ESRF	**Experiment title:** Interdiffusion and strain in InAs quantum dots on GaAs(001)	**Experiment number**: 08-01-181
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Report:

The objective of the proposal was to assess the degree of strain and Ga-In interdiffusion in a series of InAs quantum dots deposited on GaAs; the method chosen, XAFS in the fluorescence mode, has recently demonstrated the presence of considerable Ge-Si intermixing in the related system of Ge quantum dots on Si(001) [1]. In the present case the measurements posed a particular challenge due to the very low x-ray absorption cross section at the In K-edge and the limited equivalent thickness of the quantum dot structures. In fact, in samples consisting of single layers of quantum dots with equivalent thickness of a few monolayers the signal-to-noise of the spectra is such that only qualitative information is obtainable (relative errors on the local structural parameters are high). On the other hand, good quality spectra were acquired on a sample consisting of 10 layers (each layer 3 ML equivalent thickness) InAs quantum dots with GaAs spacer layers. This sample was deposited by MBE in the MASPEC – CNR laboratory in Parma, Italy.

A series of spectra were acquired of this sample as a function of the relative orientation of sample and beam polarization in order to probe possible anisotropies in strain and interdiffusion. In this preliminary report we discuss the spectrum acquired at 45˚. In Fig 1 we report the XAFS signal of bulk InAs (measured in the transmission mode) and of the sample: we notice that there is an overall similarity with a slight shift in phase between the two signals, which is related to the slightly different bond lengths. In Fig. 2 the

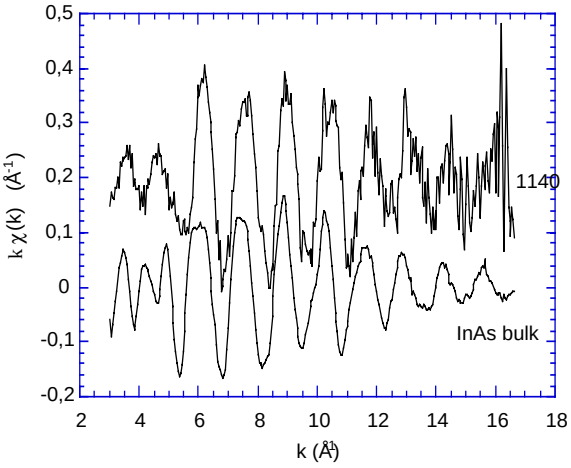

Fig. 1

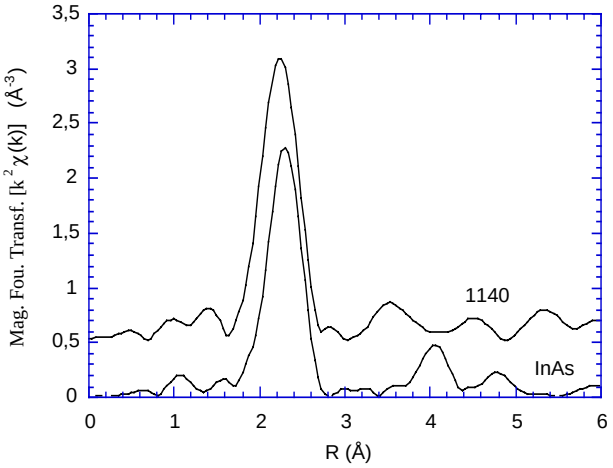

Fig. 2

Two comments can be made: the maximum of the first shell peak appears at slightly smaller distances with respect to the bulk and the second and third shell structure is completely different. The latter observation is most probably related to interdiffusion of Ga from the GaAs substrate into the InAs dots, compatible with what found in the Ge on Si system [1] and with recent analysis by X-ray diffraction [2]. It will be quantitatively investigated in the near future.

The shortening of the In-As bond in the dots has been quantitatively analysized by k-space fitting.

The In-As bond length was determined from the fit as 2.583 ± 0.006 Å. This is a contraction of 0.04 Å with respect to the bulk values; very similar values were obtained for the other samples (non-stacked) although with a much bigger error bar (from ± 0.02 Å to ± 0.07 Å) due to the lower signal-to-noise and to the shorter k-range available.

This is the first evidence of bond length variation in semiconductor quantum dots, the origin of which is the strain due to pseudomorphic growth. We compare the present results for the In-As bond length with previous publications and data relative to two-dimensional strained layers. A model which applies to the local scale the macroscopic strain tensor and which gives excellent agreement for strained $In_xGa_{1-x}As/InP(001)$ [3, 4], when applied to strained InAs/GaAs(001) predicts a value of 2.567 Å. Our experimental value for InAs dots on GaAs(001) therefore indicates that the parallel strain is 5%, instead of the full 7% for 2D InAs on GaAs. The origin of this could be due to Ga-In interdiffusion or to the inhomogeneous strain distribution in the alloy, or both.

[1] F. Boscherini et. al., Appl. Phys. Lett. **76**, 682 (2000).
[2] H. Metzger, reported at the Surface Science 2000 workshop at the ESRF Users Meeting, 2000
[3] Romanato et. al., Phys. Rev. B **57** 14619 (1998)
[4] Tormen et. al., J. Appl. Physics **86**, 2533 (1999).