switched on in many different light scenarios to test what conditions work best. This included natural and artificial light from completely bright to shaded light circumstances.

bright space

(1) In direct sun- or strong artificial light or a well lit room the tiles are definitely not luminous enough (no picture) to create a large enough contrast to become sufficiently visible. The surface of the plastic can also be very reflective (depending on the angle), taking away even more from the effect.

medium bright space

(2) With the tile not placed into strong direct light or in medium bright lit room (picture taken in no direct sunlight, with artificial lighting) the situation immediately becomes better, the light emitted by the tile starts to become visible.

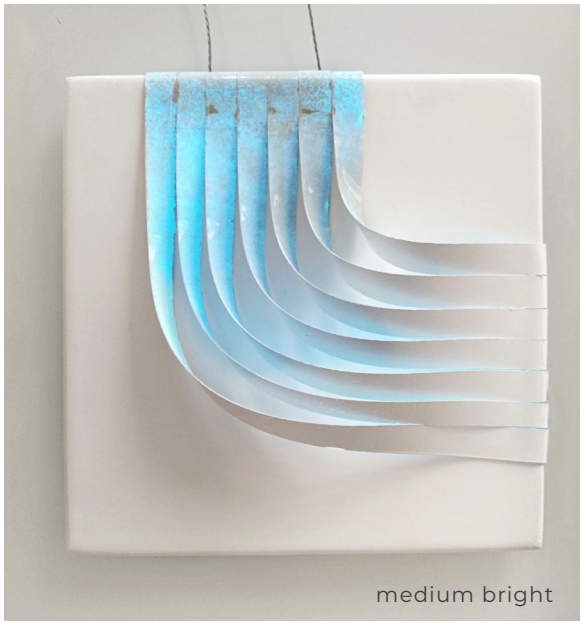
medium bright space

(3) Placed in a slightly shaded or medium lit room (picture taken next to a window on cloudy day with no artificial light) the contrast grew large enough that the EL sheets start to look decently bright. On the downside, reflections of the blue lights start to appear on the tile. In this case a reflection of a window is visible on the strips, that can be avoided with a better angle compared to the main light source.

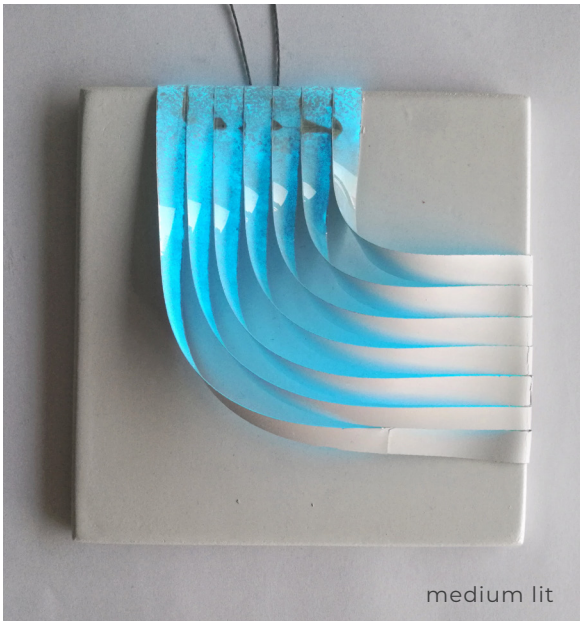
In a medium lit room (3) the tile can beautifully blend in with a white wall (the tile colour could be changed to match more environments), the neon lights will not be obnoxious even on a larger surface as they are not at their brightest.

medium low lit space

(4) Placed in ambient or scattered light, or a medium low lit room (picture taken around twilight with no artificial light) the EL sheets are showing really well while the tile in the back is still completely visible. With no direct or focused light no distracting reflections appear on the strips. On the other hand the emitted light starts to brighten up its surroundings, affecting the overall look quite seriously.



medium bright



medium lit

In a medium low lit room (4) both the tile and the light are beautifully visible, brightness and reflections are not too distracting, thus this could be a fitting situation for semi-public medium lit areas, like an office building, library or museum lobby.

low lit space

(5) In a low lit or dark room with small light sources (picture taken at night with faint lighting) the tile in the background slowly starts to disappear, while the emitted light does not look that much brighter. The colour of the light can also appear quite different depending on the colour of the artificial light, in this case it looks bluer compared to the yellow lit surroundings.

In a low lit dark room with small light sources (5) the tile starts to disappear, however with more placed next to each other the edges will probably be lit. The light is quite bright, possible too much with a lot of tiles next to each other, however the brightness can always be dimmed down. Environments like this are restaurants and bars.

dark space

(6) The last possible situation is complete darkness (picture taken at night with no artificial lighting), where only the parts that emit light or lit by the sheets are visible. The back of the strips shine light on each other and light up the tile directly under them, creating strong lines following the edge of the strips and a spotlight effect behind the curves.

Completely dark spaces (6) are not very common, maybe on a light show or in a light museum this piece could work as an installation.

summary

Situation 3, 4 and 5 - medium or low lit rooms - seem to be the best options, depending on the desired effect (how visible or bright the light should be, how many tiles will be placed there, etc.).

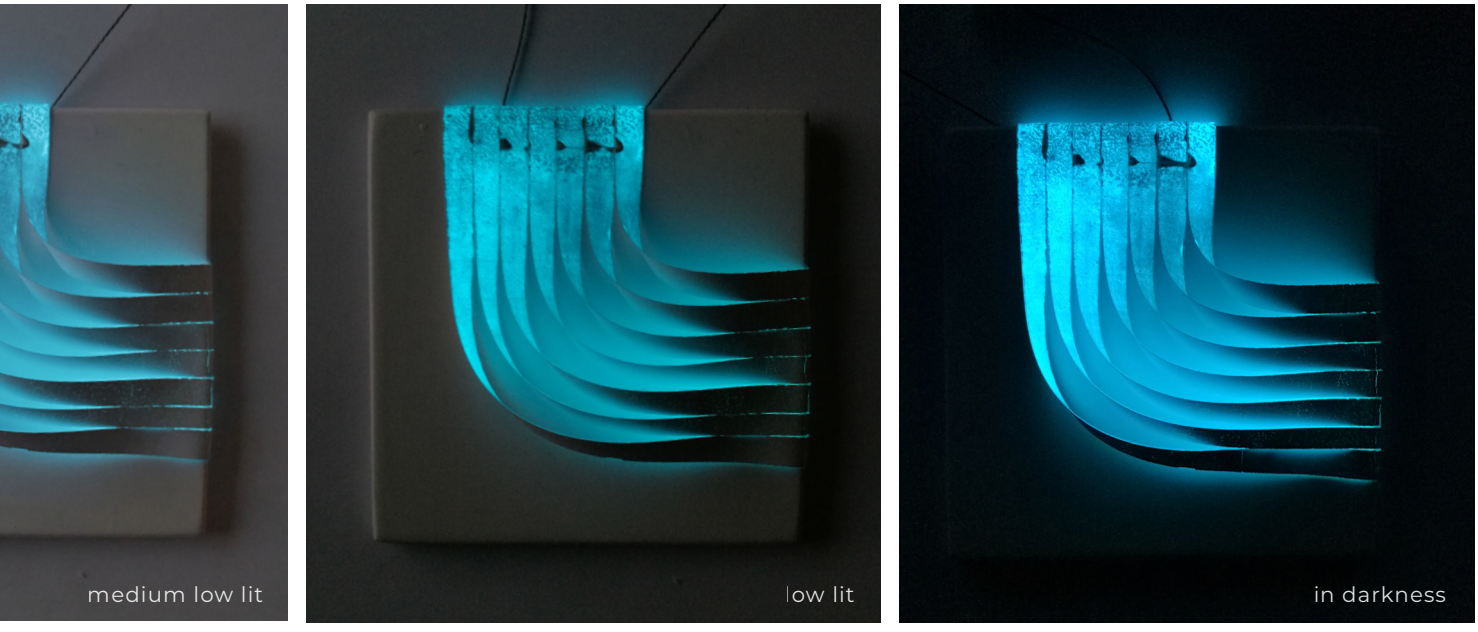


fig. 5.25 photos of the **curved design in different light situations**

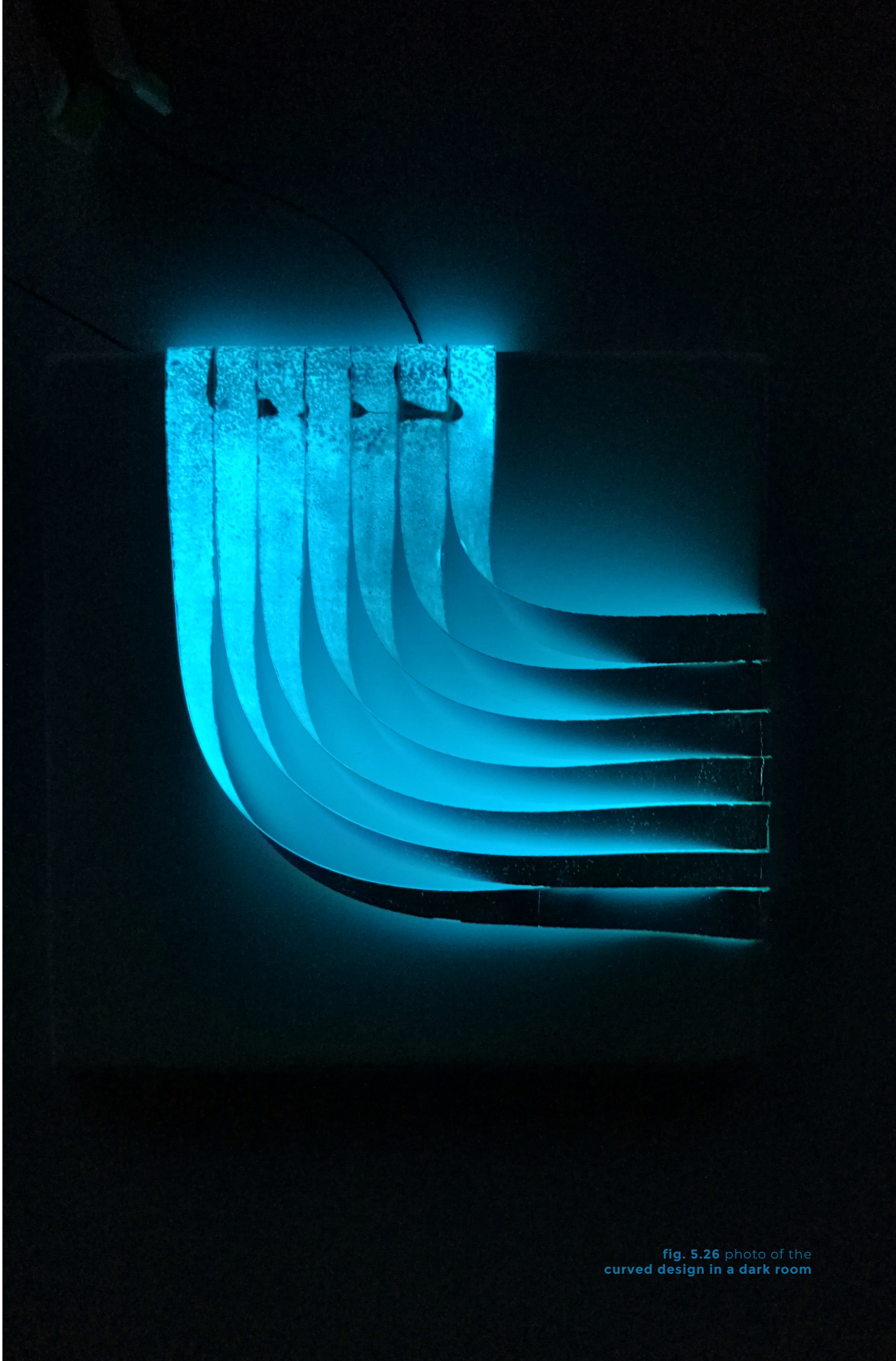


fig. 5.26 photo of the
curved design in a dark room

5.7

RECOMMENDATIONS

for further development

With the end of this project the design can not be called 'finished', it still contains multiple unsolved issues that should be further researched. This list contains recommendations for a follow-up development or continuation of the project by the client:

- use a screen printable, more reliable, non-brittle insulation material (like a transparent dielectric),
- use a heat-resistant white paint to cover the tiles and the silver layer,
- instead of double-sided tape use a very strong 1-minute glue to attach the EL sheet to the tiles around the edges of the tile,
- find a way to make the layers less easy to peel away from the surface (maybe with a different layer structure),
- research how to make the (white) light appear brighter,
- research the safety of lasercutting.

personal

REFLECTION

Even though working with such a unique material, like the electroluminescent one, is a fantastic opportunity, some phases of the project were extremely demanding. I faced many small defeats during the material phase, as creating samples (even with already being familiar with the DIY screen printing method) can be highly challenging. Of course when something was finally working as intended was always rewarding. I especially enjoyed creating new patterns and colours, also seeing the reaction of fellow students when I showed my new creations around.

The nature of this project was super experimental and open, I honestly did not know what the exact outcomes would be until the very end. There were points when I was quite lost, especially starting with the physical design. Surface design and creating something 3D out of flat objects is its own genre that I was definitely not familiar with. It was going nowhere until I got my hands dirty and just started making things out of scrap paper and cereal boxes. And then something just hit me, and I started making boxes full of these models, including the first version of the final design, which still resembles the original paper model very closely. I feel like I learnt a lot from this part of the project about not waiting around but diving head first into the unknown.

What came after nobody could predict, and I am not talking about the Corona-virus. The early prototyping phase was going quite well, but when I decided to make full size prototypes they suddenly started to give out very little light or just straight up short-circuit. I had a hard time hitting the mark. I needed to take a step back multiple times to see what went wrong (spoiler: many-many things), do a small research and then continue again. This going back and forth made the prototyping difficult and time consuming.

And the problems did not stop at the making of the sheets, they continued with literally every step of the assembly. Day after day, then week after week with very little progress was the most frustrating part of my project. I made 36 attempts until I finally assembled the two different designs, that is a 5.6% success rate (not great). But I have to admit, when something finally worked was a phenomenal feeling, and I savoured it for days. I did learn to hold onto small victories, also to be persistent and hard-working, then nothing can stop me from getting to where I need to be.

fig. 5.27 my last demonstrator on **top of the garbage pile**

One is supposed to do 20% of the project after Greenlight. It feels like I did 40% because of all the unpredictable mistakes and circumstances. I am fairly sure this process would have been very different without the COVID-19 lock down, as access to certain materials and facilities was cut off just after my Greenlight. I am still very grateful that I was allowed to continue working at the university, as my project would have been impossible to finish without the needed materials and a chemistry lab.

Somehow after all the mountains of problems to climb and deep oceans of failed experiments to swim through I managed to pull off making something really beautiful. I am very proud of the demonstrators, and honestly would love to have one in my living room as a reminder to how proud I am of finishing this project. I have only one thing left to say, I am glad that I ended up with such an ambitious and challenging project which truly pushed me to my limits as a student, a designer and just a human being, as I got to learn many valuable lessons.

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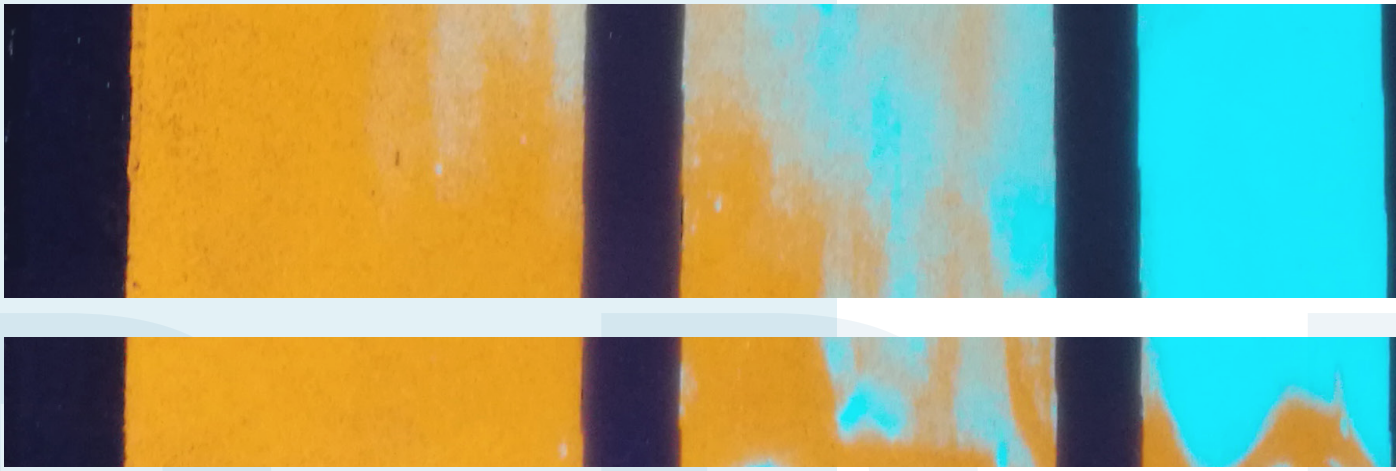
APPEND A-F

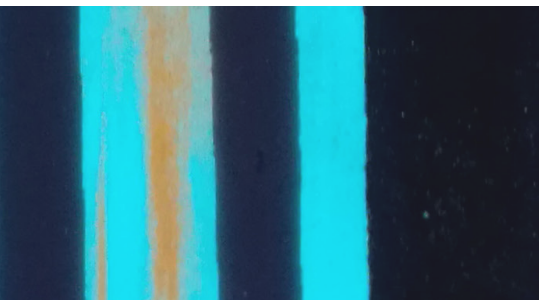
what did not

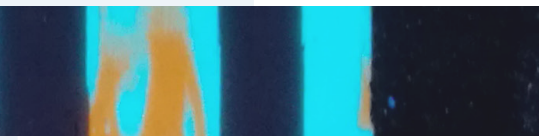
MAKE IT INTO THE REPORT



APPENDICES:

IX





APPENDIX A
EXPERIEMENT LOG

Experiment 1

Trying UV samples with blue phosphor paste and curing in oven → stayed wet

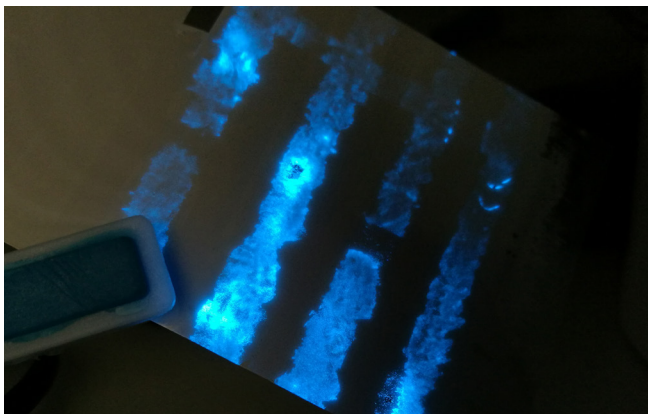
- very messy samples
- cutting vinyl and PET together is really hard, especially at curves
- bending it can cause the aluminium foil to tear → phosphor can detach from the aluminium foil

UV cured sample (working)

Experiment 2

Making screen printed sample

- phosphor is uneven and bubbly
- dielectric is too thick for the mesh
- hand-painted dielectric is a bit too thick, sample only works partially
- light quality is bad and uneven

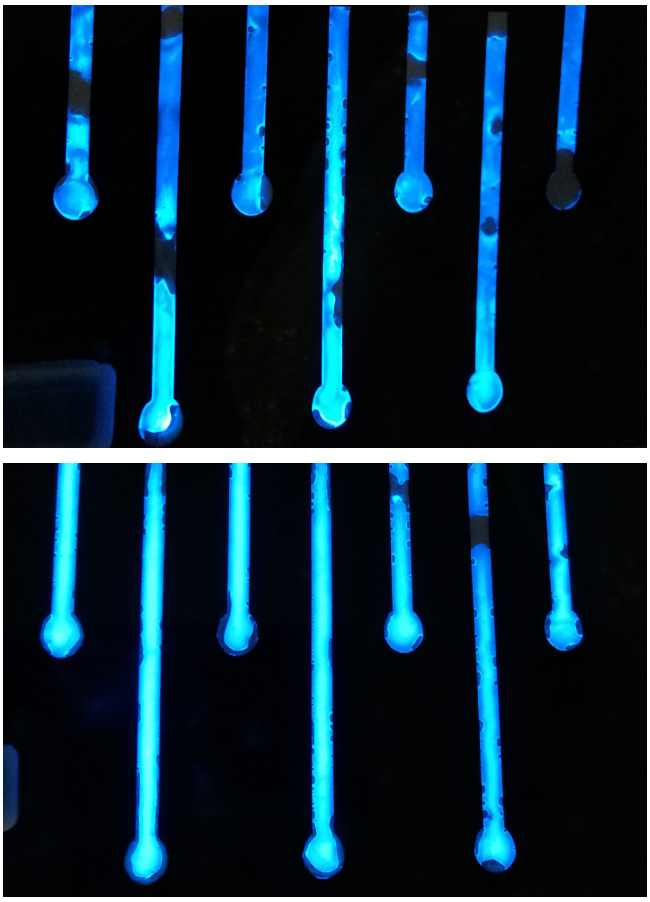


Screen-printed sample (working)

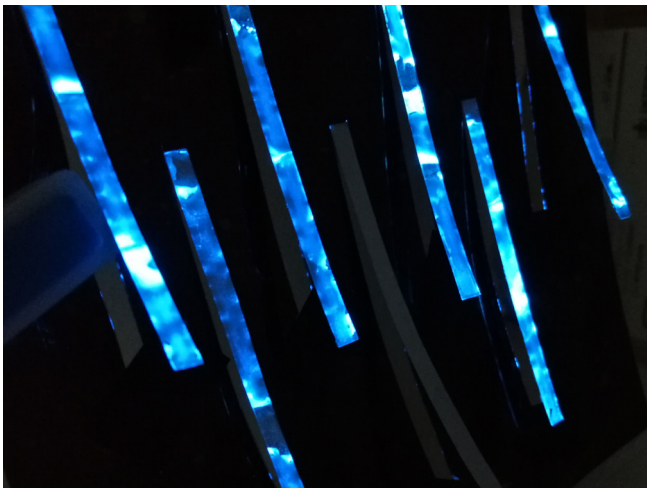
Experiment 3

Trying out UV method with hand-painted phosphor layer

- Painting it with a brush → too thick and uneven
- UV method with using squeegee for phosphor → better results
- Trying to cure UV resin phosphor in the oven → sort of worked



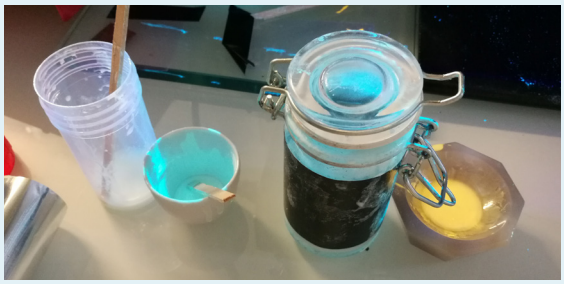
Brush (top), squeegee (bottom)



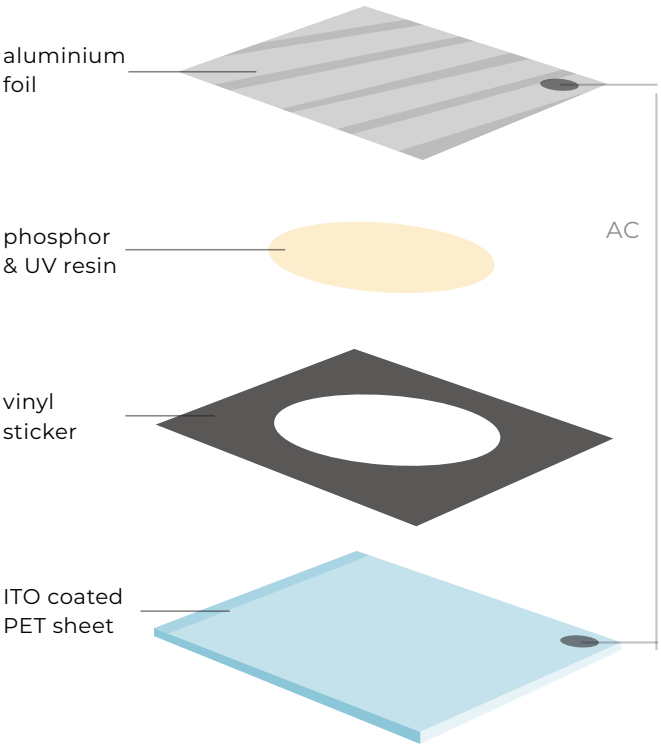
Cut UV cured sample (working) → the middle one went out because the aluminium foil got torn

HOW IS IT MADE?

15 minute - UV curing



The DIY 15 minute method uses ITO PET as a substrate, also only one layer for luminescence and isolation, a mixture of phosphor powder and UV resin. This reduces the number of steps and cleaning needed. Furthermore aluminium foil (one-sided illumination) or another layer of ITO PET (double-sided illumination) is used as the back electrode, which makes the process even easier. Find a detailed guide in the graduation report of Wajwakana (Wajwakana, 2017)

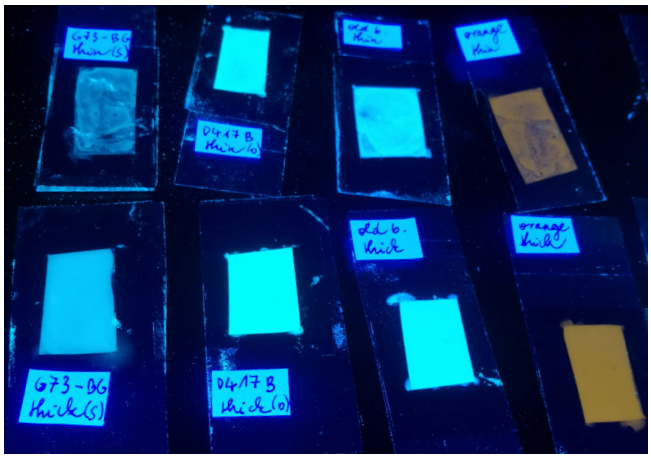


Layer structure of a DIY UV cured sample

Experiment 4

Mixing phosphor powders with the UV glue

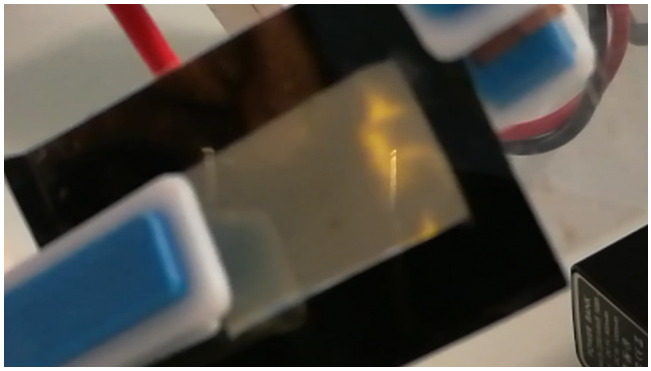
1. Mixing orange powder
2. Using mixture from the lab (a dark blue one)
3. Mixing blue powder (D417 B)
4. Mixing green-blue powder (G73-BG)



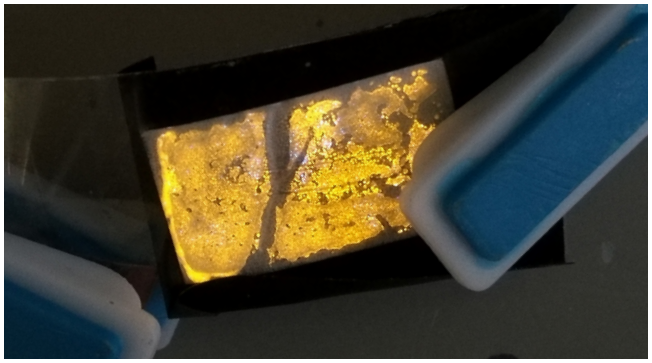
Samples under UV

Creating thick and medium thin samples to see what works best (using the 15 minutes method)
In general the mixture doesn't cure well or sometimes at all, which makes the thick samples short-circuit easily (mixture moves a bit and then the ITO layer and aluminium foil can touch). Medium samples are a bit more stable.
Sample looks different than under UV light, both colour and intensity. Switched on most looks bluer.

1. Orange samples
Thick sample barely switched on, when it did it was short-lived and faint.

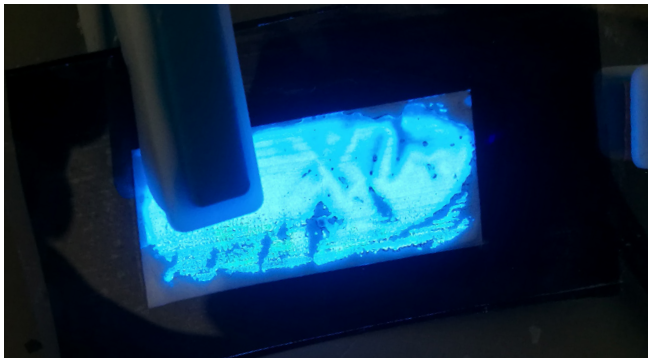


Thick sample (snapshot from a video)

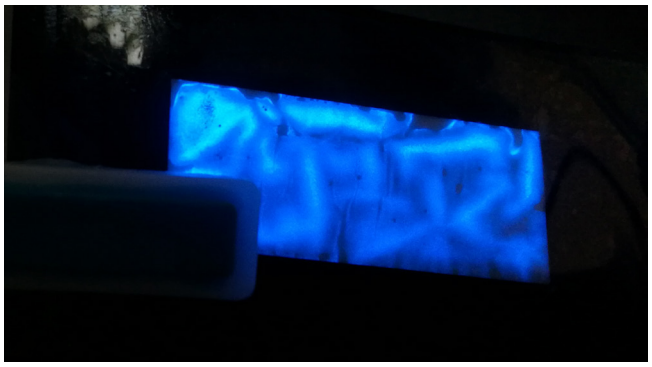


Thin sample works a bit better, bit unstable

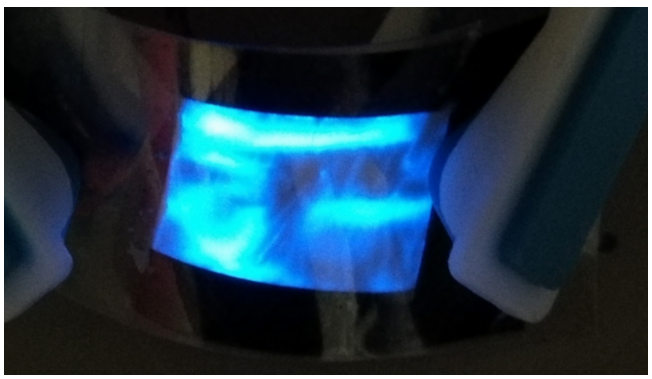
2. Dark blue samples
First, trial samples are really hard to switch on and short-circuit really easily



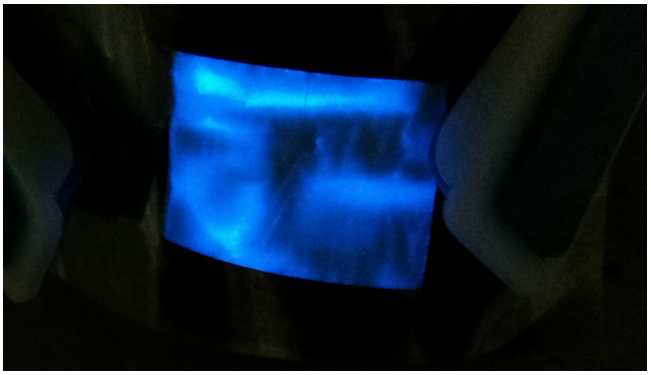
The sample is bright, but the UV paste is not dry on the inside



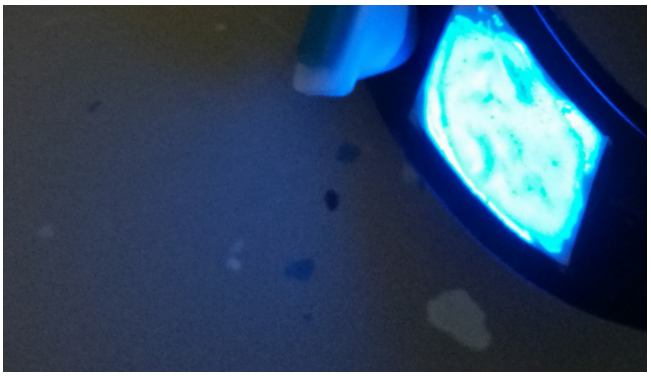
Sample only switches on for a few seconds at a time, it twitches a lot.

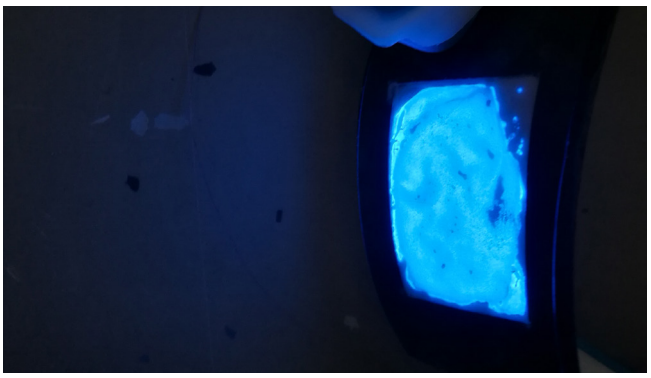


Thick blue sample has a nice pattern, that also moves a bit when pushed - colour is dark blue (picture in dim light)



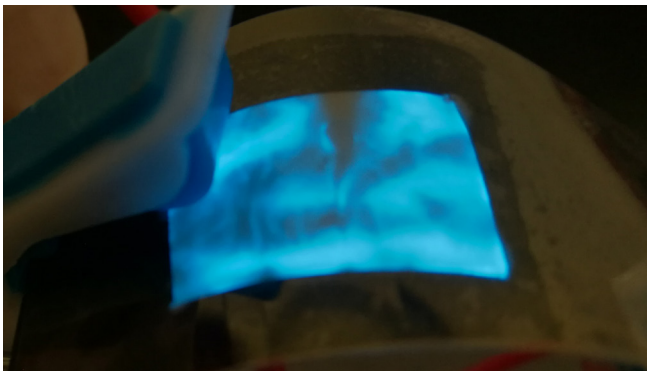
Thick blue samples in complete darkness



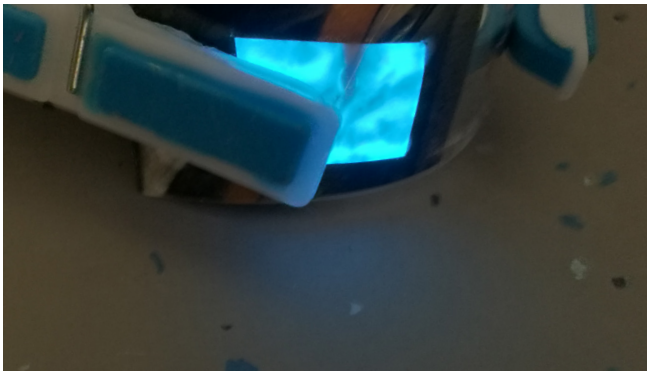


Thin sample is bright and has an equal phosphor paste layer (lights up the floor)

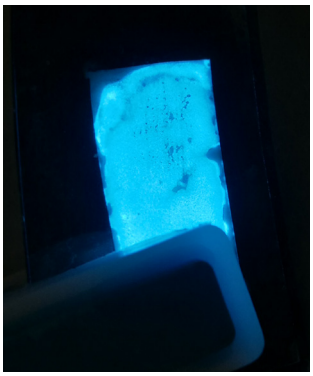
3. D417 Blue
The samples are the brightest, lighting up their surroundings too.



Pattern partially created by a tear in the phosphor layer



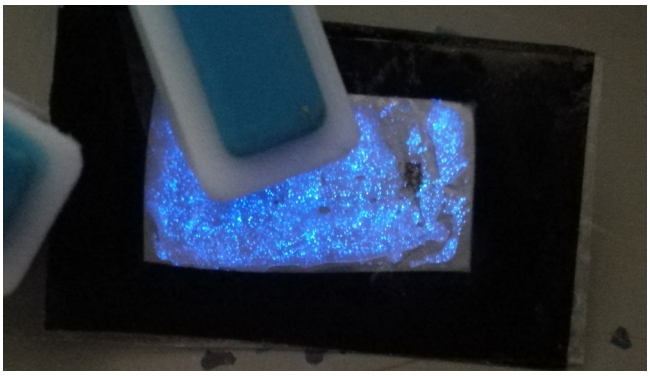
Showing the emitted light on the floor by the thin sample



Thin sample has a more equal layer, it's even brighter than the thick sample

4. G73 - BG Blue Green
Supposed to be a greenish blue colour, but it looks more like a dark blue. It's also turned out to be a bit grainy, looks a bit like stars, or a galaxy effect. The light is faint.

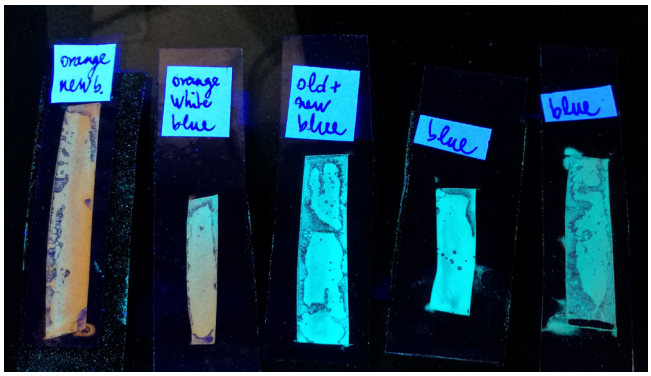
Only the thin sample works, the thick sample never lit up, only gives sound.



Starry effect on the thin sample

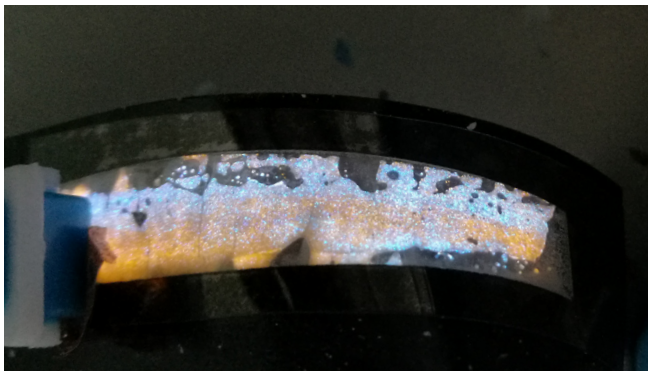
Experiment 5

Trying to mix different type and colour phosphor pastes with the UV method



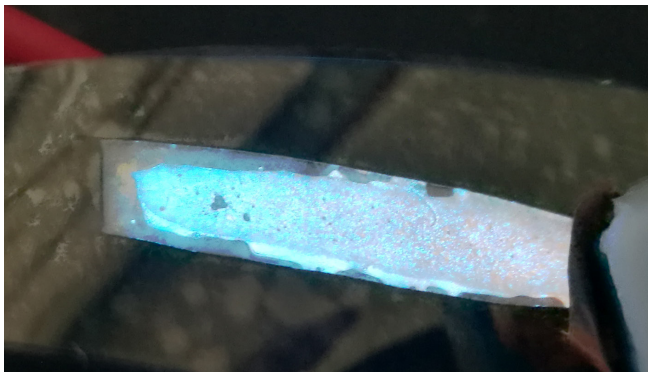
- Orange + green "new" blue (G73-BG)
- Orange + green blue gradient
- Dark blue (D417 B) + green blue
- Blue (D417 B)
- Blue (D417 B)
- Thin blue

1. Orange + blue
Mixing the orange with the "starry" blue maintains the starry effect, even inside the orange. The sample is less orange than under UV.

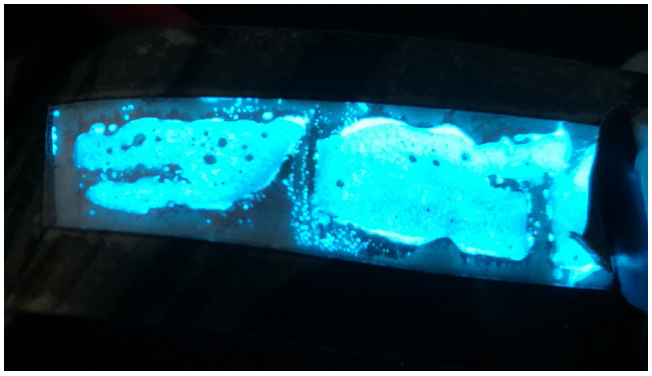


The 2 colours are not mixed much, just applied next to each other before curing.

2. Orange + blue gradient
Where the 2 colours are better mixed, the light becomes more white. Blue easily overpowers the orange.



3. Blue + “starry” blue
The starry effect is only visible when the mixture is not in big chunks. The print accidentally looks like a lizard.

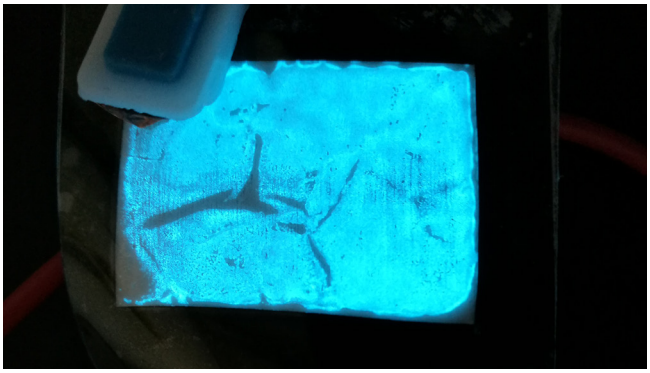


2 blue mixtures are not visible separated

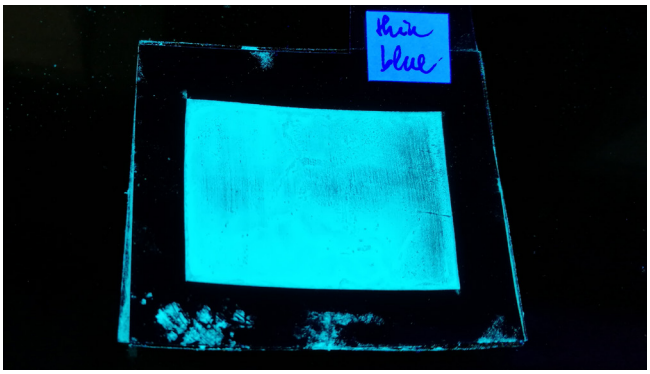
4. Blue (D417 B)
Creates a quite bright light and equal layer.

5. Blue (D417 B)
The light looks slightly like streaming water, but it’s the uncured mixture still moving inside the sample when pushed.

6. Thin blue (D417 B)
The sample is made with two very thin layers of phosphor cured on top of each other. The layer actually cures, creates a brighter and more consistent light. → phosphor should be applied in extremely thin layers (use the squeegee), rather multiple times than a lot at once



With electricity the layer has a crack where the aluminium foil did not attach to the mixture really well

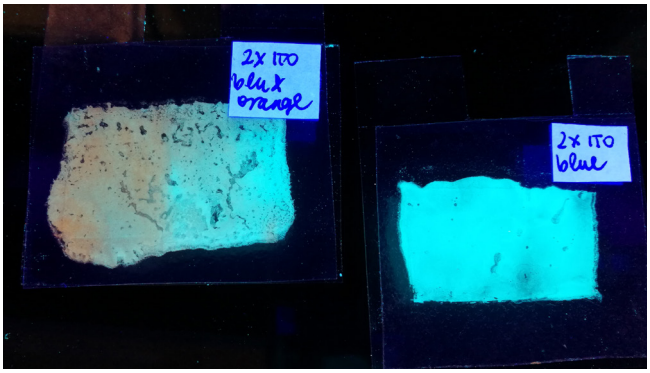


Under UV

Experiment 6

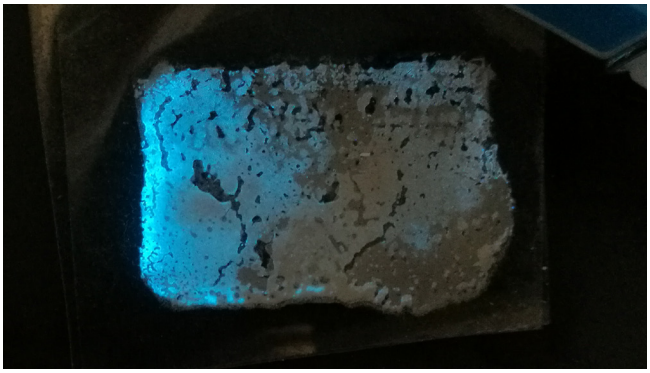
UV method with 2 layers of ITO:
ITO - insulation spray - phosphor mixture - insulation spray - ITO

The spray is applied on the ITO, so it has an equal layer under it. 2 little flaps are left on the opposite side of the sample, so it can be switched on. The phosphor mixture had a hard time curing, it needs to be applied way thinner.



Samples under UV

1. Blue (D417 B) + orange
The orange light is barely visible, the sample was way brighter on the blue side. The brightness gradually went down from the blue side towards the orange.



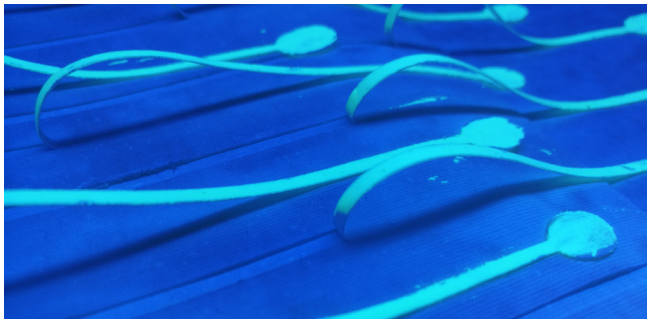
Blue x orange sample

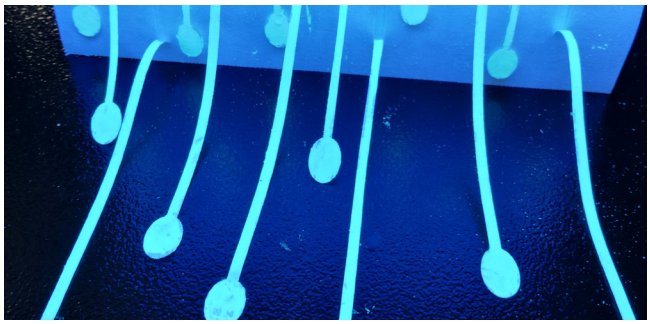
2. Blue (D417 B)
The blue sample switched on only once, there are no photographs of it. It was brighter and more consistent than the orange-blue one.

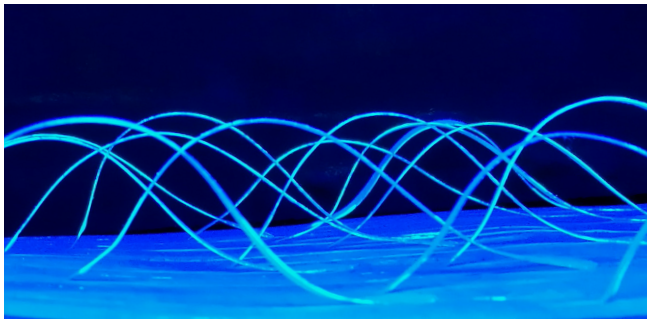
Experiment 7

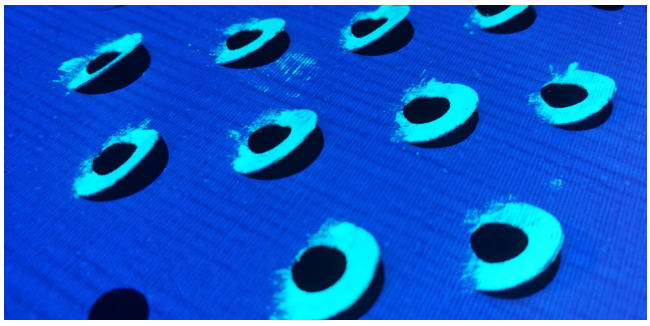
Hand-painting the A+N products with phosphor paint

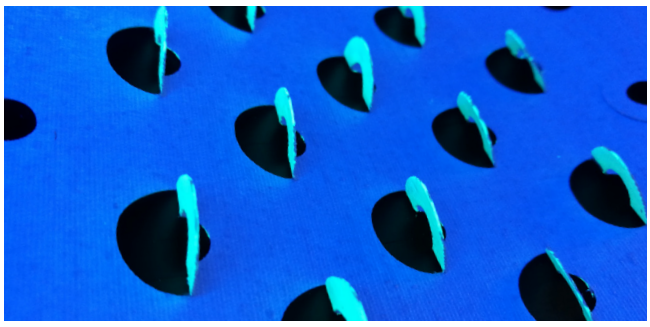
- Fully painted samples loose 3D effect, also a bit aggressive
- Phosphor is hard to apply
- Back light hard to simulate









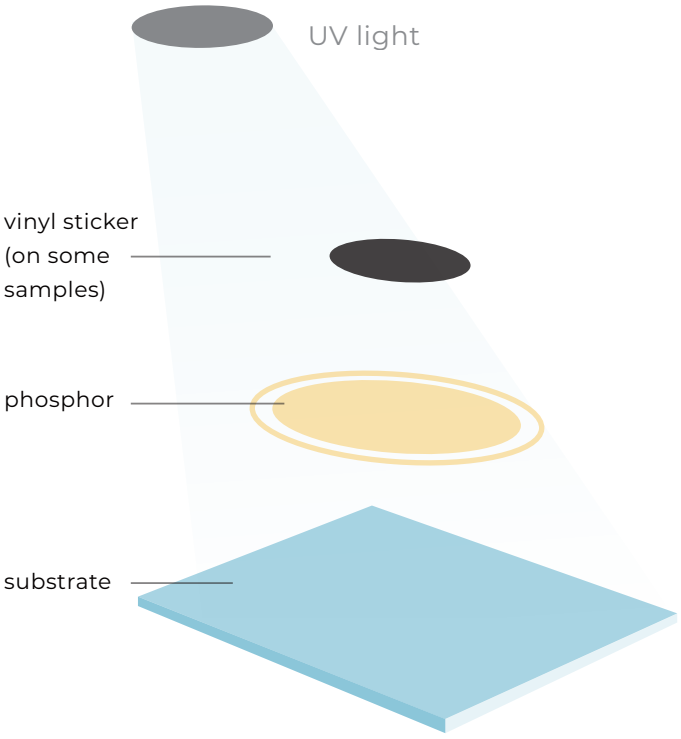


Photographed under UV

HOW IS IT MADE?

painting with phosphor

To simulate light without cretaing a working sample there is a simple solution available, painting a mock-up with phosphor paint, then taking pictures under UV light. It is a quick prototyping method that can save a lot of time and material. Take note that the colours slightly differ from what they look like using electricity. Also only those surfaces 'light up' that are directly hit by UV which can make it hard to take pictures of samples with 3D or complex geometry.

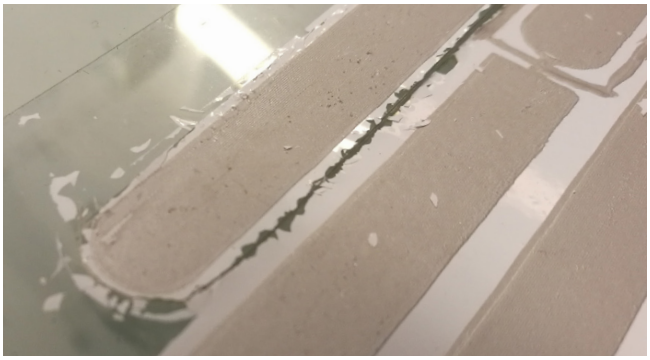


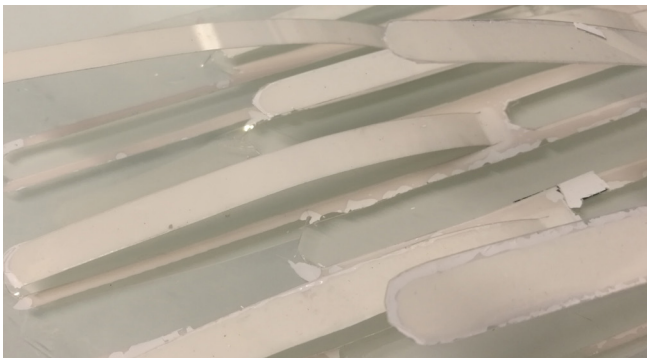
Layer structure of a UV light samples

Experiment 8

Trying to screen print sample → bubbly dielectric causes short-circuiting

- Cutting up the screen-printed sample, dielectric shatters
- Cutting on the part that has silver it works better
- Reusing broken sample with taking pictures of it under UV light

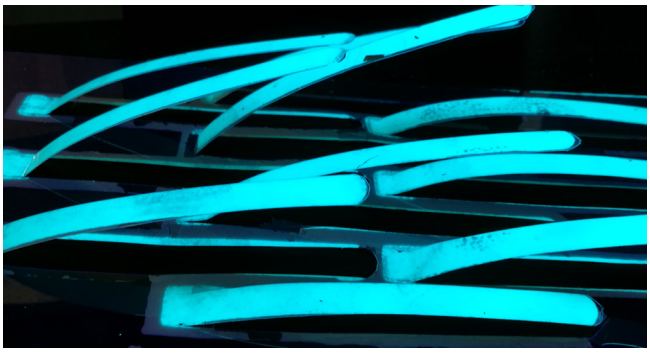




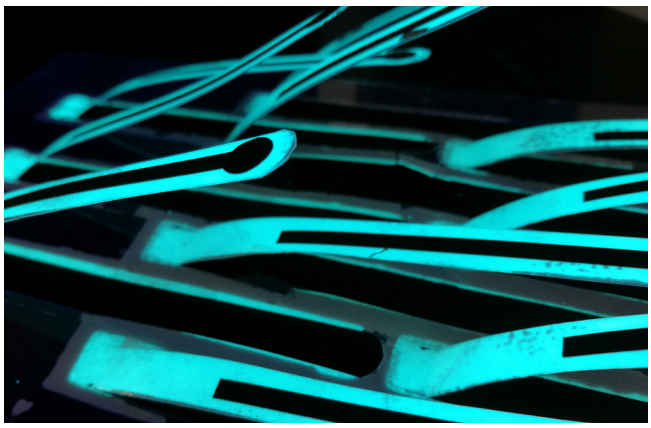
Cutting makes dielectric shatter

Samples under UV

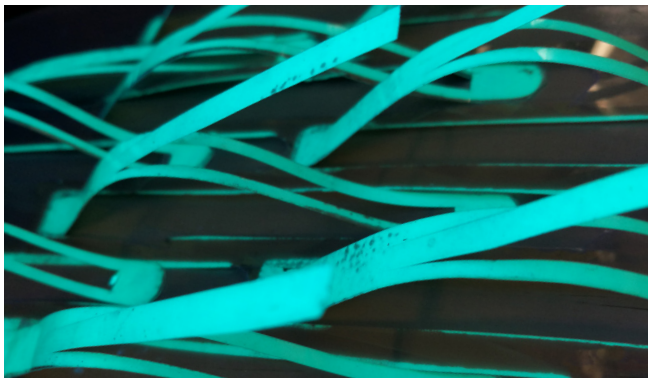
- The movement of the samples feels really natural, like grass in the wind
- Creating negative space with the vinyl makes the sample more interesting and engaging
- Fully cut and bent sample has a nice effect when it's moving, but full on light is a bit too aggressive
- Colours in real life are bluer

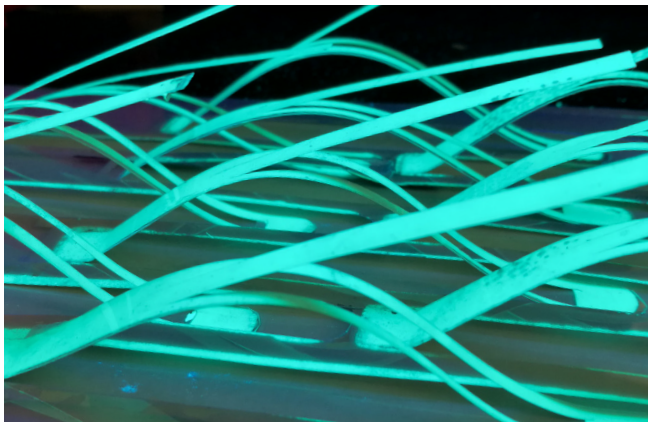


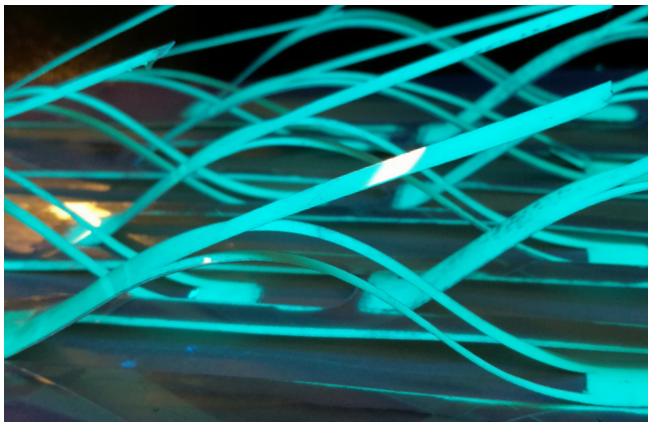
Bent flaps under UV light



Negative space shown with vinyl sticker



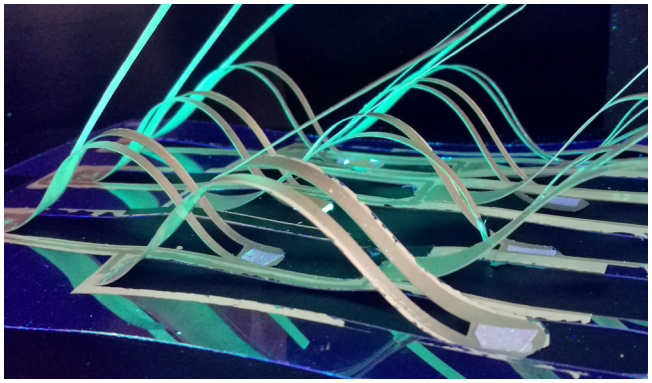


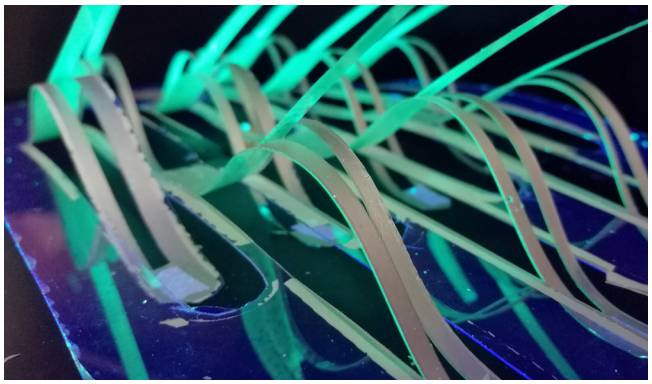


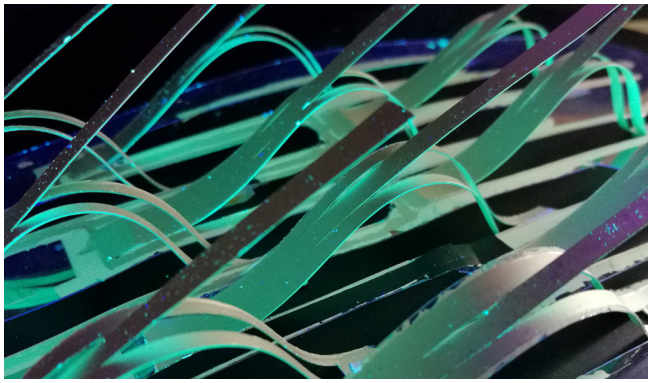
Fully cut sample under UV

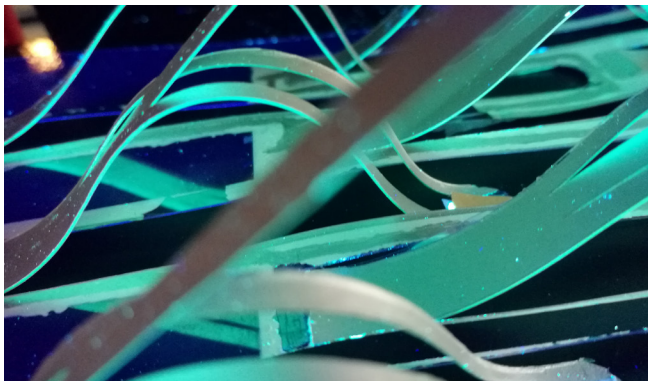
Experiment 9

Trying to create a backlight effect by flipping the sample upside down → the PET is too reflective, silver and dielectric is too light coloured → lot of reflections





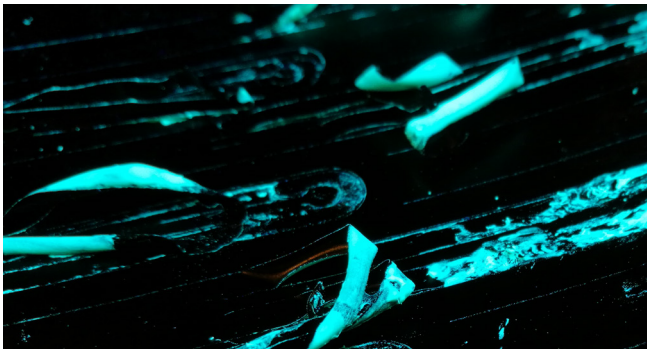


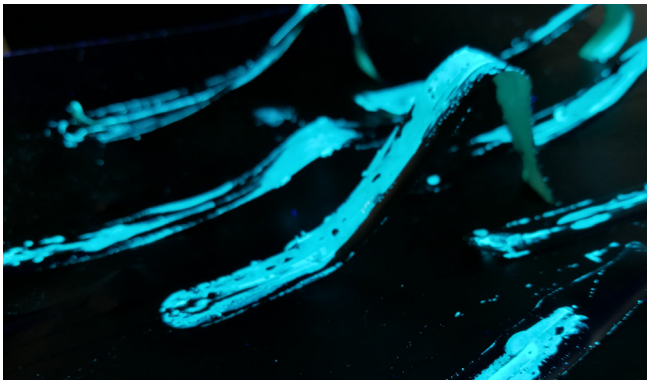


Moving the sample under UV → light visibly appears when opened and disappears when closed

Experiment 10

Trying to create a backlit version from vinyl → does not hold shape → messy

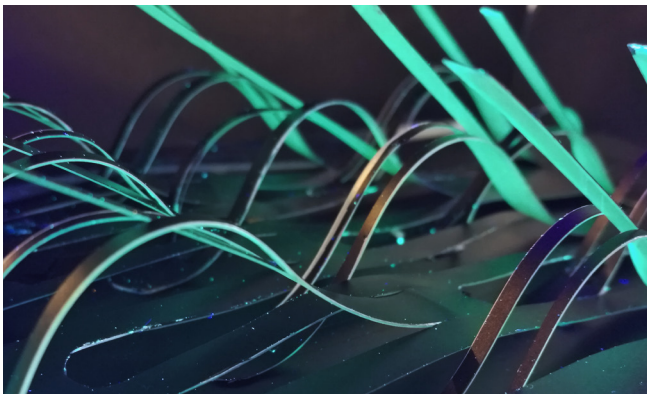


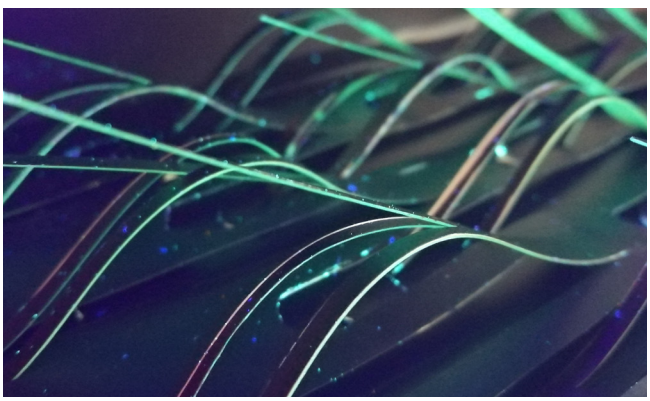


Photos under UV light

Experiment 11

Creating backlight sample with putting vinyl on the flipped sample → more subtle, opening and closing creates a nice effect

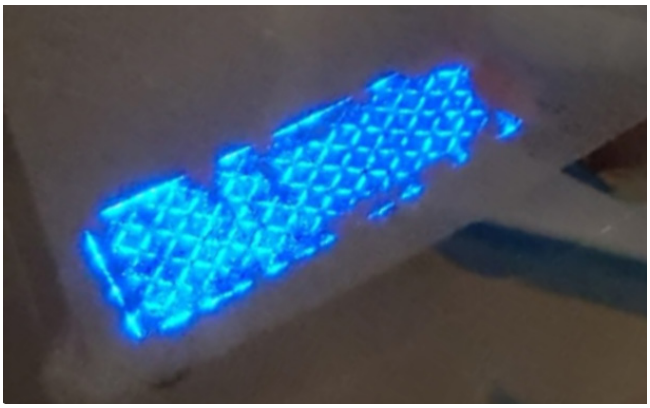




Experiment 12

Experiments with the dielectric and replacing in the dielectric

- The dielectric doesn't work well, no matter hand painting the holes, it still short-circuited
- The sample first works → when connecting the different part with silver paint it short-circuits
- Insulating spray works quite well, created a working sample



Pattern comes from the copper tape (w)

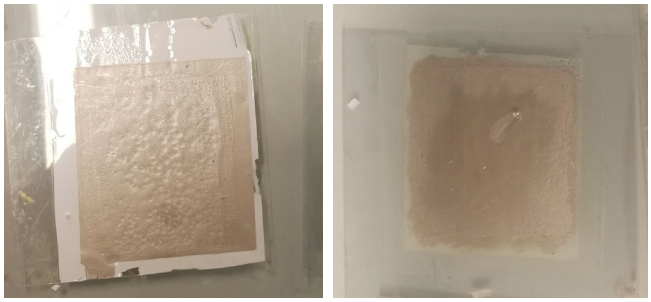
HOW IS IT MADE?

using the insulation spray

The insulation spray is an electric insulator, which makes it suitable to replace the dielectric. When using a spray paint it can be harder to create a homogeneous layer then with screen printing (using not cans but a spray gun can help this). In case of small samples this is less of a problem, which makes the spray an ideal solution for rapid prototyping or experimenting. In case of a simple design few and thin layers are sufficient, which can help creating extremely thin and flexible samples. Most blue samples had a high brightness, but quite a few of them had 'stars' (shiny dots) in it.

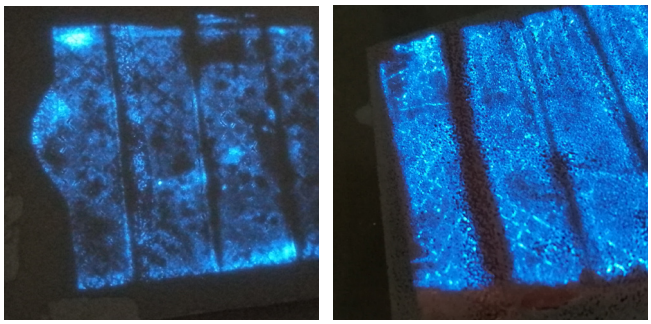
Experiment 13

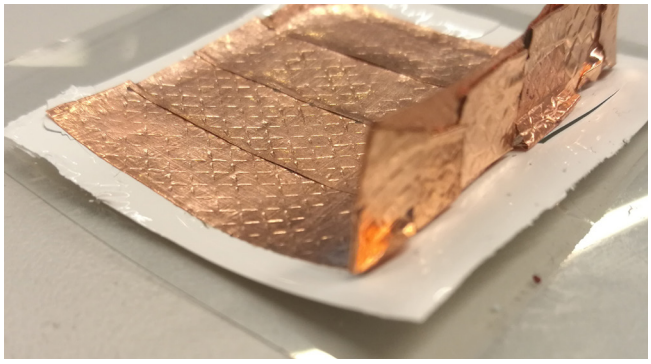
Making samples to cut
Dielectric + silver → no light
Spray + silver → no light



Dielectric (left), spray (right)

- Dielectric + copper tape → barely works (left)
- Spray + copper tape → works nicely (right)



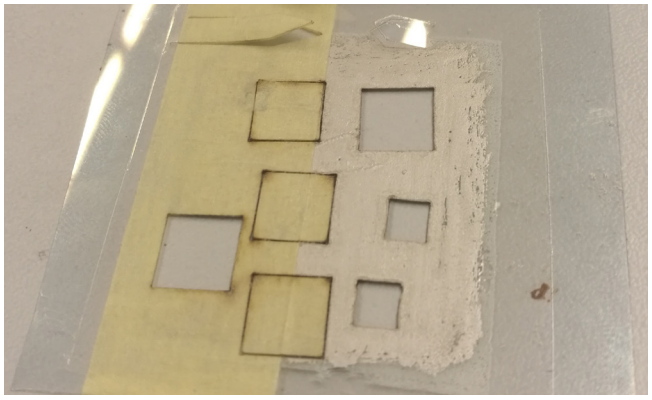


Dielectric is peeling away from ITO, very fragile

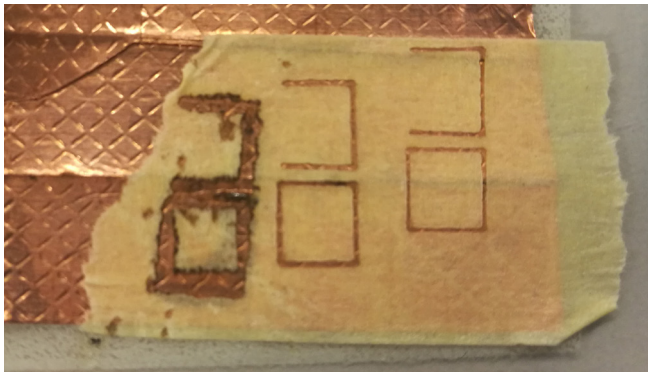
Experiment 14

Laser-cutting EL pieces

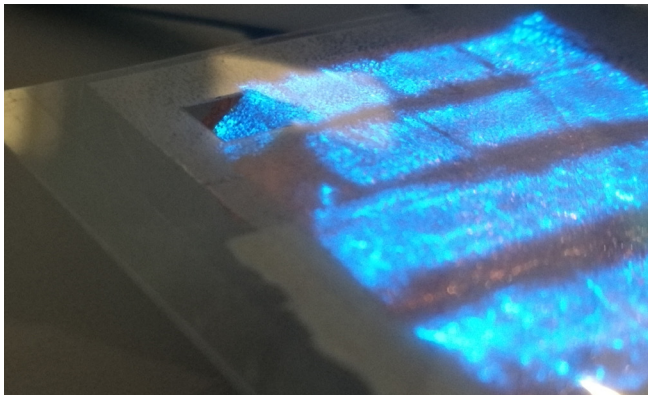
- Shiny surfaces need to be taped so they do not sparkle too much (if so the cutting needs to be stopped)
- It needs really low power (5-10%) so the ITO sheet doesn't melt/burn
- The tape also protects from burn
- Corner acceleration needs to be circa 2x as much as normal



All materials were possible to cut: ITO PET, silver, dielectric, insulation spray (PEDOT didn't try)



Copper tape cannot be cut

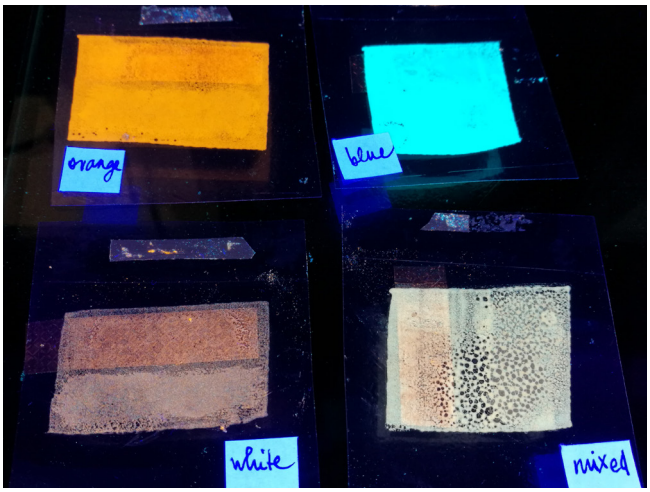


Cut and bent out piece (without tape) still works on a sample

Experiment 15

Trying out different phosphor pastes with screen printing

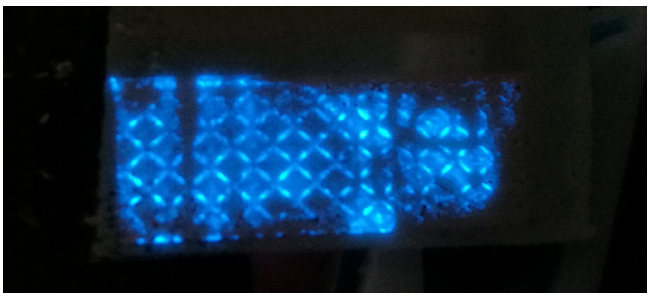
1. Blue phosphor
2. Orange phosphor
3. White phosphor
4. Hand-mixed blue-orange



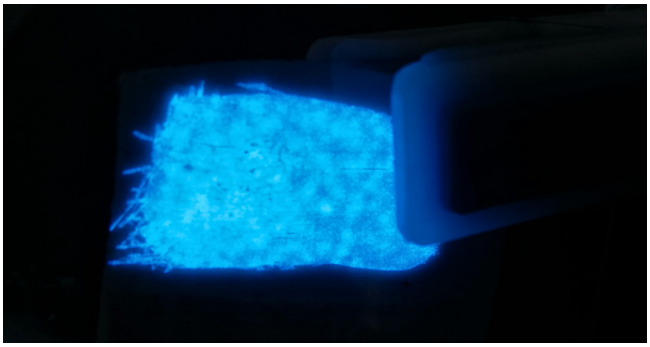
Samples under UV, colours are quite different with electricity on, they are bluer and brighter

Method: ITO - phosphor - insulation spray - silver / copper tape (patterned)

Results:
1. Blue - Bright light, equal phosphor layer

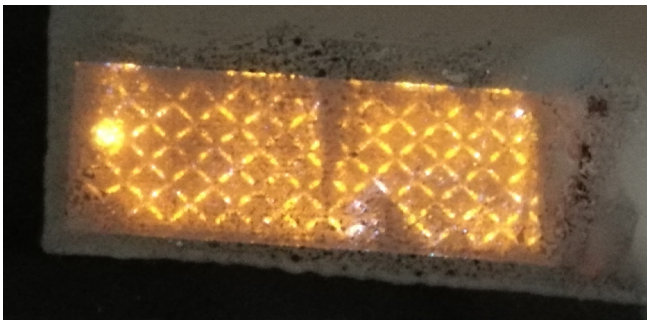


With copper tape

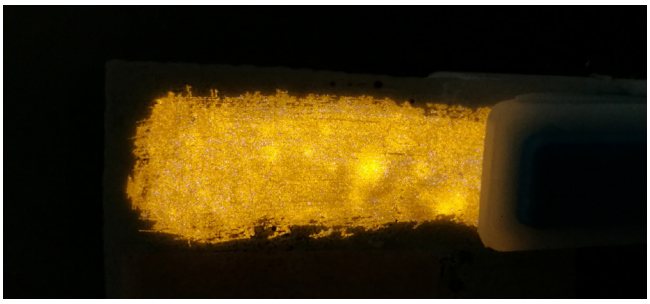


Silver paint on the blue sample

2. Orange - Medium bright light, decently equal phosphor layer

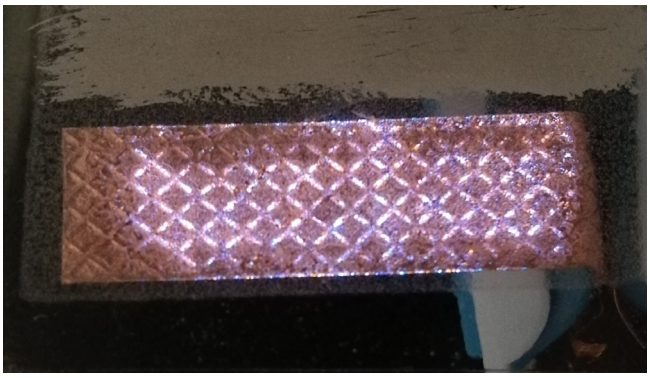


Orange sample with copper tape



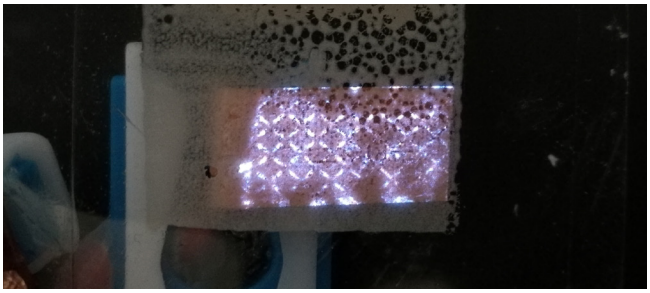
Orange sample with silver paint

3. White - Extra thin phosphor layer, only lights up with copper tape, silver ink short-circuits. Faint, ghostly light.



White sample with copper tape

4. Mixed - Bubbly phosphor layer, brighter and whiter than the actual white phosphor, only lights up with the tape, not with silver



Mixed sample with the copper tape

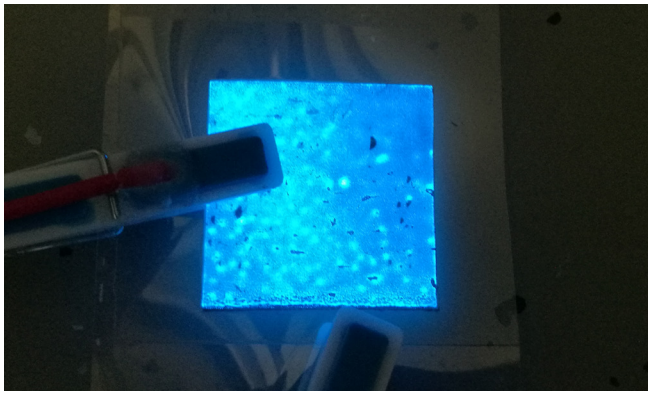
Experiment 16

Trying out different phosphor pastes with screen printing (PEDOT x2)

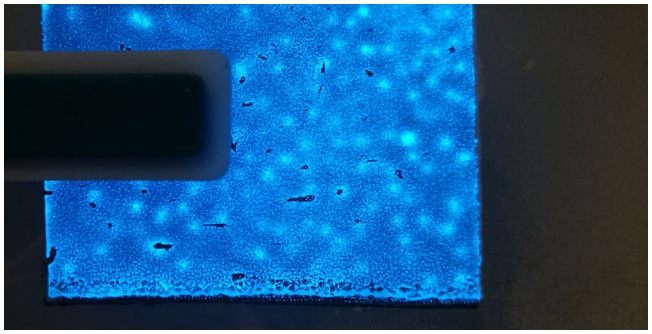
5. Blue phosphor
6. Orange phosphor
7. White phosphor
8. Hand-mixed blue-orange

A dot of silver can make it easier to connect and have a stable light from the sample.

1. Blue - starry effect, bright spots on a medium bright layer.

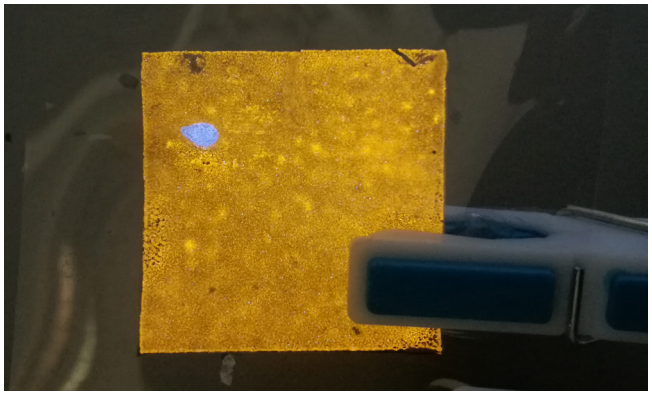


Blue sample in dim light



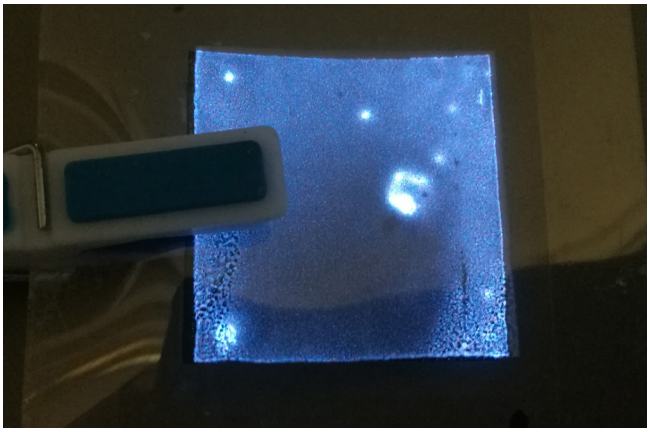
Blue sample in darkness

2. Orange - Medium bright light, decently equal phosphor layer with some stars



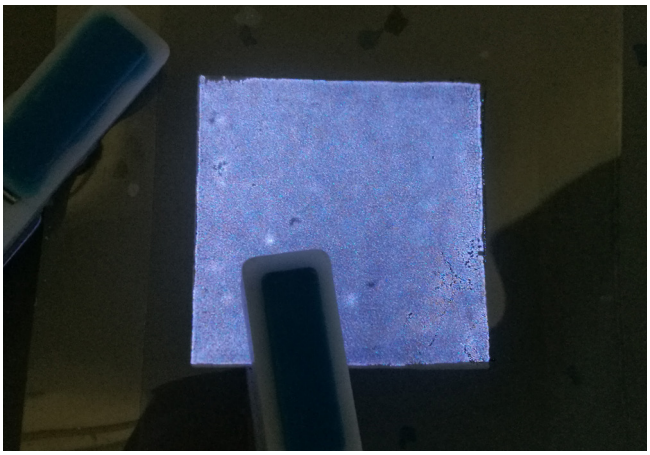
Orange sample in dim light

3. White - The phosphor layer looks equal but doesn't light up fully. Has some stars and a large bright spot in the middle.



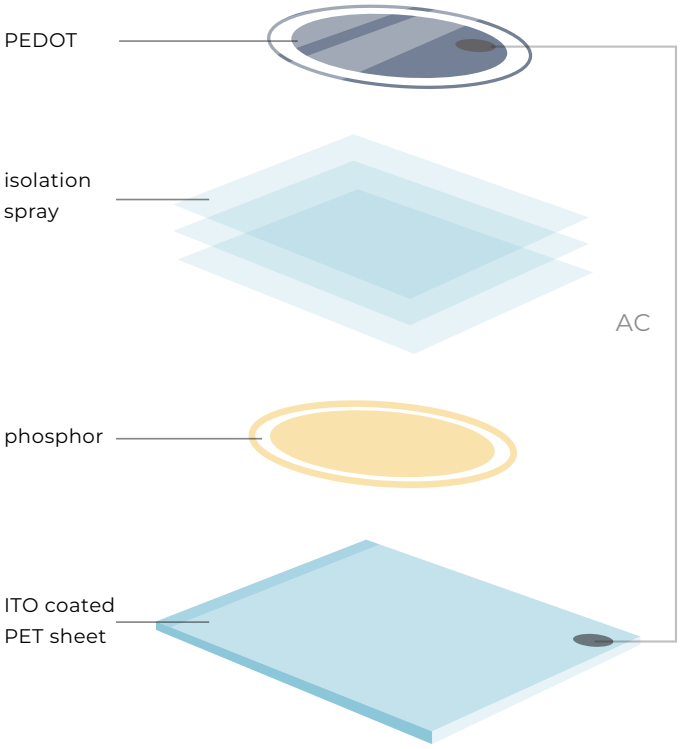
White sample in dim light

4. Mixed - most equal layer, lights up nicely
Mixed sample in dim light



Summary:

Thicker (more viscous) phosphor pastes seem to work nicer with screen printing, when stirring phosphor it is really important to incorporate solid part.
Copper tape shows less bright light than silver, it has to be very roughly pushed onto the material, hard to remove
Silver ink shows so far the best brightness, but goes into bubbles really easily, which can create short circuits
PEDOT is harder to work with then silver, but it creates a thinner layer and slightly less bright sample.



Layer structure of double-sided samples with ITO PET + PEDOT combination

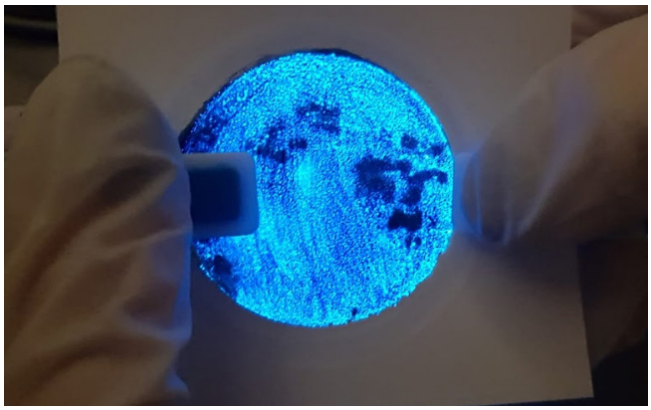
HOW IS IT MADE?

colour mixing

The experiments showed that the blue colour is way brighter than the orange and the white. Also, as light has additive mixing, white can be mixed from blue and orange. In a very close up photo the standalone blue and orange grains are actually visible individually. To create a better white option a DIY white was created with a 6:4 = blue:orange ratio to have a higher brightness and colder colour.

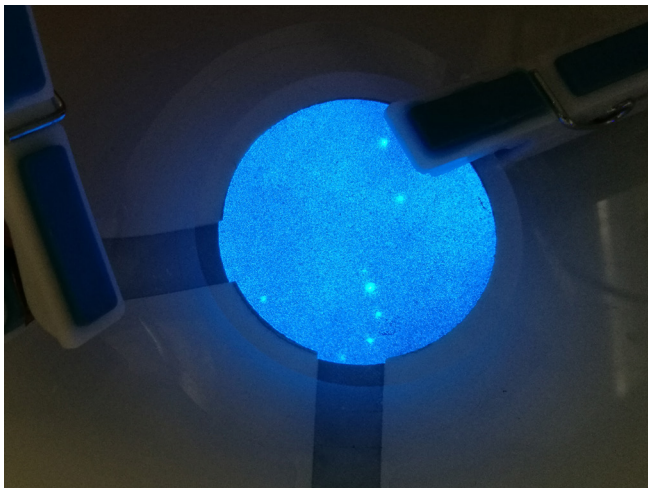
Experiment 17

Using tattoo paper with PEDOT - phosphor - dielectric x3 - PEDOT → barely, but works Unstable, only works if pushed together

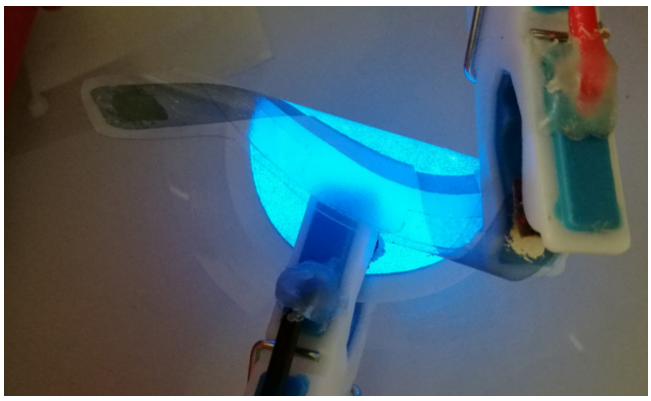


Experiment 18

Creating a very flexible double-sided sample. Thin PET - PEDOT - phosphor - spray x2 - PEDOT. Stars are dots in spray.



Flexible sample switched on

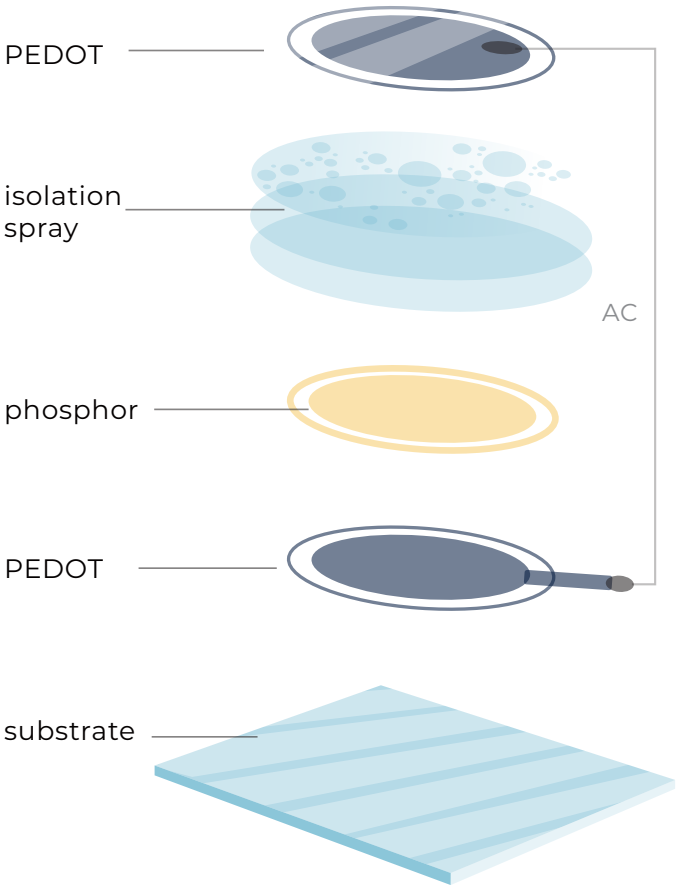


Flexibility of the sample shown

HOW IS IT MADE?

galaxy pattern

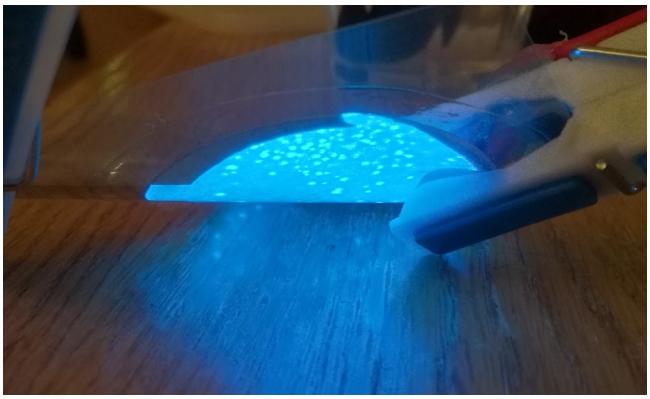
The galaxy / starry pattern can be created with the isolation spray. If the applied layer is equal the light will appear homogeneous. On the other hand if the layer has dots and spots in it, it is thicker or thinner on some parts that will appear in light output as well with larger or smaller dots and a differing brightness. It is not easy to control this, but in general small dots can be made with spraying from a larger distance. Large dots are creating by splattering the spray or letting it drip on the sample.

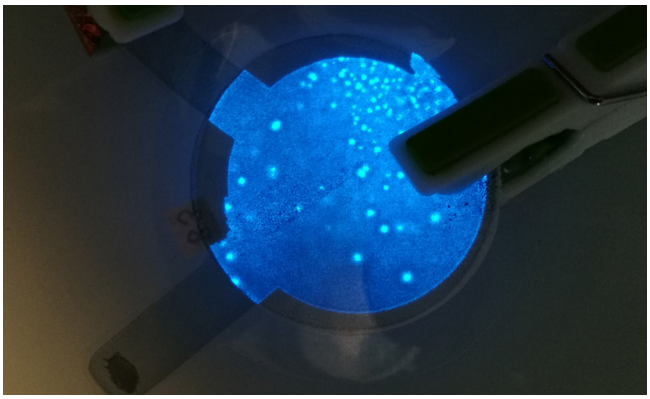


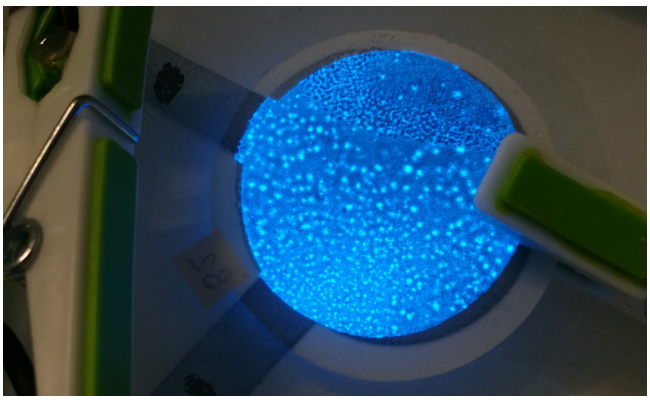
Layer structure of double-sided samples with PEDOT + PEDOT combination

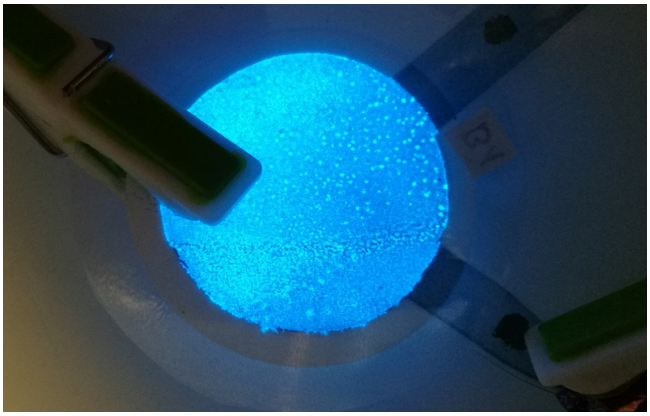
Experiment 19

Creating 3 more very flexible double-sided sample. Thin PET - PEDOT - phosphor - spray x2 - PEDOT. Stars are dots in spray.









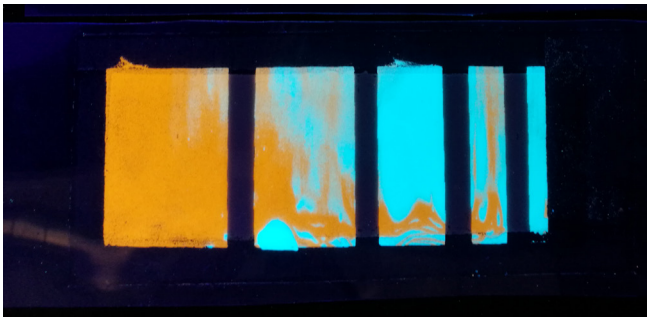
Experiment 20

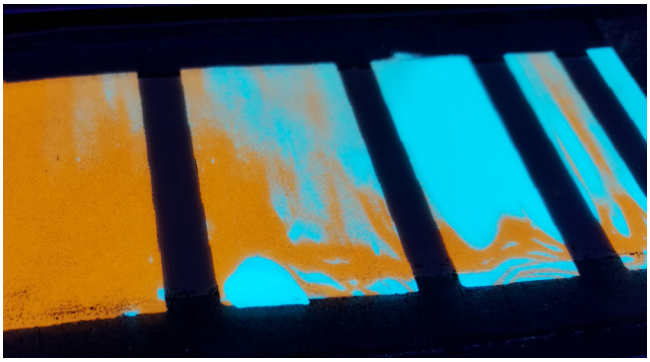
Trying to create a more intricate design with ITO - phosphor - insulation spray - PEDOT (butterfly) / silver (bars) layering, where the silver/ PEDOT is applied onto places as well where there is no phosphor. The samples gave sound, but did not create light at all. → One layer between the two conductive layers, even if it is thick, is not enough.

1. PEDOT layer, hand-painted corrections

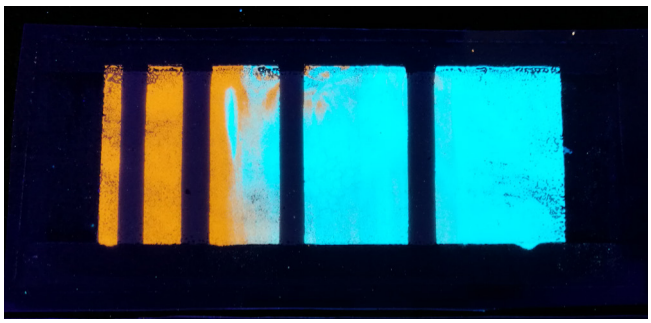
Butterfly design under UV

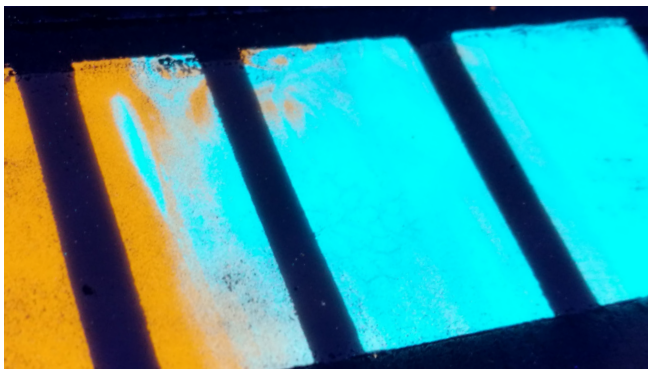
2. Silver top layer - orange-blue mixture
They do not work, short circuit on the parts where there is no phosphor.





First design under UV - painting-like





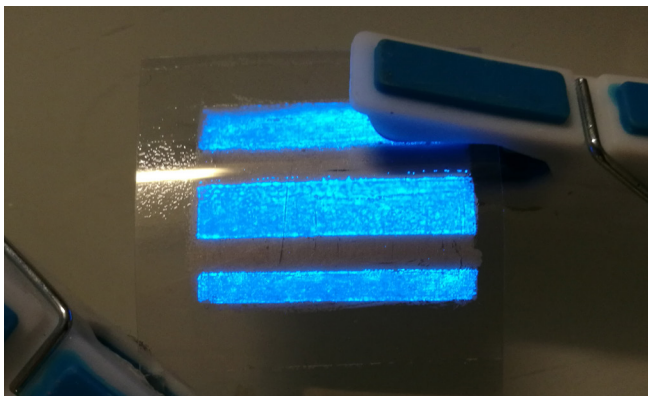
Blue - orange gradient sample under UV

Veins-like cracking in the sample - appears after the last layer is out of the oven

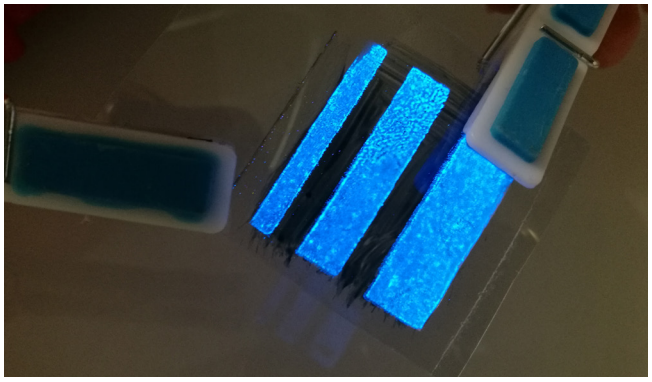
Experiment 21

Trying to create a more intricate design with ITO - phosphor - insulation spray x3 - PEDOT / silver layering. The PEDOT needs a small pot of silver for a nice connection. Both of the samples work, even stable.

1. With silver



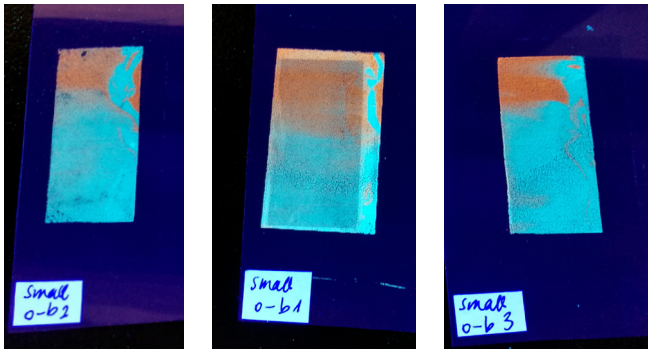
2. With PEDOT



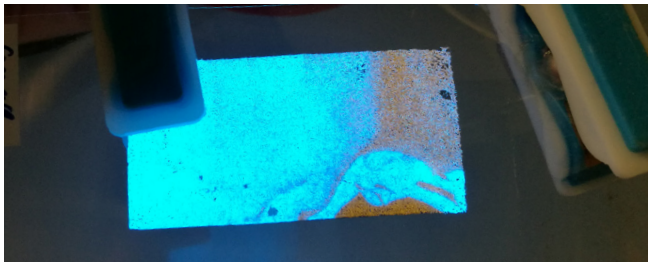
Experiment 22

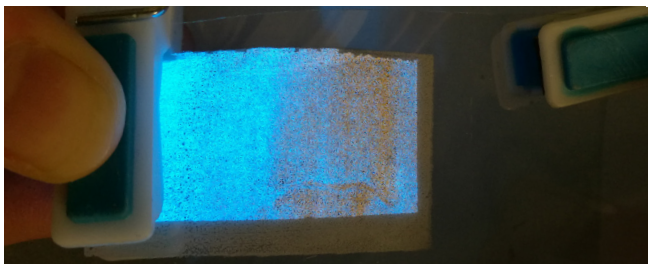
Creating orange-blue samples with mixing and lining phosphor paste on top of each other, then not mixing them.

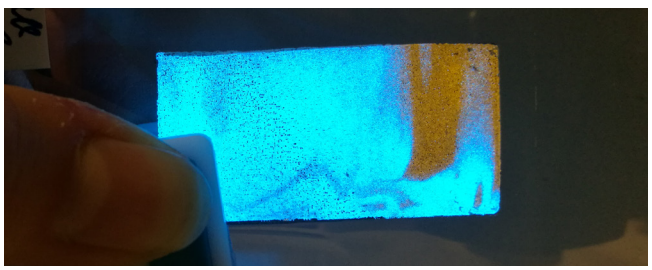
1. Small gradient samples



Small gradient samples under UV



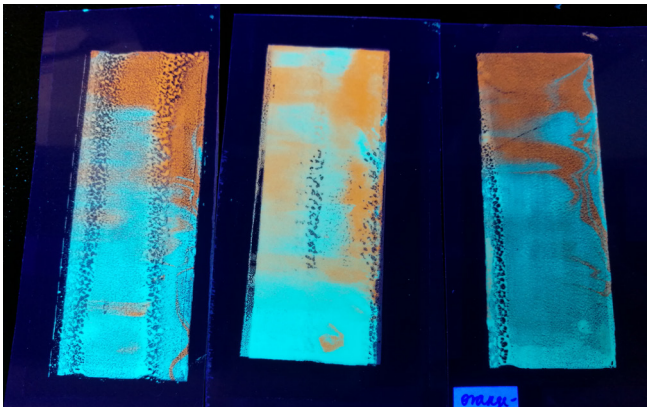




Small gradient samples switched on

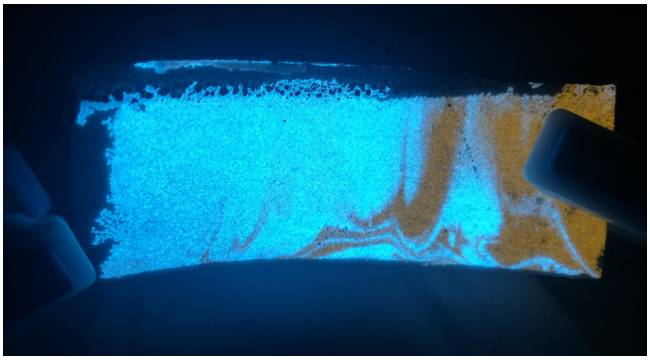
The orange light is less bright than the blue, the parts where they get mixed becomes whiter and less bright as well.

2. Large gradients - only one is working



Larger gradient samples under UV

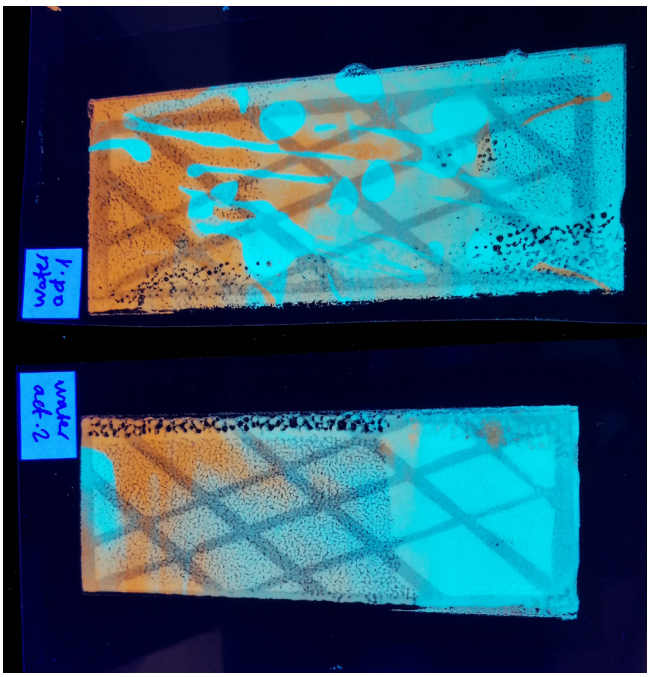
On those the phosphor layer is really uneven, bubbly. The mesh was not weighed when the samples were made and it lifted slowly and created patterns. They short circuit at the bubbles.



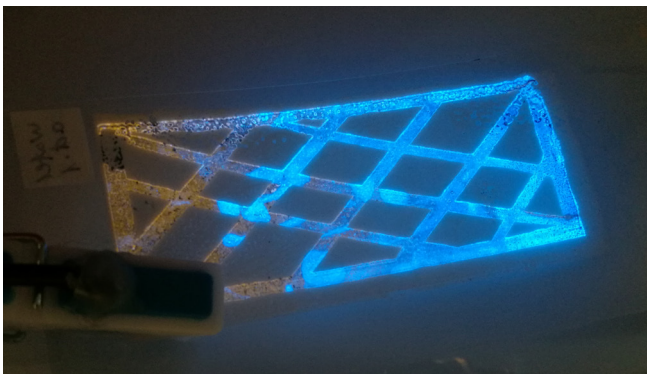
The only working sample from the batch

Experiment 23

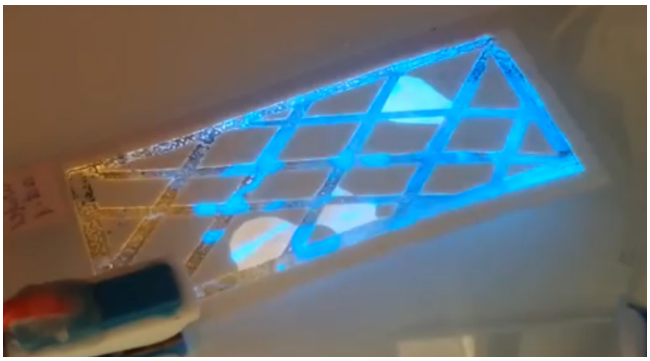
Water activated samples with gradient phosphor layer under. One was created by mixing orange and blue in the middle, the other one had blue phosphor dropped on it first. The layer is slightly bubbly.



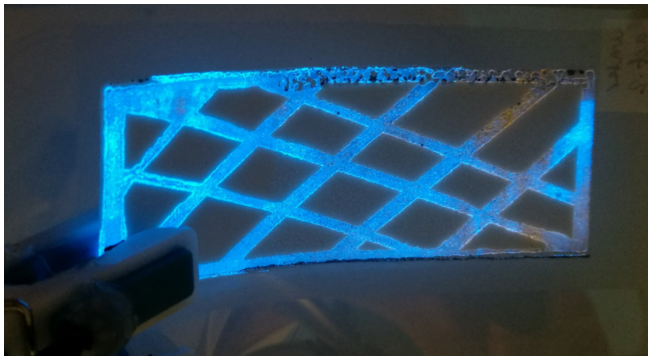
Samples under UV



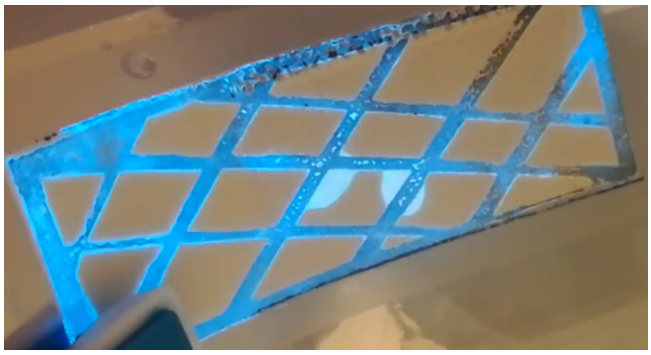
Dotty sample switched on



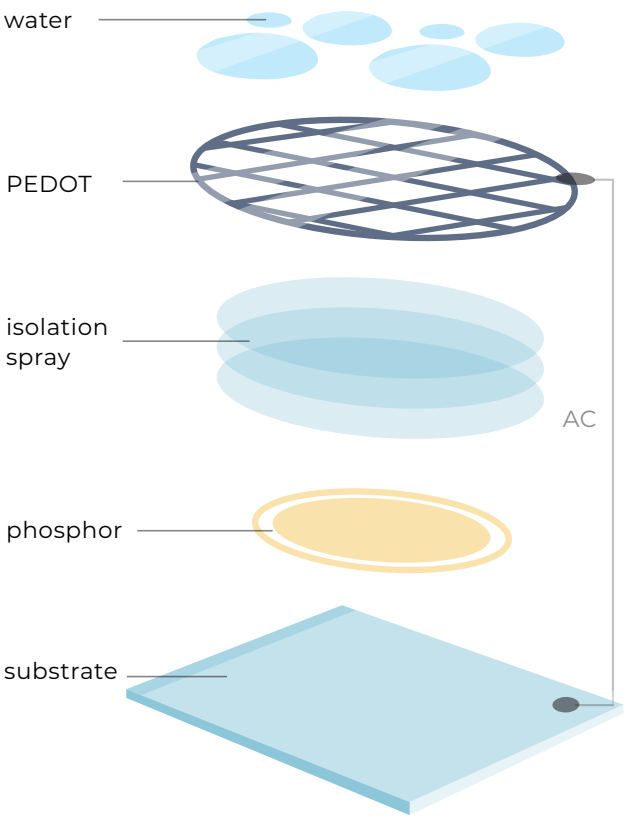
Dotty sample with water on it



Gradient sample switched on



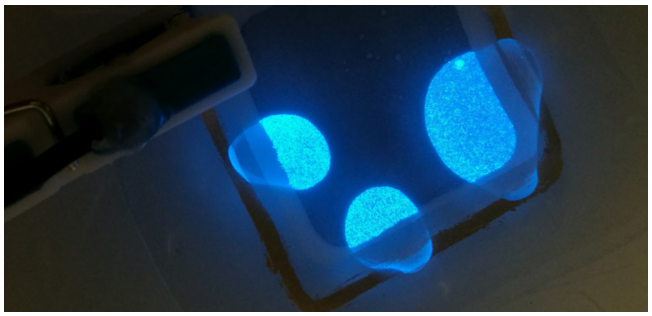
Gradient sample with water on

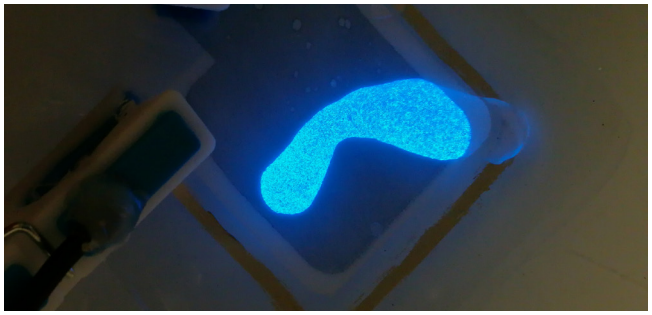


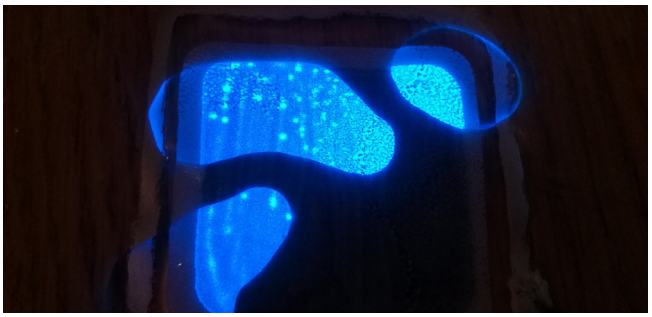
Layer structure of double-sided interactive samples with ITO PET + PEDOT combination

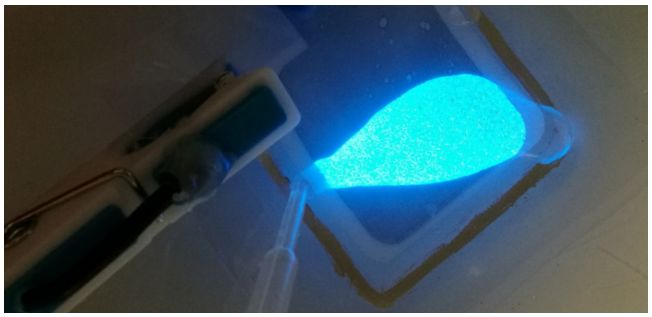
Experiment 24

Creating an interactive and flexible sample on a thin transparent plastic layer. Layering: substrate - PEDOT - phosphor - 3x spray - silver (on spray, not on phosphor).

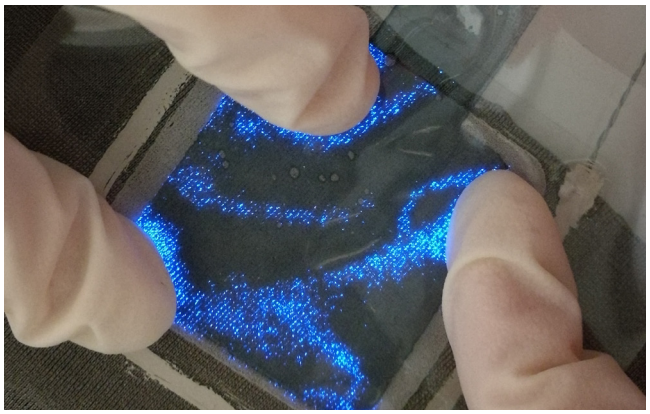


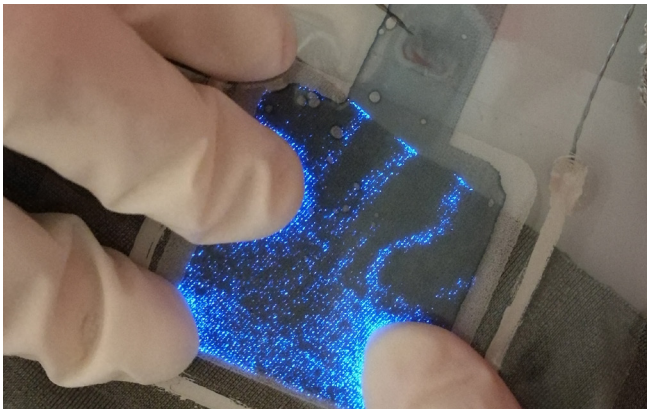




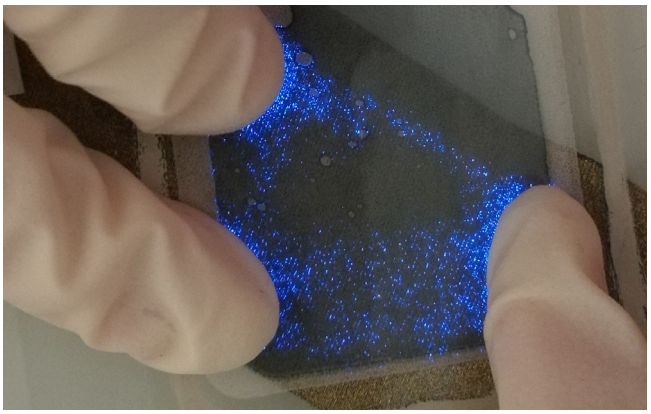


Sample activated with drops of water, the water has to touch the silver to switch on





Sample being pushed onto and crumpled together with a piece of conductive cloth

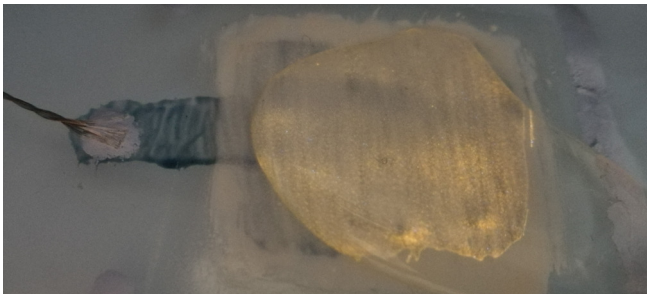


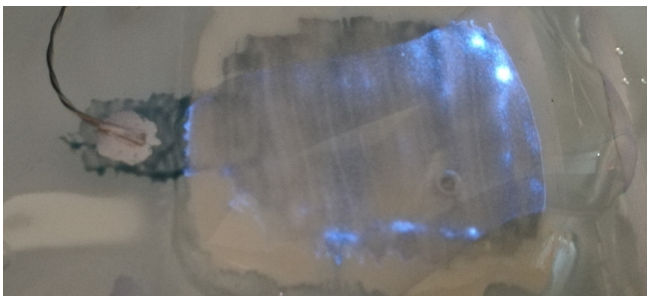
Sample pushed onto a thick piece of gold conductive cloth

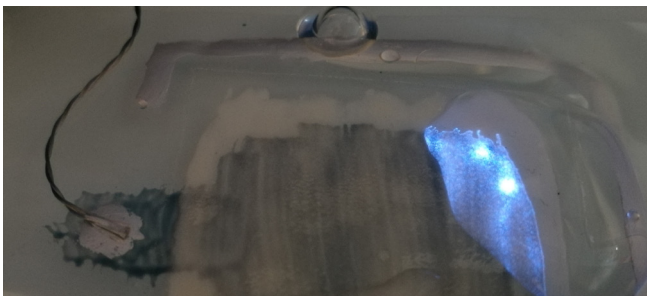
It only works well with the silver and gold conductive cloth and it gives a loud sound. The grey cloth and plastic-like cloth doesn't work.c

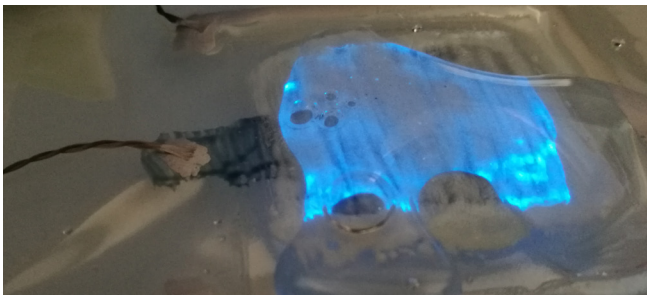
Experiment 25

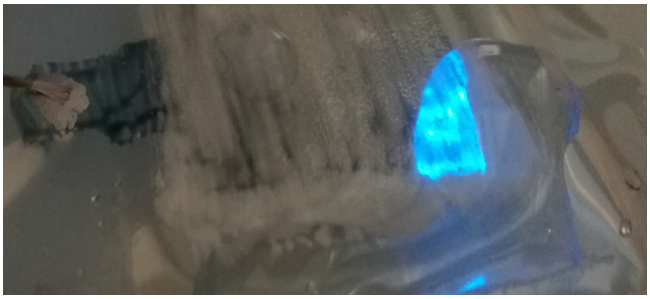
Creating 3 hand painted interactive and flexible sample on a thin transparent plastic layer.







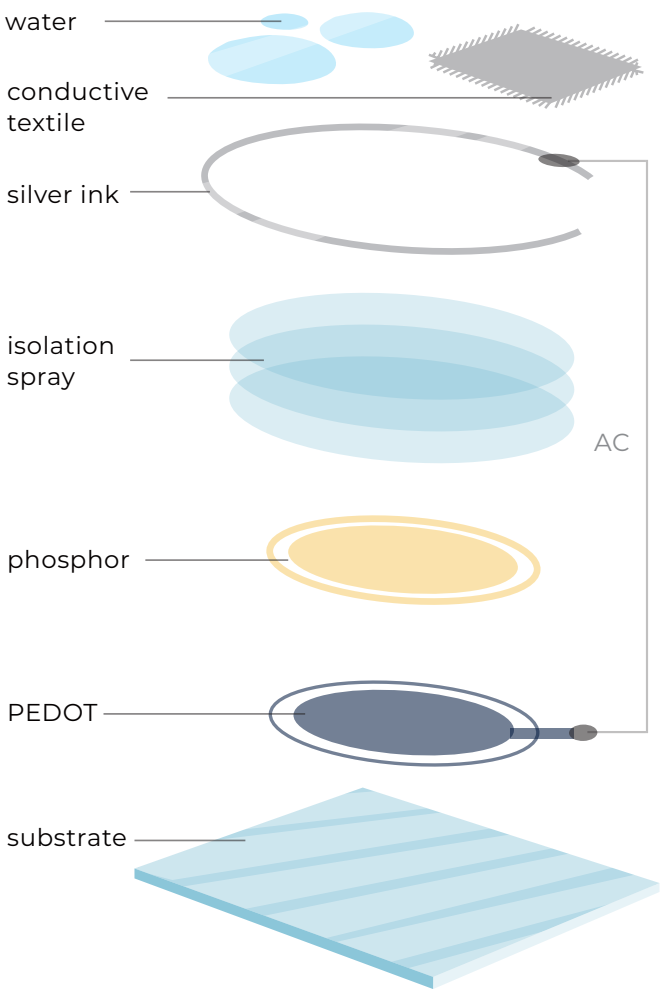




HOW IS IT MADE?

interactive samples

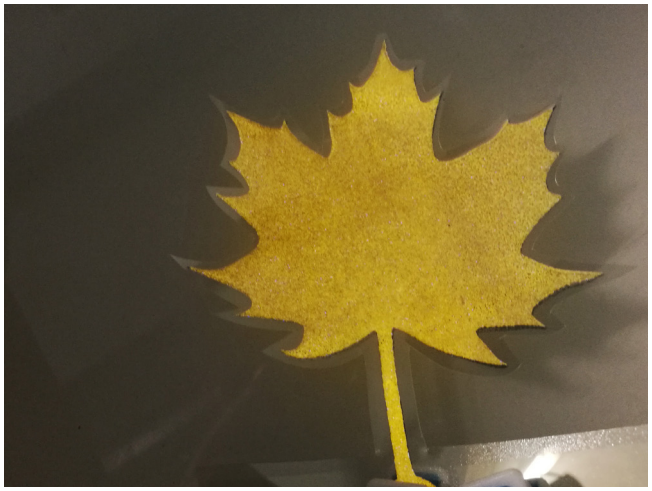
To create an interactive sample a double-sided structure with a top electrore was chosen, so an outside item can function as that, like water or conductive textile. To still have a connection the current without directly putting that onto the textile or into the water a small silver ring aroung the sample was painted. As water is transparent it can just be dripped onto the surface making sure it connects to the silver. In case of the conductive textile the sample is flipped and pushed onto the textile to create light.

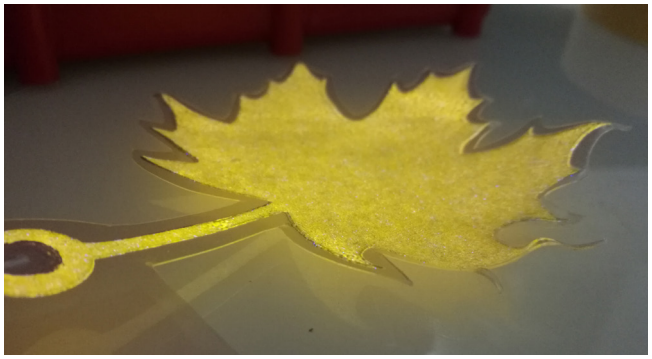


Layer structure of double-sided interactive samples without a top layer

Experiment 26

Creating a more intricate shape (maple leaf in 2 different design).





Simpler maple design before and after heat-gunning the edges of the leaf. The heat makes the material more stiff, sharp.

Second maple design with the veins left completely empty, it can be difficult to do.

HOW IS IT MADE?

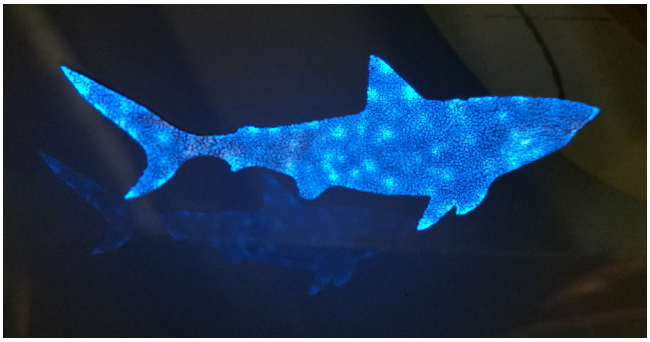
using a heat gun

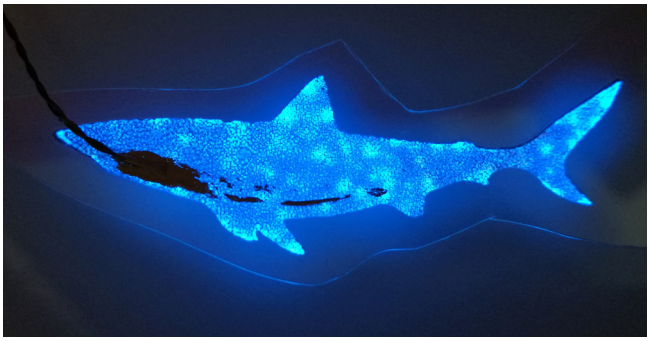
All samples made with a plastic substrate can be heated up and re- or deformed using a heat gun. It is important to not melt the substrate too much, then the layers can get stretched and de-attached. However to cause permanent damage it has to be heated over the point when the plastic is still highly elastic. Mind that the cooled down plastic will be way more stiffer in most cases then before the heat treatment.

With a mild and steady heat edges can be curved. With a higher heat even the full sample can be formed and curved around a heat-resistant shape, then the sample can cool down on that shape for a permanent deformation. For a more equal heating (especially in case of a larger sample) a high heat oven can be used.

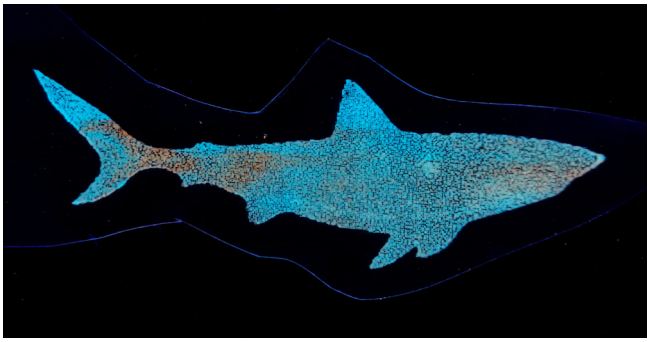
Experiment 27

Creating a small shark design with a pattern. The pattern is caused by the spray leaving large dots in one layer (the bottle is getting empty). It looks a bit like stars or the skin of the shark. Having a large reflection on the table makes it look 3D, like floating underwater.





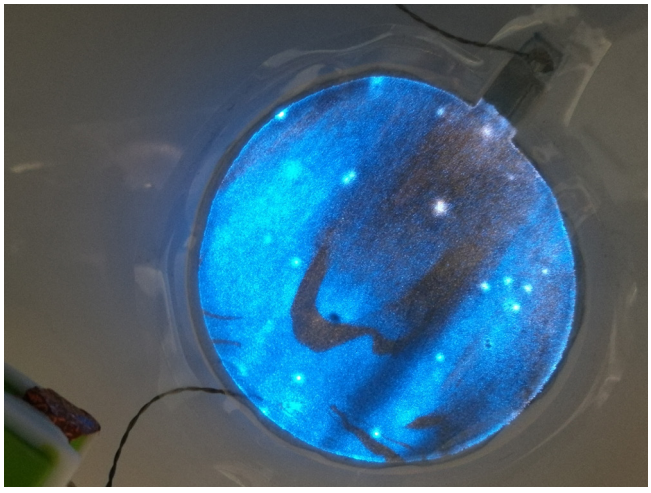
Both sides of the sample (switched on)

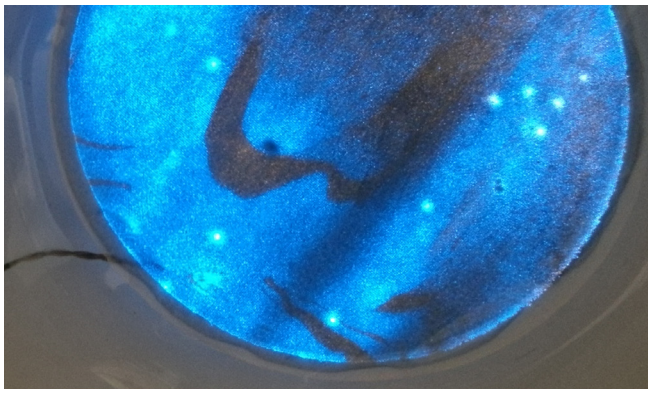


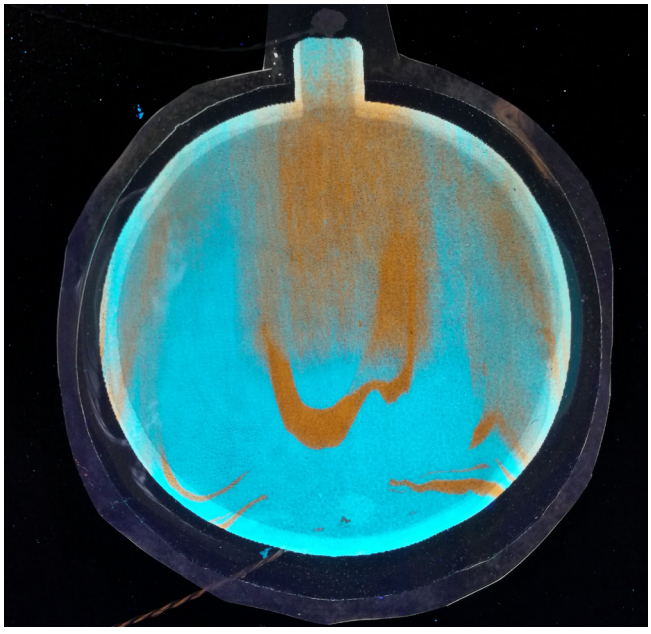
Sample under UV shows that the shark has orange in it too (tried to make the belly white) but it is overpowered by the blue

Experiment 28

Creating a large gradient sample with a simple top-bottom emitting layering with PEDOT.







Sample under UV light

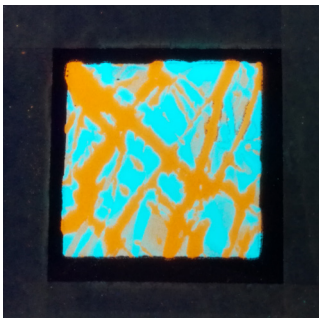
Experiment 29

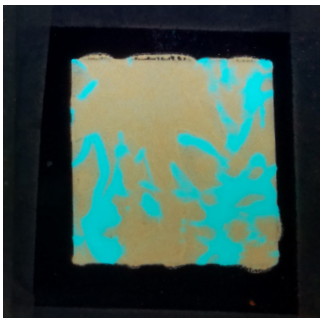
Creating a more intricate phosphor pattern in the maple leaf design, with dripping phosphor onto the top of the mesh.

None of the samples worked, first one was sprayed too light, the second one has an unknown flaw.

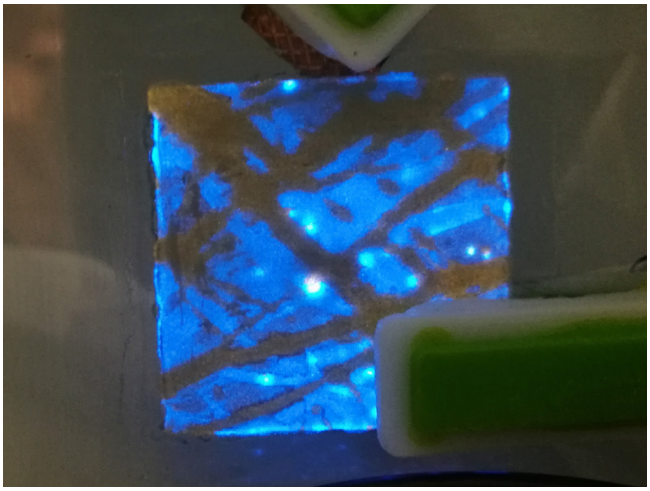
Experiment 30

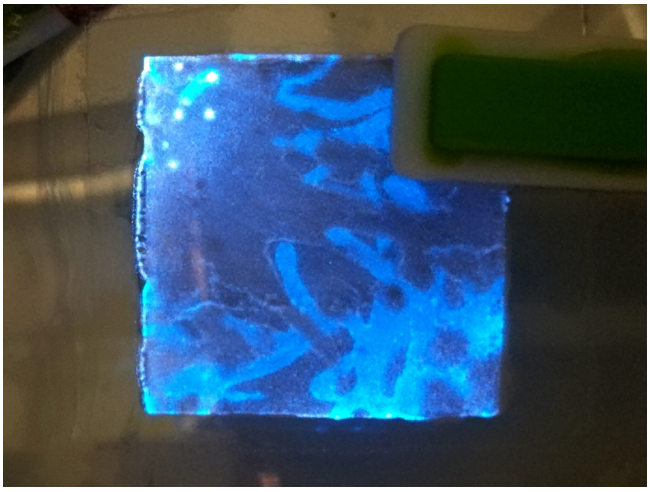
Creating a more intricate phosphor pattern in a square design, top-bottom emitting.





Under UV light





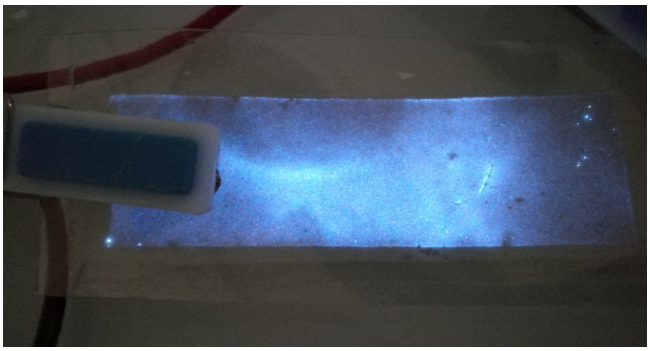
Switched on with electricity, the orange light comes through medium, the white light basically disappears next to the blue.

Experiment 31

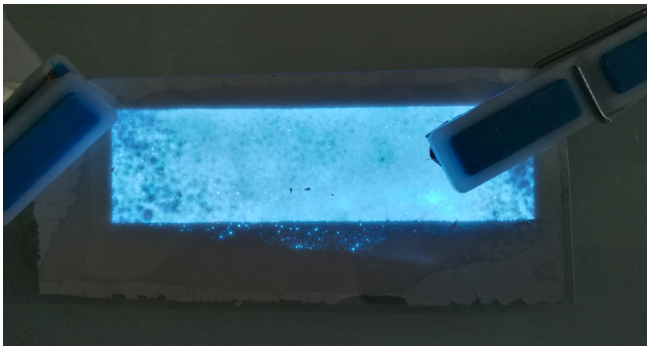
Trying to create brighter blue and aqua samples.

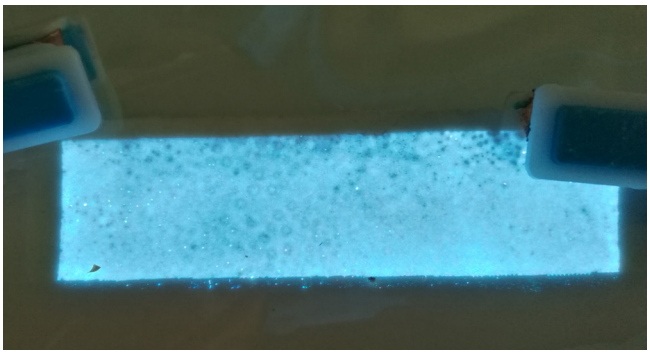
Layer structure: ITO PET / phosphor / insulation spray (1-3 layers) / silver paste

Most of the samples are patchy, uneven, or have a dotted pattern on them, however some of them are starting to get brighter.

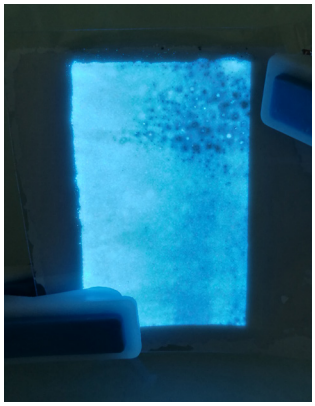


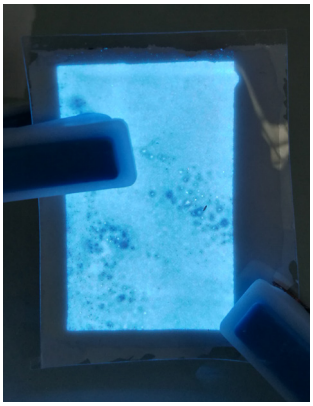
Sample with a light sprayed pattern



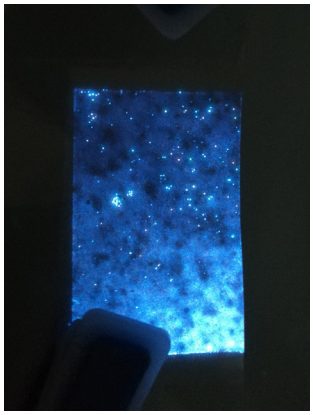


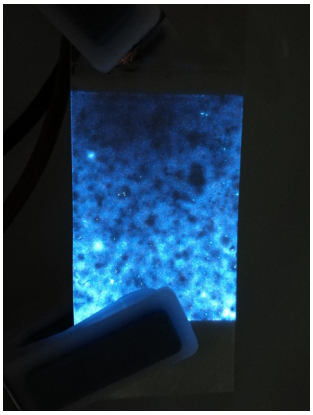
Slightly patchy, but bright aqua samples with a dotted pattern - the little sparks indicate that the samples are not insulated well enough





Slightly patchy, but even brighter whitish aqua samples with a dotted pattern - these are properly insulated (using more than 1 layers, thus no sparks are visible)



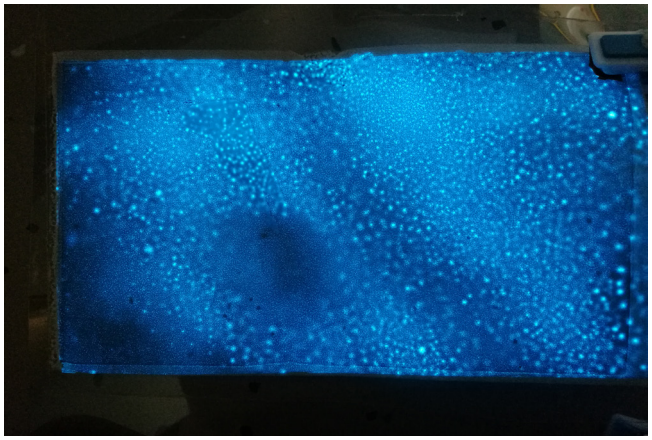


Samples with strong dotty pattern, bright on one side and really dark on the other - the spraying of the insulation is really uneven, the sparks show up again

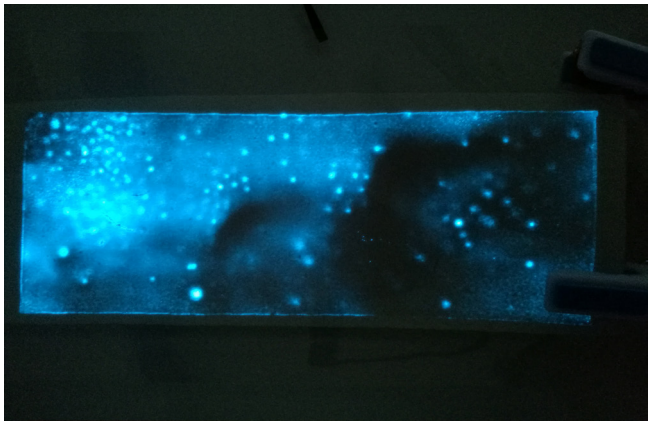
Experiment 32

Samples created for the first working prototypes

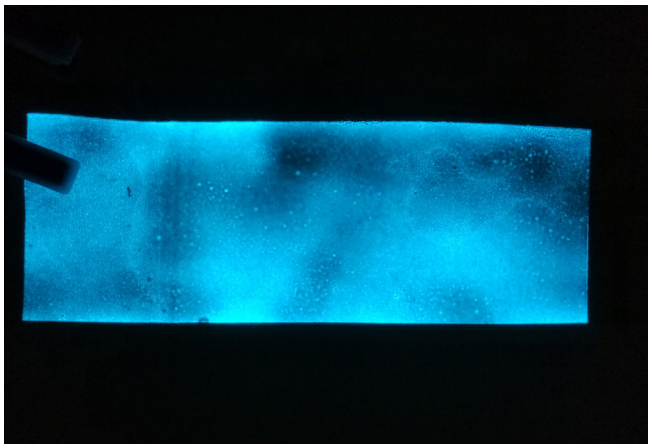
Layer structure: ITO PET / phosphor / insulation spray (2-4 layers) / silver paste



Large sample with galaxy pattern - mostly quite bright with a decently even dotted pattern, was used to create the curved first working prototypes.



Uneven galaxy pattern with a dark patch on it, not used for prototyping.

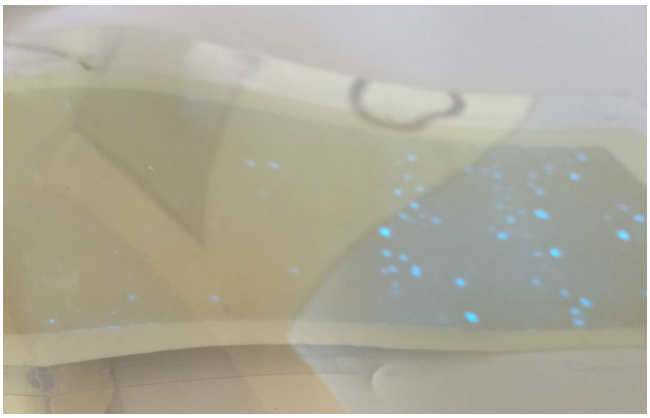


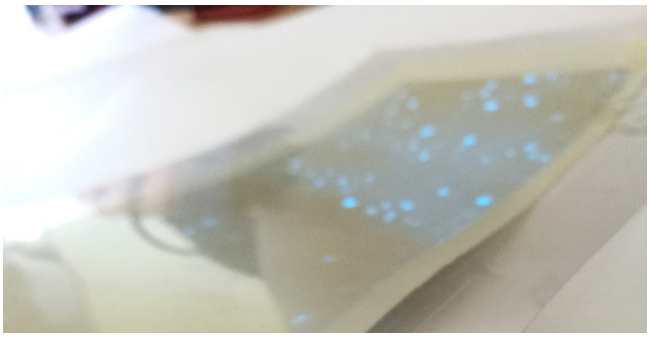
Large sample with small dotted pattern - mostly quite bright and homogeneous with some dark patches, was used to create the straight working prototypes.

Experiment 33

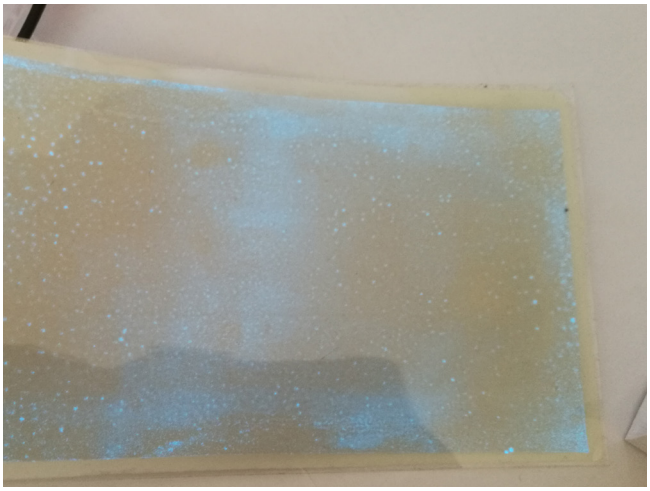
Taking attempts to create the samples for the final demonstrator

Layer structure: ITO PET / phosphor / insulation spray (3-5 layers) / silver paste





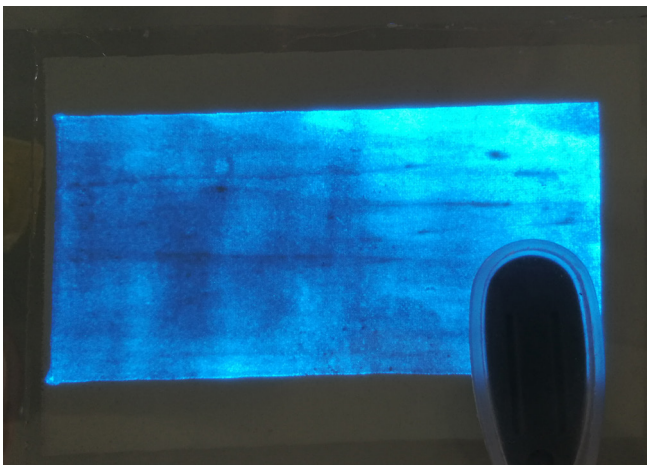
Sample with large dotted pattern, the rest barely lights up, was used to try the heat gun bending and curving.

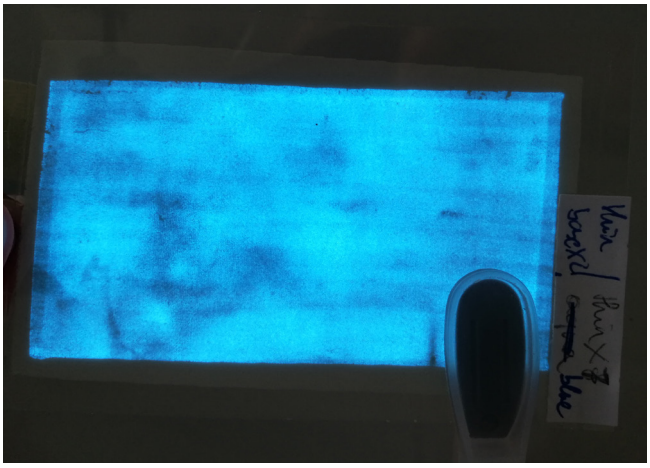


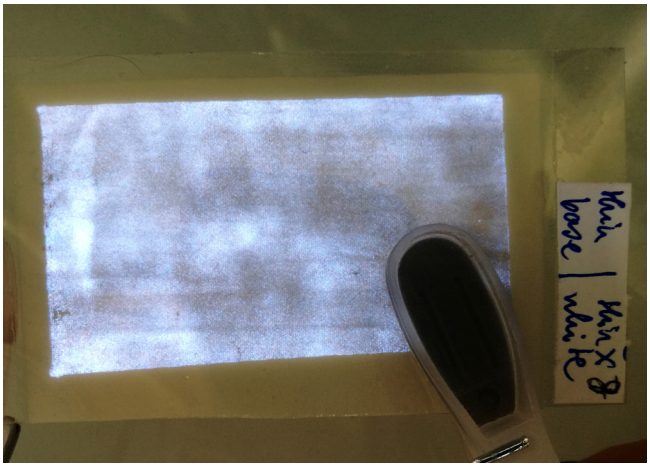
Large sample with galaxy pattern - really not bright with a decently even dotted pattern, was used to try the heat gun bending and curving.

Experiment 34

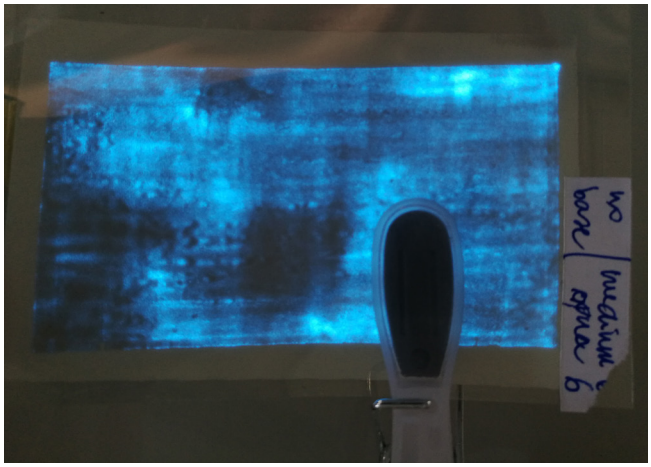
Trying to use a stick to apply the insulation liquid sprayed out of the can, the side of the stick was used to spread the liquid around on the surface. The more even and brighter samples used less layers (see on the side how many layers applied). A spray painted base was used to avoid short-circuiting. (No base = 0 layers, thin base = 1 layer, medium base = 2-3 layers).

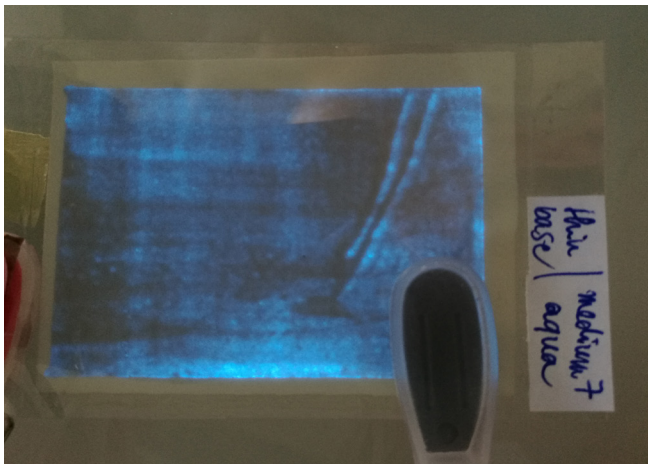






The blue, aqua and white samples with thin layers applied all look quite bright.





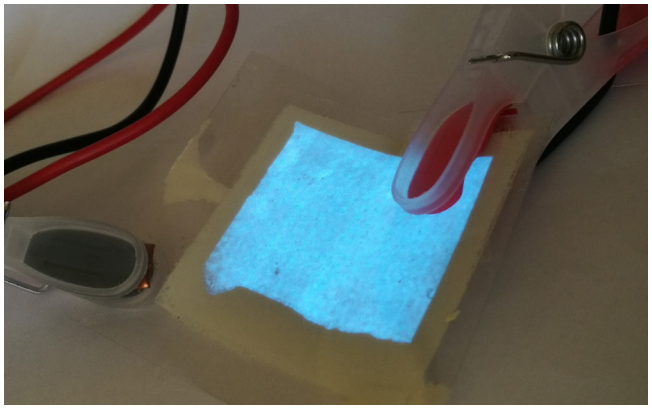
With the medium thick layers applied the blue and aqua samples are moderately bright, the white one is really patchy and dark. The more and thicker layers applied the harder it is to make them even, making the samples really patchy.

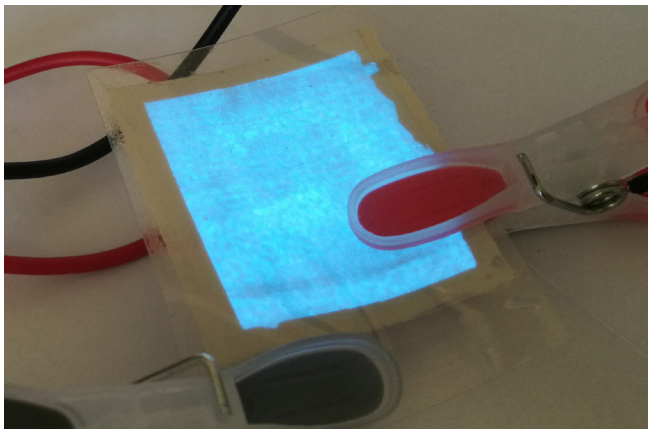
Layer structure: ITO PET / phosphor / insulation spray (5-8 layers) / silver paste

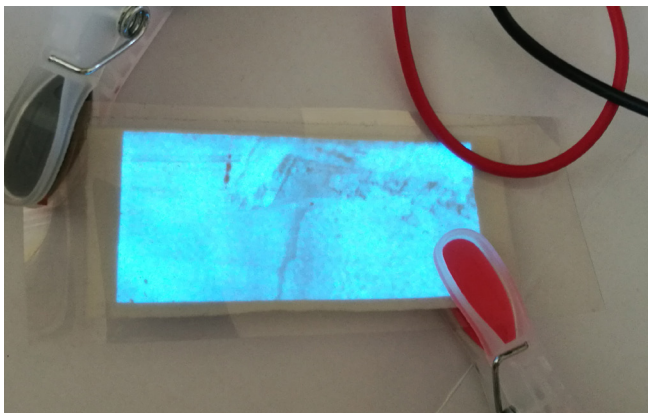
Experiment 35

Using a squeegee to apply the insulation spray instead of a stick in order to make the layers thinner and more even.

Layer structure: ITO PET / phosphor / insulation spray (5-6 layers) / silver paste







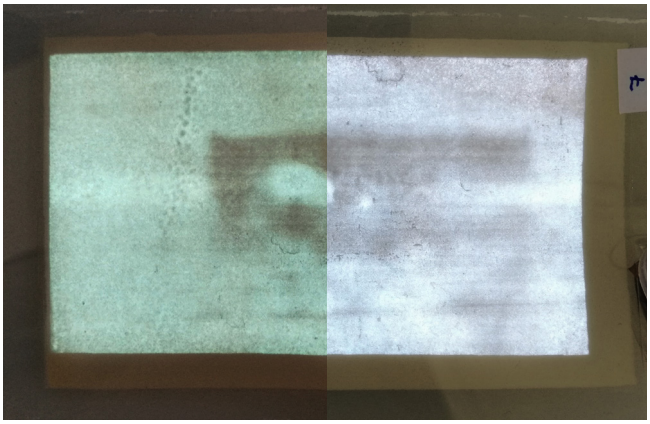
The small samples are really bright and even, the larger sample has a visible smudging of the spray in one layer.

Experiment 36

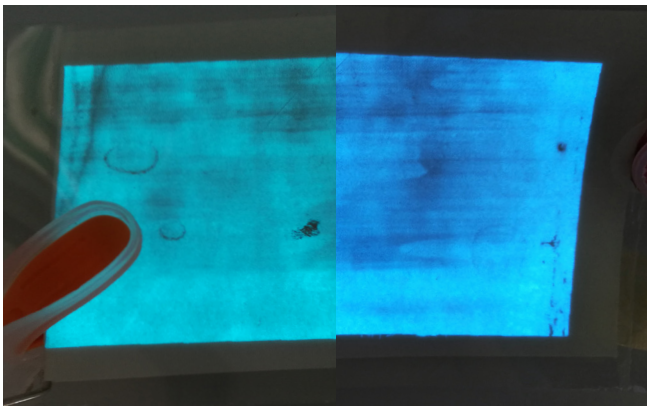
Trying to make larger samples with the squeegee application method for the insulation spray with white and blue colour.

Layer structure: ITO PET / phosphor / insulation spray (5-6 layers) / silver paste

During this experiment it was also realised that the two available inverters (pocket and one for EL wire) operate on quite different frequencies which can affect the colour. On the left pictures the sample is switched on with the EL wire inverter on the right a regular powerbank and a pocket inverter has been used.



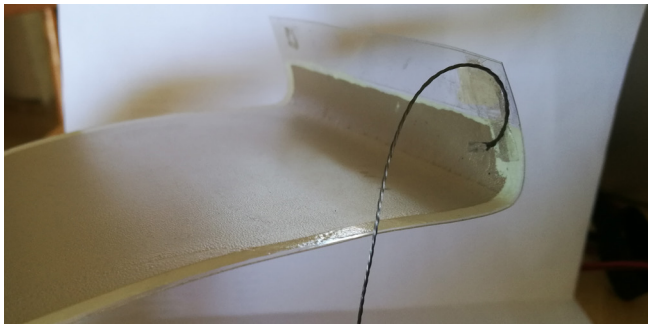
The white sample appears greenish with the EL wire inverter, it is a little bit patchy but overall great brightness and white colour.

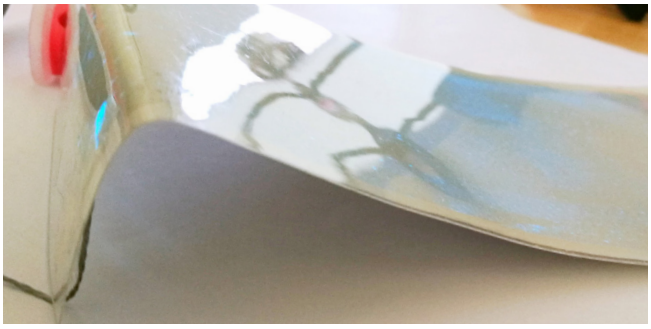


The blue sample appears greenish with the EL wire inverter, it is a little bit patchy but overall great brightness.

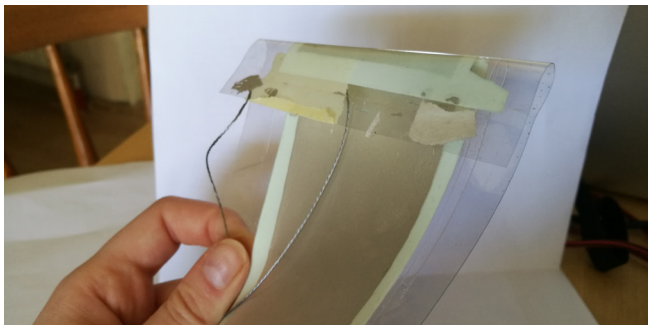
Experiment 37

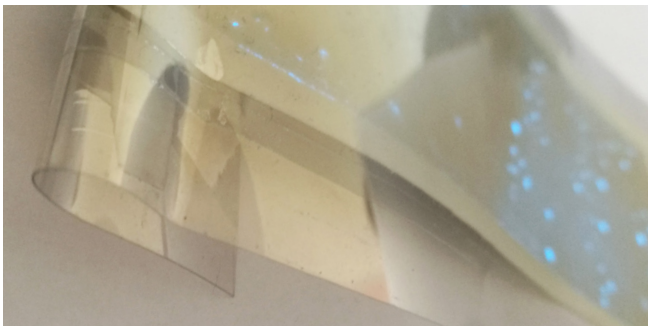
Bending the samples by heating it with a heat gun around a corner, using the side of a metal weight. It has to be done slowly and carefully to make sure it is just hot enough to be slightly elastic, but to not accidentally shrink the plastic.





The bending in this case was pushed further by folding the sample slowly with 30-45s interval of heating, then bending.

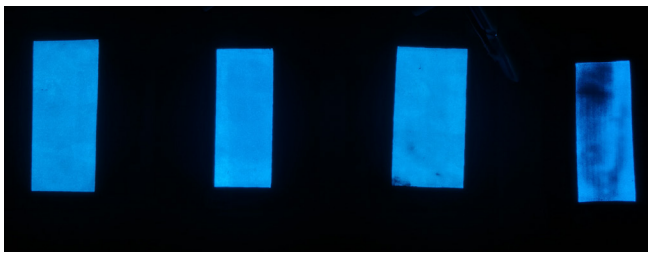




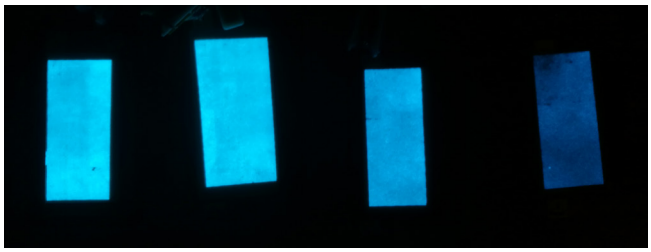
Experiment 38

Luminous measurements

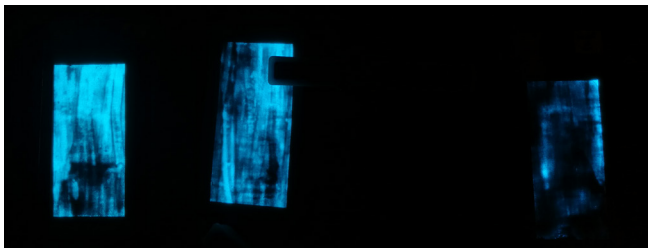
For creating the test sample for the luminous measurements the methods in How it's made - insulation layer were used for the squeegee (without the turning) and the spraying. For the squeegee method the 1 layer one did not work, thus a 2 layer one was created, for the stick method 1 and 2 short-circuited, more tries were not done due to the lack of time. For the spray paint the 3 layer one short-circuited on one occasion, thus it was recreated before the measurements.



Squegee method: 2, 3, 6, 9



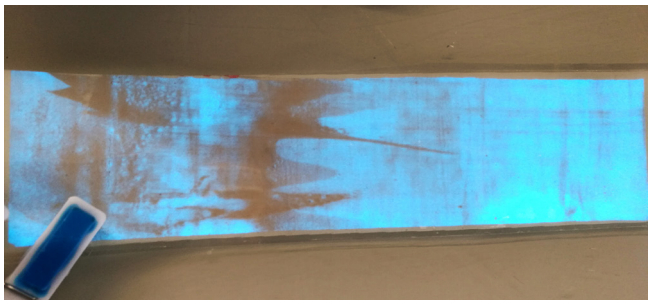
Squegee method: 1, 3, 6, 9

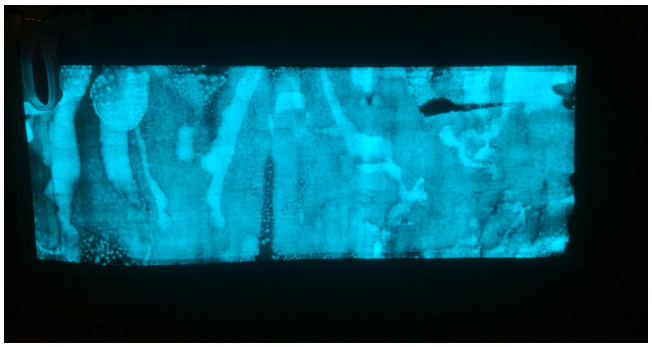


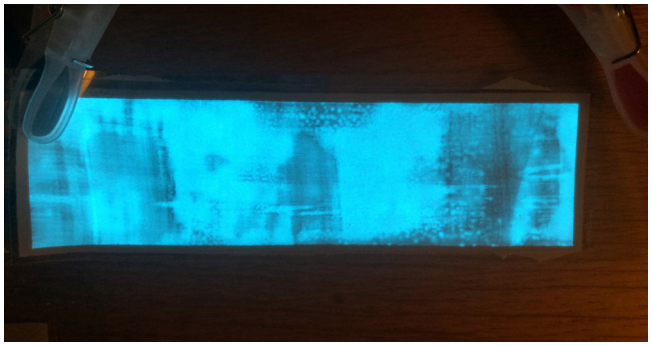
Stick / medium layer method: 3, 6, 9

Experiment 39

Taking attempts to create the samples for the final demonstrator - second run







As the samples size was slowly increased it was noticed that more and more insulation layer is needed. Really small samples work with 1 layers, 2-5 cm ones with 2-3 layers, 8-10 cm needs 4-8 layers, larger ones need more than 8. The made samples are 5x18 cm, the layer number is around 9-14.

With the more layers the chances of having some uneven parts become quite high, as seen on the patchy or patterned samples above.

HOW IS IT MADE?

insulation layer

Before applying the insulation spray make sure that the parts of the sheet that need to remain not insulated are covered with a vinyl stencil (about a 2 cm strip on the ITO sheet). Then tape the material to a flat surface so it cannot move during the spray application.

The spray painted layers need to be applied from 30 cm and for a very short while at a time, thus the applied layer will be really thin. If larger dots that do not become matt after drying are visible the applied layer is too thick or it was sprayed too close or the can is getting empty and does not spray equal anymore.

For the 'printed-style' application place a thin line of the material (liquid sprayed out of the can) on the vinyl stencil, then use a rubber squeegee to lightly press and spread it all over the surface. If the material is applied evenly the layers turn out quite even as well. With the increasing number of layers this can become quite difficult to achieve. This was solved by changing the application direction after every 2-4 layers by rotating the sample 90° (and taping it down again after every rotation).

Also make sure that the previous layer is completely dry before applying the next one (does not feel sticky when touched). It can be dried in an oven on 75-100°C for a short while, if the applied layer is think it will not bubble or shrink.

APPENDIX B
MATERIAL LIST

Silver Paste
- silver / silver ink in text
Sun Chemical
C2120918P1

Transparent insulation spray
- insulation spray in text
3M Vernis Isolant transparent 81042
Scotch 1601
DE-9999-5305-7
7100036939

Indium tin oxide coated PET
- ITO sheet / ITO-PET / ITO coated PET in text
Aldrich
PCode: 1003009077
639303-5EA

Phosphor paste
GWENT Group
C2061027P13 (blue)
C2070126P5 (white)
C2070126P4 (orange)

Phosphor powders:
Tri-Phosphor G73 Blue Green / 1
Petrol
Part no. 1504

Tri-Phosphor G7 Blue / 1
Mountain Blue
Part no. 1501

Tri-Phosphor G5 Green / 1
Grass Green
Part no. 1506

Tri-Phosphor G69 White / 6500
White 6500°K
Part no. 1520

orange white
FnSiCu/Mn
D611B

Phosphor powders (continue):
dark blue
ZnSiCu/Au
D417B

Clear conductor
- PEDOT in text - mostly used
GWENT Group
C2100629D1

PEDOT
- PEDOT in text - in early experiments
Aldrich
poly(3,4-ethylenedioxythiophene)-poly(styrenesulfonate)
7686500-25G
5.0 wt% conductive screen printable ink

Dielectric paste (white)
- dielectric in text
Sun Chemical
D2080121P12

Transparent dielectric
- not used during project, only recommended
DuPont 8153
BaTiO3 dielectric

APPENDIX C

EXPERIENTIAL CHARACTERISATION

1: performative level

	1	2	3	4	5	6	frequency
pressing	1			1			2
rubbing	1	1		1	1		4
grazing					1		1
compressing							0
poking		1	1	1	1	1	4
caressing			1				1
fiddling				1			1
pounding							0
pushing						1	0
folding	1	1				1	2
flexing				1	1		2
lifting				1			1
picking					1	1	1
weighing							0
squeezing						1	0
bending		1	1	1	1	1	4
smelling							0
shifting		1					1
holding		1		1	1		3
grasping							0
seizing							0
pinching	1	1		1	1	1	4
grabbing				1		1	1
leave on table			1				1

2: sensorial level - material

	-2	-1	0	1	2		6
hard	1	2	1	1	1	soft	-0.2
smooth	3	1	0	2	0	rough	-0.8
matte	1	2	0	2	1	glossy	0.0
not reflective	2	2	1	1	0	reflective	-0.8
cold	0	1	4	1	0	warm	0.0
not elastic	5	0	0	1	0	elastic	-1.5
opaque	2	1	1	2	0	trasparent	-0.5
tough	0	0	0	1	5	ductile	1.8
strong	1	3	2	0	0	weak	-0.8
light	6	0	0	0	0	heavy	-2.0
regular texture	2	1	0	2	1	irregular texture	-0.2
fibred	0	0	0	3	3	not-fibred	1.5

2: sensorial level - light

	-2	-1	0	1	2		6
even	0	0	0	2	4	uneven	1.7
dark/weak	0	1	3	2	0	bright/strong	0.2
soft	0	3	1	2	0	harsh	-0.2
simple	0	0	1	3	2	complex	1.2
cold	4	2	0	0	0	warm	-1.7
textured	5	1	0	0	0	smooth	-1.8

3: affective level - material

	1	2	3	4	5	6	
frustration							0
boredom		1			1		2
disappointment							0
reluctance			1				1
confusion	1			1			2
rejection							0
disgust							0
menlancholy							0
distrust		1		1		1	3
doubt					1		1
amusement							0
surprise	1				1	1	3
confidence							0
enchantment			1				1
respect							0
attraction			1				1
curiosity	1	1		1		1	4
fascination							0
comfort							0

3: affective level - light

	1	2	3	4	5	6	
frustration							0
boredom			1				1
disappointment							0
reluctance							0
confusion	1			1			2
rejection							0
disgust							0
menlancholy				1	1		2
distrust		1					1
doubt							0
amusement		1				1	2
surprise						1	1
confidence			1				1
enchantment	1						1
respect							0
attraction							0
curiosity		1			1	1	3
fascination	1			1	1		3
comfort			1				1

4: interpretive level - material

	1st	2nd	3rd	
agressive	0	0	0	0
cozy	0	1	0	1
elegant	0	0	0	0
frivolous	0	1	0	1
futuristic	1	0	1	2
masculine	0	0	0	0
ordinary	0	0	0	0
sexy	1	0	0	1
toy-like	0	0	0	0
natural	0	0	0	0
hand-crafted	1	2	0	3
calm	1	0	0	1
aloof	0	0	0	0
vulgar	0	0	0	0
sober	0	0	0	0
nostalgic	0	0	0	0
feminine	0	0	0	0
strange	1	1	1	3
not sexy	0	0	1	1
professional	0	1	0	1
innatural	0	0	2	2
manufactured	1	0	1	2

4: interpretive level - light

	1st	2nd	3rd	
agressive	0	0	0	0
cozy	0	0	0	0
elegant	0	0	0	0
frivolous	0	0	0	0
futuristic	2	0	0	2
masculine	0	0	0	0
ordinary	0	0	0	0
sexy	0	0	0	0
toy-like	0	1	2	3
natural	0	0	0	0
hand-crafted	0	1	0	1
			0	
calm	0	0	0	0
aloof	0	0	1	1
vulgar	1	0	0	1
sober	0	0	1	1
nostalgic	0	0	0	0
feminine	0	0	0	0
strange	0	2	0	2
not sexy	1	0	1	2
professional	0	1	0	1
innatural	0	1	0	1
manufactured	2	0	1	3

APPENDIX D

LUMINOUS MEASUREMENTS

Squeegee method - thickness

SQ2				SQ3				SQ6				S
45	50	50		50	50	45		50	50	65		
45	45	45		45	45	45		50	55	50		
45	40	45		45	45	45		45	45	50		
45	45	45		40	40	45		55	50	55		
		45				45				52		

Spraying method - thickness

S1				S3				S6				S
40	45	50		45	50	55		70	70	65		
50	50	45		55	50	45		55	75	60		
55	50	50		60	45	55		50	50	60		
50	50	50		55	45	45		50	60	55		
		49				50				60		

Stick method - thickness

M1				M3				M6				M
40	50	40		40	65	45		55	55	120		
40	40	45		45	70	45		65	60	105		
40	45	40		45	50	45		65	70	95		
40	50	45		40	45	45		65	75	90		
		43				48				77		

Luminous measurements

SQ	2	3	6	9
	80	75	70	38
	80	74	59	40
	78	74	69	45
	78	75	62	47
	78	50	70	45
	79	70	66	43

S	1	3	6	9
	70	64	35	7
	71	65	37	6
	76	48	36	6
	47	64	35	6
	58	54	36	6
	64	59	36	6

M	3	dark	6	dark	9
	71	9	44	11	3
	72	11	43	10	4
	60	9	41	11	4
	64	9	42	12	3
	52	12	43	12	8
	61		42		
	59				
	63	10	43	11	4
		41		28	

SQ9		
55	75	70
60	70	65
60	65	60
55	65	55
		63

S9		
70	80	85
85	75	75
65	85	65
65	85	70
		75

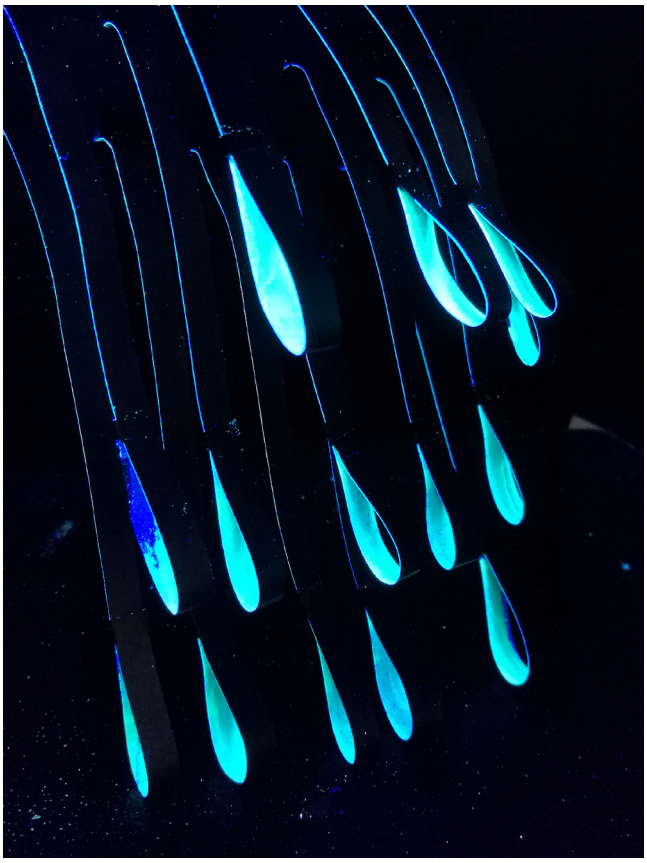
M9		
60	120	105
60	70	85
55	80	80
90	70	75
		79

APPENDIX E

ANSWERS TO OPINION SURVEY

What do you think of Rain 1 - line (wall-mounted)?
21 responses

- Looks like a waterfall, it is pretty
- it looks like peacock feathers, same shape and same kind of colors. It especially looks this way because it falls down in a certain way.
- Fancy, but should the strings not be dark instead for floating visual effect of the drops?
- I would do different lengths and sizes, more displaced and irregular
- neon color scheme.
- Smooth
- I like the end points where it's the actual drop cause it's a more concealed shape that gives you this cool mysterious material vibe. Not so sure abkht the streaks that lead up to them tho. Colour fits with the water theme imo.
- Looks a bit awkward like hanging loops - functional not attractive
- Soothing but more reminiscent of some sort of extraterrestrial porcupine skin than rain. Feels organic either way
- This, and the other rain patterns as well, look like a fish swarm swimming in the ocean. I get the feeling of watching Blue Planet. I wonder if the wind would make it seem like they are swimming. It's pretty cool.
- They feel like a weird multiverse design from any science fiction
- It reminds me of dog leashes and this is the part where you hold the leash
- Feels a bit off
- Waterfall-like presentation
- Fish, ocean, deep, nice contrast, maybe with the addition of orange it would look futuristic instead
- It looks a bit too structured for rain; they hang at similar heights which makes it very static while rain is very random
- Feels like a tidal wave due to the small lines
- Pretty cyan colors. Not sure about the darkblue bleeding through
- I would want to touch it. Kinda creepy, would not walk close to it. Could be spread out more.
- rain drops
- Magical by night, silly by day; seatbelts



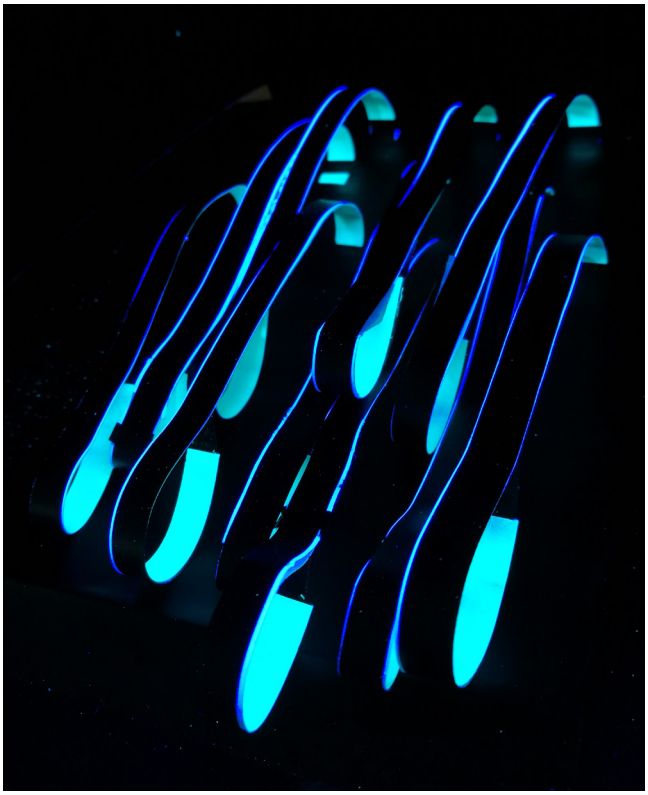
What do you think of hanging Rain 1 (roof mounted)?
20 responses

- It looks a bit like rain, but from this perspective also a bit like the hanging noose...
- Would be nicer if they were not horizontally aligned, but at different heights perhaps? Otherwise very fancy
- I prefer this version but same suggestions as before
- better neon color scheme. this wouldn't hurt my eyes or soul
- Bit to dense from this angle
- OK this would be cool in a restaurant

or something like it gives really great mood and it's not in the way. Little bit futury but not too artificial for my taste :)
- this is cool, especially if each strand moves independently. i think blue is a good choice if you want to represent rain
- Once again soothing but now it reminds me of leaves on a tree. Once again very organic
- Other than fish I see metro handrails in this. I have the urge to grab onto one.
- They look like glow in the dark sex toys
- It reminds me of dog leashes and this is the part where you hold the leash
- Nice, but might look weird if you look from underneath it
- Party bus loops for standing places in said party bus
- Fitting for the concept. Motion probably enhances it further.
- Coral, tree with hanging fruits, tears
- This looks more like rain, more dynamic. They look a bit like a cooler version of the loops in the bus to hold on to
- Still prettty, makes me think more of a chandelier
- Reminds me of gallows. Feel to close to eachother.
- would be cool to see it moving
- like raindrops; still bulky

What do you think of Rain 2 - stripes?
20 responses

- Looks a bit Sci-Fi, because of the shape (it curls back up) but also because of the extra blue straight lines. However, it might be a bit too loud/overwhelming to look at it.)
- Looks more like spoons from current angle
- I can't understand the difference from rain1 and how it will be mounted
- those are look vaguely like music notes
- More collerfull, like the improvement
- This looks a bit more messy but it also has cool shapes I think with the futury tron colors these harder edges also work well. I do feel like this kinda shape would befenit from being super regular and patterned without having too much variation
- looks like door handles. Bugs me that they are not completely the same in shape.
- They seem more rigid than the previous two
- Kind of fishy again, but more like tadpoles. Or those reflective bicycle bands that you can snap on your wrist. That's why I would not do this in orange.



- They look like cutlery for an unnecessarily fancy dark dinner experience
- I like the stripes in this one
- Reminds me of an anglerfish
- Not very "rainy". More "wavy" I would say
- Highway, movement
- Waterfall! It reminds me of a waterfall due to the more random placement and the light on the side. Very dynamic, I like this one
- Gives me a seaweed feeling.
- Love the neonsign-like effect. Very cool the darkblue stripes accentuate it well.
- They feel straigther than the ones before. Reminds me less of rain and more a conveyor belt.
- looks like some bicycle gear
- dynamic

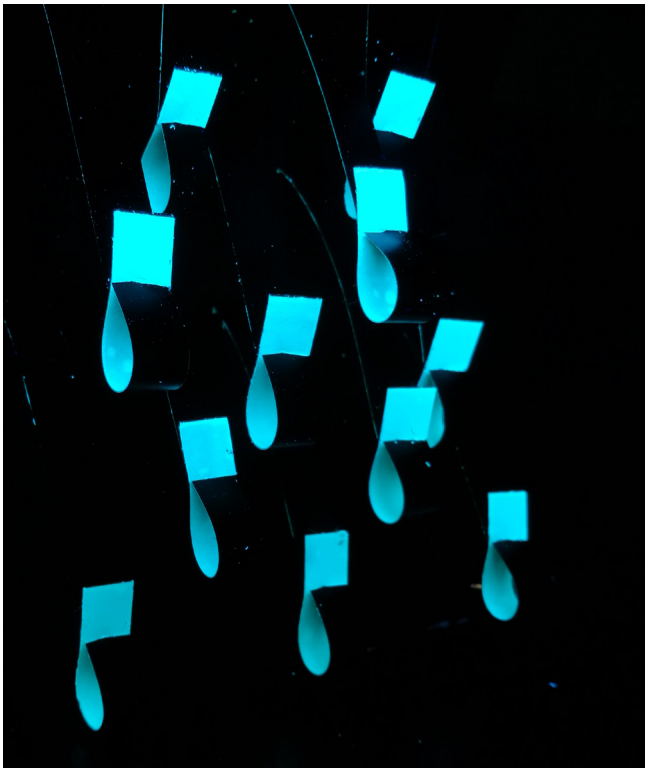
What do you think of Rain 3 - waves?
20 responses

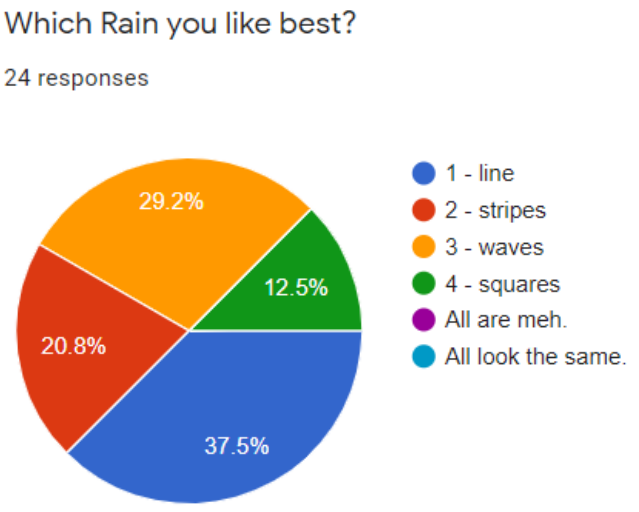
- I like the curves that you can see. I looks like waves of water.
- Meh
- cool colors
- perspective is weird on this one. nice
- more natural
- I'm not quite sure how this one is different again from sample 1.does it have more wave? I like this photo better though
- this is nice and would look good in varying sizes
- If we're talking sea animals they're dolphins. And a little bit of handrail again. But I absolutely love it.
- I'd put this on my wall as nightlights
- It reminds me of dog leashes and this is the part where you hold the leash
- I like the clustering
- Dripping down the wall
- Diving, drowning, underwater
- I don't see a big difference between this one and Rain 1. Maybe a bit more dynamic.
- Normal waves
- Its sorta soothing and relaxing but not as pretty as the last ones
- I like this one most so far. In both color and shape.
- nice
- bulky

What do you think of Rain 4 - squares?
22 responses

- Meh
- a bit dark, upper squares look a bit out of place
- Oh! super playful! Very nice pattern.
- Nice effect they look like musical notes
- weirdly enough these don't look like notes.
- Not that found of the squares
- It's a bit confusing shape maybe I wouldn't know the intention was rain if the other pics didn't come first. It reminds me of the music note shape because of the squares but a bit more odd looking. I guess you could say it looks more playful than the others but I don't really prefer playful themed things in my house haha
- I'm confused, part like it, part don'. I like how the blue shapes look like musical notes.
- Less organic, more futuristic
- These are the cute small fish. For some reason, Gustav Klimt's painting 'Tree of Life' comes to my mind.
- They make me feel uncomfortable for some reason
- Looks like music notes
- DOES NOT LOOK FANCY, TOO MUCH OF A MOCKUP
- Hard to see, but it seems quite ugly

- Feels like the top halves are looking at something
- More artistic. Reminds me of music notes, but still faithful to the concept
- leaves, brirds, fish, music in nature
- It has fun shapes to it, but it is a bit too square for rain maybe. But the random pattern gives it a more natural look. It is a fun pattern
- Can't see depth so don't know how this looks exactly
- Thats freaky and supercool, like abstract art wit a cool colour
- playful





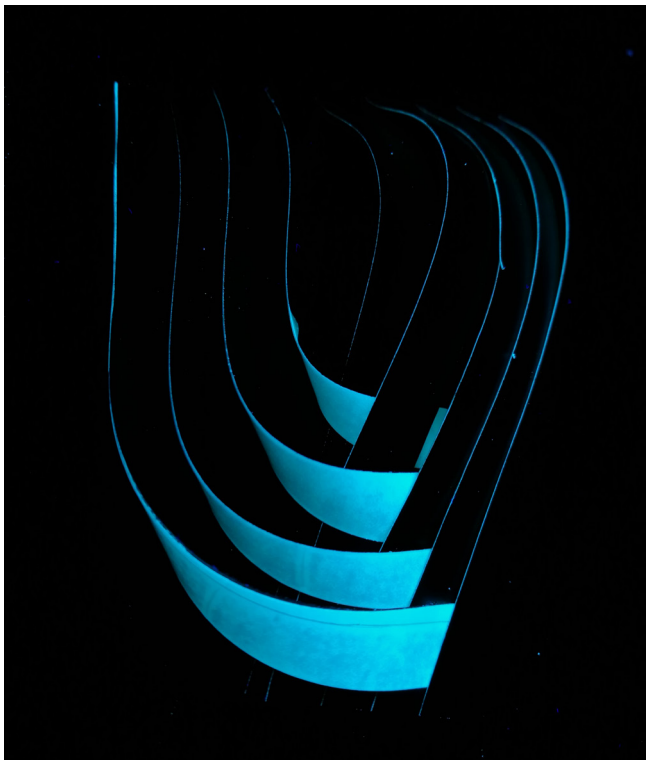
Why?

19 responses

- You can do something with the wind and the blowing effect, which will be really nice. But I like 4 as well.
- They give some kind of illusion, especially if they move (I can imagine piano music and rain background with them)
- Feels less in my face.
- most smooth curves
- I like the roof mounted one because it allows for a larger immersive surface and changes in lengths to add a cool effect to a room.
- seems to use the material best and looks best
- Not sure why but they seem soothing moreso than the other ones
- It's the most streamlined one (on the photo at least), and very pleasing to look at. But I like the 1 -line as equally. It feels less crowded, because the loop is smaller.
- It's soothing. The others are meh or weird
- I like that I can see music notes and other people might see different things
- Toss up between 2 and 3, they flow better than the others.
- The notion of flowing water with waterlike colors
- Rain has a musicality, thus its depiction using schemes resembling of notes seems fitting.
- They hang from the wall in a nice way
- Looks dynamic and reminds me the most of water, would look nicest on a wall I think
- Feels the least clumped together.
- The shape was more in an active state then the rest like it was still moving. The colors were sharp ans mixed well together. Big fan of the darkblue stripes with lighter blue sections below em.
- Does not feel like it it going to grab you. Also visually pleasing
- Looked more dynamic and less bulky

What do you think of Line 1 - knot?
21 responses

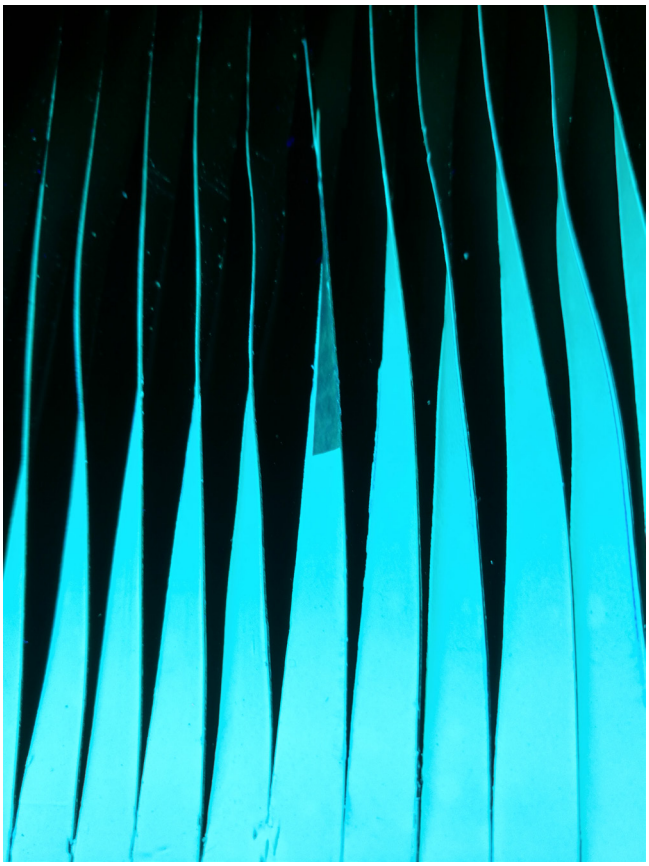
- Looks nice, simple but still interesting to look at and calming.
- Cool
- So much armony, I like it
- cool
- Pretty, because it is smooth
- That looks really nice and clean. Not too much noise going on. Feels likes something you could add to cool fashion stuff
- Like it. reminds me of guitar strings. this looks elegant, I want to see if the pattern continues lower down, I think it would be nice with a repeated knot, like a plait in hair
- Flowy, natural.
- Looks like braided hair.
- If I ever had to design the new unwearable fashion item, it would definitely look something like this
- Very nice shape and sort of a repeating movement
- Nice shape
- Looks like a static capture of wind
- Looks like a harp
- Musical instrument, math, order, structure



- It's a bit confusing, with the curves and the weaving.
- Oeeh wavey
- Cool design, nice colours
- Really focusses your attention on one point, I'm not sure how well that works as wall decoration.
- sick
- harplike, pretty

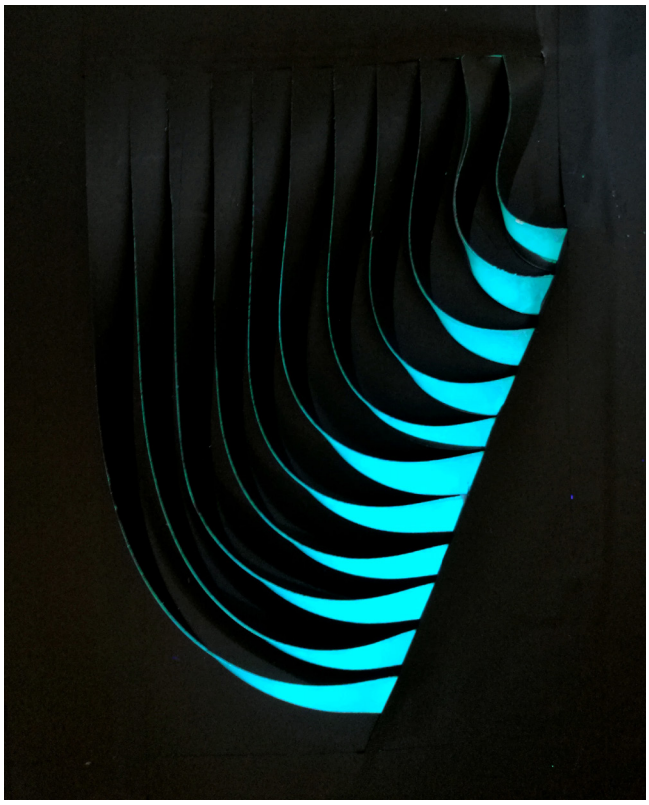
What do you think of Line 2 - twist?
20 responses

- This might be a bit too overwhelming, especially now with the black and the light.
- Too periodic
- Less special than the other
- too bright
- Get a shark vibe
- Not sure? That game called backgammon? Doesn't really make me feel much except which Colour you'd pick probb
- I don't like this as the edges are irregular and it looks like shark teeth
- More intense, more present than previous ones
- Not as exciting as the other ones. Maybe if every strip would be a different colour. Like blue, orange, white and repeat. That would be bomb.
- It reminds me of my childhood swimming lessons
- A bit like a forrest but very intense light wise
- Would look nice if it moves in wind
- Razor sharp
- Tall blue grass
- Change, the unknown, space travel, ice melting
- Quite simple, would be a nice wall filler
- Feels....too fixed? Especially compared to the others
- It's a bit busy, lots of colour, not my preference
- I like it, would love to have a more side angle to review it though. Hard to say what the difference is between this and pain from this angle.
- overwhelming



What do you think of Line 3 - long?
19 responses

- Looks ok, but it is the same pattern over and over.
- Fancier
- Looks more like a water slide
- honestly no opinion
- Like it
- That looks pretty cool. Looks almost like a glowy logo design of some sort. I like more abstract shapes like this when using simpler forms like strips
- I like because the pattern is regular but you can see the difference between the short and long curves
- Reminds me of a logo, but I can't tell which one, now I'm annoyed.It looks good regardless.
- I think this is a yet undiscovered deep sea creature
- nice repetion and interesting movement
- I LIKE THE EFFECT
- I bit plain
- Adidas logo
- Tilt of the lines not so pleasant aesthetically
- Data transfer, connection, internet, claws, overshadowing
- Looks like a corporate logo
- Its a cool geometric shape. Kinda like a harp. Real nice
- Feels like what would happen if you would use twist next to stairs. Kinda cool, but it does not inspire me as much as rain.
- could be the symbol of a greek god, stylish

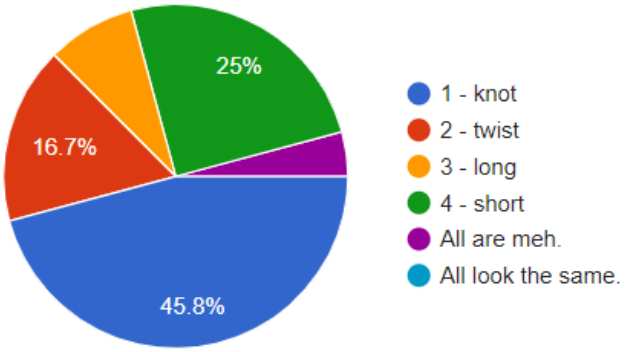


What do you think of Line 4 - short?
19 responses

- Better than the previous one.
- Less fancy
- Same but nicer effect
- piano ish
- Similar to long
- It has less impact than the previous one. But that means it might look good if you have multiple then. Maybe mirrored or something
- Also like this one, the pattern is regular and you can see the difference in shape made by the short and long curves. I want the lower edge to be completely straight though
- Feels more like a standalone art piece
- Pretty.
- Unnecessarily expensive modern art
- I like there is still some structure visible in the black
- Even more plain
- Drippling waves after a stone dropped in water
- Bit too small
- Clean, abstraction, perfection
- Cute, it reminds me of tiny fish is a bigger school of fish.
- Smaller harp. Its nice to look at still. More relaxing
- I cant really see the difference between this one and the previous one. Again I expect there to be some stairs.
- crowded

Which one of the Lines you like best?

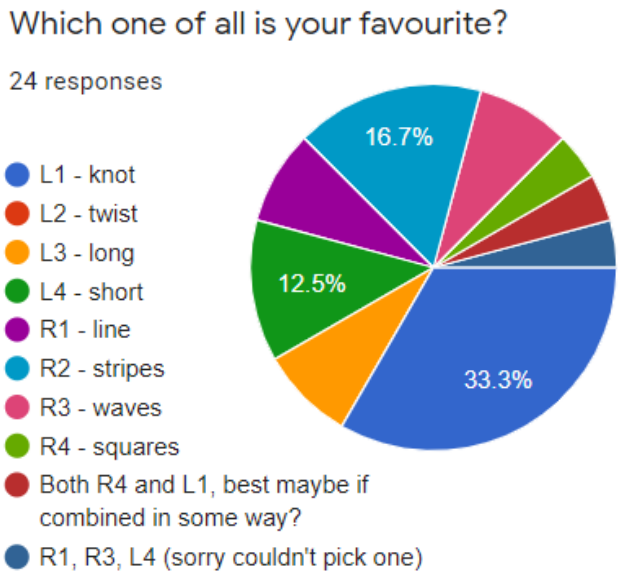
24 responses



Why?
19 responses

- As mentioned before, interesting to look at without being too much
- Pleasing geometry
- They look more than just stripes
- less bright
- most diverse
- This shape shows the quality of the material really well that it's a bit bendy and thin. I'm only focusing on how much i like the shape though in this case and not how badly I'd want it on the my wall. It reminds me a bit of certain plant types (palm leaf or fern like thing) but also a weave for old skool baskets and those kinda things. I think using old school technique like weaving with new looking material is nice to make something look cool
- its the most interesting
- Aesthetically pleasing
- It's just aesthetically pleasing.
- I like swimming
- I like the difference between the black and light
- Toss up between 1 and 2, the others are too plain
- The scenery of "cold" wind being captured
- It is a very clean image and has few irregularities
- They spark a bit of curiosity as to what they could be

- The most calm one, without being boring
- Most engaging and unique style. The the long and short were nice but weren't as sharp.
- Feels most repeatable
- It looked more classy and decorative than the other options



Which one (from all samples) could you see repeated on a large wall (maybe combined with white not black)?

21 responses

- Twist
- R1, R3, R4, L1 and L4. Something that is still interesting if you repeat it, but not too much to look at and maybe something that is more than just a wallpaper, like the hanging/blowing in the wind kind of thing.
- The knot
- R4
- R3 waves
- R3 - Wave
- I'd really love to see the ceiling one idk if that counts as a wall for you
- maybe the knot one but then the knots need to be connected
- L2 twist
- R1 - I feel like that one wouldn't be too much, even if it were repeated.
- Line 1
- I would say 4, but not a very large repetition. I think a few lines are enough. and I would like the black more
- R2 or R3 would make for the nicest patterns I think, definitely when it can move
- Rain 2 stripes or Rain 1 line with the same waterfall-like presentation
- Rain 1 combination of size, shape and color can fit nice in a large white wall
- Rain 1 and Line 4. But not on a white background. Maybe Line 4 would look good on a hard orange background, red or grey could also work. White would take away the depth/darkness too much.
- The short ones, they wouldn't be too overwhelming and can combine into fun patterns
- R1 or L4. Do not make the wall too busy so it's not too chaotic
- Even though i love R2 stripes, i think L1 knot would work better on a wall in repeat.
- Waves, twist (short/long)
- Probably L3 - Long