# STRUCTURAL STUDIES OF HEAVILY TRANSITION METAL IMPLANTED ZnO

**E. Dynowska [1], W. Szuszkiewicz [1], C. Ziereis [2], J. Geurts [2], S. Müller [3], C. Ronning [4], J. Domagala [1], P. Romanowski [1], and W. Caliebe [5]**

[1] *Institute of Physics, Polish Academy of Sciences, al. Lotników 32/46, 02-668 Warszawa, Poland*
[2] *Physikalisches Institut, Universität Würzburg, am Hubland, 97074 Würzburg, Germany*
[3] *II. Physikalisches Institut, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany*
[4] *Institut für Festkörperphysik, Universität Jena, Max-Wien-Platz 1, 07743 Jena, Germany*
[5] *Hasylab at DESY, Notkestr. 85, D-22603 Hamburg, Germany*

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The study of ZnO alloyed with transition metals (TM) has been stimulated by theoretical predictions of room temperature ferromagnetism for these compounds [1, 2]. One of the methods for the incorporation of TM into ZnO is ion implantation connected with proper thermal treatment. The magnetic properties of ZnO:TM compounds depend on their crystal structure after such procedure.

In this work we report the results of structural characterization of ZnO crystals implanted with 16 at.% of Mn, Co, Fe and Ni ions and annealed at 900°C in air. The X-ray structural characterization was performed using synchrotron radiation at the W1.1 beamline at DESY-Hasylab. The monochromatic X-ray beam of wavelength $\lambda$ = 1.54056 Å was used. Two modes of measurement were applied: symmetrical $\omega$-$2\theta$ scan and coplanar $2\theta$ scan in the glancing incidence geometry.

Fig. 1 shows the X-ray $\omega$-$2\theta$ patterns for Mn- and Co-implanted and annealed ZnO samples, respectively. The interpretation of these patterns leads to different results for these two samples. The main effect of annealing of Mn-implanted ZnO sample is the creation of monocrystalline inclusion of $ZnMn_2O_4$ tetragonal phase ($a$ = 5.7204 Å and $c$ = 9.2450 Å) - the (101) lattice planes of this phase are parallel to the (0001) lattice planes of ZnO matrix. Moreover, the left-side asymmetry of 000$l$ peaks of ZnO matrix (Fig. 1a) indicates the presence of the solid solution $Zn_{1-x}Mn_xO$ phase with very low quantity of Mn corresponding to $x \approx 0.005$.

In the pattern presented in Fig. 1b the very strong peaks originating mainly from the bulk ZnO and several much weaker ones are visible. The detailed analysis of the peaks originated from ZnO exhibits the right-side asymmetry of these peaks that confirms a creation of the solid solution $Zn_{1-x}Co_xO$ with estimated composition $x \approx$ 0.075. The weak peaks visible in the pattern are probably caused by a trace inclusions of some single crystalline phases with crystallographic orientation closely connected with (0001) planes of ZnO. Only three weak reflections have been identified up to now: two of them as belonging to the elemental Zn and one can be attributed to the $ZnCo_2O_4$ or $Co_3O_4$ phases – these phases have very similar crystal structure.

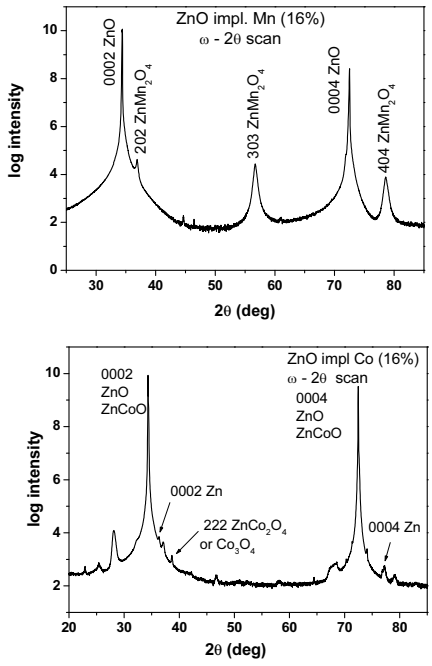


Figure 1. The X-ray $\omega$-$2\theta$ diffraction patterns of ZnO:Mn (a) and ZnO:Co (b) samples after annealing.

Concluding, we can state that in the case of ZnO:Mn majority of Mn incorporated by implantation into bulk sample of ZnO after annealing has been located in $ZnMn_2O_4$ spinel phase, while in ZnO:Co majority of Co have been built into ZnO matrix creating the ternary compound $Zn_{0.925}Co_{0.075}O$.

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