Magnetic studies of mechanically alloyed metastable fcc $Fe_{23}Cu_{77}$: superferromagnetism with bimodal cluster size distribution.

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Abstract

Nanocrystalline materials can be prepared using specific synthesis processes that stabilize non-equilibrium structures, which may present enhanced physical properties. According to the Fe-Cu phase diagram, Fe and Cu are essentially immiscible at room temperature. High Energy Ball-milling of Fe and Cu powder mixtures induces the formation of nanostructured solid solutions, either bcc for Fe-rich Fe(Cu) alloys (Fe>~80 at%) or fcc for Cu-rich (Fe<~40-50 at%) Cu(Fe) alloys while two phases (bcc+fcc) coexist in the intermediate range. The magnetic and Mössbauer spectroscopy properties of a nanostructured fcc Fe23Cu77 at % alloy are presented. The use of a magnetic mean-field method [1] reveals that the system is a bimodal size distribution of magnetic Fe-rich nanoclusters, where the smaller ones are close to the stable 13 atom icosahedral/cuboctahedral arrangement with magnetic moment $30\mu_B$, and the large clusters present a magnetic moment 860 μ_B containing ~400 Fe atoms. The inter-cluster ferromagnetic interactions that lead to super-ferromagnetism with a Curie temperature Tc~220K are determined by the smaller clusters only, which account for 90% of the magnetization.

[1] J. S. Amaral, N. J. O. Silva and V. S. Amaral, Appl. Phys. Lett. 91, 172503 (2007).

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