Contribution ID: **29** Type: **Submitted**

Lattice location of transition metals in dilute magnetic semiconductors using EC-SLI (IS453)

Wednesday 19 December 2012 09:45 (20 minutes)

The coexistence of semiconducting behavior and ferromagnetic order in dilute magnetic semiconductors (DMS) continue to challenge our understanding of condensed matter [1,2]. For a given impurity-host combination, the electrical and magnetic properties are largely determined by the lattice sites occupied by the dopant atoms. The canonical example is Mn-doped GaAs (narrow-gap), where Ga-substitutional Mn orders ferromagnetically and interstitial Mn acts as a compensating defect which reduces the Curie (ordering) temperature. The situation is somewhat different in wide-gap DMS materials such as ZnO and GaN doped Mn, Co and Ni, for which it is generally accepted that the transition metals occupy only cation substitutional sites.

In this talk, we will review recent emission channeling experiments on the lattice location of 56Mn, 61Co and 65Ni in GaAs, ZnO and GaN [3-6], carried out at the on-line EC-SLI (Emission Channeling of Short-lived Isotopes) setup at ISOLDE. In Mn-implanted GaAs, we have shown that, while the majority of the implanted Mn impurities occupy substitutional Ga sites, up to ~30% occupy tetrahedral interstitial sites with As nearest neighbors [3,5]. Contrary to the general belief that interstitial Mn is removed by thermal annealing at ~200ºC [5,6], we have shown that the interstitial fraction persists above 400ºC [3,5]. In Co- and Mn-implanted ZnO and GaN, in addition to the expected majority in cation sites, we have shown that significant fractions (~20%) of the implanted Co and Mn impurities substitute the anion (O in ZnO and N in GaN) [4,6], a behavior which had never been observed or even considered theoretically before.

These results have profound implications on the current understanding of DMS materials, in terms of self-compensation mechanisms and the prospects to achieve room temperature ferromagnetism. As an outlook, we will outline how the new opportunities created by these findings will be explored at the Nuclear Solid State Physics group at IKS (KU Leuven), not only at ISOLDE but also at neutron (at ILL-Grenoble and HZB-Berlin) and synchrotron (ESRF-Grenoble and the Australian Synchrotron) facilities.

[1] T. Dietl, Nature Materials 9 (2010) 965.
[2] M. Dobrowolska, K. Tivakornsasithorn, X. Liu, J. K. Furdyna, M. Berciu, K. M. Yu, and W. Walukiewicz, Nature Materials 11 (2012) 444.
[3] L. M. C. Pereira, U. Wahl, S. Decoster, J. G. Correia, M. R. da Silva, A. Vantomme, and J. P. Araújo, Appl. Phys. Lett. 98 (2011) 201905.
[4] L. M. C. Pereira, U. Wahl, S. Decoster, J. G. Correia, L. M. Amorim, M. R. da Silva, J. P. Araújo, and A. Vantomme, Phys. Rev. B 84 (2011) 125204.
[5] L. M. C. Pereira, U. Wahl, S. Decoster, J. G. Correia, L. M. Amorim, M. R. da Silva, J. P. Araújo, and A. Vantomme, Phys. Rev. B 86 (2012) 125206.
[6] L. M. C. Pereira, U. Wahl, S. Decoster, J. G. Correia, L. M. Amorim, M. R. da Silva, J. P. Araújo, and A. Vantomme, accepted for publication in Physical Review B.

Primary author: Dr PEREIRA, Lino M. C. (Instituut voor Kern- en Stralingsfysica, KU Leuven, B-3001 Leuven, Belgium.)

Co-authors: Prof. VANTOMME, André (Instituut voor Kern- en Stralingsfysica, KU Leuven, B-3001 Leuven, Belgium.); Prof. ARAÚJO, Joao P. E. (IFIMUP and IN–Institute of Nanoscience and Nanotechnology, Universidade do Porto, 4169-007 Porto, Portugal.); Dr CORREIA, João Guilherme M. (Instituto Tecnológico e Nuclear, Instituto Superior Técnico, Universidade Técnica de Lisboa, 2686-953 Sacavém, Portugal.); Prof. TEMST, Kristiaan (Instituut voor Kern- en Stralingsfysica, KU Leuven, B-3001 Leuven, Belgium.); AMORIM, Ligia P. A. (Instituut voor Kern- en Stralingsfysica, KU Leuven, B-3001 Leuven, Belgium.); Dr DECOSTER, Stefan (Instituut voor Kern- en Stralingsfysica, KU Leuven, B-3001 Leuven, Belgium.); Dr WAHL, Ulrich (Instituto Tecnológico e Nuclear, Instituto Superior Técnico, Universidade Técnica de Lisboa, 2686-953 Sacavém, Portugal.)

Presenter: Dr PEREIRA, Lino M. C. (Instituut voor Kern- en Stralingsfysica, KU Leuven, B-3001 Leuven, Belgium.)

Session Classification: Solid State Physics