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Magnetism in Iron Implanted Oxides: A Status Report

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Diluted magnetic semiconductors form a special class of magnetic materials which has drawn a lot of attention over the last years both for the interest in the basic physics involved and for possible applications, e.g., in the field of spintronics. However, there is no general agreement on the origin of this type of magnetism. Various coupling mechanisms between the magnetic ions have been proposed, in addition the role of intrinsic defects as well as of unintentional magnetic impurities and precipitations was considered. Oxides with embedded magnetic ions form a subclass of the magnetic semiconductors. To study magnetism at the atomic level Mössbauer spectroscopy (MS) can be utilized, especially with 57Fe. Since the solubility of 3d magnetic ions in most semiconductors is small, their introduction is difficult. So, implantation is a favorable technique. In addition it creates intrinsic defects and thus may influence (create) magnetic phenomena. With this idea in mind 57Fe MS was performed at the ISOLDE facility at CERN following implantation of radioactive 57Mn (T1/2 = 1.5 min) in diverse oxides with a focus on ZnO, one of the most important materials for magnetic semiconductors [1]. The Mössbauer spectra obtained consist to a large part of a magnetic sextet with splitting up to about 50 T and in addition of nonmagnetic components indicating different lattice sites and/or charge states of the Fe atoms. Surprisingly the sextet persists up to measuring temperatures of about 600 K. Experiments performed on other oxides (e.g., MgO, Al2O3) show results with partly similar and partly differing features. Detailed MS studies as function of temperature, implanted Mn concentration, pre-doping of the oxides with various magnetic and nonmagnetic ions and in particular experiments with an external magnetic field of 0.6 T show a variety of phenomena with respect to the occurrence of the magnetic fraction and permit attributing it to Fe-ions in a 3+ paramagnetic state. This observation of a static magnetic pattern is enabled by the unusually long relaxation time > 20 ns even at 600 K though this relaxation time normally strongly decreases with rising temperature. Unlike a first report [2] there is presently no necessity to involve ordered magnetism in the interpretation of the magnetic spectra [3]. The assets of MS in these studies compared to, e.g., the EPR technique (Electron Paramagnetic Resonance) will be discussed. References [1] T. Dietl et al., Science 287, 1019 (2000). [2] G. Weyer et al., J. Appl. Phys. 102, 113915 (2007). [3] H.P. Gunnlaugsson et al., Appl. Phys. Lett. (manuscript in preparation).

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Oral

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