Production and characterization of exchange-coupled nano-composites of SmCo nanoparticles embedded in a Fe matrix

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Modern small-scaled permanent magnets achieve high coercivity by coupling the crystal sites of *3d* transition metals to rare-earth metals such as Sm or Nd. Since the rare-earth additions have, at most, the same magnetic moment as the *3d* metals while occupying at least three times more space, this increased coercivity penalizes the total magnetization of the magnet. Furthermore, rare-earths have high chemical corrosion rates and significantly increase the overall cost of production. A solution to these issues was proposed almost 20 years ago by Kneller and Hawig [1] who suggest hard magnetic phases, with high coercive fields, could be exchange-coupled to soft phases, with high saturation magnetization. Such coupling would therefore increase the performance of the magnet while also reducing the cost since less rare-earth additions would be needed. Even though such systems are usually studied on multi-layers, the inclusion of magnetically hard spherical inclusions on a soft matrix corresponds to a more optimized structure since the surface/volume ratio, crucial to achieving high exchange-coupling, is maximized in spherical objects. Here, we report on the production of such systems by co-sputtering Fe with SmCo nanoparticles produced *in-situ* in an auxiliary condensation chamber via the gas-aggregation technique. This apparatus, developed on top of one of the guns of a 4-gun commercial magnetron sputtering system, is capable of producing nanoparticles of any material compatible with sputtering [2,3]. By changing the operation parameters of the system we are able to control the mean size of the nanoparticles which, for SmCo, range between 10 to 50 nm with a quasi-monodisperse size distribution, as determined by transmission electron microscopy. The nanoparticle-matrix stoichiometry can also be easily controlled adjusting the deposition rate of Fe. X-ray diffraction and magnetic measurements of the samples will also be presented.

Keywords: Nanoparticle, exchange-coupling, gas-aggregation

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