Probing New Materials and Novel Anisotropies for Rare-Earth-Free Permanent Magnets

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While rare-earth metallic elements are essential ingredients for the synthesis of high energy-product permanent magnets, recent geopolitical events emphasize that new materials design paradigms for the creation of advanced rare-earth-free magnets must be developed. Two previously-unexplored materials design options for the realization of high-energy-product permanent magnets with zero rare-earth element content will be presented. The first option is exchange-biased nanocomposites comprised of antiferromagnetic Mn-based phases and ferromagnetic Fe/FeCo-based phases exhibiting simultaneously an exchange-bias effect and an exchange-spring effect. The second option is optimization of the nominally-equiatomic FeNi phase with the tetragonal $L1_0$ crystal structure known as "tetrataenite". To date, Tetrataenite has only been found in meteorites subjected to extremely slow cooling rates occurring over one billion years. It is anticipated that synchrotron-based structural and spectroscopic probes will help clarify pathways towards stabilization of desired magnetic phases in these two classes of materials.

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