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Designed novel magnetocaloric materials: magnetic refrigeration for the future

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Abstract content
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Modern society is heavily reliant on refrigeration. For example, in the US about 34% of the electricity is consumed by cooling appliances and 15% of the total worldwide energy consumption involves the use of refrigeration. It is predicted that refrigerants will contribute up to 45% of global warming effects in the future. In addition, a high fraction of our energy consumption goes towards cooling. These two factors are sparking renewed interest in solid state alternatives to the conventional cooling cycle. The main aim of the program is to develop novel giant magnetocaloric materials for fulfilling the operational demands of Magnetic Refrigeration (MR) at room temperature. This research will contribute to the building of a better society by developing an energy efficient, safe, and environmentally friendly cooling technology, and contribute to the economic and social goals.

Magnetic refrigeration techniques based on the magnetocaloric effect (MCE) have recently been demonstrated as a promising alternative to conventional vapour-cycle refrigeration. In a material displaying the MCE, the alignment of randomly oriented magnetic moments by an external magnetic field results in heating. This heat can then be removed from the MCE material to the ambient atmosphere by heat transfer. If the magnetic field is subsequently turned off, the magnetic moments randomize again, which leads to cooling of the material below the ambient temperature. This warming and cooling in response to the application and removal of an external magnetic field is called the Magnetocaloric effect "MCE".

Magnetic refrigeration is an environmentally friendly cooling technology. It does not use ozone-depleting chemicals (such as chlorofluorocarbons), hazardous chemicals (such as ammonia), or greenhouse gases (hydrochlorofluorocarbons and hydrofluorocarbons). Another important difference between vapour-cycle refrigerators and magnetic refrigerators is the amount of energy loss incurred during the refrigeration cycle. The cooling efficiency of magnetic refrigerators working with Gd has been shown to reach 60% of the theoretical limit, compared to only about 40% in the best gas-compression refrigerators. The use of magnetic refrigerators with such high energy efficiency will result in a reduced consumption of fossil fuels, in this way contributing to a reduced CO2 release. However, with the currently available magnetic materials, this high efficiency is only realized in high magnetic fields of 5 T. Scientists are therefore searching for new magnetic materials displaying larger MCEs, which then can be operated in lower fields of about 2 T that can be generated by permanent magnets.

The discovery of a large magnetic entropy change in the manganite's especially for La0.7Ca0.3MnO3 will be reported. Change in the giant magnetic entropy was observed without any noticeable magnetic hysteresis but with small thermal hysteresis losses. We observed a first order magnetic phase transition around 251 K. The magnetic entropy change observed in this work is estimated to be 5.27 J/kg K for field changes from 0 to 1.5 T based on magnetization measurements. In addition, the entropy change was estimated by using the heat capacity method, which can be well explained by the Maxwell relation.

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