Multivariable tuning and optimization in selected magnetostructural systems

L. H. Lewis

Department of Chemical Engineering and
Department of Mechanical and Industrial Engineering
Northeastern University, Boston, Massachusetts USA
E-mail: lhlewis@neu.edu

Response tunability, essential for performance optimization, is a central focus for functional materials and applications that rely upon them. Magnetostructural materials are characterized by simultaneous changes in the crystal and magnetic structures at a given transition temperature T_t and underlie the operation of proposed magnetic cooling and sensor devices. The very strong spin-lattice coupling present in this family of materials permits aspects of their functional response to be tuned by variation of extrinsic (pressure P, temperature T, magnetic field ($\mu_0 H$)) or intrinsic (compositional) parameters, or by some combination of all these drivers, providing a multidimensional phase space for response optimization.

In this presentation the magnetostructural response of a selection of materials subjected to alterations of strain, pressure, magnetic field and composition will be discussed. In particular, new results obtained from the model FeRh system subjected to application of differential strain (in film forms) and simultaneous elevated pressure and magnetic field (in bulk forms) will be examined. Highlights of this investigation include construction of a three-dimensional ($\mu_0 H$–P–T) phase diagram that graphically depicts the isocompositional magnetostructural response of Ni-modified FeRh, allowing visualization of the synergistic influence on the transition temperature T_t of all three drivers. Additionally, connections between composition and magnetic character in the layered magnetostructural $Al(TM)_2B_2$ system, where TM is a transition metal, will be presented and discussed from a fundamental electronic phase transition perspective as well as within an applied technological context. This lightweight system is comprised of earth-abundant materials and exhibits a very small unit cell volume change through the magnetostructural phase transition temperature, despite possessing a latent heat of 4.4 J/g, similar to that of other magnetostructural materials [1]. Lastly, extending beyond these data, concepts for incorporating tuned magnetostructural materials into working devices will be offered to bridge fundamental science and applied engineering goals.

Research was funded by the U.S. National Science Foundation, by the U.S. Department of Energy, by the U.S. Army and by Northeastern University.

[1] L. H. Lewis, R. Barua and B. Lejeune, *J. Alloys Compounds* **650** 482 (2015).