

**Direct fabrication of sub-20 nm nanopores using focused ion beam, and further closure with electron beams.**

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**ABSTRACT**

Molecular-scale pores are promising as new ways of detecting and characterizing tiny molecules, such as DNA ribbons. Actually there are several ways of achieving nanometer-sized pores, by choosing a specifically thin membrane and using either ion beam milling, dry etching or electrochemical etching. The pores can then be further reduced with a TEM beam, an ion beam or by surface coating.  
Here we report the direct fabrication of 15nm-wide pores in ultrathin silicon nitride membrane using focused ion beam etching with a very small aperture. Using scanning electron microscopy, we then further reduced the pores to sub-8nm holes within minutes. This phenomenon may be due to a change in atom’s mobility induced by the electron exposure, and could be used to build other kind of structures, such as bridges or cantilevers.

For all experiments we used a Raith-IonLine device, with a Ga+ Column. To mill the smallest holes we used a focused beam with a beam current of 1pA, which provide a beam of aperture around 10nm. This beam pierced through a 10nm-thin SiN membrane, previously coated with 6nm of Au in order to improve imaging and to avoid charge accumulation.

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The fact that an electron beam can expand or shrink holes is not new (<http://www.nature.com/nmat/journal/v2/n8/full/nmat941.html>) but it has mostly been achieved with TEM.

We used a E-Beam 150-TWO (Raith) Device at Voltage 5 or 10kV . This device achieve faster shrinking rate as with TEM (about 0.3nm/minute) but as a counterpart we achieve a smaller final resolution (~5nm). We never observed the expansion of holes due to electron beam exposure and could shrink pores as wide as 200nm.

Closure

Bridge

3D ? not observed