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J. Han

William B. Yelon

Missouri University of Science and Technology, yelonw@mst.edu

Naushad Ali

I. Dubenko

et. al. For a complete list of authors, see http://scholarsmine.mst.edu/phys_facwork/318Follow this and additional works at: http://scholarsmine.mst.edu/phys_facworkPart of the [Chemistry Commons](#)

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THE EFFECTS OF SUBSTITUTING IRON FOR MANGANESE IN $\text{SmMn}_x\text{Fe}_{1-x}\text{Ge}_6$:
MAGNETIC AND CRYSTALLOGRAPHIC PROPERTIES

J. Han,^{a)} G. K. Marasinghe,^{a)} W. J. James,^{a)} W. B. Yelon,^{b)} Ph. H. Rietler,^{c)} I. Dubenko,^{d)} and N. Ali^{d)}

^{a)} Graduate Center for Materials Research, University of Missouri-Rolla, Rolla, MO 65409

^{b)} Research Reactor, University of Missouri-Columbia, Columbia, MO 65211

^{c)} Laboratoire des Matériaux et du Génie Physique, ENSPG, 38402 Saint Martin d'Hères, France

^{d)} Department of Physics, Southern Illinois University at Carbondale, Carbondale, IL 62901

In order to further understand the interaction between the magnetic moments of iron and manganese atoms in rare earth-transition metal intermetallics, we have investigated selected magnetic and crystallographic properties of several $\text{SmMn}_x\text{Fe}_{1-x}\text{Ge}_6$ ($0 \leq x \leq 1.5$) solid solutions.

$\text{SmMn}_x\text{Fe}_{1-x}\text{Ge}_6$ samples were prepared from elements of purity 99.99% or better by induction melting in a cold copper crucible followed by annealing at 750°C for two weeks. The phase purity of the samples was checked by X-ray diffraction (XRD). The bulk magnetic properties were measured on a SQUID or vibrating sample magnetometer. Information about the easy direction of magnetization was obtained from X-ray diffraction studies of powder samples that were magnetically aligned in-plane.

All of the $\text{SmMn}_x\text{Fe}_{1-x}\text{Ge}_6$ samples crystallized in the hexagonal YCo_5Ge_6 -type structure [1] with a small amount (<9% wt) of $\text{Sm}(\text{MnFe})_2\text{Ge}_6$ as an impurity phase. The lattice parameters were obtained by Rietveld analysis [2] of powder XRD patterns. The unit cell volume decreases with increasing iron content at an average rate of 2.4% per substituted atom. This rate of contraction is almost twice that observed for $\text{NdMn}_x\text{Fe}_{1-x}\text{Ge}_6$ [3].

Fig. 1 shows thermo-magnetic data measured at an applied field of 2000 Oe for $\text{SmMn}_x\text{Fe}_{1-x}\text{Ge}_6$ samples. The data for SmMn_0Ge_6 which is indicative of ferromagnetic ordering, is in good agreement with prior work [4]. The Curie temperature of $\text{SmMn}_x\text{Fe}_{1-x}\text{Ge}_6$, 446 K, is similar to that of SmMn_0Ge_6 . However, the Curie temperature decreases rapidly as the iron content increases beyond $x = 0.5$, see Fig. 1. In addition, the thermo-magnetic data show another magnetic transition, in addition to that at the Curie Temperature, occurring around 50 K for the iron containing samples. The thermo-magnetic behavior of these samples are somewhat different from that reported for $\text{NdMn}_x\text{Fe}_{1-x}\text{Ge}_6$ intermetallics [3].

The net of magnetization of $\text{SmMn}_x\text{Fe}_{1-x}\text{Ge}_6$ intermetallics decreases with increasing iron content.

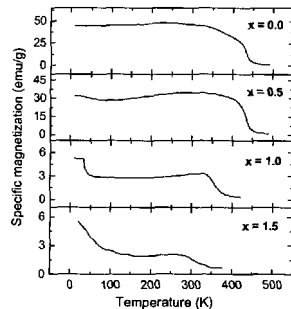


Fig. 1. Temperature dependence of the magnetization for $\text{SmMn}_x\text{Fe}_{1-x}\text{Ge}_6$ intermetallics measured at an applied field of 2000 Oe.

The magnetization of $\text{SmMn}_{0.5}\text{Fe}_{0.5}\text{Ge}_6$ approaches that of SmMn_0Ge_6 at high applied fields, in excess of 7 and 3 T at 30 and 300 K, respectively. Here again, the magnetization drops drastically as the iron content exceeds $x = 0.5$. As a result, $\text{SmMn}_1\text{Fe}_0\text{Ge}_6$ and $\text{SmMn}_{1.5}\text{Fe}_{0.5}\text{Ge}_6$ do not magnetically saturate even at an applied field of 8 T. M vs. H data for $\text{SmMn}_x\text{Fe}_{1-x}\text{Ge}_6$ samples are remarkably similar to that for $\text{NdMn}_x\text{Fe}_{1-x}\text{Ge}_6$ [3]. As was the case for $\text{NdMn}_x\text{Fe}_{1-x}\text{Ge}_6$ intermetallics, the magnetic moment of the iron sublattice appears to couple antiferro/ferrimagnetically with ferromagnetically coupled moments of the manganese and samarium sublattices.

Fig. 3 compares the XRD pattern for random powders of $\text{SmMn}_{0.5}\text{Fe}_{0.5}\text{Ge}_6$ with that of powders magnetically aligned in the reflecting plane of the XRD sample. The growth of the (002) reflection upon alignment indicates that the basal planes are preferentially oriented parallel to the reflecting surface of the XRD specimen. Taking into account that the aligning field was parallel to the surface, we conclude that the net moment is parallel or close to being parallel to the basal plane of the unit cell. Similar results were observed for the other $\text{SmMn}_x\text{Fe}_{1-x}\text{Ge}_6$ samples as well. In contrast, the easy direction of magnetization of $\text{NdMn}_x\text{Fe}_{1-x}\text{Ge}_6$ intermetallics at 300 K was found to be the c-axis [3].

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[1] Von Werner Buchholz, Hans-Uwe Schuster, *Z. Anorg. Allg. Chem.*, **482** (1981) 40.

[2] H.M. Rietveld, *J. Appl. Crystallogr.* **2** (1969) 65.

[3] "The atomic and magnetic structure of $\text{NdMn}_{(1-x)}\text{Fe}_x\text{Ge}_6$ solid solutions," J. Han et al., submitted to *J. Appl. Phys.*

[4] B. Chafik El Idrissi, G. Venturini, B. Malaman, and E. Ressouche, *Journal of Alloys and Compounds*, **215** (1994) 187.

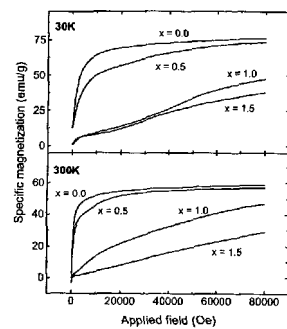


Fig. 2. Magnetization vs. applied field for $\text{SmMn}_x\text{Fe}_{1-x}\text{Ge}_6$ intermetallics measured at 30 and 300 K.

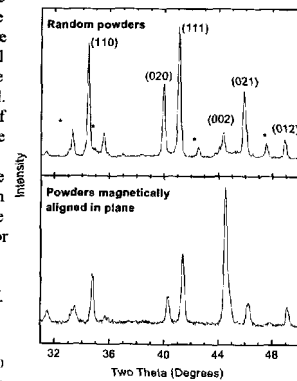


Fig. 3. X-ray diffraction data for random (top) and magnetically aligned (bottom) powders of $\text{SmMn}_{0.5}\text{Fe}_{0.5}\text{Ge}_6$. The magnetic field was applied parallel to the sample surface. Lines marked by (*) belong to the impurity 1:2:2 phase.