Prospect for research on spintronics of U_3As_4 ferromagnet and its semiconducting Th derivatives

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Uranium arsenide of U_3As_4 composition crystallises in cubic structure and shows a ferromagnetic behavior with strongly anisotropic magnetisation below T_C = 198 K. Easy magnetic axis is <111> and the hard one is <100>. Magnetic field of 2 T along the hard axis does not tilt noticeably the magnetic moments from the easy axis (at 77 K) but the 20 T at 4.2 K causes a spin-reorientation transition [1]. We show that, despite it seems unfavorable, a spintronic use of U_3As_4 is possible and may lead to new applications in this field.

The large magnetic anisotropy results from hybridisation of conduction electrons with 5*f* states leading to strong dependence of density of states on magnetic moment direction [2] and lowered ratio of orbital to spin magnetic moment [3]. In consequence U_3As_4 exhibits strong magnetic anisotropy of resistivity and high anomalous Hall coefficient. On the other hand the magnetic field of 0.2 T at 77 K is sufficient to switch magnetisation of any domain to the easy magnetic axis closest to the field direction. This offers various possibilities to modify the resistivity, of U_3As_4. As an example the effect of magnetic field of different direction on the resistivity along [100] is shown in Fig. 1. Fig. 2 shows the resistivity behaviour in magnetic field rotating in plane perpendicular or parallel to the sample. It is easy to realize that such sample is already sensor to determine plane of magnetic field rotation.

Examination of diluted n-type ($m^*/m_o \sim 0.2$) solid solutions of U_3As_4 [4] in semiconducting Th_3As_4 (ΔE = 0.43 eV) showed location of the 5*f* states well below the conduction band. Obtaining recently the *p*-type of Th_3As_4 with by one order higher effective mass of the carrier seems to open a new ferromagnetic semiconductor field of research.

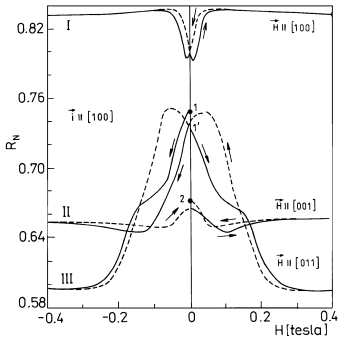

Fig. 1. The effect of magnetic field of different direction on U_3As_4 resistivity along [100]

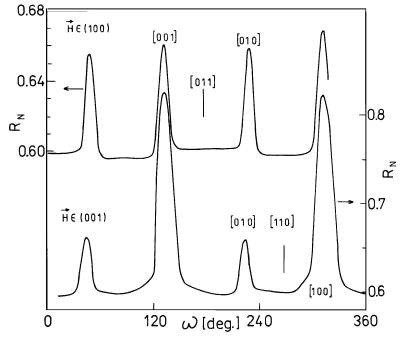

Fig. 2. The resistivity in magnetic field rotating in plane perpendicular or parallel to the sample

[1] R. Troć, J. Sznajd, P. Novotny, and T. Mydlarz, J. Magn. Magn. Mater. **23** (1981) 129.
[2] L. M. Sandratskii and J. Kübler, Phys. Rev. B **55** (1997) 11395.
[3] P.Wiśniewski, A.Gukasow, and Z.Henkie, Phys. Rev. B **60** (1999) 6242.
[4] P.J. Markowski, Z. Henkie and A. Wojakowski, Solid State Commun. **32** (1979) 1119.

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