Giant Zeeman effect in polycrystalline zinc oxide with Fe^{3+} ions

Joanna Papierska[1], Ekaterina Chikoidze[2], Mostafa Boshta[3], Hans-J. von Bardeleben[4], Yves Dumont[2], M. H. Sayed[3], Wojciech Pacuski[1], Michał Nawrocki[1], and Jan Suffczyński[1]

[1] Faculty of Physics, University of Warsaw, Warsaw, Poland
[2] Groupe d'Etudes de la Matiere Condensee (GEMaC), Universite de Versailles St-Quentin en Yvelines – CNRS, Versailles, France
[3] Solid State Physics Department, National Research Center, Giza, Egypt
[4] Sorbonne Universités, UPMC Université Paris 06, UMR7588, Institut des Nanosciences de Paris, F-75005, Paris, France

Ultra long spin coherence time (>150 μs) found recently for Fe^{3+} ions in ZnO [1] makes Fe doped ZnO one of the most promising and yet unexplored spintronic systems. The long relaxation time [1] suggests that Fe^{3+} ions in ZnO are decoupled from their environment. Hence, a question arises: do Fe^{3+} ions couple to band carriers through to *s,p-d* exchange interaction? Previous Magnetic Circular Dichroism (MCD) study of (Zn,Fe)O [2] did not give a clear answer, since the iron charge state was not determined. Moreover, a giant Zeeman splitting has been not observed for individual excitonic lines in Fe^{3+}doped ZnO so far.

The studied polycrystalline (70-80 nm grain size) ZnO layers with Fe ions are produced by a spray pyrolysis on glass or fused silica substrates. The respective pure ZnO layers serve as a reference. XRD measurements reveal preferential c-axis orientation perpendicular to the film plane or directed through the (101) plane in the case of films deposited on glass [3] or fused silica substrates, respectively. The reflectivity measurements are performed in the Faraday configuration in magnetic field up 10 T, in temperature range from 1.5 K to 50 K, with a halogen lamp serving as a source of the ultraviolet light. The MCD is determined basing on the acquired reflectivity spectra.

Clear transitions of three excitons characteristic for a wurtzite structure semiconductor, where the valence band is split into three subbands, are observed at energy around 3.38 eV, 3.39 eV and 3.43 eV, respectively, in the case of the layers deposited on glass. Much weaker excitonic transitions are observed in the case of the layers deposited on fused silica substrates.

A comparison of two types of samples indicates that the MCD signal in the excitonic spectral region is much stronger in the case of ZnO with Fe grown on the glass. The integrated MCD intensity from ZnO with Fe on glass is well described by the paramagnetic Brillouin function with g factor = 2.0062 [4] and spin 5/2 (as for Fe^{3+} ions), without any free fitting parameters. The electron paramagnetic resonance measurement confirms the presence of ions Fe^{3+} in the samples grown on glass and on fused silica substrates.

Through the observation of the excitonic giant Zeeman effect, the experiment confirms the existence of *s,p-d* interactions between the Fe^{3+} ions and band carriers in ZnO. The studies highlight the impact of a substrate on the crystalline quality and crystallographic orientation of ZnO layers, as well as on incorporation of the Fe ions into them.

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