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Investigating lattice sites and charge states of Fe in InGaN via 57Mn+ implantation

$In_xGa_{1-x}N$ is a highly versatile material with tunable properties, widely used in modern optoelectronics[1−3]. Doping it with iron (Fe) introduces new possibilities for tailoring its properties, potentially enabling advancements in electronics, optoelectronics, and spintronics. In this study, ^{57}Fe emission Mössbauer Spectroscopy (eMS) was used to probe the lattice site, charge state and magnetic behaviour of Fe in $In_xGa_{1-x}N$. Temperature- and angle-dependent eMS measurements were conducted at ISOLDE/CERN using radioactive $^{57}Mn^+$ ($t_{1/2}$ = 1.5 min) ions which decay to ^{57}Fe. Our analysis of the $In_xGa_{1-x}N$ spectra for concentrations x = 3, 9, 16, 18, 30 and 34% revealed that more than 55% of the Fe species were Fe^{2+} in a cation site (In/Ga) stabilized by a nitrogen-vacancy. Moreover, each recorded spectra exhibited paramagnetic Fe^{3+} features similar to those seen in nitrides[4] and metal oxides[5,6]. Further analysis of Fe^{3+} revealed slow-spin lattice relaxation. A T^2 temperature relation of the relaxation rates was observed, akin to a two-phonon Raman process. This presentation will also explore how changes in concentration influence hyperfine interactions.

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Notes

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