IBC Laser cutting routine

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For this project the SunPower IBC cells needed to be cut in three pieces of equal area. This was done with a MT-F10/20/30/50 Fiber Laser Marking Machine (www.lasergraaf.nl) using EZCAD software to control the laser. The cells need to be cut in three pieces of equal area without losing much of the cell efficiency. The interdigitated back contact of the cells added some difficulty to the cutting process, meaning a trial-and-error method was needed to find the optimal cutting routine. In total 48 cells were used to provide 72 one-third pieces.

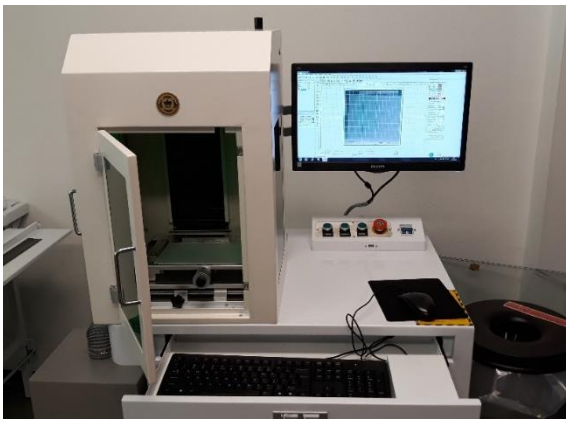


Figure 1: Setup of the laser cutter.

Pre-cutting procedure

The figure above shows the setup for laser cutting. When starting up the laser, the user should do the following:

- Flip the main switch to allow power to the laser and computer.
- Start the computer from below the desk. No login is required on this PC.
- Start the program “EZCAD2” to control the laser. Currently version 2.10.6 is used.
- Press the “Red Power”, “Scanner Power” and “Laser Power” buttons to turn everything on. Note: To prevent laser beam damage the ***Laser*** button should be ***turned on last***.

After the laser has been turned on, it has a small misalignment in the laser, which causes two dots on the table instead of them being coincident. This can be solved by drawing a small line in the software after which [Mark (F2)] should be pressed.

Positioning of the cell

The cells were placed on the flatbed table in the cutting box. The upper knots can be turned to precisely move the table, so that the specimen can be placed directly under the laser.

The cells were pressed down by some weights on the sides as can be seen in the figure on the right. Due to the curling up nature of the IBC cells, four weights were needed on each corner.

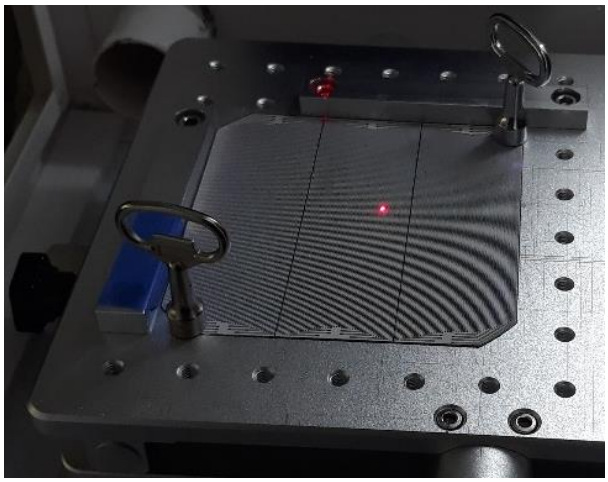


Figure 2: SunPower IBC cell on the flatbed with two weights on the corners

Location of the cut

For this project the cells were cut in three pieces. Some wholesalers were found online selling IBC cells cut in even 6 parts. The interdigitated back contact only allows for cuts in the direction of the contacts on the backside of the module. For a 5-inch cell with chamfered corners the total area is 153.3 cm^2, meaning the middle part needs to have a width of 40.88 mm and the sides a width of 42.06 mm, to make sure the parts are of equal size. With a caliper the parts were measured with the accuracy of a tenth of a millimeter as shown in the figure on the right.

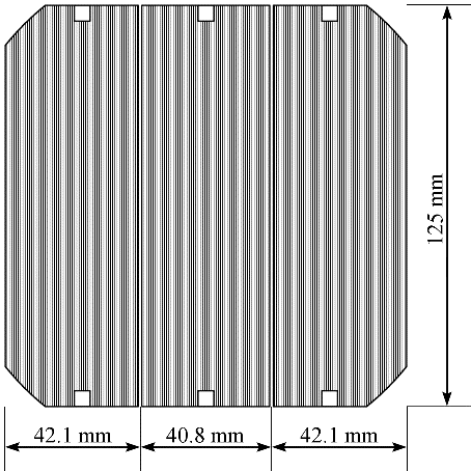
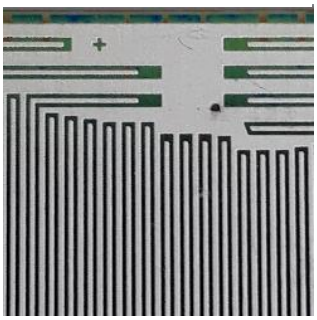


Figure 4: Schematic figure of a cut IBC cell.

Figure 3: Close up of the IBC SunPower cell



Looking closely at the back of a SunPower IBC cell, one can see the white/grey conductive aluminum separated by the blue lines of passivated silicon. The aluminum is tough to cut with this laser, so ideally the cuts are made on the blue lines instead of the white ones. However, the alignment of the laser makes it very tricky to precisely aim for the narrow blue line and a cut will always traverse some part of the aluminum contacts. This means that the settings are adjusted to cut the tough aluminum contacts anyways, so in this case the cut can also be made on the white lines, but associated with higher risk of failure.

Settings of the cutting software

As mentioned in the previous part, the aluminum back contact is much tougher to cut, meaning that two different cuts are required to get through the cell. Also, separate cuts are needed for the left and right side. This is likely because the laser is not aligned perfectly to the center of the cell, as can be seen in Figure 2. The right side (closer to center) needed extra cuts.

In EZCAD2.0, the right side of the panel allows for different line colors, each can have its own set of parameters. The table shows the different parameters used for each of the four cuts.

	Cut #1	**Cut #2**	**Cut #3**	**Cut #4**
Position	Left side	Left side	Right side	Right side
Mark Loop	60	300	70	400
Speed (mm/s)	400	1200	300	1000
Power (%)	100	100	100	100
Frequency (KHz)	325	325	325	325
Q Pulse Width (ns)	30	22	32	26
Laser On TC (us)	-200	-200	-200	-200
Laser Off TC (us)	100	100	100	100
End TC (us)	300	300	300	300
Polygon TC (us)	100	100	100	100

Table 1: All settings used in the EZCAD2.0 program and their values for all four cuts.

Here “Mark Loop” is the number of times the cut will be made, “Speed” is the average path speed of the laser in mm/s, the “Power” of the laser is always set on 100%, the “Frequency” of 325 KHz was used as default, “Q Pulse Width” determines the high-level time per cycle. Changing the marking settings alters the spreading of spots. The option to change the spot diameter also shows the inverse relation between speed and frequency, as can be seen in Figure 5.

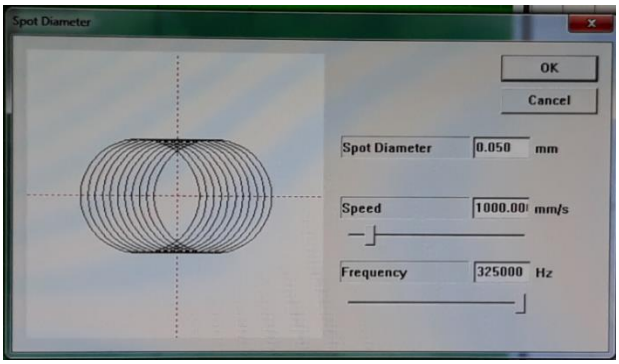


Figure 5: Option to see spot overlap.

The last four parameters “Laser On TC”, “Laser Off TC”, “End TC” and “Polygon TC” are delay times set between markings needed for the laser and mirrors to reach a steady state. They were unchanged for any of the cuts.

Cutting procedure

With the laser now turned on and the lines and settings set to the correct values, the laser cutting procedure can be carried out. Make sure you wear rubber gloves and clean the flatbed surface with a clean cloth.

- Gently place the cell face down on the flatbed.
- Turn on [Light (F1)] to show a preview of the laser cutting line on the flatbed. The checkbox [(S) Mark Select] can be used to only show certain markings.
- Align the cell and place the weights on the corners as shown in Figure 2.
- Turn on the ventilation by using the switch on the left side beside the desk.
- Close the doors of the box and press [Mark (F2)] to start the cutting process.
- In most cases the pieces are still a bit attached at the edges. In this case, break the pieces by putting both thumbs on the back side of the cell and your fingers on the front side along the cutting line, and push your thumbs into the cell.

Results

It was found out that ideally the cut is made on the blue lines with the cell facing down. After refining the procedure, the failure rate of the cells was approximately 20%. In these cases, the cells had either rough edges or a slight nick diagonally across the cell. Both failures however, did not result in big losses of efficiency, only a decrease in aesthetics. IV Measurements were done on all cells, showing an average efficiency of 21.2% meaning the cells had lost only 1% of efficiency during the cutting process. This means that for the purpose of this project the cutting procedure is satisfying the requirements.

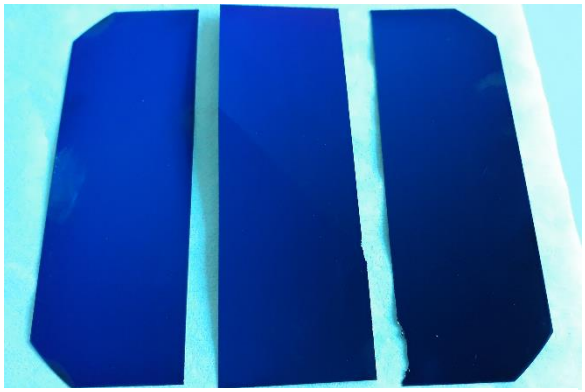


Figure 6: Three poor cut pieces, The left has become dirty due to improper handling, the middle one has a nick through it and the right one has a rough edge.