Investigation of macroscopic magnetic properties of Mn_5Si_3 compound

Nour Abboushi

Thu ,25.3.2021, 2:30 PM

Regarding the frame work of my master thesis project, we have worked on single crystal samples of Mn_5Si_3 intermetallic compound. DC-field direction dependent mass magnetization measurements were performed, using different protocols with magnetic field along three different crystallographic directions, to investigate the physical macroscopic magnetic properties of this compound, and then to calculate the potential of MCE.

As a general overview about this compound , at room temperature it's found to be in paramagnetic state and crystalizes in a hexagonal structure type $D8_8$ with space group $(P6_3/mcm)$, with two distinct crystallographic sites for Mn atoms [1-3]. Interestingly, it displays a complex modulated magnetic structure, which is known to give rise to two first-order transitions from a non-collinear anti- ferromagnetic structure to a collinear antiferromagnetic structure at 66 K (AFM1), and from the latter to Paramagnetism at 99 K (AFM2) [2, 4-7]. Sürgers et al [8] , recently reported the presence of another intermediate magnetic configuration, AFM1´ , through which the AFM1 state transforms to the AFM2 state in the presence of an applied magnetics field (H) , with highly dependent on temperature and magnetic field.

In addition to such unusual magnetic properties, Mn5Si3 also shows different functional properties, such as large inverse magnetocaloric effect, cooling by adiabatic magnetization, which is associated with the AFM1-AFM2 phase transition [9-11].

In the context of this work, we have presented an overview about how the field direction affects the observed transitions. In addition to the complex magnetic phase diagram of Mn5Si3, we have calculated the MCE for the different directions both for the transitions AFM1-AFM2 and AFM2-paramagnetic.

References

1. Aronsson, B., *Borides and silicides of the transition metals.* Arkiv Kemi, 1960. **16**.
2. Lander, G.H., P.J. Brown, and J.B. Forsyth, *ANTIFERROMAGNETIC STRUCTURE OF MN5SI3.* Proceedings of the Physical Society of London, 1967. **91**(572P): p. 332-&.
3. Menshikov, A.Z., A.P. Vokhmyanin, and Y.A. Dorofeev, *Magnetic-Structure and Phase-Transformations in Mn5si3.* Physica Status Solidi B-Basic Research, 1990. **158**(1): p. 319-328.
4. Alkanani, H.J. and J.G. Booth, *MAGNETIC-FIELD-INDUCED TRANSITIONS IN MN5SI3.* Journal of Magnetism and Magnetic Materials, 1995. **140**: p. 1539-1540.
5. Brown, P.J. and J.B. Forsyth, *Antiferromagnetism in Mn5si3 - the Magnetic-Structure of the Af2 Phase at 70 K.* Journal of Physics-Condensed Matter, 1995. **7**(39): p. 7619-7628.
6. Vinokurova, L., et al., *Magnetic phase transitions and electronic structure of the manganese silicides.* Journal of Magnetism and Magnetic Materials, 1990. **90-91**: p. 121-125.
7. Silva, M.R., P.J. Brown, and J.B. Forsyth, *Magnetic moments and magnetic site susceptibilities in Mn5Si3.* Journal of Physics-Condensed Matter, 2002. **14**(37): p. 8707-8713.
8. Sürgers, C., et al., *Switching of a large anomalous Hall effect between metamagnetic phases of a non-collinear antiferromagnet.* 2017. **7**: p. 42982.
9. Biniskos, N., et al., *Spin Fluctuations Drive the Inverse Magnetocaloric Effect in Mn5Si3.* Physical Review Letters, 2018. **120**(25): p. 6.
10. Gottschilch, M., et al., *Study of the antiferromagnetism of Mn5Si3: an inverse magnetocaloric effect material.* Journal of Materials Chemistry, 2012. **22**(30): p. 15275-15284.
11. Tegus, O., et al., *Magnetic and magnetocaloric properties of Mn5Ge3− xSbx.* Journal of Alloys and Compounds, 2002. **337**(1-2): p. 269-271.