Nanofabrication with a Focused Helium Ion Beam

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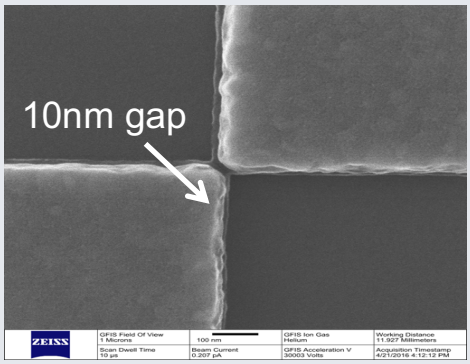
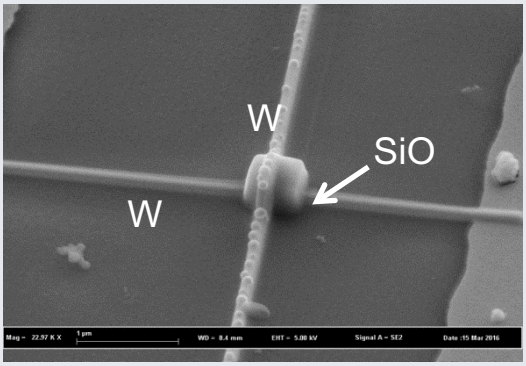
The investigation of quantum matter at nanometer length scales has made tremendous progress during these last decades. In this context, three teams Phynano (CNRS-C2N), Quantronics CEA-SPEC) and Meso (CNRS-UPS LPS), have combined their efforts and expertise in nanofabrication, in order to create a new platform entirely devoted to nanofabrication beyond the ten nanometer scale. This platform unique in France, open to the UPSaclay community, has been recently installed in the C2N. This platform is based on a recently acquired focused ion beam microscope manufactured by Zeiss and called Orion Nanofab.





The Orion Nanofab microscope is based on helium and neon field ion gun. The ultimate probe size in a scanning electron microscope (SEM) is limited by diffraction and chromatic aberration. Due to the very high source brightness and the shorter wavelength of the helium ions, it is possible to focus the ion beam to a smaller probe size relative to the SEM. The helium ion beam allows sub-10 nm nanofabrication as well as high resolution imaging capability in the same instrument. On the other hand the neon ion beam offers precise machining and nanofabrication capabilities due to higher sputter yields in ion beam milling and faster resists exposure in ion beam lithography. The ORION NanoFab multiple beam solution permits direct write ion machining from the meso-scale provided by neon to the nanometer scale made possible by helium.

Gas injection systems (GIS) are commonly employed on SEM and FIB tools. The use of the beam to induce local chemical reactions on a substrate allows direct writing of nanostructures (either metallic or insulating) without the added pattern transfer steps that lithography requires. The ORION NanoFab helium ion microscope (HIM) is equipped with such a system. The structures can be observed and measured using the same beam which does not create any lateral ion damage in contrast with the Ga ion source.

The instrument is now in service since 2016. The researchers work on the optimization of the machine in terms of resolution and reproducibility of the etching conditions on various materials. Some experiments have been realized: realization of nano-slits and holes in suspended graphene, nanogaps in metallic electrodes and deposition of metallic nanoelectrodes using the injection system. Those nanowires exhibit superconductivity below 6K and can be used as superconducting contacts on mesoscopic samples.

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