Progress Towards a New and Sustainable Advanced Permanent Magnet

Speaker: Professor Laura H. Lewis
Northeastern University, Boston, MA, USA

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Permanent magnet development has historically been driven by the need to supply larger magnetic energy in ever-smaller volumes for incorporation in an enormous variety of applications, including consumer products, transportation components, military hardware, and clean energy technologies. Since the 1960s, the so-called rare-earth “supermagnets,” composed of iron, cobalt, and rare-earth elements such as Nd, Pr, and Sm, have accounted for the majority of global sales of high-energy–product permanent magnets for advanced applications. However, 20th-century global supply uncertainties continue to motivate the search for new types of sustainable, ecologically friendly and accessible advanced permanent magnets[(1)]. Recently a cosmic form of FeNi with the chemically ordered (tetragonal $L1_0$-type) structure, known as “tetrataenite”, has been confirmed to exhibit a theoretical magnetic energy product exceeding 335 kJ/m^3, which is 66% of that of the best rare-earth magnets[(2)]. While this discovery has generated considerable global interest, natural formation of tetrataenite takes up to one billion years, due to its very low driving force for formation. In this work FeNi-based materials were subjected to specialized processing protocols designed to accelerate the ordering transformation to enable a high magnetic energy product. Preliminary results confirm stabilization of a tetragonal phase and a large change in the nature of the FeNi magnetic domains as a function of processing. These outcomes are consistent with the development of elevated magnetic anisotropy and support the case that attainment of $L1_0$ FeNi is indeed possible on earthly timescales.

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1. L. H. Lewis and F. Jiménez-Villacorta. *Met. Mat. Trans*. A 44.1 (2013): 2-20.
2. L.H. Lewis *et al*., *J. Phys.: Condensed Matter* 26 (6) 2014.