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A neutron diffraction structural study of R$_2$Fe$_{17-x}$Al$_x$(C) (R=Tb,Ho) alloys

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Our group has reported previously that the coercivity of 1.5 T could be obtained in Sm$_2$Fe$_{15}$Ga$_2$C$_{1.5}$ ribbons by direct quenching at the optimum wheel velocity. Recently, it was discovered that the coercivity up to 2.2 T could be achieved in melt-spun Sm$_2$Fe$_{15}$Ga$_2$C$_{2.0}$ with overstoichiometric Sm content by annealing the amorphous ribbons. In this paper, the coercivity and microstructure of melt-spun Sm$_2$Fe$_{15}$Ga$_2$C$_{1.5}$ and Sm$_2$Fe$_{15}$-xM$_x$Ga$_2$C$_{1.5}$ (M = Cu, Nb; 0.5x(2.0)) alloys have been studied as a function of composition and annealing temperature and time. The as-quenched almost amorphous ribbons were annealed at 823-1173 K. Before annealing, the ribbons showed low coercivity (< 0.5T). After annealing, the ribbons with the main phase of Th$_2$Zn$_{17}$ and a small amount of (-Fe were detected from X-ray diffraction patterns and SEM. The coercivities of all ribbons first increase monotonically with increasing annealing temperature. The maximum coercivities at room temperature are about 1.4T. 2.2T and 1.6T for Sm$_2$Fe$_{15}$Ga$_2$C$_{1.5}$, Sm$_2$Fe$_{15}$CuGa$_2$C$_{1.5}$ and SmFe$_{14}$NbGa$_2$C$_{1.5}$, respectively, after annealing at 1073 K for 15 min. Then coercivities decrease at the higher annealing temperature. For SmFe$_{14}$CuGa$_2$C$_{1.5}$ ribbons annealing at 1073 K for 5-60 min., the maximum coercivities were obtained between 15 min. and 20 min. Although the substitution of Cu or Nb for Fe has a small effect on the average size of crystalline grain, but affects the coercivity obviously. From the initial magnetizing curves and the applied magnetic field dependencies of $H_c$ and $H_m$, the ribbons magnetically couple the grains and is consequently the reason for the high coercivities of these samples. Electron microscopy studies of these melt-spun Sm$_2$Fe$_{15}$Ga$_2$C$_{x}$ samples with different Sm contents have been performed by SEM and TEM. A broad grain size distribution (50-250 nm) is observed in the SEM, but there is no difference between samples with different Sm contents. TEM studies show no change in grain shape with variation of the $\delta$ value. High resolution TEM studies indicate the existence of a very thin intergranular phase for samples with an excess of Sm. To prove this we performed high resolution EDX studies with a scanning-TEM. These investigations show a significant increase of the Sm content at the grain boundaries for these high coercive samples.

ED-05. THE HARD-MAGNETIC PROPERTIES OF MELT-SPUN Sm$_2$Fe$_{15}$Ga$_2$C$_{1.5}$ AND Sm$_2$Fe$_{15}$-xM$_x$Ga$_2$C$_{1.5}$ (M = Cu, Nb; 0.5x(2.0)) ALLOYS*.

ED-06. ELECTRON MICROSCOPY STUDIES OF HIGH COERCIVE MELT-SPUN Sm$_2$Fe$_{15}$Ga$_2$C$_{x}$ PERMANENT MAGNETS. J. van Lier, A. Zern, H. Labitzke, J. Thomas, M. Seeger, and H. Kronmüller (Max-Plank-Inst. für Metallforschung, Heisenbergstrasse 1, D-70569 Stuttgart, Germany).

The influence of overstoichiometric Sm contents on the magnetic properties of melt-spun Ga stabilized Sm$_2$Fe$_{15}$C$_{x}$ ribbons has been investigated. For optimum heat treatment Sm$_2$Fe$_{15}$Ga$_2$C$_{2.0}$ ribbon flakes an increase of the room temperature coercivity could be observed from $\mu_0H_c = 1.7$ T for stoichiometric samples to $\mu_0H_c = 2.2$ T for $\delta = 0.15$. This effect is very interesting because of an improved temperature stability. At 500 K a maximum energy density of $(BH)_{max} = 31.4$ kJ/m$^3$ for $\delta = 0.13$ can be observed. It is shown, that a Sm rich nonmagnetic intergranular phase decouples the grains magnetically and is consequently the reason for the high coercivities of these samples. Electron microscopy studies of these melt-spun Sm$_2$Fe$_{15}$Ga$_2$C$_{x}$ samples with different Sm contents have been performed by SEM and TEM. A broad grain size distribution (50-250 nm) is observed in the SEM, but there is no difference between samples with different Sm contents. TEM studies show no change in grain shape with variation of the $\delta$ value. High resolution TEM studies indicate the existence of a very thin intergranular phase for samples with an excess of Sm. To prove this we performed high resolution EDX studies with a scanning-TEM. These investigations show a significant increase of the Sm content at the grain boundaries for these high coercive samples.