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HRTEM and STEM Study of Interfaces in FePt/CoCrPt/MgO Structure for Perpendicular Magnetic Recording

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This research is driven by the continuous demand to increase the areal density of magnetic recording devices [1]. $L1_0$ FePt and CoCrPt are important candidates for high-density magnetic recording media [2, 3]. Using DC magnetron sputtering, we have successfully prepared the perpendicular exchange-coupled hard/soft $Fe_{52}Pt_{48}$ (=FePt)/$Co_{64}Cr_{17}Pt_{19}$ (=CoCrPt) magnetic bilayers on MgO (100) single crystal substrate [4]. Their magnetic properties are influenced by the substrate and preparation conditions. Their structures and defects are key factors to understand their properties.

This paper focuses on the structural characterization of FePt/CoCrPt bilayers, in particular the interfaces, by means of advanced TEM techniques, such as HRTEM, STEM and EDS, and first-principles calculations.

Fig. 1 is a STEM annual dark field image of the nano-structured CoCrPt/FePt/MgO device, where the two layers are clearly shown in different brightness which is mainly related to their electron scattering capability. The FePt layer is about 6.6 nm and the CoCrPt layer 13.2 nm. The interface between them is very sharp. It should be noted that there is a columnar structure in the CoCrPt layer and the columns are parallel to the film growth direction. Selected area electron diffraction patterns indicate that FePt layer has an epitaxial growth on the MgO (100) substrate. The growth direction of FePt layer is along the c-axis. More structural details can be revealed by high-resolution TEM images as shown in Fig. 2, where the electron beam is parallel to the [010] direction of both MgO and FePt. In the film growth direction, Fe and Pt atomic layers are arranged alternatively in FePt, forming a periodicity 2 times as large as the inter-planar lattice spacing. The interface between the FePt layer and the substrate is atomically abrupt. Due to different lattice parameters, the misfit dislocations are observed at the interface (Fig. 4). The spacing between the neighboring interfacial dislocations is consistent with the calculated value. Fig. 3 shows the interface between the FePt and CoCrPt layers. It is clearly seen that there is no amorphous phase between the two phases. The lattice planes continue from FePt to CoCrPt across the interface. There is a misfit between FePt and CoCrPt layers, but the misfit dislocations were not observed. This may be due to the columnar structure in the CoCrPt layer. First-principles calculations are performed to identify the stable atomic configuration at the interfaces, which help reveal the mechanism of the film growth.

In summary, the FePt/CoCrPt/MgO system provides quite unique interfacial structures. Advanced TEM techniques and first-principles calculations help fully understand the interfacial structures [5].

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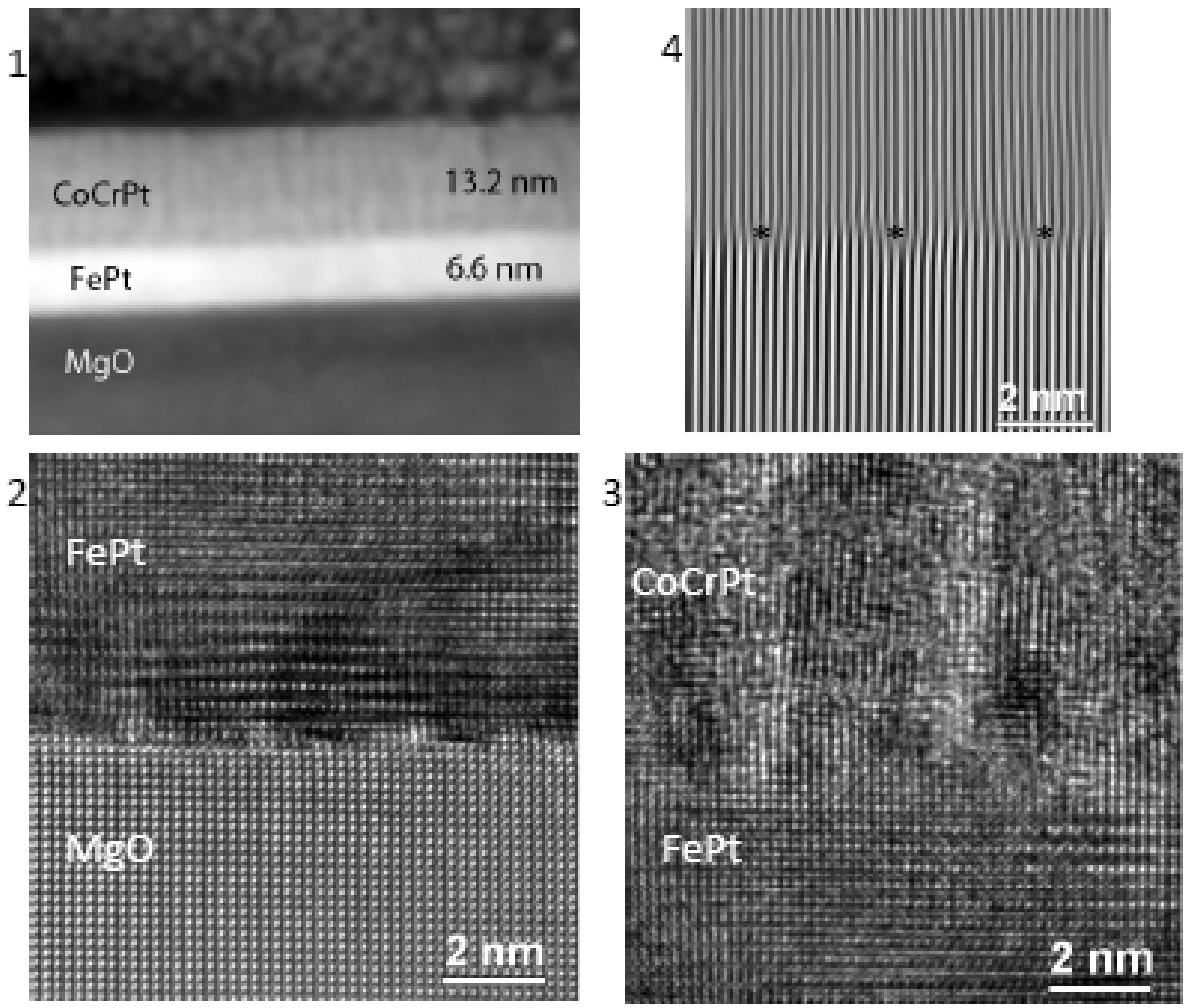

Fig. 1 Annual dark field STEM image of FePt/CoCrPt hard/soft magnetic bilayers on MgO (100) substrate. Fig. 2 High-resolution TEM image of the interface between FePt and MgO layers. Fig. 3 High-resolution TEM image of the interface between CoCrPt and FePt layers. Fig. 4 Processed HRTEM image of the FePt/MgO interface, showing misfit dislocations as marked by * at the interface.

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