Magnetic and Electrical Transport Properties of Intermetallic Fe-based Heusler Alloys

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Heusler-type intermetallics with a general formula X_2YZ (where X and Y are transition metals and *Z* is often an element from columns III through VI in the periodic table) have attracted considerable attention because of their various transport and magnetic features. Semiconductors, semimetals, normal Pauli metals, weak ferromagnets, antiferromagnets, as well as half-metallic ferromagnets exist in this class of materials. Fe_2VAl, a material of this prototype, has been characterized as a nonmagnetic semimetal from intense experimental and theoretical researches [1,2]. It has been observed that the doping of quarternary elements (B,In,Si,Ge) into Fe_2VAl at the Al site causes a significant decrease in the low temperature electrical resistivity. In this work, we report the temperature dependence of electrical transport and magnetic characterizations of electrical resistivity and Seebeck coefficient of the $Fe_2VAl_{1-x}Z_x$ alloys with Z = Si, Ge, B, In and x=0-1. The data for Ge-substituted alloys is taken from the reference [3].

The alloy ingots of all the studied alloys were prepared with high purity elemental constituents using an arc-melting furnace under argon atmosphere. The ingots were annealed in evacuated quartz tubes at 1200 K for 48 hours to improve the homogeneity of the alloys. Nominal composition assigned to each sample was regarded as accurate, because the weight loss was found to be less than 0.3-0.5%. All the studied samples were found to be a Heusler phase with Fm3m space group. While the Fe_2VAl exhibits a semiconductor-like resistivity behavior, a slight substitution of elements B,In,Si,Ge for Al causes metallic nature [4]. But a drastic change in magnetic properties are observed for the substitution of B,In elements only. The aspects that have been discussed are the relative influence of atomic sizes/lattice parameter (a) and electron concentration (e) of substitution elements on the transport and magnetic properties. It is observed that the Fe_2VAl alloy system is found to have an optimum ratio of e/a =4.18. By changing the ratio of e/a one can tune to produce high magnetic and high resistivity materials which are useful for the memory recording materials and spintronic applications. Thus, the Fe_2VAl alloy is a key compound to exhibit novel magnetic and transport properties, namely AFM, FM, SPM and half-metallic ferromagnets, ideal for spintronic applications.

References

[1] Nishino Y., Kato M., Asano S., Soda K., Hayasaki M., and Mizutani U., 1997, Phys. Rev. Letters, Vol. 79, pp. 1909.

[2] Okamura H., Kawahara J., Namba T., Kimura S., Soda K., Mizutani U., Nishino Y., Kato M., Shimoyama I., Miura H., Fukui K., Nakagawa K., Nakagawa H. and Kinoshita T., 2000, Phys. Rev. Letters, Vol. 84, pp. 3674.

[3] Nishino Y., Deguchi S., and Mizutani U., Phys. Rev. B **74**, 115115 (2006).

[4] Vasundhara M., Srinivas V., and Rao V. V., 2008, Phys. Rev. B, Vol. 77, pp. 224415.