	Experiment title: **Strain and diffusion in geterosystems with GaN/AlN thin films superlattice and SiGe nanorings by XAFS spectroscopy**	**Experiment number**: MA-2334
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Report

III-nitride heterostructures in the form of multilayered quantum wells (MQWs) or quantum dots (QDs) are promising candidates for high-speed intersubband (ISB) optical devices relying on the quantum confinement of electrons [1].

The systems with interacting QDs - molecules, (in particular, GeSi nanorings, or quantum rings (QRs)) have attracted much attention both as ground for studying coupling and energy transfer processes between “artificial atoms” and a new systems, which substantially extend the range of possible applications of QDs [2, 3]. This nanostructure is a symmetric assembly of four QDs bound by the central pit and has been suggested as a candidate structure for logic architecture based on quantum cellular automata [4].

Extended X-ray absorption fine structure (EXAFS) and X-ray absorption near edge structure (XANES) spectroscopy in high-energy-resolution fluorescence detection (HERFD) mode are the powerful tools allowing to determine local atomic and electronic parameters of nanosized systems and were used to characterize strain and diffusion in geterosystems with GaN/AlN thin films superlattice and SiGe nanorings by XAFS spectroscopy.

Microstructural parameters (interatomic distances, coordination numbers, and Debye–Waller factors) were determined by means of EXAFS spectroscopy, and the relationship between the variations in these parameters and the morphology of superlattices and symmetric assembles of QDs were established (Fig.1).

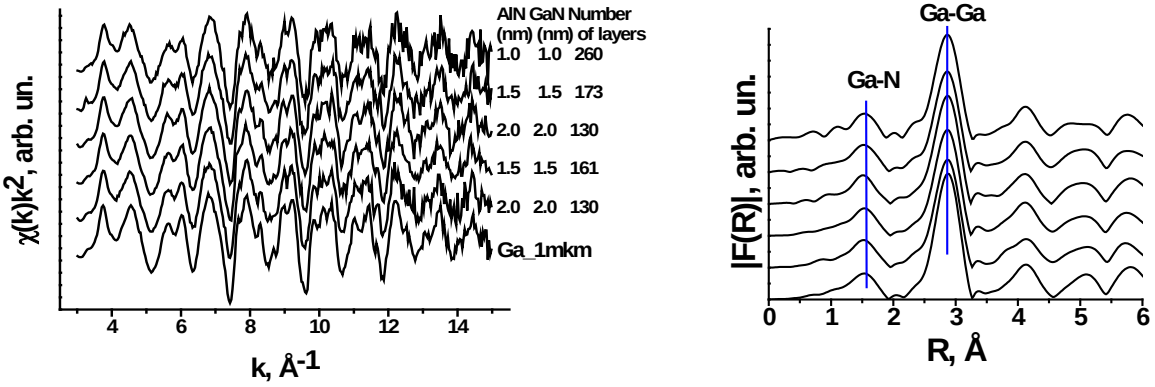

Figure 1. *Experimental $k^2\chi(k)$ GaK EXAFS spectra and their Fourier transform magnitude |F(R)|of the GaN/AlN samples with thick superlattices and GaN bulk measured at 12 K.*

A minimal drop (~0.01 Å) in the interatomic Ga–Ga distances *R*(Ga) relative to a thick film was observed for multilayered GaN/AlN samples with thick (550–850 nm) superlattices, agreeing with the numerous dislocations found in them and the corresponding stress relaxation in the GaN layers.
The interatomic Ga–Ga distances *R*(Ga) for samples with fewer layers and thin (80–150 nm) superlating corresponds to the more substantial deformations and stresses (~0.03 Å) indicated by our earlier results for GaN quantum dots in a AlN host [5–7].
The EXAFS technique has been used to study the local structure of thin hexagonal GaN/AlN MQWs grown by ammonia MBE at different temperatures. It is shown that the heterointerface intermixing leads to a decrease in the Ga-Al interatomic distance and the Ga-Ga coordination number in MQWs.
The degree of intermixing in the boundary layers rises from 30% to 40% with increase of the growth temperature from 795 to 895 °C.

It was found that in the first phase of growth Ge atoms concentration is ≈ 25%. With further growth (deposition of the base layers) Ge concentration increases up to 35-45%, depending on the temperature (610 - 550 °C) of deposition (Fig.2). It was established for the samples with stoichiometric formula Ge_xSi_{1-x} (0.25 <x< 0.45), that interatomic distances Ge-Ge and Ge-Si correspond to distances, defined in [8] for solid solutions and in [9] for quantum dots Ge/Si.

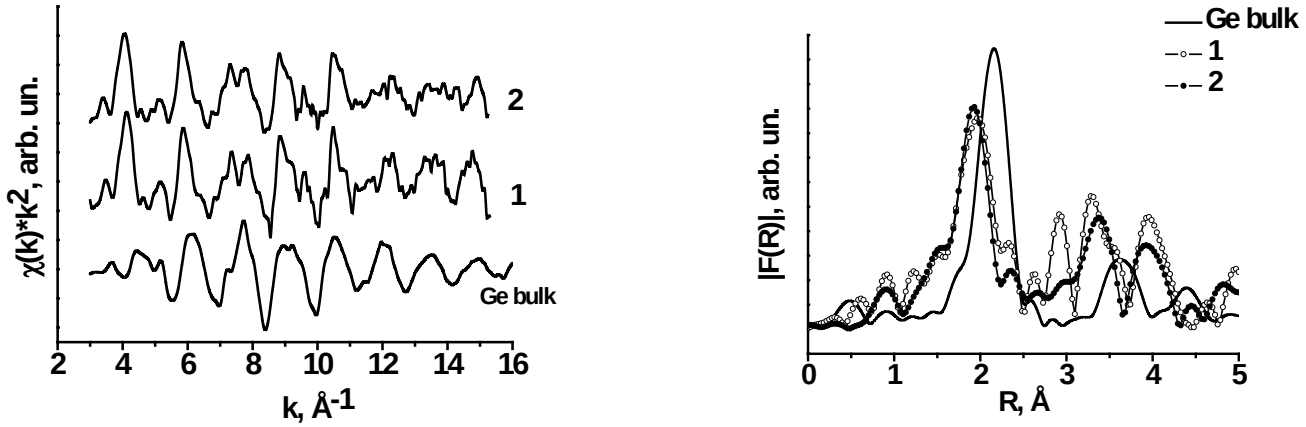

Figure 2. *Experimental $k^2\chi(k)$ GeK EXAFS spectra and their Fourier transform magnitude |F(R)|of the Ge/Si samples with quantum rings (1 – without doping;2 – Sb doping)and Ge bulk measured at 12 K. The temperature of Ge rings deposition is 600ºC.*

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