

日本物理学会九州支部特別講演会

題目 : Crystallinity and stability of single/bi-layer epitaxial Fe₃O₄ thin films

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主催 : 日本物理学会九州支部

Abstract

Magnetite (Fe₃O₄) is one of the most known magnetic materials. Due to its fascinating properties and especially its wide application as recording media and in catalyst, it has attracted a large attention since 1960s. Recently, due to the fact that Fe₃O₄ is referred as a half-metallic material having a full spin polarization at the Fermi level and has a high critical temperature, it is considered as a promising candidate for technical applications as spintronic devices at room temperature.

Spintronic devices are based on a thin film technology and thus it is highly required to obtain thin films with a high crystalline quality (crystallinity) and controllable physical properties. The difficulty in using magnetite thin films is that their properties are strongly dependent on the layer properties as well as on the interaction between the layers and the substrates. Thus, it is very important to have a deep understanding of not only the surface as well as the entire film properties but also the influence of different processes at the interfaces of the magnetite films on those properties.

We focus on investigating the crystallinity and stability of the single and bi-layer films grown epitaxially on MgO(001) substrates (Fe₃O₄/MgO(001), Fe₃O₄/Fe/MgO(001), Fe/Fe₃O₄/MgO(001)) with different layer thickness in the range of 10-100nm. The influence of interdiffusion during the film-growth and of external conditions (e.g. ageing, thermal annealing, and 1MeV Ar⁺, Kr⁺ and Au⁺ ion irradiation) on the film crystallinity, on the layer structure and composition have been thoroughly studied by means of Rutherford backscattering spectrometry (RBS), channeling experiments (RBS-C) and X-ray reflectometry (XRR). TRIM/SRIM SIMNRA computer code were used for data estimation and analysis.

The single-layer has always a good crystallinity. However, a pure magnetite layer could be found on the surface of single-layer film in the case if the layer thickness is larger than 20 nm. In the case of bi-layer films, independently on the layer thickness, on the film surface is always the stoichiometric Fe₃O₄ layer. However, their crystallinity is lower.

Thermal annealing promotes Mg out-diffusion and consequently the surface layer composition change into a spinel one.

The magnetite composition in the single-layer films was easily modified even if upon ion irradiations by small ions fluence.

The important outcome is our finding the high stability of the surface Fe₃O₄ layer of the bi-layer film upon ion irradiations. For all bi-layer films, the stoichiometric Fe₃O₄ layer on the film surface is well preserved at a quite high rare-gas (Ar⁺ and Kr⁺) ion as well as upon metallic (Au⁺) ion irradiations, despite of some decreasing in the layer thickness, strong intermixing at the interfaces and a partial or complete oxidization of the buffer Fe layer.

The research has been realized within the scope of cooperation between NanoLab-UP Krakow (author, M. Krupska, S. Sowa, A. Duda) and other research groups in Krakow (led by J. Korecki), Frankfurt-Damstadt (A.G. Balogh) and in Prague (A. Mackova, P. Malinsky).

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