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X-ray Photoemission Electron Microscopy study of Fe/Mn/NiO (100) sandwich

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Introduction

The exchange bias effect occurring at the ferromagnetic/antiferromagnetic (FM/AFM) interface regions attracts the worldwide attentions due to both the practical applications and fundamental research interest. The AFM spin structure is a key ingredient to understand this phenomenon. However, the self-compensated magnetic structure renders antiferromagnets a difficult class of materials to study. The advent of X-ray photoemission electron microscopy (XPEEM) makes both FM and AFM domains observable with elemental-specificity and high spatial resolution, and further deepen our understanding of the exchange bias [1].

Since the set-up of PEEM facility at Photon Factory (Staib PEEM 350), we have carried out a serial of experiments on NiO (100) surface [2]. In this contribution, we present the XPEEM results of Fe (20ML)/Mn (wedge 0-20ML)/NiO (100) system. Considering the Mn (wedge)/Fe with perfect interface, due to the AFM type coupling between Fe and Mn spins at interface and also among the Mn layers, the top surface layer of Mn wedge should has opposite magnetization direction among the adjacent layers. Our original motivation is to study the influence of these surface moments of Fe biased Mn wedge on the NiO AFM domains. However, we found some special contrast in this system.

The Fe and Mn are evaporated by electron bombardment and the thickness is calibrated with quartz-crystal oscillator. The experiments were performed at BL-2C at Photon Factory and only linearly polarized light is available.

Results and discussion

Fig. 1 (a) shows the topographic PEEM images where Mn is estimated to be around 15ML by X-ray absorption spectroscopy (XAS), and (b) illustrates the NiO AFM domain contrast at Ni L_2 edge. Except for the clear stripe-like domains as illustrated in the rectangle-framed area, some cloud-like contrast also presents as shown in the circle-framed region. The origin of this cloud-like contrast is assumed as the oxidization/reduction reaction at Mn/NiO interface. The reduction of Ni will alter the NiO AFM domain structure in the interfacial region. Fig. 1(c) and (d) denote the XAS at the Mn and Fe edge, respectively. The Mn XAS curve shows multiple peaks at both L_2 and L_3 edge, which directly reflect the partial oxidization of Mn at NiO surface. The Fe XAS curve indicates that Fe film is kept in a metallic phase.

Upon dividing the image taken at Fe L_2 and L_3 edge, we get the domain contrast as illustrated in the Fig. 1(e). The Mn edge demonstrates almost the same contrast with respect to Fe as shown in Fig. 1(f). The contrast at Mn edge is obtained by dividing the L_3 main peak with its shoulder. It is noticed from the comparison between Fig.1 (b) and (e) or (f) that the domain contrasts at Fe and Mn edge have no direct spatial correlation with domains of NiO substrate. The Fe-Mn contrast pattern demonstrates a dendrite structure and has protrusive crystalline whiskers around the edge, which imply that a new FeMn alloy phase should form at Fe/Mn interface and also the growth of the new Fe-Mn phase have some preferential directions on the NiO substrate.

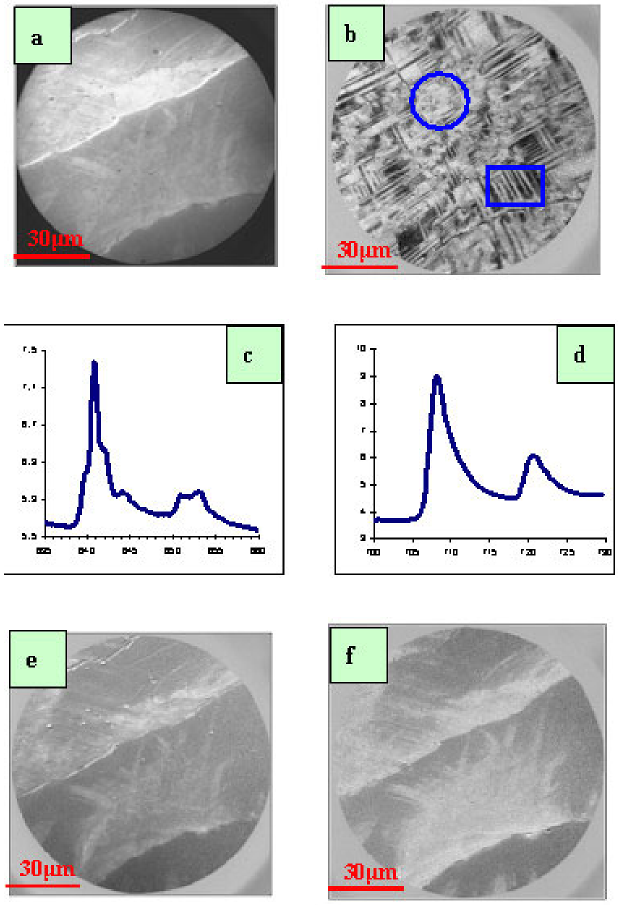

Fig. 1 (a) topographic images taken at Ni L2 edge; (b) NiO AFM domain contrast image;(c) and (d) are X-ray absorption spectroscopy at Mn and Fe edge respectively; (e) and (f) are Fe and Mn XMLD contrast images respectively.

References

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