ESRF	**Experiment title:** **A systematic investigation of the self-organised growth of semiconductor nano-structures („Quantum Dots“)** *Part 1, first 6 months of long term project*	**Experiment number:** Si-454
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Report:

Grazing Incidence Diffraction (GID) was used to study the strain and interdiffusion profiles in InAs/GaAs quantum dot samples.

The InAs dot sample under investigation was composed of a GaAs(100) substrate on which InAs (7% lattice mismatch) has been deposited by MBE, exceeding the critical thickness for layer-by-layer growth, and resulting in coherent InAs dots of density 10^{10} cm^{-2}. The experiment had the twofold focus of collecting an extensive data set for the determination of strain profiles as well as developing a contrast variation technique for the investigation of the material composition of the dots.

For the strain profiles in the InAs dots, three-dimensional reciprocal space mappings were performed at four surface Bragg-reflections of the substrate, where the intensity distribution between the nominal positions of GaAs and InAs was recorded with angular variations and exit-angle spectra at each point. Within our theoretical framework of iso-strain scattering, this intensity distribution can be translated to three functional relationships:

(i) Relationship between strain and lateral size, which is extracted from angular slices at low exit angles. [1]

(ii) Relationship between strain and mean height z of a particular iso-strain area above the surface. This information results from the shift of the Yoneda wing with increasing z.

(iii) Relationship between strain and radius of curvature of the iso-strain-area. This connection is calculated from the functional dependence of the increase in angular half-width with increasing exit angle.

The second part consisted of a measurement of the interdiffusion profile within the dots by comparing data from a strong and a weak reflection. Due to the differences in electron numbers of GaAs and InAs, at the weak reflection (200) GaAs contributes very weakly to the scattered intensity as compared to InAs. All four measured relationships are shown in Fig.1

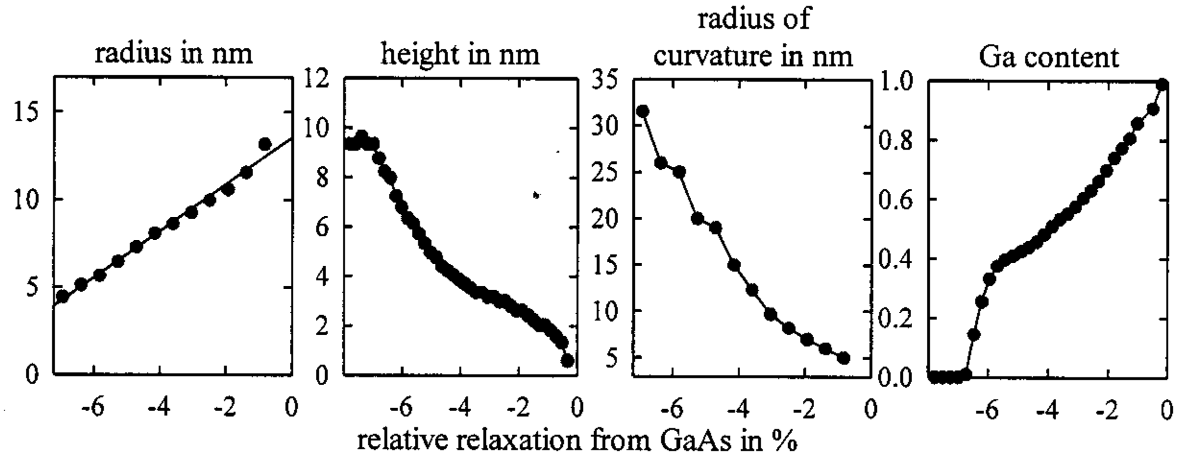

Fig.1: results for strain profile and interdiffusion in InAs/GaAs(001) dots

In our purpose to study differences in nanostructures in different material systems, the same method was also applied to Ge islands (6 ML of Ge have been deposited onto (001)-oriented Si substrate at a growth temperature of 600°C). As the diamond lattice of Si and Ge does not exhibit weak reflections as InAs or GaAs, the same method of contrast variation is not applicable, and a different approach (contrast variation via energy variation) is subject to an oncoming experiment at beamline ID10B.

In the Ge/Si heterosystem, dot sizes are usually significantly larger than in InAs/GaAs. In order to yield smaller Ge dots, the predeposition of a fraction of a monolayer of carbon prior to Ge deposition seems to be most promising. We have investigated such a Ge/C/Si multilayer sample by grazing incidence small angle scattering. 50 bilayers consisting of 0.2ML of C and 2.4ML of Ge, separated by 9.6nm Si, were grown at a substrate temperature of 600°C. Our measurements revealed a size of the buried dots of about 12nm width and 1.7nm height, significantly smaller than "conventional" Ge islands on Si [2].

[1] I. Kegel, T.H. Metzger, P.Fratzl, J. Peisl, A.Lorke, J. M. Garcia, P.M. Petroff, Europhys. Lett. **45**, 222 (1999)

[2] J. Stangl, V. Holý, P. Mikulik, G. Bauer, I. Kegel, T.H. Metzger, O.G. Schmidt, C. Lange, K. Eberl, Appl. Phys. Lett. **74**, 3785 (1999).