Magnetocaloric properties of $Fe_6Ge_{5-x}Ga_x$

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Substances exhibiting a large magnetocaloric effect at room temperature have attracted great attention over the past quarter century due to the possibility of creating energy-efficient and noiseless refrigeration units on their basis. Intermetallic compounds and alloys based on rare-earth elements have demonstrated high cooling capability, however their commercial use is limited by high price and low availability of the elements. Thus, developing rare-earth free materials, such as ones based on intermetallics with high iron and manganese content, is of a great interest.

In the Fe-Ge-Ga system, we have discovered and characterized two new phases with their general formula being $Fe_6Ge_{5-x}Ga_x$. The homogeneity range of the first phase lies in the range of $3 < x < 4.5$, and the phase itself crystallizes in the α-Ti_6Sn_5 structure type. The second phase is formed at $2 < x < 3$, and its crystal structure is an intermediate between Fe_6Ge_5 and α-Ti_6Sn_5. In this work, we have investigated the magnetic properties of the new $Fe_6Ge_{5-x}Ga_x$ phases, as well as the known Fe_6Ge_5 and Fe_6Ga_5 phases.

A study of the temperature dependence of the magnetization and magnetic susceptibility of the phases has shown that Fe_6Ge_5 is an antiferromagnet with two phase transitions at 110 K and 330 K, while the phases containing gallium are ferromagnets with relatively high Curie temperatures ranging from 470 K to 760 K.

Magnetocaloric properties for phases containing gallium have been measured near the respective Curie temperatures. The magnetic entropy change at 5 T for all compounds has a broad maximum at the Curie temperature, the width at half maximum of which is about 100 K, and the maximum values of the magnetic entropy change are about 1.5, 2, and 2.4 $J \cdot kg^{-1} \cdot K^{-1}$ for $Fe_6Ge_{2.5}Ga_{2.5}$, $Fe_6Ge_{1.5}Ga_{3.5}$ and Fe_6Ga_5, respectively.

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