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Report:

The III-V nitrides AlN, GaN and InN are wide and direct band gap semiconductors, which find applications in optoelectronics for the fabrication of emitters and detectors. Due to their good thermal and chemical stability they also find applications as substrate materials in microelectronics. Alloying of III-V nitrides permits band gap engineering and a laser, which operates in the blue-green range of the visible spectrum, has already been constructed using InGaN/GaN heterostructures.

The objective of the present measurements was to study the local environment of a series of $In_xGa_{1-x}N$ alloys with XAFS spectroscopy at the Ga and In K edges in order to obtain information on chemical ordering, lattice symmetry and dependence of the interatomic distances on concentration. The measurements were successfully performed and the data analysis is in an advanced state. We illustrate here the main results.

Five samples were measured with x = 0, 0.08, 0.12, 0.30, 0.34 and 1. They were grown by electron cyclotron resonance molecular beam epitaxy on $(0001)Al_2O_3$ substrates, using a plasma source for the activation of nitrogen [1]. A buffer layer was grown at 500-600^{o}C (~300Å thick) on the nitridated sapphire substrates and the III-V epilayers were grown at 700-800^{o}C.

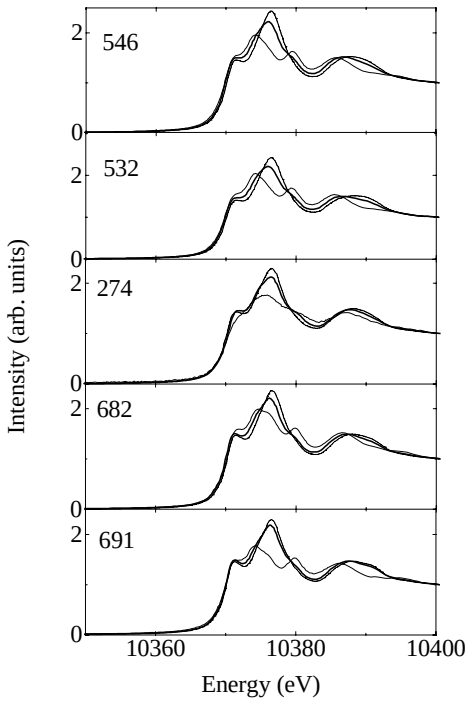

Fig. 1: *Ga near edge spectra: samples 691 ($In_{0.08}Ga_{0.92}N$), 682 ($In_{0.12}Ga_{0.88}N$), 274 ($In_{0.12}Ga_{0.88}N$), 532 ($In_{0.30}Ga_{0.70}N$), 546 ($In_{0.34}Ga_{0.66}N$) recorded at normal incidence (dotted line), at the magic angle (thick solid line) and at the grazing incidence (thin solid line).*

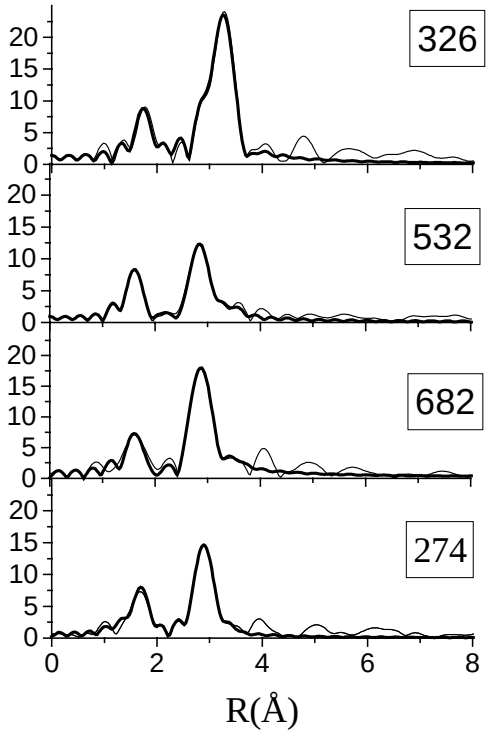

Fig. 2: *Magnitude of the Fourier transform of In edge spectra and their fitting.The 326 is pure InN sample.*

In Fig. 1 we show the Ga near-edge spectra, measured at three relative orientations of sample and photon beam polarization: near normal incidence, the “magic angle” and grazing incidence. The spectra exhibit a polarization dependence typical of the wurzite strucure [2], proving that incorporation of In maintains the lattice symmetry of hexagonal GaN. The In edge XAFS measurements were analyzed using the FEFF package and the fitting up to the second coordination shell (Ga or In sublattice) is reported in Fig. 2. From the values of the local structural parameters the following conclusions can be reached:

1) The behaviour of In – N, In – Ga and In – In interatomic distances (first and second shells) as a function of concentration follow the general trend found in III – V alloys: strong tendency for the first shell bond lengths to remain close to the value in the binary compound In-N (deviation from the Virtual Crystal Approximation). The values found are in good agreement with a recent theoretical study [3].
2) The second shell In – In and In – Ga coordination numbers indicate a random arrangement of In and Ga in the cationic sublattice; this rules out the presence of significant clustering.

[1] T. D. Moustakas, R. J. Molnar, Mat. Res. Soc. Symp. Proc. ***281****, 753 (1993).*
[2] M. Katsikini, E. C. Paloura, T. D. Moustakas, Appl. Phys. Lett. ***69****, 4206 (1996).*
[3] T. Mattila and A. Zunger, J. Appl. Phys. ***85****, 160 (1999).*