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Anisotropic Ferromagnetism in High Dose Iron Implanted Magnesium Oxide

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The observation of ferromagnetism ($T_C \leq 200$ K) in Mn-doped indium and gallium arsenides stimulated studies of magnetism in other semiconductor materials doped with magnetic ions [1]. It was theoretically predicted that in wide-gap semiconductors with a 3d-element impurity, the Curie temperature may be even higher than room temperature [2]. Meanwhile, one of the possible mechanisms of high-temperature ferromagnetism in such compounds is the formation of magnetically ordered clusters from implanted 3d-elements [3]. New multifunctional devices may be developed on the basis of such nanostructured systems [4].

Here we present the results of a study of single-crystal magnesium oxide (MgO) implanted with iron ions (^{57}Fe – 40 %) with an energy of 40 keV and to a fluence of $1.5 \cdot 10^{17}$ ions/cm^2. The valence state and local environment of the introduced iron impurity were studied by Mössbauer spectroscopy at room and low (80 K) temperatures. The magnetic properties of the sample were investigated by vibration magnetometry in the temperature range of 10–300 K and ferromagnetic resonance (FMR) at room temperature in various geometries.

It was found that MgO single crystal implanted with iron ions exhibits a strong ferromagnetic response at room temperature and fourth-order in-plane magnetic anisotropy. The implanted iron impurity was found in different valence and phase states. A significant part of the impurity forms α-Fe nanoparticles. They are the main source of the observed ferromagnetism at room temperature. We suppose that these nanoparticles are coherently buried into the MgO host matrix. This explains the discovered magnetic anisotropy in the plane of the implanted surface.

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