Room Temperature Magnetocaloric MnFe$_x$Ga and MnNi$_x$Ga Materials for Solid State Refrigeration

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The solid state refrigeration market is expected to exceed $300 M by 2022, growing at an astounding CAGR of nearly 100%from 2017 to 2022. The market for such technology is growing because of reduced operating cost, higher efficiency, lower energy consumption, and reduced maintenance cost, associated with having only one moving part. In addition, the lack absence of environmentally unfriendly HFCs means there is zero emission of hazardous gases.

Currently, the commercialization of magnetocaloric refrigerators is stymied by the need to produce low cost, stable, high magnetocaloric effect material (MCE); the need to design a low cost, high efficiency heat transfer system; and the need for low cost, strong magnets. Ideally, the magnetocaloric material for solid state refrigeration should comprise elements that are non-critical (available in large quantities), preferably non-rare earth, inexpensive and not toxic. In addition, suitable materials must meet requirements for Curie temperature, efficient magnetocaloric effect, a wide temperature range, near-zero magnetic hysteresis, high electrical resistivity, and good corrosion resistance. Currently used magnetocaloric materials do not possess all these factors together and are prohibitively expensive to produce.

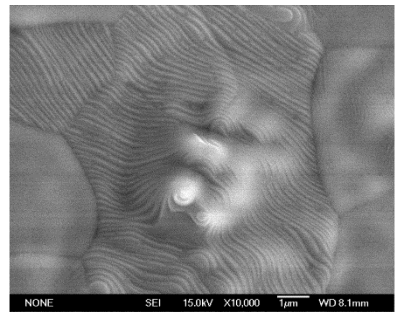

Fig. 1 microstructural morphology of MnFexGa

One of the members of Nanofoundry's scientific staff, Ahmed El-Gendy, has recently led research and development of a specific class of magnetocaloric material. Other members of our staff are experts in chemical processing and magnetic science. As a company, we see an opportunity to develop a non-rare earth magnetocaloric material that performs better, and is lower cost, than current technologies on the market.

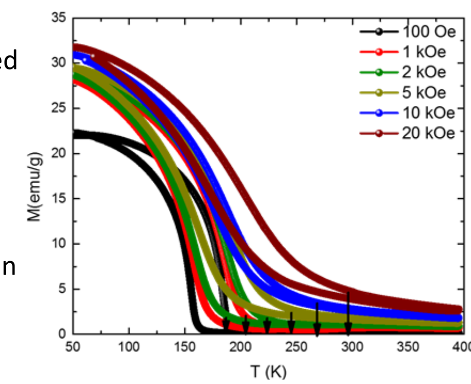

Fig. 2 Thermal Hysteresis of MnFexGa

We propose a development project to develop a material based on MnFe$_x$Ga and MnNi$_x$Ga as a room temperature magnetocaloric material. Adjusting the Mn/Fe or Mn/Ni ratio can tune the TC in a large temperature range (from 150 to 350 K) with a high change in entropy. Physical methods (Arc Melting, ball milling and supercritical conditions of liquids) can be applied to synthesize MnFexGa and MnNixGa nanoparticles with different sizes and compositions.

Ahmed El-Gendy recently performed research on the MnFe$_x$Ga system. His results have been accepted for publication, and we expect the publication to be announced by February, 2016 (El-Gendy et al., J. Alloys Comp. Mater. 2016). We include some of his findings here:

The micro structure morphology in Fig. 1 shows hexagonal shaped micro particles in the range of 3 to 5 microns. The thermal hysteresis (Fig. 2) shows a wide temperature range of about 50 K. The Curie temperature is close to room temperature and can be tuned by applying a magnetic field (Fig. 3). These properties are promising and the process for developing these materials is reasonably well understood.

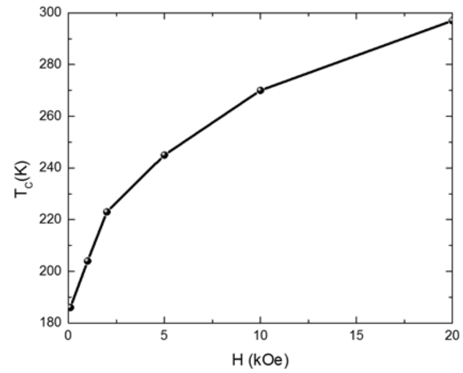

Fig. 3 Curie Temp. tuned by fields

Based on the preliminary data for MnFexGa system, we propose further development of this class of materials and piloting production of various compositions of MnFexGa and MnNixGa, using hybrid process techniques (Arc Melting, ball milling and supercritical conditions of liquids) as mentioned above.

Due to our unique mix of technical capabilities—magnetocaloric materials development, chemical synthesis, and magnet science—Nanofoundry is uniquely qualified to undertake this research. This research may also be leveraged for the development of hard magnet materials (MnXGa), and outcomes of the project include the magnetic properties characterization of this class of materials.