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On the origin of the ferromagnetism in diluted magnetic semiconductors and diluted magnetic oxides

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Abstract:

In the field of spintronics, diluted magnetic semiconductors (DMSs) and diluted magnetic oxides (DMOs) have attracted much interest in recent years. These materials, consisting of semiconductor (i.e., ZnO) or oxide (i.e., CeO_2), in which the cation is randomly substituted by a transition metal (Fe, Co, and Mn), present both semiconducting properties required by classic microelectronics and a spin polarization of the carriers in conjunction with macroscopic ferromagnetic properties. Since 2001, extensive research has been performed on these materials, a large amount of experimental data has been accumulated and a corresponding mechanism to explain the observed magnetism has been proposed. However, the origin of the ferromagnetic behaviour remains a matter of debate to this day

In this controversial context, highly sensitive characterization techniques have been used to elucidate the origin of this experimentally observed ferromagnetism. In addition to conventional techniques such as x-ray diffraction or high resolution electron microscopy, many methods have been used to identify the local structure of doping elements such as electron energy loss spectroscopy, x-ray photoelectron spectroscopy, x-ray absorption spectroscopy, and x-ray magnetic circular dichroism and also to investigate the spatial distribution of magnetic dopants and to detect the eventual formation of magnetic clusters or parasitic phases such as atom probe tomography. The results obtained bring a good support to the defects-induced ferromagnetism models suggested by some research groups.