# Effect of magnetoelastic anisotropy on domain wall dynamics in amorphous microwires

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Recently studies of current and magnetic field driven domain walls (DW) propagation in thin magnetic wires (planar and cylindrical) attracted considerable attention [1-3] owing to possibility of application of DW propagation for data storage and logics (magnetic random memory MRAM devices, logic devices)[1]. Quite fast DW propagation of single domain wall at relatively low magnetic field has been reported for cylindrical glass coated amorphous microwires with positive magnetostriction constant with typical diameters of ferromagnetic nucleus about 10-20 $\mu$m[3,4].

Glass-coated ferromagnetic wires exhibit a number of unusual and interesting magnetic properties such as magnetic bistability and giant magneto-impedance, GMI, effect [3,5,6]. Magnetic bistability, observed previously in few amorphous materials, is related with single and large Barkhausen jump [3,5,7]. From the point of view of DW dynamics studies, amorphous glass-coated microwires with positive magnetostriction constant are unique materials allowing studies of single domain wall dymaics in a cylindrical micrometric wire. The magnetization process in axial direction runs through the depinning and subsequent propagation of the single closure domain, although the micromagnetic origin of rapidly moving head-to head DW in microwires is still [8].

It is worth mentioning, that the preparation of glass-coated microwires involves simultaneous solidification of composite microwire consisting of ferromagnetic metallic nucleus inside the glass coating introducing in this way considerable residual stresses inside the ferromagnetic metallic nucleus and glass coating and induce additional magnetoelastic anisotropy [5]. But until now little attention has been paid to studies of the influence of magnetoelastic anisotropy on DW dynamics in microwires [9].

Therefore in this paper we studied the effect of magnetoelastic anisotropy on DW propagation in family of amorphous magnetically Fe-Co based bistable microwires with different magnetostriction constant, $\lambda_s$, varying from $\lambda_s \approx 10^{-7}$ to $\lambda_s \approx 35\ x10^{-6}$. The magnetostriction constant, $\lambda_s$, in system $(Co_xFe_{1-x})_{75}Si_{15}B_{10}$ changes with x from $-5x10^{-6}$ at x= 1, to $\lambda_s \approx 35\ x10^{-6}$ at x≈0.2[10].

Within each composition of metallic nucleus we also produced microwires with different ratio of metallic nucleus diameter and total diameter, D, i.e. with different ratios $\rho$=d/D. This allowed us to control residual stresses, since the strength of internal stresses is determined by ratio $\rho$ [5].

The experimental set-up is described elsewhere [4,9].The magnetoelastic energy, $K_{me}$, is given by

$$K_{me} \approx 3/2\ \lambda_s \sigma, \qquad (1)$$

where $\sigma = \sigma_i + \sigma_a$ – total stress, $\sigma_i$ –are the internal stresses, $\sigma_a$ – applied stresses and $\lambda_s$ - magnetostriction constant [5,8]. In this way we studied the effect of magnetoelastic contribution on DW dynamics controlling the magnetostriction constant, applied and/or residual stresses.

Usually it is assumed that domain wall (DW) propagates along the wire with a velocity, *v*:

$$v=S(H-H_0) \qquad (2)$$

where *S* is the DW mobility, *H* is the axial magnetic field and $H_0$ is the critical propagation field. Dependences of domain wall velocity, *v*, on magnetic field, *H* for $Fe_{16}Co_{60}Si_{13}B_{11}$ and $Co_{41.7}Fe_{36.4}Si_{10.1}B_{11.8}$ amorphous microwires with the same $\rho$–ratio are shown in Fig.1. In this case, the effect of only magnetostriction constant is that higher magnetostriction constant (in according to ref. [10] for $Co_{41.7}Fe_{36.4}Si_{10.1}B_{11}$ microwire $\lambda_s \approx 30x10^{-6}$ should be considered, while for $Fe_{16}Co_{60}Si_{13}B_{11}$ composition $\lambda_s \approx 15x10^{-6}$) results in smaller DW velocity at the same magnetic field and smaller DW mobility, *S*.

In order to evaluate the effect of $\rho$-ratio, i.e. effect of residual stresses on DW dynamics, we performed measurements of *v(H)* dependences in the microwires with the same composition, but with different $\rho$–ratios. Dependences of DW velocity on applied field for $Co_{41.7}Fe_{36.4}Si_{10.1}B_{11.8}$ microwires with different ratios are shown on Fig.2. Like in Fig.1, at the same values of applied field, *H*, the domain wall velocity is higher for microwires with higher $\rho$–ratio, i.e. when the internal stresses are lower [5]. We also measured *v(H)* dependences for one of already measured in Fig.3 $Co_{41.7}Fe_{36.4}Si_{10.1}B_{11.8}$ microwires ($\rho \approx$ 0,55) under applied stresses (see Fig. 3). Considerable decreasing of domain wall velocity, *v*, at the same magnetic field value, *H*, have been observed under application of applies stress. Additionally, increasing of applied stress, $\sigma_a$, results in decreasing of DW velocity.

Consequently, from observed experimental dependences we can conclude, that the magnetoelastic energy can affect domain wall mobility, *S*, what we experimentally observed in few Co-Fe-rich magnetically bistable microwires.

## References

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## Figures

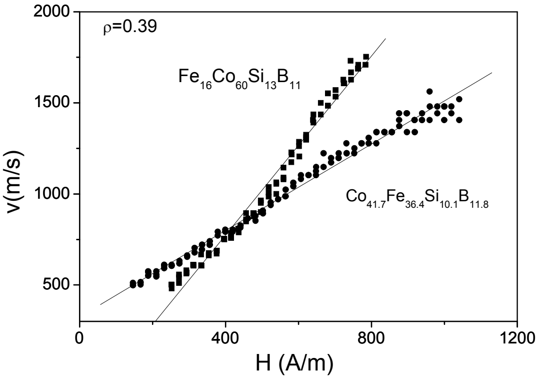

Fig.1. *v(H)* dependences for $Fe_{16}Co_{60}Si_{13}B_{11}$ and $Co_{41.7}Fe_{36.4}Si_{10.1}B_{11.8}$ microwires with ρ=0,39.

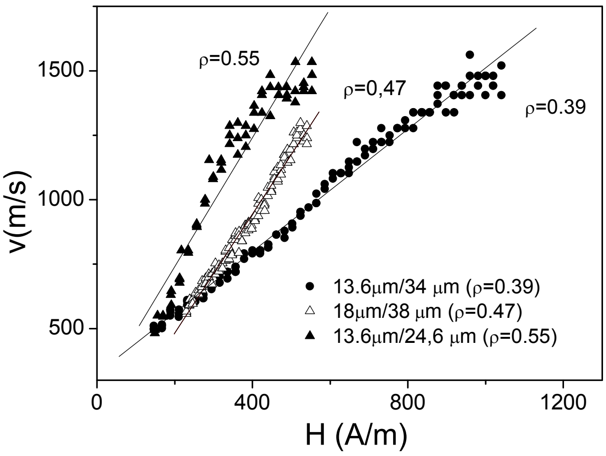

Fig.2. *v(H)* dependences for $Co_{41.7}Fe_{36.4}Si_{10.1}B_{11.8}$ microwires with different ratios ρ.

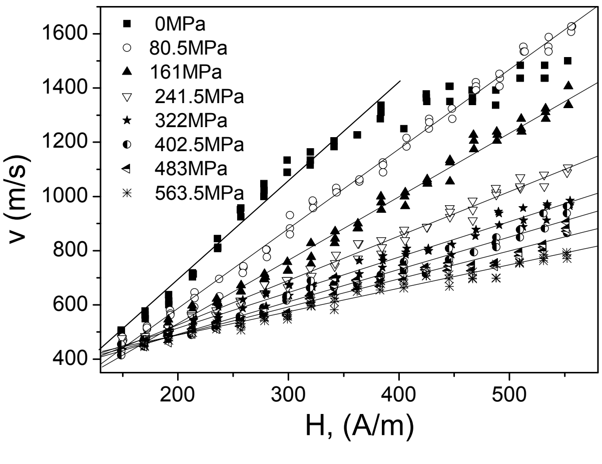

Fig.3. *v(H)* dependences for $Co_{41.7}Fe_{36.4}Si_{10.1}B_{11.8}$ microwires (d≈ 13,6μm, D≈ 24,6μm, ρ≈ 0,55) measured under application of applied stresses, $\sigma_a$.