# Surface compositional profiles of self-assembled InAs/GaAs quantum rings

Stefan Heun and Lucia Sorba

*NEST INFM-CNR and Scuola Normale Superiore, I-56126 Pisa, Italy*

Giorgio Biasiol and Tomaz Mlakar

*Laboratorio Nazionale TASC INFM-CNR, I-34012 Trieste, Italy*

Rita Magri

*$S^3$ INFM-CNR and Università di Modena e Reggio Emilia, I-41100 Modena, Italy*

Andrea Locatelli and Tevfik Onur Mentes

*Sincrotrone Trieste S.C.p.A., I-34012 Trieste, Italy*

The composition profile of self-assembled InAs/GaAs quantum rings (QR) is studied both experimentally and theoretically. 2D surface maps obtained by X-ray photoemission electron microscopy (XPEEM) reveal a non-uniform profile with an In-rich core, corresponding to the central hole of the QR, surrounded by a rim with stronger In-Ga intermixing. These results are substantiated by an atomistic Valence Force Field (VFF) model which, for a given shape, identifies the composition distribution that minimizes the elastic energy of the system. The VFF calculation predicts a preference for the In atoms to remain localized in the QR hole, in agreement with the experimental findings.

Further insight into the properties of QR is obtained by conductive atomic force microscopy. 2D current maps and I-V curves show a lower conductivity of the central QR hole as compared to the rim and wetting layer. This result is quite surprising if we take into account the XPEEM data: since it has been previously established that In-

rich regions are more conducting with respect to GaAs, one would expect in such a sample the central hole to be the region with highest conductivity. However, when comparing these data, the surface native oxide layer of the QRs has to be considered. Including the presence of a surface oxide into numerical simulations yields results which show the same qualitative behaviour as the measured conductivities. Therefore, finally a consistent picture of the In concentration profile in QRs is obtained, which is in agreement with the XPEEM and the C-AFM results.