Atom probe tomography study of quantum dots formed by alloy fluctuation in GaAs/AlGaAs core-multishell nanowires

L. Mancini[1], Y. Fontana[2], I. Blum[1], L. Francaviglia[2], F. Vurpillot[1], E. Russo-Averchi[2], M. Heiss[2], A. Fontcuberta i Morral[2], L. Rigutti[1]

[1] *Groupe de Physique des Matériaux, UMR CNRS 6634, University and INSA of Rouen, Normandie University, 76800 St. Etienne du Rouvray, France*
[2] *Laboratoire des Matériaux Semiconducteurs, École Polytechnique Fédérale de Lausanne, 1015 Lausanne, Switzerland*

Core-shell nanowires are currently investigated as potential building blocks for solar cell and quantum cryptography applications. It has recently been shown that AlGaAs/GaAs core-multishell nanowires grown by molecular beam epitaxy (MBE) exhibit Al segregation mechanisms potentially leading to the self-assembly of quantum dots (QDs) yielding single photon emission [1]. Nanowires containing quantum structures are also particularly interesting as model systems for the study of correlated atom probe and optical spectroscopy measurements [2]. In this contribution the structure of a set of GaAs /AlGaAs core-multishell nanowires was analyzed in 3D by atom probe tomography (APT). The study allowed us to confirm that Al atoms within the AlGaAs shells tend to segregate towards the planes crossing the vertices of the hexagons defining the nanowire cross section along the (121) crystal direction. We also assessed that strong alloy fluctuations take place in the AlGaAs shell, leading occasionally to the formation of quantum dots which would be hardly detectable by transmission electron microscopy. The PL emission energies predicted in the framework of a 3D effective mass model for a quantum dot analyzed by APT and the PL spectra measured on other nanowires from the same growth batch are consistent within the experimental uncertainties [3].

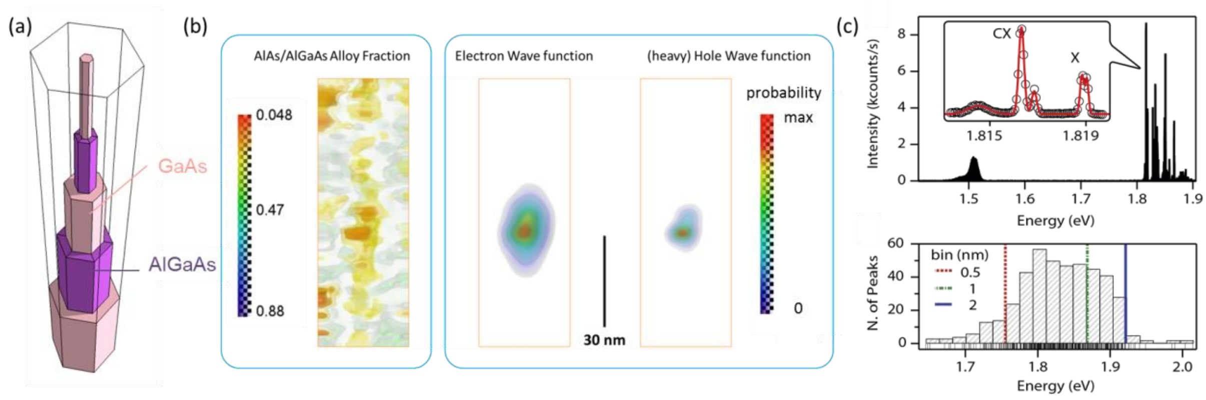

Figure 1. Analysis of self-assembled quantum dots in GaAs/AlGaAs nanowires by APT and PL. (a) Schematic representation of a core-multishell nanowire structure. (b) APT measured alloy fraction from a subvolume and wavefunctions probability distribution computed within the effective mass approximation. (c) Typical PL spectrum of a nanowire and histogram of measured emission energies from different nanowires from the same growth batch; energies predicted within the framework of the effective mass model are consistent with those observed by optical spectroscopy.

[1] M. Heiss, et al.. *Nature materials*, **12**(5), 439-444 (2013)
[2] L. Rigutti et al., *Nano letters*, **14**, 107–114 (2014)
[3] L. Mancini et al. *Appl. Phys. Lett*. **105**, 243106 (2014)