Structural Properties of N in InGaAsN

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The semiconductor alloys GaAsN and InGaAsN have shown great potential for the fabrication of VCSELs (vertical cavity surface emitting lasers) with an emission wavelenghth of 1300 μm. The determining attribute of these alloys is the strong, anomalous reduction of the bandgap when small ammounts of Nitrogen are added. This allows the light-emmitting devices to be grown on GaAs substrates with only moderate strain in the GaAsN and InGaAsN semiconductor layers. Laser operation from InGaAsN/GaAs multi-quantumwell based devices has been demonstrated, however an undesired post-growth annealing treatment is necessary for effective and stable operation. This treatment leads to a rise of up to a factor of 100 in the luminescence and a blue-shift of the peak-wavelength of up to 100 meV. The reasons for this drastic change in the luminescence characteristics are not understood [1,2].

We present structural analysis of nitrogen in (In)GaAsN structures using Channeling-ERD (Channeling Elastic Recoil Detection). This method combines the excellent depth resolution and element separation of the ERD with the structural sensitivity of the channeling process of heavy ions in crystals [3]. This allows the analysis of the occupied lattice sites of every element from the crystal separatly and with high depth resolution.

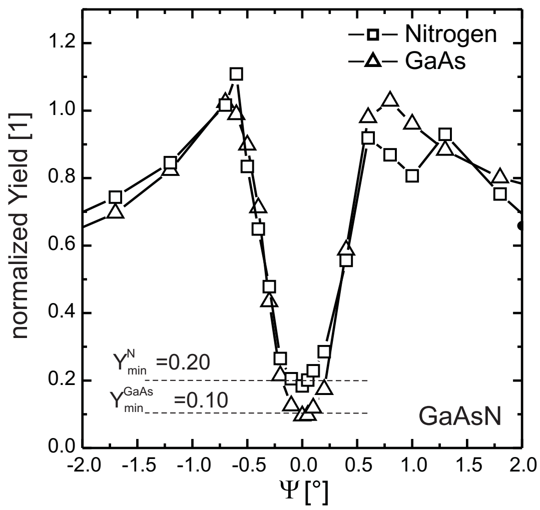

Fig. 1: Angular yield of N and GaAs from a GaAsN single layer

Fig. 1 shows the normalized angular yield from N and GaAs from a GaAsN single layer. The curves show the same angular dependency for both elements, with only a difference in the Y_{min}. This behaviour leads to the conclusion, that N is mostly (> 95%) incorporated on As lattice sites, so called N_{As} sites. The position of the remaining N cannot be determined.

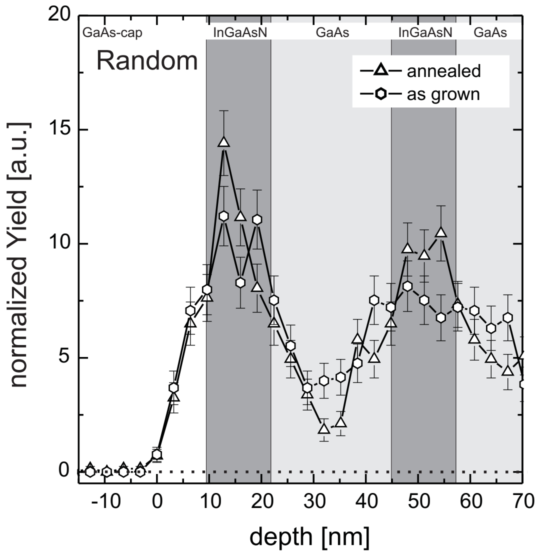

Fig. 2: N-distribution in an InGaAsN/GaAs quantumwell structure under random-alignment

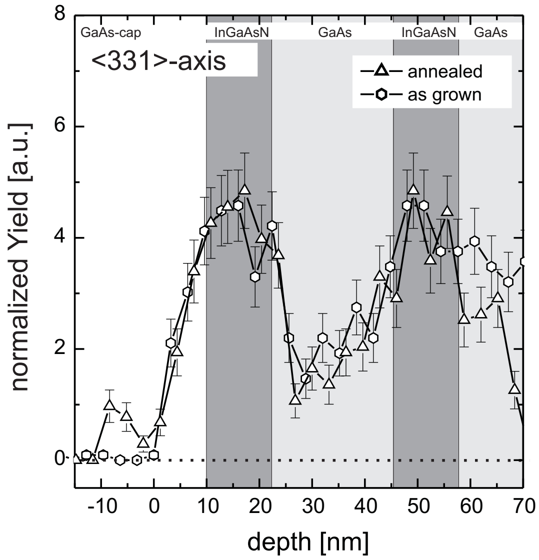

Fig. 3: N-distribution in an InGaAsN/GaAs quantumwell structure under channeling-alignment to the <3,3,1>-axis

Fig. 2 and 3 show the N-distribution in an InGaAsN/GaAs quantumwell structure prior to and after annealing for random- and channeling alignment of the crystal. The annealing process induces no change in the N-distributions. In addition a comparison of the random and channeling spectra yields no significant differences. From this measurements it can be concluded, that the nitrogen is bound to equal lattice sites in the whole structure and is not affected by the thermal treatment.

The presented measurements exclude diffusion or change of binding positions as reasons for the generally observed change in the optical properties of (In)GaAsN. However changes in N-N or N-impurity complexes without clear repositioning of N can still be a source for these effects.

References

[1] H. Riechert *et al.*, Semicond. Sci. Technol. **17(8)** (2002) 892
[2] J. Salzmann *et al.*, Mat. Sci. Eng. **B50** (1997) 148
[3] L. Görgens *et al.*, Annual report 2001, p. 31