Growth of semiconductor nanowires

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A Riber Compact-21 CBE system was recently installed in the NEST laboratory. This system is equipped with 3 injectors: one each for the group III elements (In, Ga) given by trimethylindium (TMIn) and triethylgallium (TEGa), one each for the group V elements given by tributylarsenic (TBAs) and tributylphosphur (TBP), and one for sources such as tributylselenium (TBSe) for n-doping of the nanowires and trisdimethylaminoantimony (TDMASb) for InSb nanowires growth.

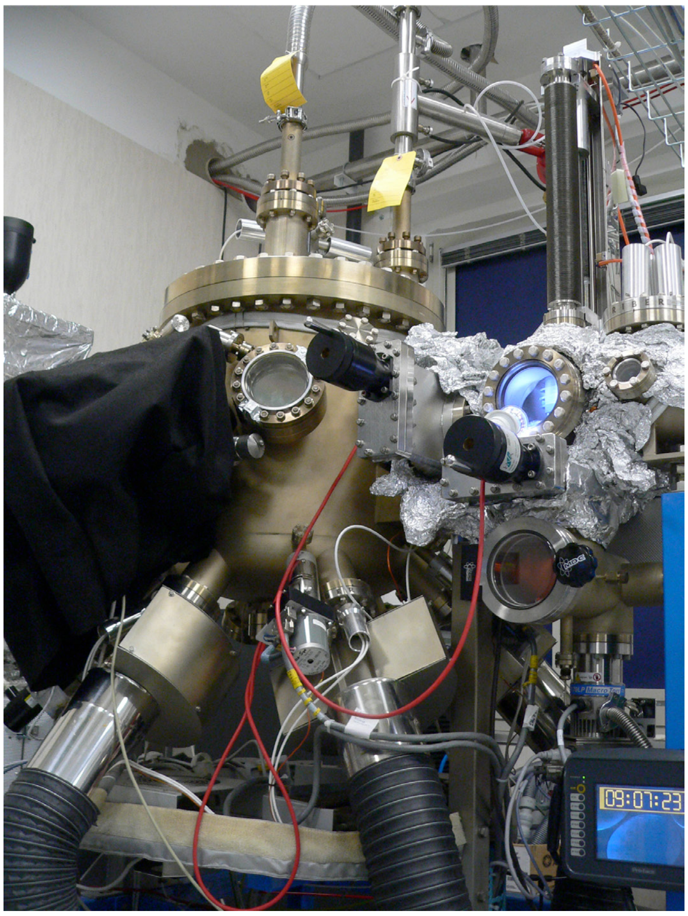

Fig. 1
Photograph of the CBE growth chamber at NEST laboratory

The synthesis of InAs nanowires is realized through a bottom-up approach based on the catalysis from metallic particles [1]. The liquid alloy with the substrate material is generally obtained through metal nanoparticles (in general gold), as shown in Fig. 2. Using the CBE technique, on InAs(111)B substrates we have synthesized InAs nanowires of diameters ranging from 10 to 100 nm, with lengths of several microns and a precision in their lateral dimensions comparable to fluctuations of a single atomic plane (see Fig. 2). Furthermore, axial and radial heterostructure InAs-InP nanowires have been synthesized with elevated crystalline quality and with variable layer thickness. Due to the very peculiar properties such as low bandgap, high Landé g-factor, small effective mass and high thermopower we are also carrying out a research activity focused on the growth of InSb-InAs nanowire heterostructures.

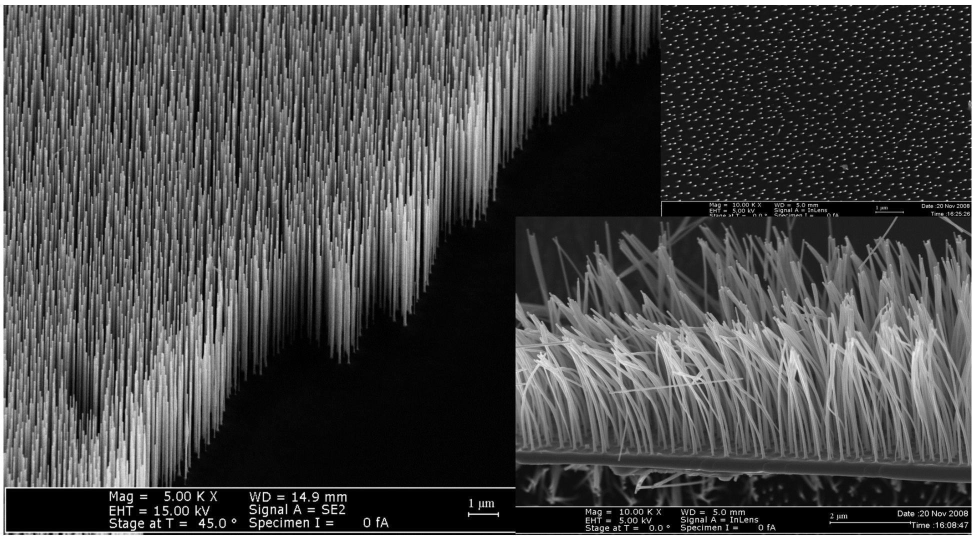

Fig. 2
SEM images of InAs nanowires measured in different geometries: 45° tilt, top view and cross section.

Furthermore, part of the research activity is focusing on the integration of semiconductor nanowires in functional superconductor devices. In particular, we aim at the investigation of the Josephson junctions based on III-V nanowires coupled to superconducting leads. The Josephson coupling will be studied both in equilibrium and non-equilibrium conditions. The latter regime will be accomplished thanks to multi terminal devices (see Fig.3) where some of the contact electrodes will be used as current injectors while others will allow the detection of nchanges in the superconductive properties of the proximized nanowire. Andreev physics will be more in general studied as a function of the interface quality in superconductor-nanowire mesoscopic structures realized using different semiconductor (InAs, InSb) and superconductor (Al, Ti, V) materials.

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Fig. 3
SEM image of an InAs nanowire connected to four Ti/Al superconductor nanofingers. The gap between consecutive electrodes is about 50 nm.