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An In-defect complex as a possible explanation for high luminous efficacy of InGaN and AlInN based devices

InGaN based LEDs show a high luminous efficacy despite a high defect concentration. These defects, mainly threading-dislocations that form during the growth of GaN films would normally lead to nonradiative recombination of excitons. However, it seems that such non-radiative recombination is efficiently suppressed in In-containing alloys. The role of indium in GaN and AlN films is investigated with the method of the perturbed angular correlation (PAC) using PAC probe 111In. In addition to In on substitutional Ga sites we observe an In-Nitrogen-vacancy (VN) defect complex, that could be a competing exciton trap and may be involved in the processes leading to the high efficacy. The observed In-VN complex is stable up to high temperatures, but is masked above 400 K [1]. This can be explained by assuming that the Cd-VN complex which is formed after the electron capture (EC) decay of 111In to 111Cd disintegrates during the time the nucleus spends in the 417 keV level preceding the PAC cascade. The same complex was observed in AlInN where the characteristic signal is even more pronounced than in GaInN. To rule out the possible influence of an after effect and to confirm the assumption that nitrogen vacancies are not bound to substitutional Cd impurities, additional measurements with 111mCd and 117Cd were performed at the ISOLDE facility. An after effect can occur, when after the EC a hole remains in the electron shell. Additional electron-gamma measurements are presented, to confirm the nonexistence of such an effect. The PAC measurements are complemented by Rutherford backscattering/channeling and X-ray diffraction to investigate the lattice site location of the implanted probes and the recovery of implantation damage by thermal annealing.

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