Gas sensing with porous nanodrums

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Gas sensing with porous nanodrums

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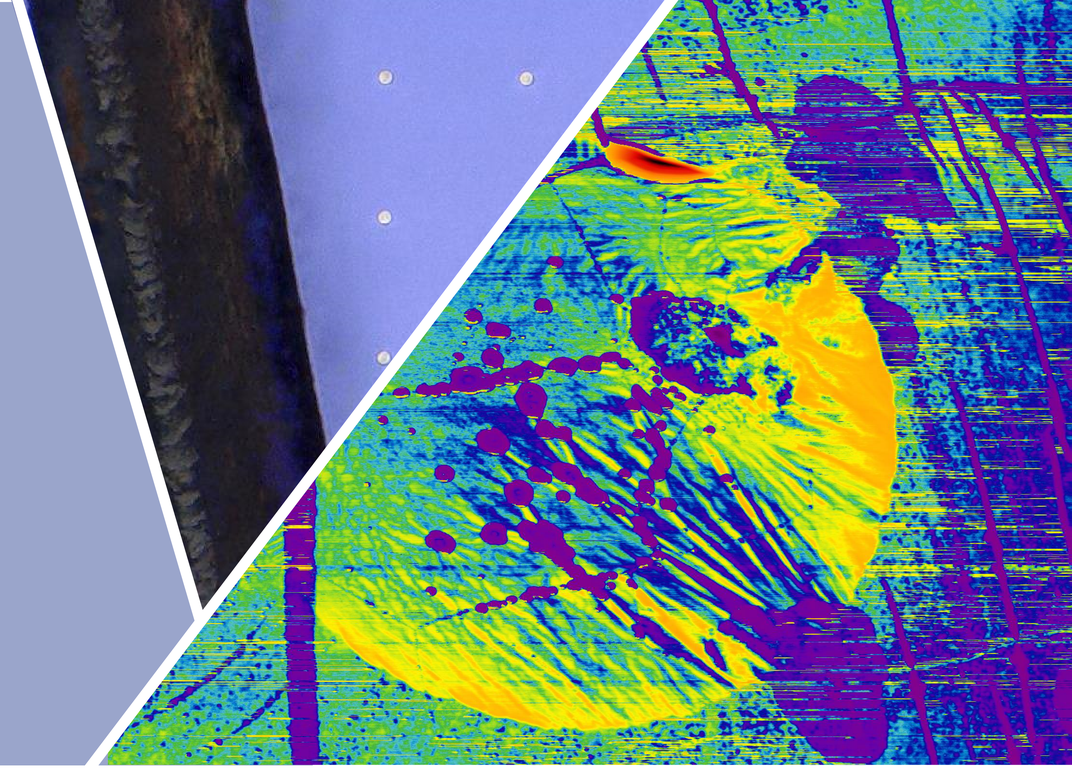
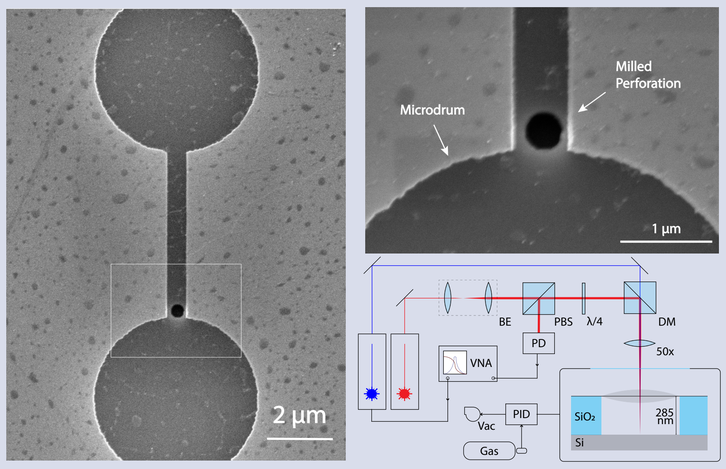


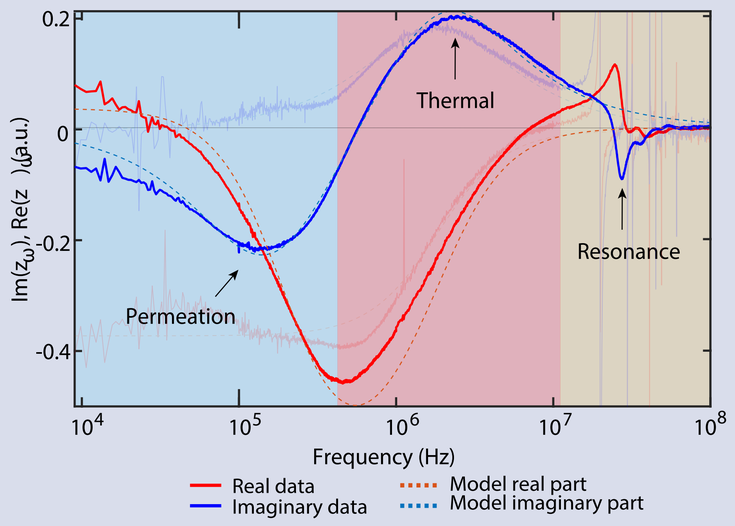
1 The device

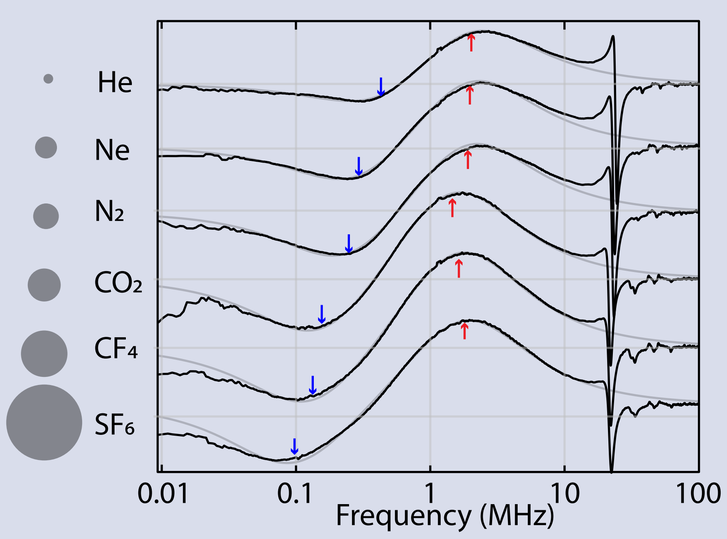


The devices consist of two-layer graphene suspended over cavities. Lasers actuate the membrane thermally and detect its motion.

2 Gas-specific fingerprint

The frequency response of the drums shows two peaks in the imaginary part below the mechanical resonance.





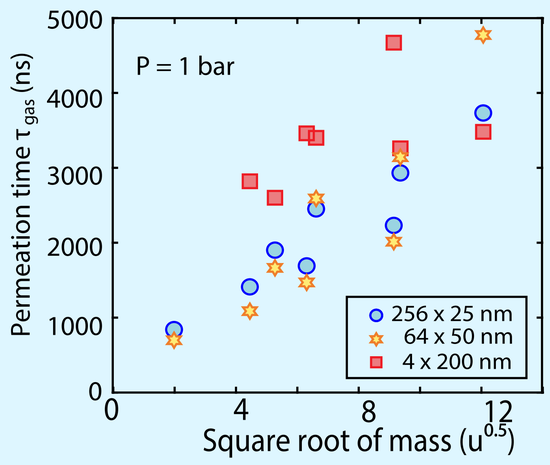
The two peaks in the response describe thermodynamic properties of the system:

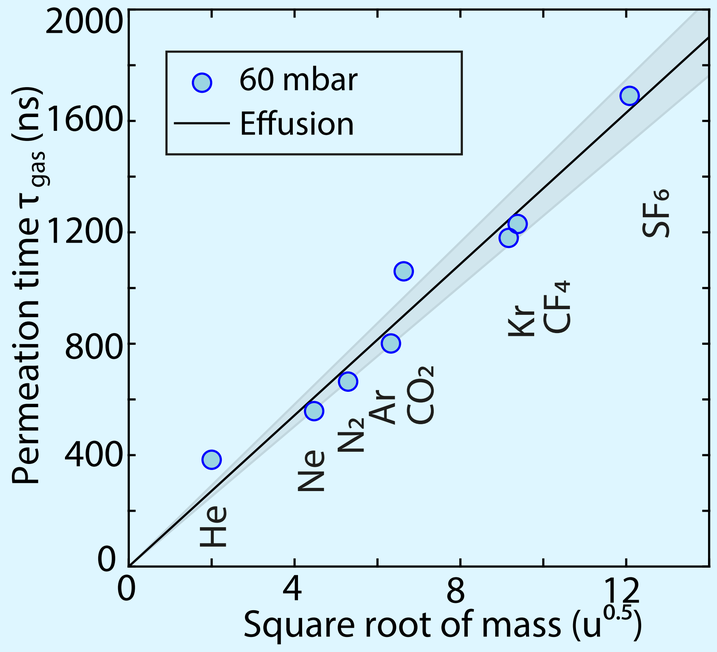
- ↓ Gas permeation time constant τ_{gas}
- ↑ Thermal equilibration time constant τ_{th}

3 Gas sensing

In the Knudsen regime, the permeation time depends linearly on the square root of the particle mass.

We have observed a gas specific response in pressures varying from 60 mbar to 1 bar and with poresizes from 10 to 400 nm.



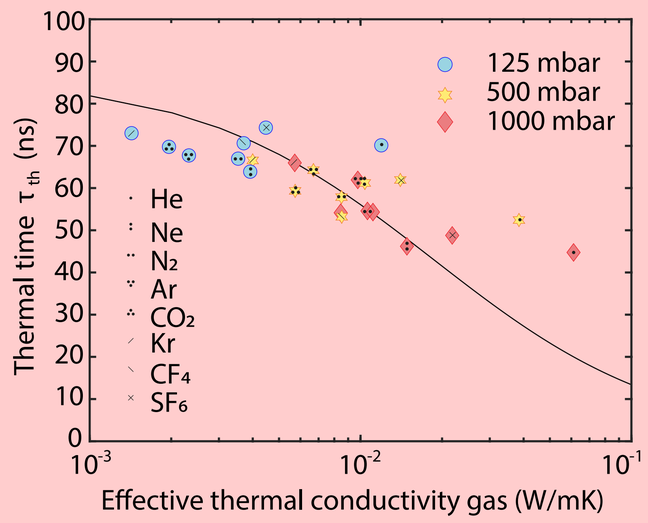


The pore size, number of perforation and cumulative area can be adjusted to shift the permeation peak and investigate the transitional flow between molecular and continuum.

4 Thermal conduction

The gas opens a new thermal pathway, decreasing the thermal equilibration time constant.

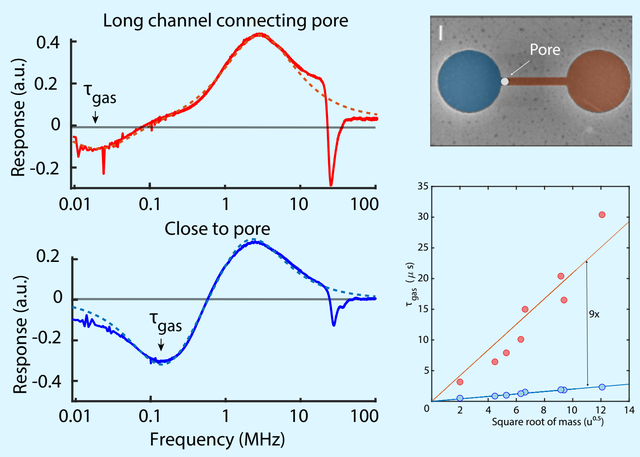
The thermal equilibration time constant depends on the thermal contact of the membrane with the surrounding and the heat capacity of the membrane.



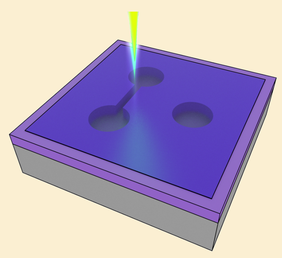
5 Microchannel flow

Here we show infuence of a permeation resistance by a channel connecting the cavity with the pore.

The permeation time is 9 times longer through the 5 x 0.65 x 0.285 µm channel as compared to a direct connection.



6 Conclusion



We show a platform for studying nanoscale thermodynamics which can enable new types of permeation based gas sensors.

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