FERROMAGNETIC FePt NANOPARTICLES FORMED IN Al_2O_3 BY ION IMPLANTATION

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Ferromagnetic FePt nanoparticles with an extremely high coercivity (greater than 1 Tesla) have been formed in Al_2O_3 by ion implantation followed by thermal annealing. Sequential implantation of Fe (350 keV) and Pt (910 keV) followed by thermal annealing (at 1100°C for 2 h in flowing Ar + 4%H_2) gives rise to the formation of oriented FePt nanoparticles in the Al_2O_3 matrix. The particle size varies from a few nm to ~100 nm depending on implantation and annealing conditions, and we have produced nanocomposites in Al_2O_3 with either single or multiple orientations of the nanoparticles. By controlling the relative doses of Fe and Pt, we have varied the Pt atomic fraction [Pt/(Fe + Pt)] from 25% Pt to 53% Pt. In the range 35% to 53% Pt, X-ray diffraction measurements show that the chemically ordered $L1_0$ phase of FePt is formed with an order parameter that approaches unity. SQUID magnetometer measurements show that these nanoparticles are ferromagnetic and the coercive field maximizes at a Pt atomic fraction of ~45%. For this case, the coercive field exceeds 2 Tesla at 30 K and is greater than 1.5 Tesla at room temperature. At lower Pt atomic fractions (25%), the chemically ordered $L1_2$ phase of Fe_3Pt is formed.

We have also used sequential ion implantation to form FePt nanoparticles in other matrices including SiO_2, MgO, and Y stabilized zirconia (YSZ). Finally, in Al_2O_3, we are exploring the use of ion implantation to form other ordered alloy nanoparticles with the $L1_0$ structure including CoPt, $Fe_{0.5}Co_{0.5}Pt_1$ and NiPt. Oak Ridge National Laboratory is managed by UT-Battelle, LLC, for the U.S. Dept. of Energy under contract DE-AC05-00OR22725.

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