From Top-down to Bottom-up fabrication

For the past fifteen years, the processes developed on the Néel Institute's Nanofab platform were variants of "top-down" technologies. Exploration of the physical properties of nano-objects, often randomly arranged, has led to the development of new "bottom-up" procedures evolving from the work of several Néel Institute research groups.

Top-down fabrication is a subtractive process in which material is removed to produce features of a controlled shape and size. An example of such a method is the lithography process developed by the micro-electronics industry to sculpt features in deposited materials.

The technology has been refined to fabricate features as small as a few tens of nanometres. Bottom-up fabrication is an additive process in which atoms and molecules are used to build up the desired objects (e.g. nanowires, nanodots).

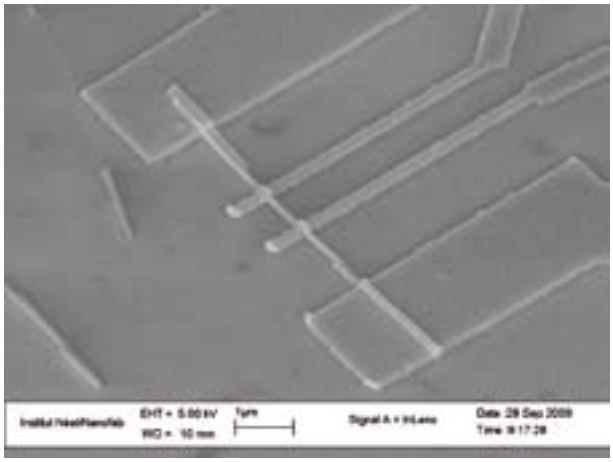
The thus produced objects are often positioned randomly on a substrate. Probing their physical properties (via electrical or thermal measurements) requires the adaptation of classical lithographic techniques to bottom-up approaches.

Though object specific, the developed techniques include the following steps:

- the creation of alignment marks on the substrate,
- dispersion or growth of nano-objects on the substrate using a bottom-up procedure. The density of objects must be controlled and adapted to the desired measurement,
- imaging (optical or electron microscopy, AFM, etc.) of nano-objects in order to locate them with respect to the alignment marks,
- integration of the image in a drawing software and design of the electrodes to connect with the nano-object(s),
- electron lithography with automatic alignment on the alignment marks. This automated step allows the connection of several tens of objects on each die,
- evaporation of the metallic contacts and Lift-Off.

The alignment accuracy is of the order of 100 nm. The initial acquisition of the images, sometimes fastidious, can be automated in the electron microscope. Thermoelectric nanowires, carbon nanotubes and graphene have been thus connected in the cleanroom.

Other procedures are also being developed: nanomanipulation and localized metallic deposit under an ion and\or an electron beam. Movement of nano-objects using micromanipulators. Deposition of metallic electrodes directly on the sample by cracking a gas under the FIB (Focused Ion Beam). This option is available on the new Dual-Beam SEM-FIB on the Nanocharacterization Platform (PFNC) at Minatec, Grenoble.



Connected thermoelectric nanowires.

CONTACT
Thierry FOURNIER
thierry.fournier@grenoble.cnrs.fr
Tel: +33 476 88 90 71