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ESRF	**Experiment title:** The site of Mn in GaAs:Mn nanowires, a possible route to one-dimensional dilute magnetic semiconductors	**Experiment number**: **SI-1422**
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Report:

The objective of this experiment was to probe the local structure of Mn in III-V semiconductor nanowires (NWs) obtained according to two different growth schemes; in the first, Mn both catalyzes the growth of the NW and acts as a dopant while in the second NW growth is catalyzed by Au and Mn dopant is added during growth. Mn-doped NWs are studied as a possible route to obtaining one-dimensional dilute magnetic semiconductors (DMS); the site location of Mn in this context is critically important since in order to obtain a DMS a subtitutional site is necessary.

GaAs and InAs NWs have been grown by molecular beam epitaxy on SiO_2 substrates. Before the NW growth, a thin film of Mn or Au was deposited on the substrates at room temperature in a metallization chamber, connected in ultra-high vacuum with the growth chamber. An equivalent two-dimensional growth rate of 1 mm/h has been used with a V/III beam-equivalent-pressure ratio (BEPR) of 15. Sample growth was terminated by keeping As overpressure on the samples during their cool down. Three types of NWs were studied as a function of growth temperature, nature of the catalyst nanoparticle and doping: i) samples grown using 5 monolayers (ML) of Mn (~1 nm) at growth temperatures ranging between 540 °C and 620 °C; ii) samples grown using 5 ML (~1 nm) of Au as catalyst and doped during the growth with Mn, using an effusion cell for the dopant; iii) InAs NWs grown by depositing 5 ML of Mn. The morphological features and the structural properties of the NWs have been

studied by scanning electron microscopy (SEM) and by scanning transmission electron microscopy (STEM).

XAFS measurements were performed on the GILDA BM8 beamline, in the fluorescence mode using the 13 element Hyper-pure Ge detector. High quality spectra have been obtained (see figure). Quantitative data analysis has been performed using state-of-the-art methods, based on curved-wave multiple scattering formalism. From the data analysis the following picture emerges.

We found that Mn forms chemical bonds with As with a bond distance of 2.56-2.58 Å, longer than the expected value for a substitutional site and most probably due to the occupation of defect sites which are the seeds for the formation of hexagonal MnAs precipitates. This behavior has been observed, at different degrees of evolution, in both GaAs and InAs NWs. In GaAs NWs, a similar local environment is found both in samples in which Mn acts as catalyzer and dopant and in those in which the growth is catalyzed by Au and Mn is supplied during growth as a dopant. In this second case the penetration of Mn into the Au nanoparticle has been also detected, with the formation of a Mn-Au intermetallic phase. Finally, in InAs NWs a higher degree of local order has been found (with respect to GaAs NWs), which is evidence for the formation of a more extended hexagonal MnAs phase.

These results provide crucial information on this emerging materials system. It appears that most of the Mn atoms do not, in fact, occupy substitutional sites. This does not imply that doping cannot be achieved but rather that incorporation of doping Mn has a low efficiency and must be improved.

These results have been published in Jabeen et al., J. Vac. Sci. Tech. B **28**, 478, (2010).