Defect Induced Magnetism in ZnO: a First Spintronic Device

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The appearance of a magnetically ordered state through atomic lattice defects with a concentration of roughly 5 at.% in a nominally non-magnetic material depends on the details of the lattice structure and the elements involved. This phenomenon, called nowadays Defect-Induced Magnetism (DIM), has been found in a broad spectrum of materials, like graphite [1], SiC [2] and several oxides [3]. The evidence for magnetic order obtained by different experimental methods like, e.g., Magnetization, XMCD, Electrical transport, EPR and NMR, and the sensitive magnetic impurities characterization through PIXE, leaves no doubt about its intrinsic origin in solids.

An interesting example of DIM in oxides can be found in ZnO, a large gap semiconductor that has been thoroughly studied in the last years [3]. DIM in pure ZnO is induced by increasing the concentration of Zn vacancies through, e.g., proton irradiation [4]. These defects can be stabilized in the ZnO lattice and remain above room temperature by previous doping it with Li or Na [5], for example. The Curie temperature reached in this case remains always above 300K [3,4,6].

In spite of a large amount of work, a possible application of DIM has not yet been realized. In this work we present an electron-spin filter and a magnetoresistance sensor based on ZnO nanostructures, in which magnetic order was reached by introducing atomic lattice defects following the simple procedure to produce vacancies in ZnO through low-energy plasma treatment [4,6]. The measured signals and the scalability of the phenomenon indicate that the proposed device has good potentials for applications in micro- and nanospintronics.