Experimental report / Proposal 20170327 (Standard)

MBE grown core (GaAs) / shell (Au) nanowires: Influence of the shell

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Objectives:
The aims of the experiments are to obtain fundamental information concerning the growth of a metal on GaAs nanowires. Various morphologies and growth conditions will be investigated such as a metallic shell completely wrapping the GaAs nanowires or a metallic shell covering only half of the six facets of the GaAs nanowires. Two metals will be investigated: Au which is promising thanks to its plasmonic properties and Al which is known to be epitaxially grown on GaAs 2D substrate or InAs nanowires.

Results:
First, sets of GaAs nanowires were fabricated by MBE using the self-catalyzed growth method on Si(111) substrates. The samples were capped with an arsenic (As) layer after the growth in order to avoid oxidation or contamination of the nanowires during the transport.

- **Decapping**

After introduction in UHV, the sample was measured by GIXRD along different directions. Bragg peaks related to the GaAs structure are clearly identified, an "amorphous peak" related to the As capping layer is evidenced (figure 1.a). The sample was then annealed in UHV and the intensity of the amorphous peak was continuously measured as a function of the time (and therefore of the temperature). As expected at a temperature of 350°C the peak disappeared progressively leading to clean nanowires in the UHV chamber.

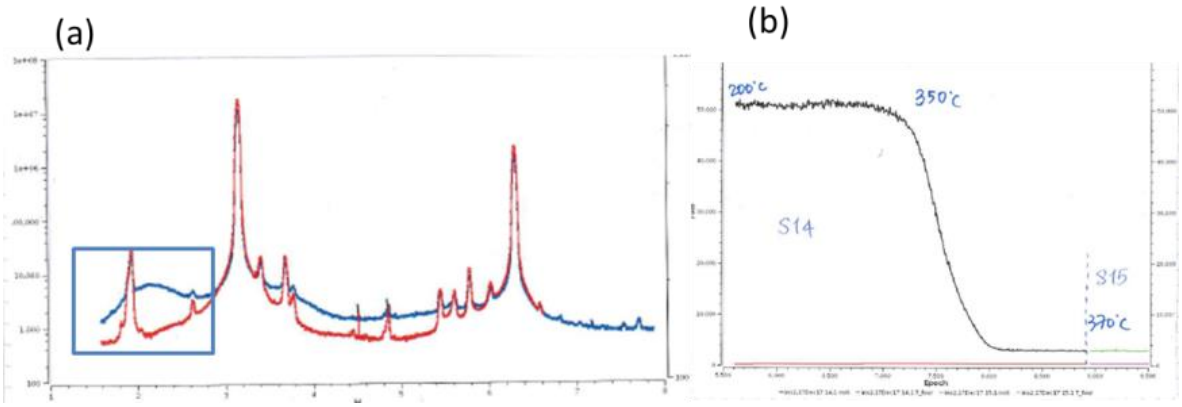

Figure 1: (a) GIXRD scan before (blue) and after (red) the As decapping. (b) Monitored intensity of the "amorphous peak" as a function of the temperature.

GISAXS measurements have also been performed before and after the As decapping. Figure 2 shows reconstructed GISAXS mapping performed by a complete rotation of the sample leading to a picture of the nanowire faceting. Figure 2 a-b correspond to GaAs nanowires capped with a thick (a) and thin (b) amorphous As shell. Clearly, the thick As shell leads to a smoothed morphology of the nanowires where the faceting is not visible while the thin As shell preserved the facetted morphology. After the As decapping the faceting became more intense.

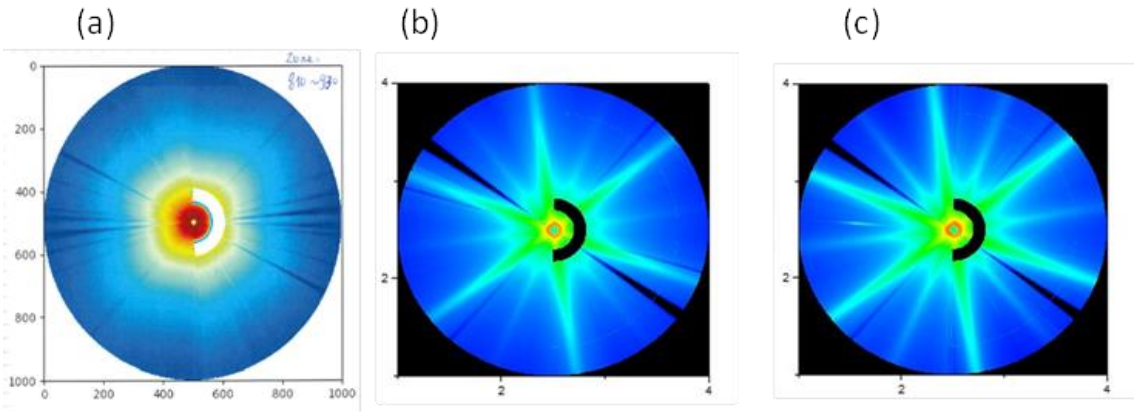

Figure 2: GISAXS maps showing the nanowire faceting. (a) with a thick As cap, (b) with a thin As cap, (c), for decapped nanowires.

- **Metal shell growth**

Then Au was deposited at low temperature on the GaAs nanowires without rotation of the sample in order to obtain an asymmetric shell. Au 111 and 220 peaks are evidenced (figure 3) along two different directions with intensities depending on the amount of deposited Au. The peaks are in agreement with an epitaxial growth of Au on the GaAs nanowire facets.

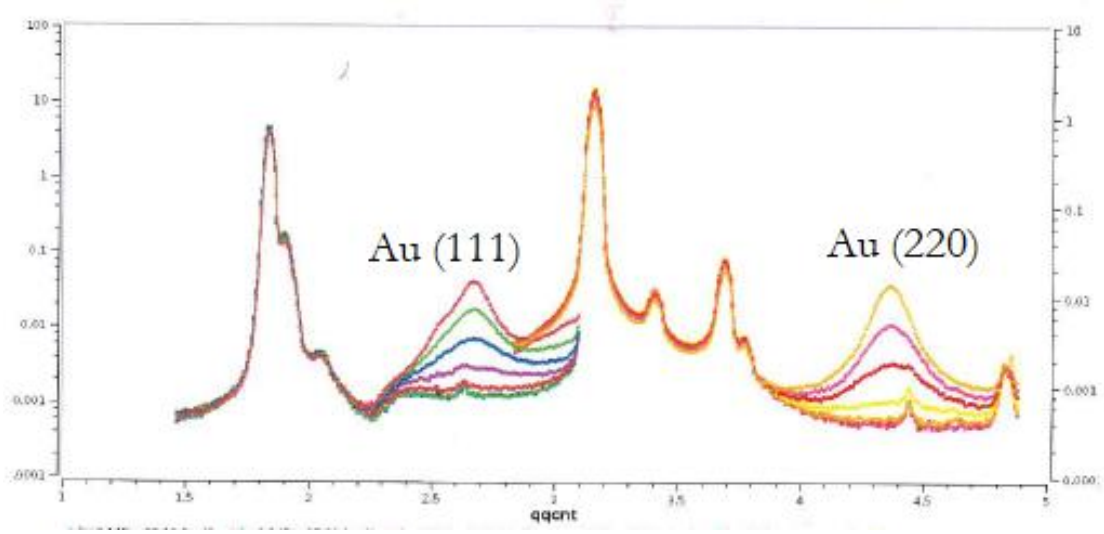

Figure 3:

Complementary measurements such as XPS, electron microscopy and photoluminescence are in progress on these semiconductor core/metal shell nanowires.