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FLUENCE DEPENDENCE OF THE ATOMIC CONFIGURATION OF 57Fe IN ION-IMPLANTED ZnO

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ZnO doped with 3d-metal impurities has been of scientific interest since the suggestion that it could be a magnetic semiconductor with applications in spintronics [1]. Since then, inconsistent reports on the presence of dilute magnetism have been published, with only few reports using local atomic probe methods such as Mössbauer spectroscopy. In our previous work utilizing emission Mössbauer spectroscopy (MS) following 57Mn (T½ = 1.5 min.) implantation we have demonstrated that in the dilute case (< 10-3 at. %) we observe Fe3+ atoms in a paramagnetic state [2] exhibiting slow (˜105 Hz) spin-lattice relaxation at room temperature [3]. At higher concentrations (˜1 at. %), implanted Fe is known to form precipitates [4]. Little is known about what happens on the atomic scale within the concentration range between the above extremes, and whether within this range carrier mediated magnetism as described by Dietl et al. [1], bound polarons as suggested by Coey et al. [5], or spin polarized defects could form a long-range ferromagnetic coupling.
In this contribution we present emission MS results obtained on 57Mn implanted into 56Fe pre-implanted ZnO and on 57Co/57Fe implanted ZnO.
At the lowest fluence (<3×10-5 at.%) the spectra are dominated by a fairly narrow single line due to Fe2+ on substitutional Zn sites. For medium fluences (2×10-4 at.% to 0.3 at.%) the spectra show evidence of paramagnetic side wings attributed to Fe3+ showing slow paramagnetic relaxation. At the highest fluences (>0.1 at.%) the paramagnetic side wings broaden due to increasing spin-spin relaxation and the spectra are finally (>1 at.%) dominated by Fe2+ on distorted substitutional sites and on damage sites [6].
The fluence dependence and in particular the concentration dependence of the spin-spin relaxation rate will be discussed. This work supports the suggestions given in recent papers that the observed magnetism in many cases is an artifact caused by unintentional precipitation or misinterpretation of the experimental data (see e.g. discussions in [7]).

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