PE12

Theoretical Description of Magnetocaloric Effect in Ferromagnetic Alloys

S.V. Taskaev, V.D. Buchelnikov*, V.V. Sokolovskiy
Chelyabinsk State University, 454021 Chelyabinsk, Russia
*Corresponding author: buche@csu.ru, Phone: +7 351 799 7117, Fax: +7 351 742 29 05

Materials having large magnetocaloric effect are utilized as magnetic refrigerants because of their energy efficiency and environmental safety. To obtain a high performance of magnetic refrigeration, it is necessary to investigate magnetic refrigerants having large magnetocaloric effectin relatively low magnetic fields. Recently, the magnetocaloric effect due to the itinerant-electron metamagnetic transition for the La(FexSi12x)13 compounds have been experimentally investigated [1]. It has been reported that they exhibit large MCE in relatively low magnetic fields. Additionally, the temperature Curie of these compounds can be increased by hydrogen absorption. Thus, investigations of the magnetocaloric properties for the La(FexSi12x)13 and La(FexSi12x)13Hy compounds are meaningful for the magnetic refrigerants.

The itinerant-electron metamagnetic transition is the field-induced first-order transition from the paramagnetic to the ferromagnetic state. The La(FexSi12x)13 compounds in the ground state are ferromagnetic in the concentration range $0.81 < x < 0.89$. For the compound with $x = 0.88$, a discontinuous change of the thermomagnetization curve due to the thermal-induced first-order transition is observed at the Curie temperature $Tc = 195$ K. Since the La(Fe0.88Si0.12)13 compound exhibits the itinerant-electron metamagnetic transition in the paramagnetic state, the magnetization curves above Tc exhibit an S-shape behavior with a clear hysteresis. This itinerant-electron metamagnetic transition is accompanied by a large volume magnetostriction of about 1.5%.

In this work we proposed the theoretical model for description of magnetic and magnetocaloric properties of La(FexSi12x)13 compounds. The model uses the Landau, statistic and molecular field theories. A temperature dependence of the Landau coefficients for an itinerant-electron metamagnet is taken from the spin fluctuation model with account of the magnetovolume effect.

By the help of theoretical model the temperature and magnetic field dependences of magnetization and the entropy change are obtained. It is shown that the theoretical calculated results are in a good agreement with the experimentally ones.

In this work we also discuss a statistical and molecular field model for the theoretical description of Ni-Mn-Ga Heusler alloys properties [2]. By the help of this model we can calculate the temperature and field dependencies of magnetization and strain, entropy change, temperature - magnetic field diagram and thermodynamic cycles. The results of modelling are compared with experimental ones.

REFERENCES

[1] A. Fujita and at al., Phys. Rev. B, 67 (2003) 104416.
[2] V.D. Buchelnikov, S.V. Taskaev, T.Takagi, V.V. Koledov, V.G. Shavrov, Proceedings of Fist Int. Conf. on Magnetic Refrigeration at Room Temperature, Montreux, Switzerland, 27-30 September 2005, p.143-147.

PE13

Magnetocaloric Effect in Nanocrystallized $Fe_{91-x}Y_xZr_9$ (x = 0,5,10) Alloys

K.S. Kim*[1,2], Y.S. Kim[1,2], J. Zeromic[3], S.G. Min[3] and S.C. Yu[3]
[1]School of Electrical & Computer Engineering, Chungbuk National University, Cheongju 361-763, Korea
[2]CBNU BK21 Chungbuk Information Technology Center
[3]Department of Physics, Chungbuk National University, Cheongju 361-763, Korea
*Corresponding author: kkim@chungbuk.ac.kr, Phone: +82-43-261-3467, Fax: +82 43 261-3467

The temperature change of a magnetic material associated with an external magnetic field change in an adiabatic process is defined as the magnetocaloric effect (MCE). Room temperature magnetic refrigeration is a new highly efficient and environmentally protective technology[1]. Although it has not been maturely developed, it shows great applicable prosperity and seems to be a substitute for the traditional vapor compression technology. Especially, nanocrystallized samples with good soft magnetic characteristics and low Curie temperature have many useful properties that are attractive for application as magnetic refrigerants. For this purpose we studied the nanocrystallized $Fe_{91-x}Y_xZr_9$ (x = 0,5,10) alloys. Samples were prepared by arc melting the high-purity elemental constituents under argon gas atmosphere and by single roller melt spinning. These alloys were annealed one hour which is slightly higher the spontaneous crystallization temperature for this system. The magnetization measurements as a function of temperature and field were carried out on a ribbon style sample using a superconducting quantum interference device magnetometer and a vibrating sample magnetometer. The magnetization behavior, which relate thermodynamic quantities near ferromagnetic(FM) - paramagnetic(PM) phase transition, have been performed in order to understand the nature of the magnetic phase transition at the near of Curie temperature and type of magnetic ordering. The large magnetocaloric effect can be expected near the order-disorder phase transition of magnetic materials. From the magnetization data, the magnetic entropy change for isothermal magnetization was calculated by applying the thermodynamic Maxwell equation to a magnetic system. As Y content is increased, Curie temperature is increased and the maximum entropy change (ΔS_M) is seen about Curie temperature in all samples. Our results show that these nanocrystallized $Fe_{91-x}Y_xZr_9$ (x – 0,5,10) alloys have a good magnetocaloric effect than that those in amorphous alloys[2], indicating that these alloys can be considered as candidates for magnetic refrigeration applications.

REFERENCES

[1] K.A. Gschneidner Jr and V.K. Pecharsky, J. Appl. Phys. 85, 5365 (1999)
[2] K.S. Kim, S.G. Min, S.C. Yu, S.K. Oh, Y.C. Kim and K.Y. Kim, J. Magn. Magn. Mater. 304, e642 (2006)