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“Modulated Magneto-Thermal response of La$_{0.85}$Sr$_{0.15}$MnO$_3$ and (Ni$_{0.6}$Cu$_{0.2}$Zn$_{0.2}$)Fe$_2$O$_4$ composites”

Abstract

New mechanisms for converting thermal energy into electricity are highly desired. Thermoelectric devices that convert thermal energy directly into electrical energy have been widely investigated. However, thermoelectric energy harvesters typically show low output power and efficiency at low temperature gradients. Further, there is increasing difficulty in enhancing the magnitude of figure of merit ($ZT$) in the bulk materials. To overcome these limitations, we present the concept of magneto thermoelectric generator (MTG) that exploits the ferromagnetic phase transition of soft magnetic materials to drive the movement of a serpentine spring with piezoelectric plates whose mechanical energy is converted to electrical energy. To operate MTG, the fundamental challenge lies in synthesizing soft magnetic materials that exhibit magnetic Curie temperature close to the room temperature while possessing high saturation ($M_s$) and remnant ($M_r$) magnetization with small coercive field ($H_c$). La$_{1-x}$Sr$_x$MnO$_3$ system is known to exhibit the insulator to metal phase transition at room temperature that can be tuned by modulating the Sr ($x$) content. In this study, we describe the composite material design using base La$_{0.85}$Sr$_{0.15}$MnO$_3$ (LSMO) composition and modifying with Ni$_{0.6}$Cu$_{0.2}$Zn$_{0.2}$Fe$_2$O$_4$ (NCZF) in order to achieve large $M_r$ and $M_s$, while maintaining it soft magnetic nature. Systematic experimental investigations were conducted on the newly designed composites using magnetic force microscope (MFM), superconducting quantum interference device (SQUID) magnetometer, X-ray diffraction (XRD) and energy-dispersive X-ray spectroscopy (EDS). We further provide mechanistic model that accounts for the domain structure, phase, and microstructure to describe the magnetic behavior as a function of temperature.

Biosketch

Mr. Song is currently pursuing a Ph.D. in Materials Science and Engineering under the advisement of Dr. Shashank Priya and Dr. William Reynold Jr. He received B.S. and M.S. degrees in Materials and Science Engineering in Korea University in 2004 and 2006, respectively. Before joining Virginia Tech., he worked as research scientist for 7 years at Korea Institute of Science and Technology, where he mainly researched for piezoelectric materials and applications including lead free piezoelectric materials, piezoelectric thin film and nano-materials, electro-caloric materials, piezoelectric energy harvesters, MEMS actuators and so on. His research is currently focused on the investigation of new types of energy harvesters and their related materials.