Surface/Interface effects for size-selected FeRh nanomagnets deposited on perovskite oxide crystals

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The major importance of surface atoms in small nanoparticles (NPs) offers the opportunity to tailor magnetic properties by playing with the interface between a nanomagnet and its surrounding. FeRh alloy has attracted a lot of attention because the bulk material presents an antiferromagnetic to ferromagnetic order (AFM-FM) transition close to room temperature, for the chemically ordered B2 phase. Inspired by epitaxial FeRh film studies on perovskite oxide [1], and motivated by the possibility to obtain hybrid multiferroic nanosystems, we have studied the structural and magnetic properties of size-selected FeRh clusters (diameter < 10 nm) deposited on perovskite oxide surfaces. For this system, a strong interplay between surface configuration, morphology and magnetic state is taking place [2,3]. FeRh nanomagnets have been deposited on $BaTiO_3$ thin films and $SrTiO_3$ single crystals, using the mass-selected low energy cluster beam deposition technique (MS-LECBD) under ultra-high vacuum. Using synchrotron radiation, we have observed the chemical ordering of FeRh nanoparticles into the B2 crystalline phase upon annealing, which is also accompanied by a Fe magnetic moment evolution visible from X-ray magnetic circular dichroism (XMCD) measurements. The orientation dependence of x-ray diffraction FeRh peaks indicates that particles, despite their random deposition, are finally adopting preferential orientations. In addition to the usual epitaxy relationship met for thin films, a novel orientation is observed (corresponding to a 45° in-plane rotation), as well as other favorable coincidences for particles on $SrTiO_3$. At the same time, X-ray spectroscopy at iron edges reveals that NPs assemblies, systematically appear to be (partially) oxidized after transfer in air while FeRh nanoparticles can be reduced thanks to in situ vacuum annealing. Concerning magnetic behavior, as for previous FeRh NPs embedded in carbon matrix [2], no metamagnetic (AFM-FM) phase transition has been observed from XMCD measurements.

References

[1] Cherifi et al., Nature Mater. 13 (2014) 345; Liu et al., Nature Comm. 7 (2016) 11614
[2] Hillion et al., Phys. Rev. Lett. 110 (2013) 087207; Herrea et al. Eur. Phys. J. Appl. Phys. 97 (2022), 32
[3] Liu et al., Euro. Phys. Lett. 116 (2016) 27006; Lewis et al., J. Phys. D: Appl. Phys. 49 (2016) 323002

Figures

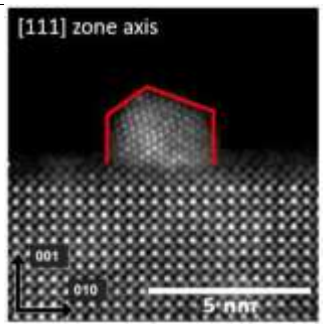

Figure 1: cross section image (STEM-HAADF) of a FeRh nanoparticle on the $SrTiO_3$ surface.