ESRF	**Microstructure features of 1)Ge/Si, GaN/AlN heterosystems sequentially on the stages of growth and 2)Ge/Si system containing quantum dots with magnetic impurities $Mn_xGe_{(1-x)}$**	**Experiment number**: MA-2942
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Report

The systems with interacting quantum dots (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 [1, 2]. 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 [3]. In dilute magnetic semiconductors spin state of the system becomes a carrier of information that is of interest for use in information technology. Electron spins in semiconductor quantum dots with magnetic impurity are promising targets for qubits in a quantum computer.

GaN/AlN 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 [4]. The EXAFS technique has been used to study the local structure of thin hexagonal GaN/AlN MQWs grown by ammonia MBE at different temperatures (Figure 1).

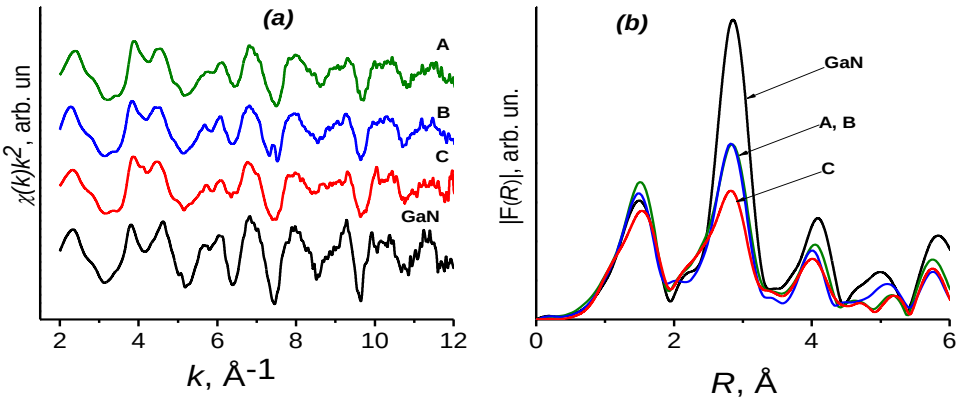

Figure 1. – (a) - Experimental k^2-weighted GaK EXAFS spectra for GaN/AlN MQWs structures and GaN film. (b) - Fourier transform magnitude |F(R)| without phase shift corrections of $k^2\chi(k)$ for GaK EXAFS of MQWs and GaN reference sample. Spectra denoted A, B and C correspond to MQWs samples grown at the substrate temperature 795, 845 and 895 °C, respectively. Spectrum marked as GaN relates to the reference GaN layer with thickness of about 17.5 nm grown at the temperature 795°C.

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 and Ga-Ga interatomic distances and the Ga-Ga coordination numbers in MQWs (Table 1) in accordance with our earlier results for GaN quantum dots in a AlN host [5–7].

Table 1. Parameters of microstructures of GaN/AlN MQWs (A, B, C) and GaN (reference) obtained in the simulation process of EXAFS data. Here N(Ga), N(Al) are the average coordination numbers Ga-Ga and Ga-Al accordingly; R(N), R(Ga), R(Al) are the interatomic distances Ga-N, Ga-Ga, Ga-Al accordingly.

Sample	N(Ga)	N(Al)	R(N)	R(Ga)	R(Al)
A	8.9	3.1	1.93	3.15	3.16
B	8.6	3.4	1.93	3.15	3.16
C	8.0	4.0	1.92	3.14	3.13
GaN ref.	12		1.95	3.17	

Ge K-edge EXAFS (Extended X-Ray Absorption Fine Structure) spectra have been measured for multilayer semiconducting heterosystems containing interacted groups of quantum dots ("molecules from quantum dots") ordered in rings on different stages of their growth depending on topologic parameters and growth conditions. In accordance with our results obtained previously for the quantum dots of SiGe, for the molecules of quantum dots it was found that deformation at the interface leads to decrease in the interatomic distance of Ge-Ge by ~0.03 Å. Effect of heterosystem topology and temperature at different stages of their growth on interlayer diffusion was investigated. It was found that at the first growth stage (growth of "seeded islands" serving as a basis for obtaining the molecules) at 700°C a concentration of Ge atoms in the system is ~38%.With further growth of the vertically-matched quantum dots groups the concentration of Ge increases up to ~43-47% depending on the growth conditions. Comparable analysis of different modes of EXAFS measurements was performed to determine precisely structural parameters of heterosystem SiGe with different thickness grown on Si (100) surface.

During the experiments were carried out the first test-measurements for very diluted magnetic heterostructures Ge/Si with quantum dots $Mn_xGe_{(1-x)}$, obtained by the ion implantation (Figures 2a,2b).

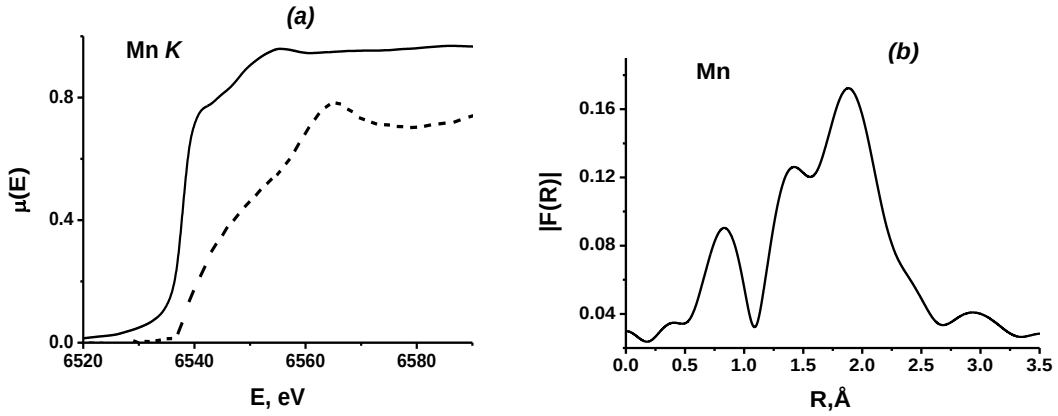

Figure2. – ***(a) - MnK absorption edges (XANES spectra) of very diluted magnetic semiconductor heterostructure with QDs (dotted line) and Mn foil (solid line).*** **(b) -** ***Fourier transform magnitude |F(R)| without phase shift corrections of $k^2\chi(k)$ for MnK EXAFS spectrum of very diluted magnetic sample.***

It should be noted (as shown in Fig. 2a), Mn*K* absorption edge of quantum dots $Mn_xGe_{(1-x)}$ shifted toward higher energies relative Mn metal K edge, which indicates that the Mn in the dots remains positively charged.

References

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