Understanding Defect Structure of Metal Ion Doped (Fe^{3+}, Mn^{2+}, Co^{2+}) ZnO Nanomaterials by Using High-Field EPR Spectroscopy

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Introduction

Doping ZnO with transition metal elements such as Fe, Co, or Mn, leads to materials with entirely different behavior towards magnetic and optical excitation. This new kind of materials systems is commonly named diluted magnetic semiconductors (DMS) [1]. DMS materials based on ZnO could show not only ferromagnetism at room temperature upon doping with transition metal ions, e.g., Fe^{3+}, Co^{2+}, and Mn^{2+}, but also exhibit semi-conducting properties.

Experimental

High-frequency EPR measurements over the temperature range 2-300 K were performed using the 15/17 T magnet and transmission instrument at the NHFML.

Results and Discussion

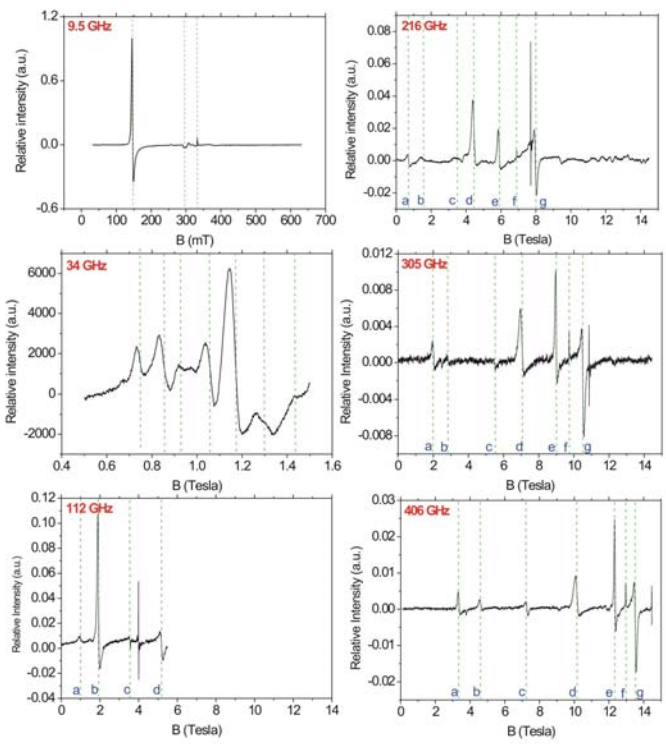

Fig. 1: Multi-frequency (from 9.5 up to 406 GHz) EPR spectra of 0.1 mol% Co doped ZnO sample. 112, 216, 305 and 406 GHz were measured at the NHMFL in Tallahassee, FL.

In Fig. 1 we present multi-frequency EPR spectra of Co-doped ZnO. It is clearly seen that the Co spectra change drastically when going from X-band frequency to 406 GHz. This is of course due to the resolution power of high-field EPR, by which it is possible to resolve higher electronic transitions for systems with large zero-field splittings (ZFS). Indeed, unpublished results on Mn-doped ZnO (data not shown) reveal that X-band EPR is not sufficient to reveal all electronic transitions for the Mn case, whereas for the Co case one needs higher magnetic fields. A thorough analysis of this spectral information will yield detailed information on the oxidation state of Co ions, the sign of the ZFS parameter and other relevant parameters, as well as the local position of Co in the ZnO lattice. To investigate size effects by EPR, the room temperature X-band EPR spectra of Fe^{3+}-doped ZnO particles (165 nm, 105 and 48 nm) were recorded. These results have been published elsewhere [2].

Acknowledgements

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References

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