ESRF	**Experiment title:** Surface EXAFS investigations of nanometric isolated germanium quantum dots grown through an ultrathin oxide layer on silicon (100).	**Experiment number**: **32-03-604**
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Report:

The development of techniques for fabricating Si-based nanostructures containing ultrasmall (<10 nm) germanium quantum dots is of great importance and many efforts are achieved to grow so called “zero dimensional quantum dots”.

Recently our group proposed a new method to grow high density (2-4 $10^{11}/cm^2$) nanometric size (~ 8 nm) Ge dots on silicon (001) surface covered by a very thin layer of dielectric [1].

The aim of the present experiment was to investigate the local structure of germanium dots grown through an ultrathin oxide layer and to provide a quantitative measurement of the average composition of the dots. The experiment was carried out at the BM32 beamline at ESRF. EXAFS measurements were performed in a fluorescence mode at room temperature with a thirteen-element pure Ge detector borrowed from the detector pool of the ESRF. This study was performed in situ to prevent any oxidation of the germanium dots and in order to increase the surface sensitivity, grazing-incidence geometry was used. As references, we used a Ge bulk sample and a dilute solid solution of $Si_{98.8}Ge_{1.2}$.

The data analysis was done using FEFFIT codes and theoretical backscattering amplitudes and phase shifts were calculated using FEFF8. The most remarkable feature shown by X(k) plot in Fig. 1 and confirmed by fitting results in Fig. 2 and table I was that Ge content is much higher into dots grown through silicon oxide (~90%) than into dots grown directly on silicon (~45%).

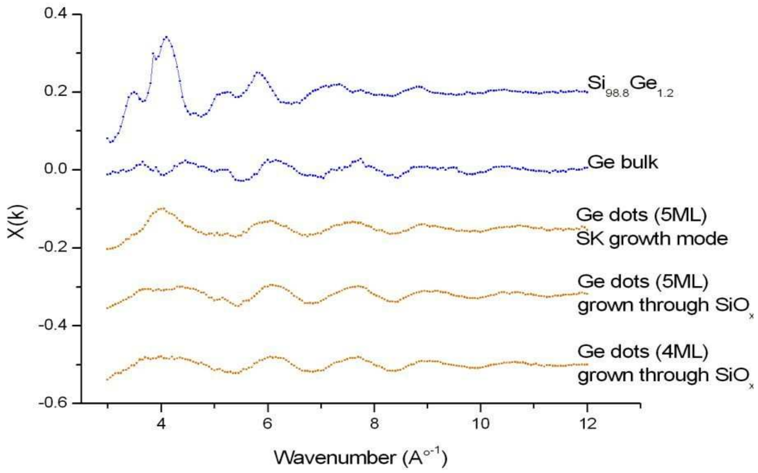

FIG. 1. Raw EXAFS oscillations of Ge dots grown through SiO_x on Si (100) and directly on Si(100) compare with those for bulk Ge and a dilute solid solution of Ge in Si.

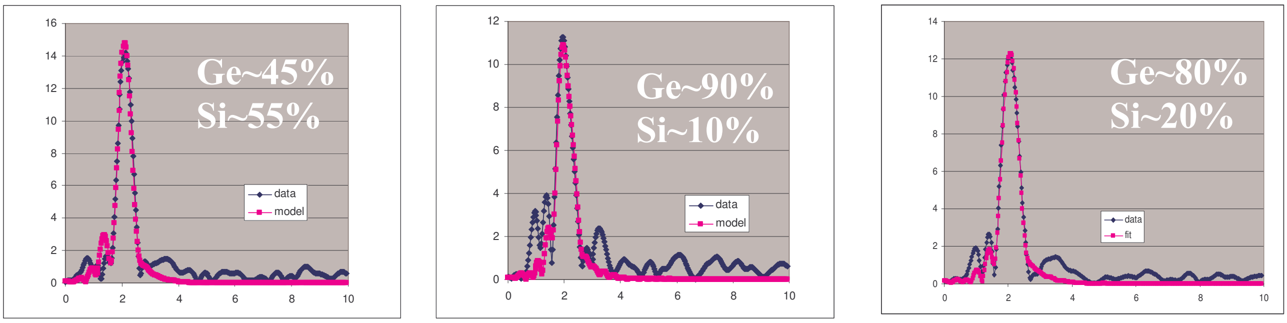

FIG. 2. Fourier Transform of EXAFS spectra around a Ge absorber along with the fitting of the first coordination shell for: a) Ge dots (5ML) grown directly on Si(100), b) Ge dots (5ML) grown through SiO_x on Si(100), c) Ge dots (4ML) grown through SiO_x on Si(100)

Sample	Ge content (%)	R_{Ge-Ge}	σ^2_{Ge-Ge}	R_{Ge-Si}	σ^2_{Ge-Si}
Ge dots (5ML) grown directly on Si(100)	42.90	2.445	0.0043	2.382	0.0069
Ge dots (5ML) grown through SiO_x on Si(100)	91.13	2.441	0.0057	-------	0.0077
Ge dots (4ML) grown through SiO_x on Si(100)	77.29	2.434	0.0057	2.385	0.0077

TABLE I. Fitting results for Ge dots grown directly on Si(100) or through SiO_x

We have shown with the EXAFS experiment that nanometric, almost pure germanium dots could be grown on Si(100) covered by an ultrathin oxide layer. A paper dealing with these results is in preparation. Next step of our work will be EXAFS investigations of the modification of dots composition after embedding in Si.

[1] A. Barski, M. Derivaz, J. L. Rouvière, and D. Buttard, Appl. Phys. Lett. **77**, 3541 (2000).