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Structural and magnetic properties of cobalt iron disulfide nanocrystals

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We report on synthesis and investigation of nanocrystalline cobalt-iron-pyrites with an emphasis on nanocrystal structure, morphology and magnetic behavior. The nanocrystals (NCs) were 5–25 nm in diameter as characterized using scanning electron microscopy (SEM) and transmission electron microscopy (TEM). Local atomic structures of the samples were studied using absorption near edge structure (XANES) and extended absorption fine structure (EXAFS) at the Synchrotron Light Research Institute (SLRI), Nakhon Ratchasima in Thailand. With an increase in Fe fraction, X-ray diffraction and small-angle-X-ray scattering (SAXS) showed a systematic decrease in lattice constant, primary grain/NC size (15 to 7 nm), and nanoparticle (NP) size (70 to 20 nm), respectively. The temperature dependence of the DC magnetization and AC susceptibility versus frequency revealed a number of magnetic phases in $Co_xFe_{1-x}S_2$. Samples with x = 1 and x = 0.875–0.625 showed evidence of superspin glass (SSG) behavior with embedded ferromagnetic (FM) clusters of NPs. For x = 0.5, samples retained their mixed phases, but showed superparamagnetic (SPM) behavior with antiferromagnetic clusters suppressing magnetic dipolar interactions. Below x = 0.5, the pyrites show increasing paramagnetic character. We construct a phase diagram, which can be understood in terms of competition between the various dipolar, exchange, inter- and intracluster interactions. Our results suggest that NC size and shape can be tuned to engineer spin-polarized ferromagnetism of n-doped iron pyrite.

Publication

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