

## Mössbauer studies of dilute magnetic semiconductors (IS-443)

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The study of materials showing multifunctional properties at room temperature (RT) is a challenging task for material science and of importance for future applications in spin-based electronics. The prediction of a Curie temperature above RT in Mn-doped ZnO [1] started a new field of research, with the aim to investigate magnetism in normally non-magnetic oxides. Despite the enormous experimental and theoretical efforts, the origin of the magnetism in (3d-elements) doped and pure ZnO is still a matter of debate in the scientific community. Calculations showing a vacancy-driven mechanism for the magnetism in ZnO have been proposed [2, 3], but clear experimental evidences for such mechanisms are still lacking.

In the framework of the experiment IS-443 at ISOLDE-CERN, we apply Mössbauer spectroscopy to investigate the magnetic properties in ZnO upon implantation with radioactive  $^{57}\text{Mn}^+$  ( $T_{1/2} = 1.5$  min), decaying to the  $^{57}\text{mFe}$  Mössbauer state ( $T_{1/2} = 100$  ns). We study the electronic and magnetic configurations of Fe atoms in the ZnO crystals, and the interaction between the Mn/Fe atoms with the defects induced during the implantation process [4]. Our results show that the majority of the Fe atoms are located on Zn sites in a high-spin  $\text{Fe}^{3+}$  state at  $\approx 600$  K, giving a strong magnetic contribution in ZnO. The formation/annealing of the magnetism in ZnO is interpreted as occurring/disappearing upon the association/dissociation of Mn/Fe complexes with the lattice defects created in the implantation process [4]. We present an overview of our experimental findings focusing on the essential role played by the lattice defects in observing magnetism in ZnO.

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[2] N. A. Spaldin, *Phys. Rev. B* 69, 125201 (2004).

[3] A. Debernardi and M. Fanciulli, *Appl. Phys. Lett.* 90, 212510 (2007).

[4] G. Weyer, H.P. Gunnlaugsson, R. Mantovan, M. Fanciulli, D. Naidoo, K. Bharuth-Ram, T. Agne, *J. Appl. Phys.*, in print.

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