$Y_{1-X}SmXCo_5$ ribbons obtained by Melt Spinning

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Abstract

YCo_5 and $Y_{0.5}Sm_{0.5}Co_5$ ribbons were synthesized by melt-spinning with a copper wheel velocity of 29 m/s. X-ray diffraction patterns showed that the samples were essentially single phase with a hexagonal $CaCu_5$-type crystal structure. A grain size of a few micrometers was observed for both composition, with equiaxed grains and dendritic-like grains for YCo_5 and $Y_{0.5}Sm_{0.5}Co_5$ respectively. The $Y_{0.5}Sm_{0.5}Co_5$ sample have a σ_r/σ_{max} ratio of 0.63 and it developed a coercivity $_iH_C$=4.4 kOe higher than that of the YCo_5 sample. From zero field cooling and field cooling curves as a function of temperature an irreversibility temperature of approximately 300 K was determined.

Keywords: Permanent magnets; magnetocrystalline anisotropy; zero field cooling; field cooling.

Introduction

The coercivity in intermetallic compounds of compositions $Y_{1-x}Sm_xCo_5$ is determined by their high magnetocristalline anisotropy and by the development of a suitable microstructure [1]. Some applications for this type of hard magnets include mobile alternators, motors for ships, and more recently for fabrication of MEMs [2,3]. The Y-Sm-Co based permanent magnets are of major interest for new applications where high operation temperatures (up to 573 K) are needed, or where a stable magnetic field in a variable temperature environment is required [4]. Recently, we reported high coercivity in nanocrystalline $Y_{0.5}Sm_{0.5}Co_5$ powders prepared by mechanical milling [5]. In this work, we present the results of the synthesis and magneto-structural characterization of $Y_{1-x}Sm_xCo_5$ ribbons produced by melt spinning.

Experimental

Samples with nominal $Y_{1-x}Sm_xCo_5$ composition were prepared by fusing them in an arc furnace under a controlled argon atmosphere (99.999 % Praxair). Chunks of Y (99.9% REO), Sm (99.9% REO) and Co (99.5 % REO) from Alfa Aesar were used as starting materials. 3 g ingots of the compounds were melted 4 times in order to ensure homogeneity The ingot fragments of mass 1 g were inserted into a quartz tube with a nozzle diameter of ~1.4 mm. The melt spinning chamber was evacuated to 1 atm. The charge was induction melted and ejected through the nozzle using a pressure difference of about 5 psi. Surface velocities of the Cu roll were 29 m/s. X-ray diffraction (XRD) patterns were determined using a Siemens, model D5000 diffractometer with a Cu-K_α radiation of 1.5406 Å. Microstructural analysis were carried out with a scanning electron microscope JEOL model JSM-5800 LV. Magnetic properties were measured with a vibrating sample magnetometer (VSM) with a maximum magnetic field of 15 kOe, and the field cooling (FC) and zero field cooling (ZFC) curves were measured with SQUID magnetometer in the temperature range from of 5 to 300 K. During ZFC measurements the samples were cooled from the higher to the lower temperature in the absence of a magnetic field and then the magnetization was measured during heating under a constant magnetic field of 50 Oe. During FC measurements the samples were cooled from the higher to the lower temperature in a constant magnetic field of 50 Oe and then the magnetization was measured during heating under the same constant magnetic field.

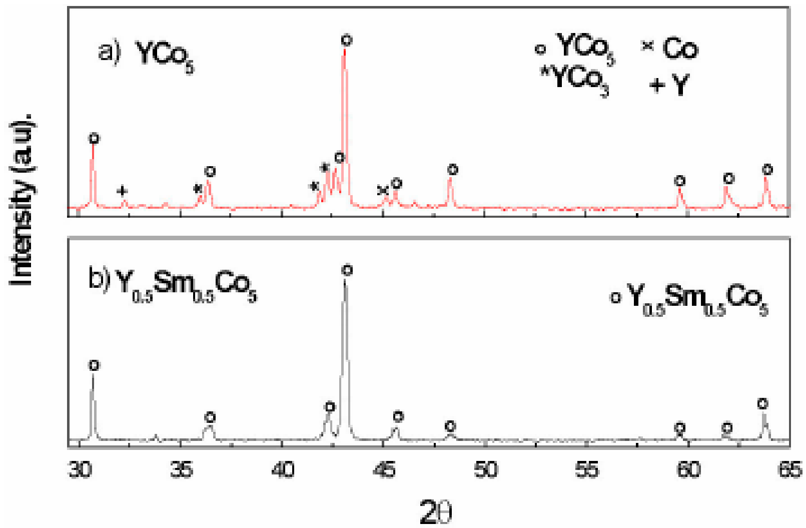

FIGURE 1. XRD patterns for the a) YCo_5 and b) $Y_{0.5}Sm_{0.5}Co_5$ as-cast alloys.

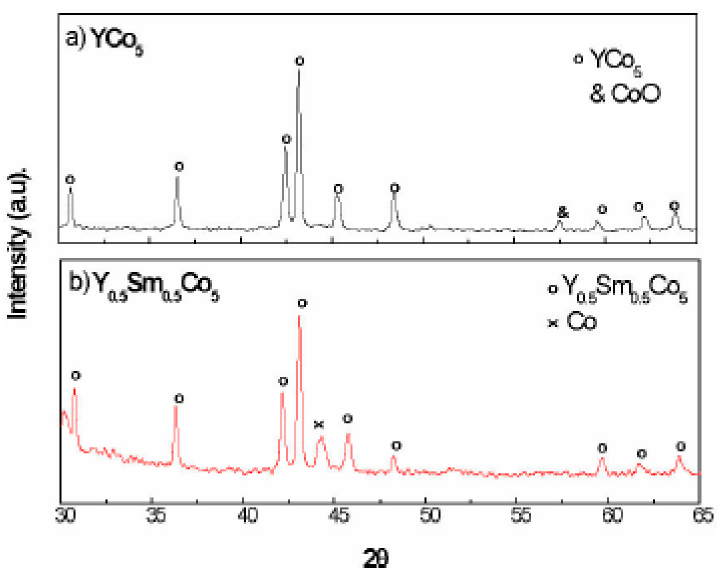

FIGURE 2. XRD patterns for the a) $YCo_5$and b) $Y_{0.5}Sm_{0.5}Co_5$ melt-spun samples obtained with a copper wheel velocity of 29 m/s.

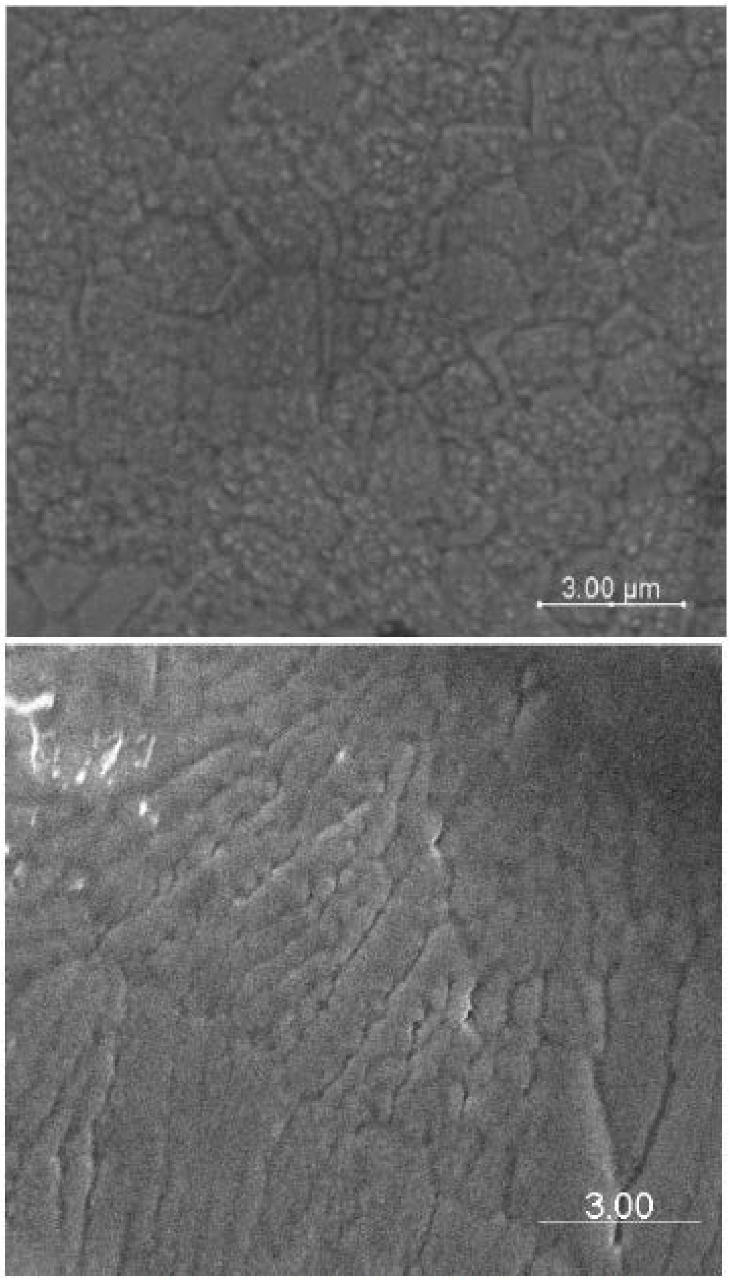

FIGURE 3. Scanning electron micrographs for the a) YCo_5 and b) $Y_{0.5}Sm_{0.5}Co_5$ melt-spun samples for the non-contacting surfaces respectively.

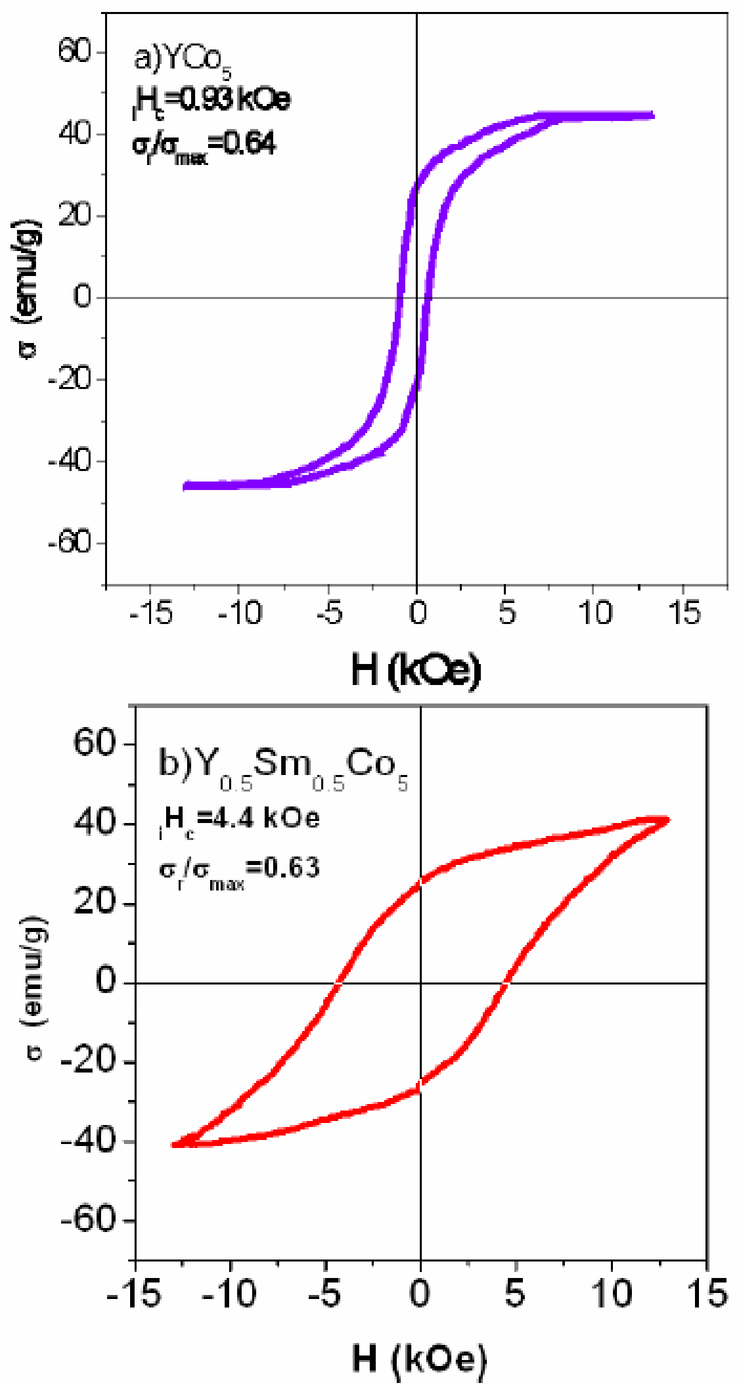

FIGURE 4. Hysteresis loops for the a) YCo_5 and b) $Y_{0.5}Sm_{0.5}Co_5$ melt-spun alloys obtained with a copper wheel velocity of 29 m/s and using a maximum applied field of 15 kOe.

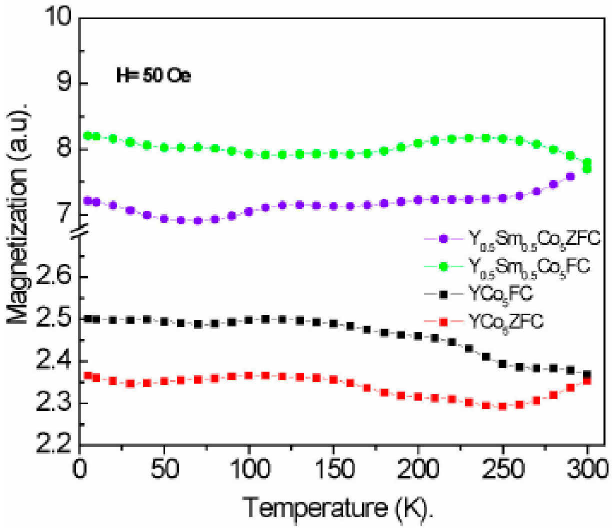

FIGURE 5. FC and ZFC magnetization curves as a function of temperature (from 5 to 300 K) with a constant field of 50 Oe for the YCo_5 and $Y_{0.5}Sm_{0.5}Co_5$ ribbons obtained with a cooper wheel velocity of 29 m/s.

Results and discussion

Figure 1 shows the XRD patterns for the a) YCo_5 and b) $Y_{0.5}Sm_{0.5}Co_5$ as-cast alloys. All peaks in the as-cast alloys were indexed using the 1:5 type hexagonal unit cell (ICSD #102670). From this analysis it was determined that the hexagonal 1:5 compound was the main phase in the ascast alloys, also others secondary phases were indexed using the unit cells (ICSD #180435) by the phase YCo_3 and (ICSD #150806) by the Co, (ICSD #180435). The presence of main phase 1:5 in the sample show that the arc-melting process produced samples with the expected YCo_5 and $Y_{0.5}Sm_{0.5}Co_5$ compositions where the Y and Sm losses were compensated correctly. Figure 2 shows the XRD patterns for the a) YCo_5 and b) $Y_{0.5}Sm_{0.5}Co_5$ melt-spun samples obtained with a copper wheel velocity of 29 m/s. Most of the peaks in the melt-spun alloys were indexed using the hexagonal $Y_{0.5}Sm_{0.5}Co_5$ unit cell (ICSD #102670) with a few small intensity peaks more probably of Co (ICSD # 150806) in the sample of $Y_{0.5}Sm_{0.5}Co_5$.

Other secondary phase were indexed in the sample de YCo_5using the unit cell (ICSD #421300) with the CoO. Figure 3 shows scanning electron micrographs for the a) YCo_5 and b) $Y_{0.5}Sm_{0.5}Co_5$ melt-spun samples for the non-contacting surfaces respectively. A grain size of a few micrometers was observed for both composition, with equiaxed grains and dendritic-like grains for YCo_5 and $Y_{0.5}Sm_{0.5}Co_5$ respectively. Figure 4 shows the hysteresis loops for the a) YCo_5 and b) $Y_{0.5}Sm_{0.5}Co_5$ melt-spun samples obtained with a copper wheel velocity of 29 m/s and using a maximum applied field of 15 kOe. The $Y_{0.5}Sm_{0.5}Co_5$ sample have a *σr/σ* max ratio of 0.63 and it developed a coercivity $_iH_C$=4.4 kOe higher than that of the YCo_5 sample. In addition the YCo_5 sample reach a saturation state for the maximum applied field, while the $Y_{0.5}$ $Sm_{0.5}Co_5$ sample shows a minor hysteresis loop. Figure 5 shows the FC and ZFC magnetization curves as a function of temperature (from 5 to 300 K) with a constant field of 50 Oe for the YC_{o5} and $Y_{0.5}Sm_{0.5}Co_5$ ribbons obtained with a cooper wheel velocity of 29 m/s. For both YCo_5 and $Y_{0.5}Sm_{0.5}Co_5$ the FC y ZFC curves define an irreversibility temperature of approximately 300 K when they intercept each other [6].

Conclusions

YCo_5 and $Y_{0.5}Sm_{0.5}Co_5$ melt-spun ribbons with the hexagonal $CaCu_5$-type crystal structure were obtained with a cooper wheel velocity of 29 m/s. Both compositions have a grain size of a few micrometers, the YCo_5 sample show a morphology of equiaxed grains and the $Y_{0.5}Sm_{0.5}Co_5$ sample has a dendritic-like morphology. The $Y_{0.5}Sm_{0.5}Co_5$ sample showed the higher coercivity $_i$HC=4.4 kOe with a σ_r/σ max ratio of 0.63. From FC and ZFC magnetization curves an irreversibility temperature of approximately 300 K was determined for both composition.

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