On the Synthesis of AlMn Nanoparticles

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This project will discover methods to synthesize AlMn nanoparticles in the τ-phase. Bulk τ-AlMn is ferromagnetic (M_s = 950 emu/cc) with a high magnetocrystalline anisotropy (K_u ~ 1 x 10^7 erg/cc). These particles will have ideal magnetic properties necessary to support the growth in data storage capacity for magnetic tape beyond the year 2020. This technology demands tight compositional and size distributions. From our previous studies in FePt, we have determined that a two-step nucleation process can be used to control the compositional uniformity. One metal forms the seed from which the other metal atom heterogeneously nucleates. In this project our approach is to nucleate the formation of Mn seed particles, followed by a heterogeneous reduction of Al^{3+} at the particle surface. The nucleation step will either be a thermal decomposition of an organometallic manganese compound (e.g., $Mn_2(CO)_{10}$) or reduction of Mn^{2+}. Cyclic voltammetry will be used to determine the reduction potentials for the Mn^{2+} and Al^{3+} precursors, thereby providing a means of identifying the reducing agents for the nucleating and the growth steps. The particles will be prepared in the presence of trioctylphosphine capping ligand to provide a dispersion of particles in an organic solvent. Reaction conditions will be identified that provide control over the particle composition and size distribution. High resolution TEM images and EDAX on individual particles will provide histograms indicating the distribution of particle sizes and compositions. Post synthesis heat treatment in an inert atmosphere will determine conditions for obtaining the chemically ordered, ferromagnetic τ-phase with high magnetocrystalline anisotropy. Time-dependent remanent coercivity measurements using a Princeton Measurements alternating gradient field magnetometer (AGM) will provide values of important magnetic properties, i.e, M_s, H_k, K_u, and V. The effect of particle size, composition and chemical ordering on the magnetic properties will be ascertained.