Magneto-electrodeposition and characterization of Co-doped ZnO thin films.

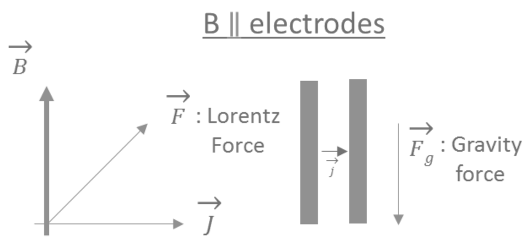
Mathilde Stübner[1], Ophélie Riou[1], Aurélie Solignac[2], Jean-Paul Chopart[1], Anne-Lise Daltin[1]

[1]LISM, Université de Reims-Champagne-Ardennes, France

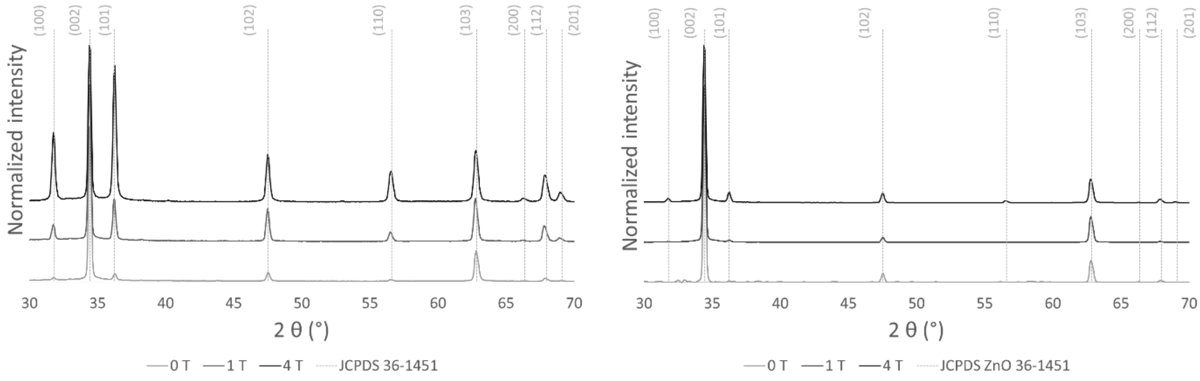
[2]Laboratoire Nano-Magnétisme et Oxydes (SPEC), IRAMIS CEA, France

Diluted magnetic semiconductors (DMS), particularly oxides (ODMS), are way attractive due to their manifold applications in the field of spintronics (memory devices, field-effect transistors) as in the optoelectronics (p-n junctions in solar cells). DMS are basically semiconductors which are doped with transition metals (TM). So, they rely on charge carriers properties, but also on their controllable spins (contribution of the dopant), revealing ferromagnetic properties. Among all the candidates, zinc oxide is one of the most studied in spintronic. Indeed, since Dietl et al. have hypothesized room temperature ferromagnetism (RT-FM) for Mn doped ZnO (Tc>300K) [1], zinc oxide fueled huge interest. It also possesses wide band gap (Eg ~ 3.3 eV at 300 K) and a high conductivity among some other properties. This transparent semiconductor is a good candidate for optoelectronics. Its valence (2+) permit a huge choice of 3d TM as dopants. In this study, zinc oxide films has been doped with cobalt, which is a ferromagnetic TM. Indeed cobalt is a suitable dopant for ZnO thanks to its close ionic radius (65 pm for Co^{2+} and 74 pm for $Zn^{2+)}$ and its numerous electronic states.

There is several way to prepare zinc oxide samples both physical and chemical. Among these electrodeposition is suitable, because it's an affordable technics, easily enforced, which allows to surimposed a magnetic field. A magnetic field is applied during the deposition, in order to study its influence during the synthesis on ZnO (Co-doped or not). Effects of a constant magnetic field on an electrochemical reaction have been studied taking in account magnetohydrodynamics (MHD) convection induced by a Lorentz force [2]. Several magnetic field amplitudes have been applied and their effects on morphologies phases, and magnetic properties have been analyzed. Characterizations such as XRD, SEM, EDX and SQUID/VSM measurements have been used to determine those properties.



(a)



(b) (c)

Figure 1. a) Electrodes position compared to field with $\vec{F}=\vec{J} \wedge \vec{B}$; XRD patterns of ZnO under 0, 1 and 4 Tesla normalized along (002) (b) Co-doped, (c) Undoped

Several authors recognize that MHD induce effects on deposits among these, they mainly report effects on morphology and/or crystallographic orientation [3]–[5]. Here, ZnO is (002) oriented on titanium substrate (Fig. 1) and magnetic field seems to act on the relative peak intensities, mostly for the doped oxides.

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Acknowledgements: Authors thank the Regional Council of Grand Est (France) for their financial support (grant SYMEDOX).