Single domain wall propagation in Co-rich magnetic microwires with graded magnetic anisotropy

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We observed that the annealing of Co-rich microwire at variable temperature allows to develop graded magnetic anisotropy. In such microwires, annealed with a temperature gradient, gradual variation of the hysteresis loops along the microwire length is observed. While inclined hysteresis loops are observed in as-prepared Co-rich microwires, perfectly rectangular hysteresis loops are obtained for microwires annealed at high enough temperature. Accordingly, single-domain wall propagation is observed in Co-rich microwires segments with rectangular hysteresis loops. In microwire segments annealed at intermediate temperatures, irregular hysteresis loops are observed. The origin of such hysteresis loops discussed considering magnetization rotation and DW propagation contributions. We observed that in Co-rich microwire with graded magnetic anisotropy the domain wall velocity is not uniform.

Keywords: Magnetic microwires; amorphous wires; GMI effect; magnetic softness; annealing.

1. Introduction

Amorphous magnetic wires have attracted great interest owing to unusual magnetic properties, suitable for promising applications [1,2]. The so-called Taylor-Ulitovsky technique allows manufacturing amorphous magnetic wires of the widest diameters range (from 200 nm up to 100 μm) coated with an insulating and flexible glass-coating [1,2]. The domain wall, DW, velocities observed in amorphous microwires with magnetic bistability are generally an order of magnitude superior to that of planar nanowires produced by lithography or sputtering [1]. For proposed applications the degree of the DW dynamics control is essentially relevant. The controllable DWs nucleation and propagation have been predicted in such magnetic materials with graded magnetic anisotropy using the theoretical simulation [3]. Such graded magnetic anisotropy was obtained using rather complex techniques, such as a change in the chemical composition during the thin films deposition [3]. Recently we proposed simple method to prepare Fe-rich glass-coated microwires with graded magnetic anisotropy by stress-annealing at variable temperature [1]. On the other hand, hysteresis loops of Co-rich microwires can be substantially tunned by annealing conditions: annealing temperature and time [1].

2. Results and discussion

We studied the effect annealing at variable annealing temperature, T_{ann}, on hysteresis loops and dependence of DW velocity, v, versus magnetic field, H, in $Co_{69.2}Fe_{3.6}Ni_1B_{12.5}Si_{11}Mo_{1.5}C_{1.2}$ microwire. The DW dynamics was studied using modified Sixtus-Tonks method using 3 pick-up coils placed along the studied microwire. In such Co-rich microwire we observed a gradual modification of the local hysteresis loops along the microwire length measured by short movable pick-up coil (see Fig. 1a-d). A gradual modification of the hysteresis loops from almost linear (typical for as-prepared sample) to perfectly rectangular along the microwire length, l, is observed. Accordingly, the sample annealed in T_{ann} gradient exhibits spatial variation in local hysteresis loops, i.e. graded magnetic anisotropy. As earlier predicted, in the region with

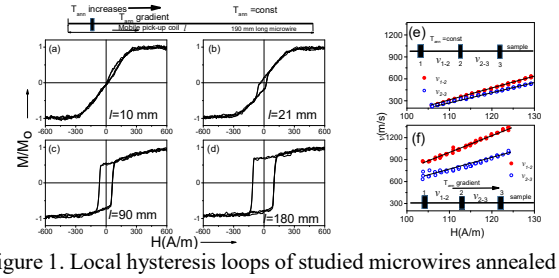

Figure 1. Local hysteresis loops of studied microwires annealed in T –gradient measured by short movable pick-up coil at different l (a-d) and $v(H)$ dependencies in the microwire segments annealed and constant T_{ann} (e) and in T_{ann} gradient (f).

graded anisotropy we observed unusual DW propagation where the DW velocity, v, is non-uniform along the microwire (see Fig.1e,f). While in the region annealed at constant T_{ann}, the DW velocity values between the pick-up coils 1-2 and 2-3, $v_{1\text{-}2}$ and $v_{2\text{-}3}$ respectively are almost the same (Fig.1f), in the region with graded anisotropy $v_{1\text{-}2} \neq v_{2\text{-}3}$.

Resuming, have proposed rather simple method to design graded magnetic anisotropy in Co-rich magnetic microwire by annealing of microwires with a temperature gradient. Such graded anisotropy is suitable for engineering of DW dynamics.

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