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Nanocomposite alternatives to rare-earth permanent magnets

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Permanent magnets are a component in many modern energy applications such as hybrid electric vehicles, wind power, magnetic refrigeration, and flywheel energy storage. The key parameter controlling the performance is the magnetic energy density, typically presented via the maximum energy product (BH)max, since it leads to an increase in the whole device efficiency (for example the volume-to-power ratio of an electric motor). For single phase material, since the development of rare earth permanent magnets in the 1970s, there have been minor advances in the (BH)max, achieved mainly by varying the synthetic processing and the ability to control the anisotropy. An alternate approach is to develop a multi-phase material consisting of an assembly of hard and soft phase nanoparticles that interact via exchange coupling. This approach is particularly exciting in view of the recent developments in chemical synthesis methods of nanoparticles that allow for size and composition control. These nanoparticles have atomic structures and compositions often different from the bulk stable phases. Recently, we have been able to synthesize a new nanocomposite material composed of a mixture of Co2C and Co3C nanoparticles of varying size using polyol reduction chemistry. The material offers unusual magnetic properties and has the potential to become the first non-rare earth permanent magnet developed in over 40 years. This new approach to permanent magnets allows one to tune the magnetic properties of the resulting material by controlling the magnetic characteristics of the mixed phase nanoparticles, serving as building blocks of the assembled material.

Biography

Carpenter is an internationally recognized materials chemist with a strong background in the synthesis, characterization, and application of magnetic nanoparticles. Currently, he is the director of Nanoscience and Nanotechnology Program and the VCU Nanomaterials Characterization Center. His interdisciplinary research made him the ideal person to coordinate and lead a new interdisciplinary Ph.D. program in Nanoscience and Nanotechnology between the Departments of Chemistry and Physics and the School of Engineering. Over the past 13 years, Professor Carpenter has authored or co-authored over 100 papers including 2 review articles (one on iron oxides), 2 book chapters and a research book published by John Wiley and Sons.

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