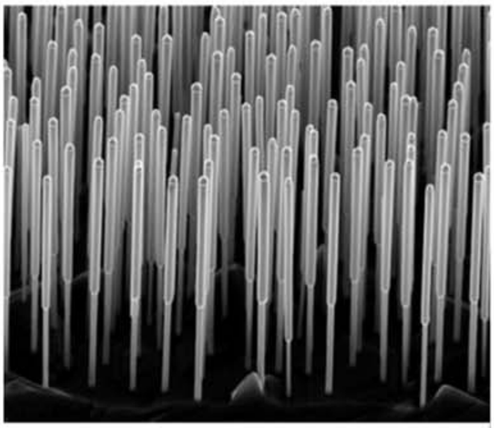
Inside the Nanowire Forest

Understanding texture at nm level is crucial to foresee and design the proper electrical and transport properties of nanowire heterostructure.

III-V semiconductor nanowires are at the forefront of the solid state physics and technology (SEM image on the right). Nanowires are quasi one dimensional crystals that can be heterostructured in different sectors having different chemical composition and crystal structure. They are grown by chemical beam epitaxy (CBE) from a III-V wafer with the Au-assisted growth method. In this method the wafer is coated with a thin layer film that by a dewetting thermal treatment in the CBE chamber transforms into small Au nanoparticles.

The Au nanoparticles act as a catalyst and drive the growth of the nanowire out from the wafer. At the final stage of the growth the wafer is a forest of nanowires each with its Au nanoparticle on top (SEM image at the right).



SEM image of a forest of InAs / InAsSb heterostructured nanowires

The challenge:	Distinguish structurally similar phases & perform orientation / phase of two different phases in a nanowire
Solution:	ASTAR technique coupled with precession electron diffraction

Experimental Data

TEM type: Zeiss Libra 120
Map resolution: 10 nm
Scanned area: 3 x 3 µm

Crystal Structure

InSb: Cubic, $F\bar{4}3m$
a =0.64 Å
InAs: Hexagonal, $P6_3mc$
a= 4.27 Å c= 7.02 Å

The growth of heterostructured nanowires is a challenge, especially if the two crystal structures, which must be piled up on top of each other, have a large lattice mismatch. This is the case of the InAs/InAs1-xSbx/InAs heterostructure, which can only be grown in nanowires, where the strain can be relaxed at the free surface, but not in a two dimensional growth. ASTAR is able to identify where the cubic Sb sector is located between the bottom and top hexagonal InAs stems. It determines the relative orientation of the two crystal structures and is able to recognize twinned layers inside the cubic Sb sector (fig. 1).

These structural details are crucial to foresee and design the proper electrical and transport properties of the heterostructure.

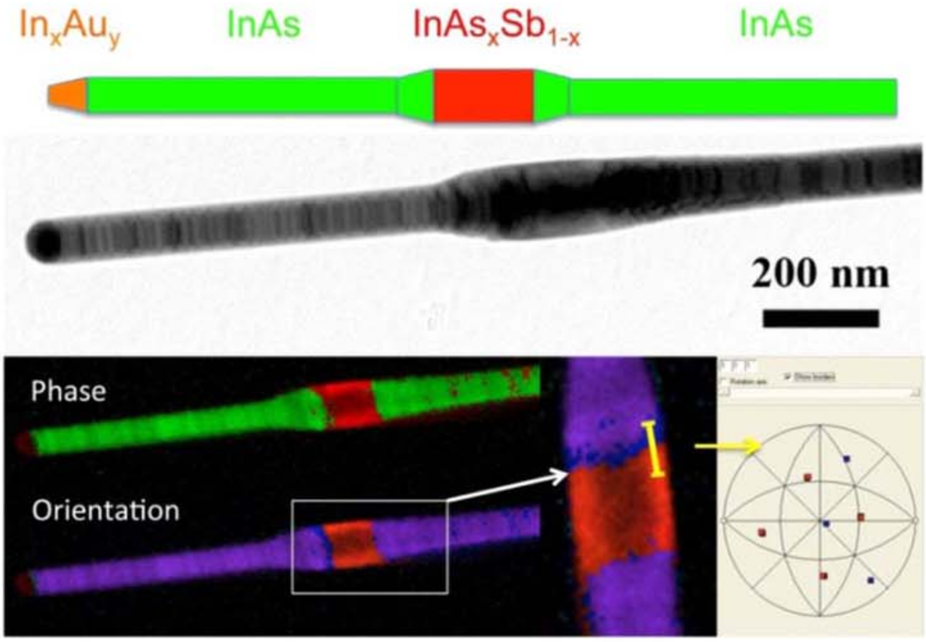


figure 1

(Top) Model and bright field image of a InAs / $InAs_{1-x}Sb_x$/ InAs heterostructured nanowire. (Bottom) Phase and orientation mapping of the same wire. In the phase map the cubic zinc blend structure of the Sb part is identified (red) while the orientation map shows that is separated from the hexagonal wurzite. InAs stem by a twinned sectorof 30 nm (blue). At the bottom left a pole figure calculated trough the twin boundary is displayed