**Mapping the Element-specific Interlayer Magnetic Coupling in $DyFe_2/YFe_2$ Superlattices by Transmitted Electrons**

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The systems consisting of rare earth (RE) and 3d transition metals (TM) are of high interest for their potential applications in permanent magnets and recording media. The $DyFe_2/YFe_2$ superlattice film is a promising TM-RE system with exchange spring behaviors[1]. A thorough understanding of its TM-RE and TM-TM interlayer magnetic coupling is crucial. As the thickness of each layer is in the scale of a few nanometers (Figure(a-c)), a high-resolution and element-specific magnetic technique is required. The emerging technique Energy-loss Magnetic Chiral Dichroism (EMCD) based on Transmission Electron Microscopy (TEM) provides the possibility[2-3]. Our previous study has demonstrated that EMCD is an effective tool to investigate the antiparallel alignment of net Fe 3d and Dy 4f spin moments with opposite signs of Fe-$L_3$ and Dy-$M_5$ dichroic peaks[4].

To directly resolve the interlayer magnetic coupling of the Fe 3d moment between $DyFe_2$ and $YFe_2$ layers and understand its variation in two dimension (2D), we propose a mapping method on the basis of EMCD. The observed area is selected by the dot square in Figure(a) and shown in Figure(e). Its EMCD signal in the whole selected area is presented in Figure(d), indicating a non-zero value of net Fe moment along the beam axis under 2T in TEM. An energy filtered image was acquired with an energy slit over Fe-$L_3$ edge from Pos A and a second one acquired from Pos B without any other changes (Figure(f-g)). After the post-treatment process including shift alignment and image subtraction, a 2D map of Fe-Fe spin coupling is obtained in Figure(h). As an example to interpret the map, intensity profiles in Figure(f-h) are all extracted exactly from the same area 2. The profile in Figure(h) demonstrates that no ferromagnetism presents in the capping layer part of area 1, and Fe 3d moments are antiparallelly coupled in neighboring $DyFe_2$ and $YFe_2$ layers (Figure(i)) as the positive and negative values alternately appear along the y axis. In addition, if comparing the area 3 and 2 in Figure(f-h), their intensity differences in the same single layer are seen to be opposite in sign, possibly indicating their different coupling behaviors. This work is to be submitted.

Reference

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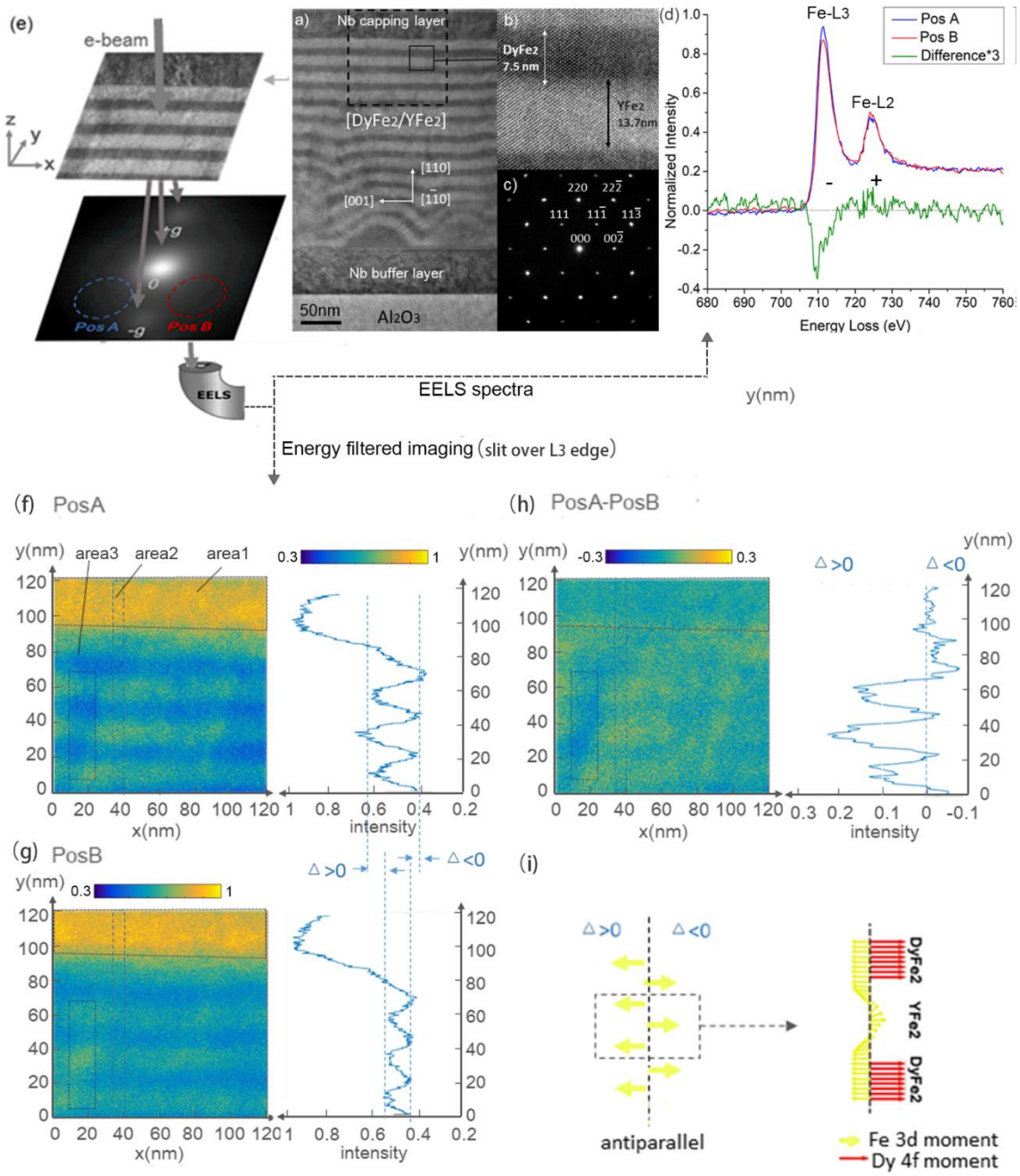


Figure. (a)A low magnification (b) high magnification image (c) a diffraction pattern of $DyFe_2/YFe_2$ superlattices; (d) EELS and EMCD spectra acquired in the area marked by dot lines in (a); (e)a sketch of the EMCD experiment setting; (f) Energy filtered image acquired with an energy slit at Fe-$L_3$ edge from PosA and (g) PosB; (h) difference of the two images; intensity profiles beside are extracted from area 2; (i) the interlayer coupling behavior of Fe-3d spin moment in area 2 are deduced from the curve in (h); Fe-Fe and Dy-Fe spin configurations further derived if combined with our previous study in [4] .

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