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Strong exchange coupling in conventional and inverse ferrimagnetic hard/soft and soft/hard core/shell heterostructured nanoparticles[1]

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Bi-magnetic core/shell nanoparticles are becoming increasingly appealing for diverse fields such as for permanent magnets, microawave absortion, biomedical applications, sensing applications, or future magnetic recording media. Ferrromagnetic (FM)/ antiferromagnetic (AFM) core/shell nanoparticles (or inverted AFM/FM) have been extensively studied. However, exchange coupled hard/soft, or inverse soft/hard, core/shell nanoparticles have been far less investigated. Interestingly, most bi-magnetic core/shell systems are derived by simple partial oxidation of the core, e.g., Co/CoO (FM/AFM) or FePt/Fe_3O_4 (hard/soft) and only few studies of heterostructured (where core and shell are formed by different magnetic ions) can be found in the literature. We have investigated conventional hard/soft and inverted soft/hard core/shell hetroestructured nanoparticles based on magnetically soft iron oxide (Fe_3O_4) and magnetically hard manganese oxide (Mn_3O_4). The core/shell samples were synthesized by seeded growth using either Fe_3O_4 or Mn_3O_4 nanoparticles as seeds. Subsequently, thin layers of the complementary material were grown by thermal decomposition of the corresponding metallorganic precursors. The structure characterization (X-ray diffraction and electron diffraction) confirms the presence of cubic (Fe_3O_4) and tetragonal (Mn_3O_4) phases both at the bulk and local levels. In addition, high resolution transmission electron microscopy (HR-TEM) with electron energy loss spectroscopy (EELS) mapping confirms the core/shell structure of the nanopartciles. Magnetic characterization and element-selective hysteresis loops obtained by x-ray magnetic circular dichroism (XMCD) reveal a strong exchange coupling between the core and the shell which results in homogeneous loops with moderate coercivity. Moreover, the magnetic properties can be tuned by controlling the core diameter or shell thickness. However, the results depend only weakly on the hard/soft or inverse soft/hard morphology.

[1]In collaboration with A. Lopez-Ortega, M. Estrader, G. Salazar-Alvarez, S. Estrade, F. Peiro, I.V. Golossvsky, M. Vasilakaki, K.N. Trohidou, R.K. Dumas, D.J. Keavney, M. Laver, K. Krycka, J. Borchers, M. Varela, S. Suriñach, M.D. Baro, J. Sort