Tuning the magnetic properties of SmCo micromagnets suitable for integration in MEMS

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The idea of use of SmCo magnetic films in MEMS systems is very attractive, because the proposed devices will allow to significantly reduce power consumption and heating, as there will be no need for energy-intensive control elements controlled by electric current [1, 2]. However, there are a number of technological barriers to their realization. Here we focused on the phase and microstructure evolution of W/SmCo/W films (Fig 1). We present a series of experimental technological steps and their analysis that can improve the coercivity and residual magnetization of the SmCo films due to the tuning of phase composition. We optimized the deposition parameters for the formation of crystalline films that are stable after annealing and patterning (Fig 1a). Annealing of the film at 650°C and 750°C causes crystallization and increase of coercivity up to 3.65 T. XRD analysis reveals a predominant Sm2Co17 phase upon annealing at 650°C and a mixture of Sm2Co17 (softer) and SmCo5 (harder) magnetic phases in films annealed at 750°C. Increase of annealing temperature results in dispersion of the magnetic phases and corresponding increase of the interphase coupling, decreasing the switching field of the hard phase [2]. The local magnetic domain structure was analyzed by magnetic force microscope (Fig 1b) and Fast Fourier transformation (FFT). Domain sizes exceed a few grains because domain wall propagation is provided by intra- and intergrain exchange and magnetic dipole interactions between magnetically harder and softer phases (Fig 1c). We also verified the effects of plasma cleaning of the substrate surface before deposition, the deposition power, the effects of deposition temperature and annealing time of the films on the magnetic properties of SmCo films. We have determined the optimal processing parameters that affect the phase transformation and functional properties of W/SmCo/W films. This work was supported by the Joint Research Centre scientific partnership between Politecnico di Milano and STMicroelectronics and by the European Fundig https://mandmems.eu (EU Project 101070536 — MandMEMS). The authors acknowledge the availability of experimental facilities at PoliFAB.

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Fig. 1. (a) SEM image of SmCo film after annealing at 650°C. (b) MFM image of SmCo domain structure. (c) Decomposition of hysteresis loop of the SmCo film annealed at 650 ° with the following components: 1 - amorphous phase, 2 - Sm2Co17 grain phase, 3 – intergrain phase, and 4 - SmCo5 phase.

References