

(Zn,Co)O films grown by Atomic Layer Deposition

**M.I. Łukasiewicz¹, M. Godlewski^{1,2}, E. Guzewicz¹, B.S. Witkowski¹, A. Wittlin¹,
M. Jaworski¹, W. Stefanowicz¹, M. Sawicki¹, R. Jakiela¹, A. Wołoś¹, Z. Wilamowski¹**

¹ *Institute of Physics PAS, Al. Lotników 32/46, 02-668 Warsaw, Poland*

² *Dept. Mathematics and Natural Sciences, College of Sciences UKSW, Dewajtis 5,
01-815 Warsaw, Poland*

Despite many efforts, origin of ferromagnetic (FM) response in (Zn,Co)O is still not clear. We demonstrated recently that the Atomic Layer Deposition (ALD) growth method enables us to control film uniformity of (Zn,Co)O films [1]. Magnetic investigations show that the room temperature ferromagnetic (FM) response is observed only in films with non-uniform Co distribution [2]. On the other hand, (Zn,Co)O films with the uniform Co distribution remain paramagnetic even at increased concentration of Co and intrinsic defects.

In the present work we employed several experimental methods to determine uniformity of Co distribution and for search of foreign phases and metallic inclusions. We employ SIMS, XPS, EDX, SEM and CL investigations finding a surprising anti-correlation between the strength of the observed FM response (SQUID measurements) and sample thickness. Both XPS sputter depth-profiles and depth-dependent XMCD [2] studies strongly indicate that the observed FM response due to Co metal accumulations at the (Zn,Co)O /Si interface. To determine an inter-link between uniformity of Co distribution and electrical and magnetic response of the films we employed two microwave techniques: microwave AC conductivity and electron spin resonance (EPR) [3]. We observed considerable differences between DC and AC conductivity of the (Zn,Co)O samples. Whereas the DC conductivity is almost the same for all studies samples, the AC conductivity is considerably higher for the (Zn,Co)O layers with non-uniform Co distribution, which indicates the important role of metallic Co inclusions.

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