Tunning the extrinsic magnetic properties of SmCoB-based compounds by composition and process parameters design

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$SmCo_4B$ exhibits the highest anisotropy field ($\mu_0H_A \approx 90$ T at 300K) among the RE-TM compounds resulting in an ultrahigh coercivity [1,2]. As an example, $SmCo_4B$ as spun ribbon which is prepared with a wheel speed of 30 m/s exhibits $\mu_0H_c = 4.4$ T [1,2]. However, their low magnetization ($\mu_0M_s \approx 0.35$T) limited their remanence ≈ to 0.2 T for isotropic magnets which limits their practical applications despite their huge coercivity.

One way to increase the magnetization of $SmCo_4B$ is by tuning its composition. Introducing a small amount of Fe increases μ_0M_s from 0.35 T to 0.48 T in $SmCo_{3.8}Fe_{0.2}B$. Further improvement is achieved by partially substituting Nd for Sm, as in $Sm_{0.7}Nd_{0.3}Co_{3.8}Fe_{0.2}B$ μ_0M_s reaches 0.55 T [3]. It should be noted that these values were measured under an applied field of 14 T where the sample wasn't saturated.

In this work, we investigated the effect of composition and process parameters on the extrinsic magnetic properties and phase development. To achieve this, $SmCo_4B$, $SmCo_{3.8}Fe_{0.2}B$, and $Sm_{0.7}Nd_{0.3}Co_{3.8}Fe_{0.2}B$ were synthesized by melt spinning at wheel speeds of 10, 30, and 50 m/s, followed by thermal treatment at 800 °C-1000°C for 30 min. Our findings indicate that the type of substituent element significantly influences the coercivity trend, as summarized in Fig. 1 for as spun and annealed (800C for 30 min) $SmCo_4B$ and $SmCo_{3.8}Fe_{0.2}B$ It has been observed that both the wheel speed and the heat treatment significantly influence phase formation, thereby altering the hysteresis loop in different ways for $SmCo_4B$ and $SmCo_{3.8}Fe_{0.2}B$.

As an example, as-spun $SmCo_4B$ ribbons with single phase display a kink-free hysteresis loop with a μ_0H_c =1.57 T and a remanence $\mu_0M_r = 0.2$ T. Annealing at 800 °C introduces a kink in the loop, reducing μ_0H_c to 0.82 T while slightly increasing μ_0M_r to 0.23 T due to the formation of a small amount of a secondary phase. Further annealing at 900 °C produces a square loop with $\mu_0H_c = 2.6$ T and $\mu_0M_r = 0.29$ T.

In contrast, Fe- and Nd-substituted ribbons exhibit an improved, kink-free hysteresis curve upon annealing. The best magnetic properties ($\mu_0Hc = 4.3$ T and $\mu_0M_r = 0.25$ T) are achieved in $SmCo_{3.8}Fe_{0.2}B$ ribbons produced at 30 m/s and annealed at 800 °C. In this study, we will discuss in detail the role of microstructure and phase formation in determining extrinsic magnetic properties and explore strategies for their enhancement.

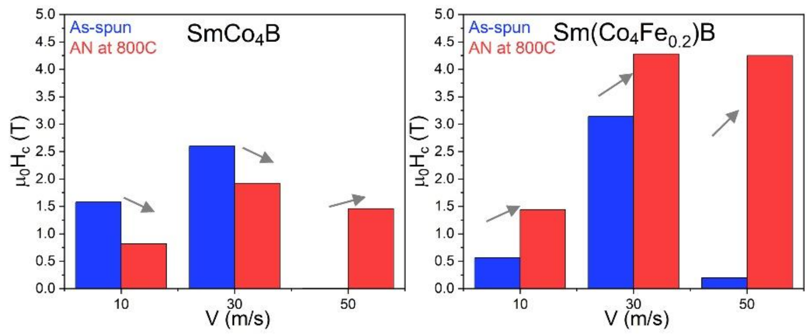

Figure 1. The coercivity trends for both as-spun and annealed $SmCo_4B$ and $SmCo_{3.8}Fe_{0.2}B$ samples, produced by melt spinning at wheel speeds of 10, 30, and 50 m/s.

Reference

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