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Emission Mössbauer spectroscopy of Mn/Fe implanted III-nitrides

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III-Nitrides doped with 3d metals have attracted much attention since the theoretical prediction that Mn-doped GaN is a potential dilute magnetic semiconductors with high Curie temperatures (Tc ≥ 300 K), resulting from carrier mediated magnetic interactions due to itinerant holes coupling with localized dopant spins. Several reports have shown these materials to exhibit different forms of magnetism, the origin of which is still under debate.

We have undertaken emission 57Fe Mössbauer spectroscopy measurements on GaN, AlN and InN films after implantation of radioactive 57Mn+ ions at ISOLDE/CERN. The samples were held at temperatures between 105–726 K in an implantation chamber and implanted with 57Mn fluences up to 10^12 ions/cm^2. Spectra were collected at gamma emission angles of 0 degrees and 60 degrees relative to the sample's c-axis.

The spectra obtained for GaN and AlN reveal magnetic structure in the 'wings' of the spectra which were analysed using a semi-empirical relaxation model utilizing two Blume-Tjon (BT) sextets. The observed magnetic effect may be explained by a slow spin-lattice relaxation due to paramagnetic substitutional Fe³⁺ weakly coupled to the lattice. The observed spin-relaxation rate closely follows a T² temperature dependence, characteristic of a Raman process. On the other hand, the spectra for InN did not reveal any presence of magnetic features; this could be explained by the absence of high spin Fe³⁺.

The central region of the spectra for all samples showed angular dependence and was initially fitted with two quadrupole split doublets assigned to Fe atoms on substitutional III sublattice (Fe_S) and the majority of Fe located on or near substitutional sites associated with vacancy type defects (Fe_C). In addition, a third quadrupole split doublet (Fe_D) was required to give good fits. The absence of anisotropy on (Fe_D) suggest that this component is due to Fe atoms in isolated amorphous zones.

The annealing behaviour and variation of hyperfine parameters for the fitted spectral components in these materials will be presented.

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