Epitaxial $MnFe_2O_4$ and $CoFe_2O_4$ ultrathin films for spin–filtering applications

B.Warot-Fonrose[1], C.Gatel[1], S.Matzen[2] and J.B. Moussy[3]

1. CEMES-CNRS, Toulouse, France
2. Solid State Materials for Electronics - Zernike Institute for Advanced Materials, University of Groningen, Groningen, The Netherlands
3. CEA-Saclay, IRAMIS, SPCSI, Gif-Sur-Yvette, France

E-mail : warot@cemes.fr

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The generation of highly spin-polarized currents is mandatory to develop high performance spintronics devices such as spin metal-oxide-semiconductor field-effect transistors [1,2]. In the last few years, spin filters have emerged as a promising alternative to create artificial spin-polarized current sources. They consist of the stacking of a non-magnetic thin film, a ferromagnetic or ferrimagnetic tunnel barrier and a ferromagnetic electrode. Ferromagnetic spin filters rely on the spin-dependent transmittance of ferromagnetic tunnel barriers due to the existence of an exchange-split band gap. Several requirements have to be fulfilled by the barrier to be efficient: the magnetism has to remain important even at room temperature and for very thin thickness (down to 3nm) to allow for spin-dependent tunnel transport.

One class of material could fit all these properties: the ferrite class, XFe_2O_4 with X=Ni [3], Mn, Co, Fe, for example. In this work, we will focus on two ferrites: $MnFe_2O_4$ and $CoFe_2O_4$ [4,5]. Both materials have Curie temperatures above room temperature and are insulators. Strain and cationic order are known to modify the magnetic properties of such ferrite thin films. We will therefore focus on the strain analysis of 5nm thick films deposited on various substrates. The quantitative analysis of the deformation in the layer by the geometrical phase analysis makes it possible to characterize the effect of epitaxial growth and correlate it with magnetic properties. In parallel, measurement of the cationic disorder by x-ray magnetic circular dichroism gives complementary information on the quality of the films.

High resolution transmission electron microscopy experiments have been carried out on a Tecnai F20 microscope, fitted with an aberration corrector. The sample preparation was done by tripod polishing and ion milling, special care has been taken to get lamella with a constant thickness to avoid contrast inversion.

One of the experimental results for the $MnFe_2O_4$ film is presented on figure 1 (a and b). The layers, deposited on Al_2O_3(0001) substrates, are fully relaxed and show a ferromagnetic behavior at room temperature as well as an insulating behavior. Figure 2 shows the deformation analysis on a $CoFe_2O_4$ layer deposited on $MgAl_2O_4$, the layer is fully strained by the substrate. This strain state will be correlated to unusual magnetic properties for cobalt ferrite deposited in thin films.

We will present the correlation between strain states and magnetic properties for both ferrites as a function of substrates (MgO, Al_2O_3, $MgAl_2O_4$) and the orientation of the substrate ($MgAl_2O_4$(001) and $MgAl_2O_4$(111) for example).

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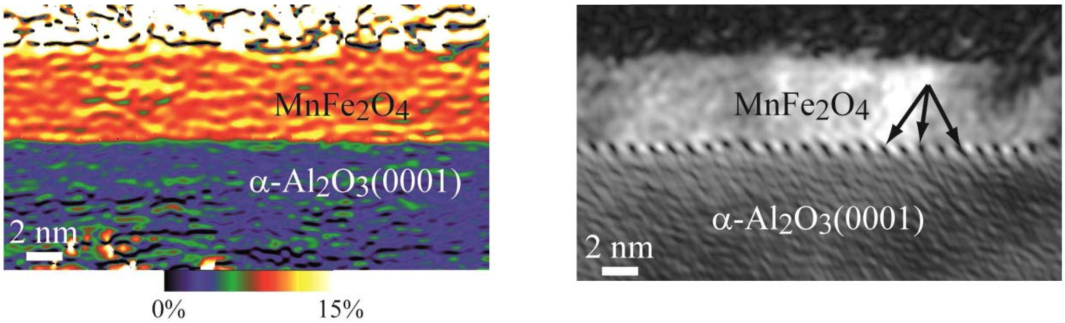

Figure 1. *left : geometrical phase analysis of the deformation inside the $MnFe_2O_4$ layer, right : phase image that present a dislocation network at the interface*

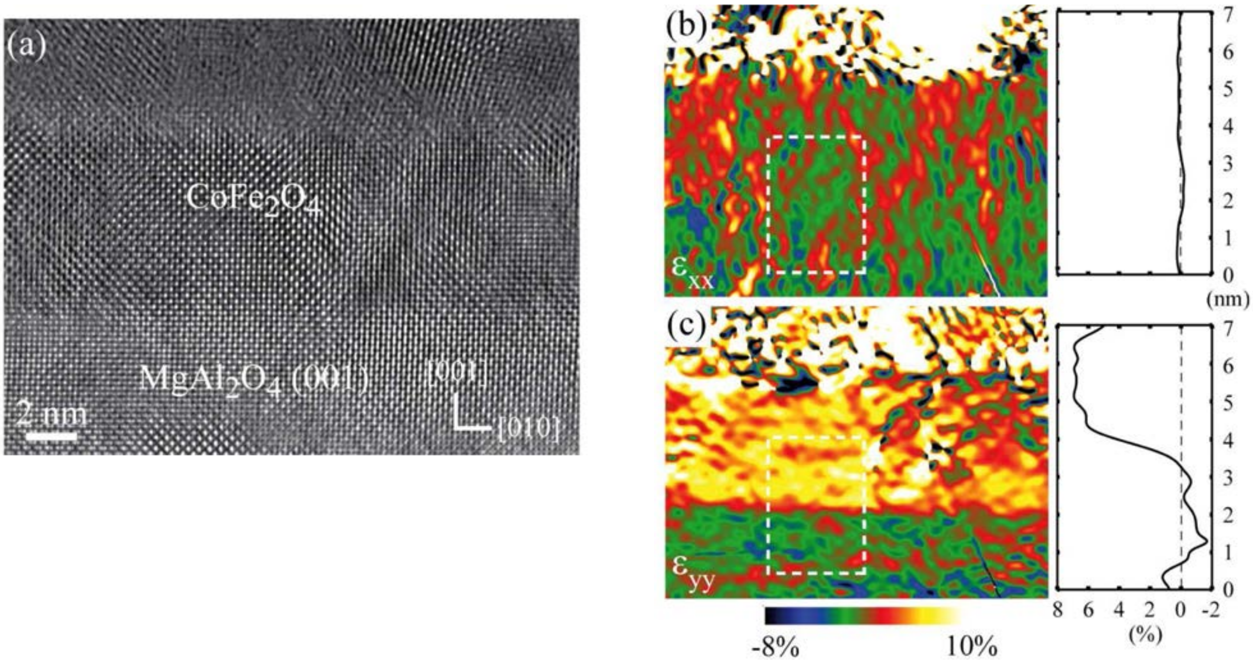

Figure 2. *(a) HRTEM image obtained on the CoFe2O4 (a) with the corresponding geometrical phase analysis for the in-plane deformation ε_{xx} (b) and the out-of-plane deformation ε_{yy} (c).*