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Formation of different magnetic phases and high Curie temperature ferromagnetism in Fe^{57}-implanted ZnO film

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ABSTRACT

We investigated magnetic properties of ZnO thin film implanted with Fe^{57} ions to the fluence of 1.00×10^{17} ions/cm^2. Both vibrating sample magnetometry and magneto-optical Kerr effect measurements revealed strong room temperature ferromagnetism with similar hysteresis loops. Temperature dependent measurements showed a very high Curie temperature around 850 K. Conversion electron Mossbauer spectroscopy experiments proved the existence of paramagnetic Fe^{+3} and Fe^{+2} ions and also the presence of substitutional Fe atoms in the hexagonal ZnO crystal resulting in intrinsic ferromagnetic order.

1. Introduction

Wide band-gap semiconductors and oxide materials recently have attracted remarkable attention due to their ferromagnetic properties at room temperature upon doping with magnetic atoms. Recently, theoretical and experimental studies have shown that ferromagnetic order can be formed in the transition metal (TM) doped ZnO [1–9] and TiO_2 [10–15] materials. In these studies incorporation of magnetic metal ions in the host lattice and coexistence of nanoclusters of magnetic ions are considered to be responsible for the observed ferromagnetism. However, a mechanism for the ferromagnetic ordering is still controversial for these compounds.

In this study, we present room temperature and temperature dependent magnetic properties of Fe^{57}-implanted single crystalline ZnO thin film, investigated by using vibrating sample magnetometry (VSM), magneto-optical Kerr effect (MOKE) measurements, as well as the conversion electron Mossbauer spectroscopy (CEMS).

2. Sample preparation

ZnO film with thickness of 135 nm was deposited on top of Si (100) substrate by rf magnetron sputtering. The film was grown at room temperature with the deposition pressure of 2×10^{-3} mbar and with the sputtering power of 100 W. Under these conditions the crystal structure of hexagonal wurtzite lattice was obtained for the film. Then, the crystalline ZnO film was implanted in an ILU-3 ion accelerator (Zavoisky Physical-Technical Institute, Russia) with 40 keV iron ions (enriched with Fe^{57} isotopes up to 40%) to a fluence of 1.00×10^{17} ions/cm^2 at an ion beam current density of $j = 8$ μA/cm^2.

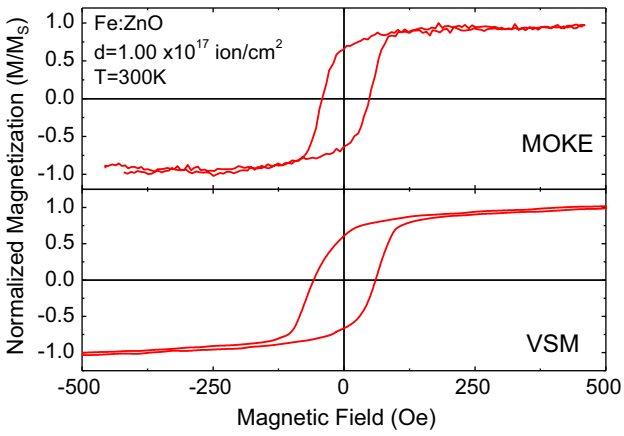

Fig. 1. Room temperature hysteresis curves (M–H) of Fe^{57}-implanted ZnO were taken by using both MOKE and VSM magnetometries.

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