Co Nano-Cluster Inclusions in L10-FePt Matrix as a Model System of Nanocomposite Magnets

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Nanocomposite magnets, consisting of a fine mixture between a large magnetocrystalline anisotropy phase and a large magnetization phase, is a promising route to develop new permanent magnets with unprecedented performances. Theoretical calculations predicted a potential energy product of 1 MJ/m^3, which is twice as large as the one of best $Nd_2Fe_{14}B$ magnets produced today [1]. But these calculations also pointed out the absolute necessity to confine the softer phase in nano-sized grains, typically smaller than 10 nm, which cannot be obtained with conventional process for mass scale material fabrication. So far only very few experimental works with encouraging results have been reported on such exchange-spring magnet [2]. Further experimental investigations are needed to assess the full potential of nancomposite for designing high energy product magnetic materials.

We recently prepared Co@FePt transition metal (TM)-based nanocomposite films from low energy cluster beam deposition technique (LECBD) of Co clusters, *in situ* embedded in FePt matrix independently produced by alternative electron gun evaporation on the same substrate [3,4]. This technique gives a fine control over the microstructure. The Co cluster inclusions can be selected in size prior their deposition, between 1 and 10 nm. The cluster to matrix volume ratio is adjusted controlling the thickness of each Co, Fe, Pt individual layers. Annealing is a crucial step to drive the initial Fe and Pt multilayers to the high-magnetic anisotropy $L1_0$ phase with a limited diffusion of the clusters in the matrix. Specular X-rays Diffraction revealed a thermal transition to a chemically ordered $L1_0$-FePt alloyed matrix with a partial texture on Si substrate while environmental-TEM and EDX analyses allowed us to observe the partial diffusion of the Co clusters in the hard matrix.

Recently, X-ray absorption spectroscopy measurements (EXAFS, XLD and XMCD) were performed on annealed Co@FePt nanocomposite with various clusters concentrations and compared to equivalent multilayer samples at Fe and Co K-edges at BM30 and ID12 beamlines at the ESRF. The structural analysis proved that the Co clusters don’t entirely mix with the matrix during annealing contrary to multilayers. The study of such model system could give insights about the role of the nanostructure on magnetic hardness and could thus guide the development of mass scale synthesis processes.

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References

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