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Lattice location and properties of Fe in Mn doped (Al, Ga)N

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Gallium nitride (GaN) and related compounds represent a unique class of semiconductors with extraordinary properties related to their crystal structure, optical-, and electrical response.
Their exceptional properties have turned them into building-blocks for a wide range of state-of-the-art applications in optoelectronic and high-frequency devices including light emitting diodes, laser diodes and high power field effect transistors. When doped with a few percents of Mn cations and in the presence of free holes, GaN has been predicted to be a magnetic semiconductor with Curie temperature above room temperature. Mixed semiconductors of AlxGa1-xN (AlGaN) composition, give rise to unexpected and critical magnetic and photonic functionalities when doped with magnetic ion species. . In order to gain control on the properties of the systems, it is of paramount importance to determine the charge state and the arrangement of the metal ions in the lattice.
We have thoroughly characterized AlGaN doped with Mn utilizing extremely dilute 57Mn (T½ = 1.5 min) for 57Fe emission Mössbauer spectroscopy as a part of our IS576 experiment. The Mössbauer spectra give information on the electronic configuration of the implanted probe atoms and on the magnetic properties, thus providing insight into the physics of the materials at the atomic-scale.
Implantation damage i.e. Fe in non-crystalline regions generated by the implantation process is only observed for implantation temperatures below 200 K. This demonstrates the possibilities of doping AlGaN with ion-implantation. In non-Mn doped samples, most of the Fe (˜70%) is observed as Fe2+ on substitutional Al/Ga sites associated with nitrogen vacancies and partly as Fe3+ on defect free substitutional sites. In Mn doped samples, Fe4+ is observed instead of Fe3+, pointing at Mn as acceptor. No evidence for magnetic ordering of Fe is observed.

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