Contribution ID: **41** Type: **Submitted**

Mg lattice location in group-III nitrides

Tuesday, 6 December 2011 09:50 (20 minutes)

The group-III nitrides (GaN, InN and AlN) are semiconductors with a large band gap which can be adjusted by combining the different nitrides into alloys. This provides them with the interesting electrical and optical properties used to create the light emitting diodes LED (from UV to red). For this the nitride semiconductors must be doped positively (p-type) and negatively (n-type), however they are unintentionally n-type doped, which makes the p-type
doping a great challenge.

The introduction of small concentrations of dopants in specific lattice positions of a semiconductor may modify the electrical properties of the whole material[1,2,3]. Depending on whether Mg becomes interstitial or substitutional it can work as a p-type dopant or compensate other dopants. Though other impurities have been predicted to introduce p-type defects in the nitrides, Mg was the most successful one so far[4].

Using on-line emission channeling [1,3,5] the lattice site location of the radioactive probe 27Mg (t1/2=9.5 min) was measured directly, in GaN, AlN and InN. In that respect, the use of a Ti target during this year's Mg RILIS run allowed for the first time to produce clean beams of 27Mg that are free of isobaric stable 27Al and short-lived 27Na (300 ms) contamination. We found that during room temperature implantation most of the 27Mg atoms occupy substitutional sites of Ga, Al and In in GaN, AlN and InN respectively. However, also a significant fraction of Mg was found in hexagonal sites in AlN and GaN. The remaining Mg was found in random sites of the semiconductor lattice. In order to investigate the temperature dependence of the Mg lattice location and the recovery of the crystal from implantation related damage the implantation and measurements were also performed at higher temperatures. We found the hexagonal interstitital Mg in AlN only for implantation temperatures of 300ºC and below but not for implantation temperatures of 600ºC and above. In GaN, interstitial Mg was still observed at 600℃ but absent at 800℃. Our results hence gave the first direct evidence of the existence of interstitial Mg in GaN and AlN and also indicated its thermal stability. In the case of InN it was found that it recovers completely from implantation damage by annealing at 300℃.

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Session Classification: Solid State and Bio Physics I