Magneto-optical study of magnetic microwires: domain structure, domain walls motion, magnetization reversal.

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The investigation of the magnetization reversal process, domain structure and domain walls motion in magnetic microwires is one of the most important tasks related to the use of magnetic wires in different technological devices. In particular, intensive studies of magnetic properties of glass coated microwires have been performed to enhance the giant magnetoimpedance (GMI) effect used in magnetic sensing technology.

The present abstract is devoted to the recent results on magneto-optical Kerr effect (MOKE) study of the surface magnetization reversal and surface domain structure in glass covered amorphous microwires.

The full cycle of the magnetization reversal between two circularly magnetized mono-domain states has been fixed using MOKE microscope in longitudinal configuration. The process of circular domains nucleation and propagation strongly depends on the dc external axial magnetic field. The comparative analysis of the magnetometry and optical microscopy results shows that the magnetization reversal consists mainly of the nucleation of circular domains and transformation to multi-domain structure when the dc axial field is relatively small. It was found also that the dc axial field suppresses the nucleation process putting in the forefront the propagation of circular domain walls.

Also the surface domain wall (DW) motion has been studied using the MOKE modified Sixtus-Tonks method when two reflections of the broken laser beam from the microwire surface were used instead of the pickup coils [1].

The surface circular DW motion was induced by the pulsed circular magnetic field. The single domain wall motion along the wire was registered as two successive jumps of the MOKE signal. This motion is associated with the circular magnetic bistability related to the giant Barkhausen jump of circular magnetization. During the experiments our attention was focused of the influence of the dc axial magnetic field on the surface circular DW motion.

It was found the influence of the axial magnetic field on the shape of the MOKE jump. Depending on the value of the axial field there are three stage of the jump transformation. At the first stage, the time duration of the jump decreases with axial field increase. At the second stage, the specific transformation of the shape of the jump was observed. We consider that this transformation is related to the transformation of the form of the DW. Finally, the absolute value of the MOKE jump decreases following by the total disappearance of the MOKE signal. This disappearance is reasonable because the dc axial filed of the relatively high value directs the magnetization along the axial direction of the microwire eliminating the transversal projection of the surface magnetization.

Based on the series of the time dependences of the MOKE jumps related to the surface DW motion along the wire, the dependence of the DW velocity on the dc axial field has been plotted (Fig. 1). The results have been obtained for the pulsed circular field of the value of 0.2 Oe.

This dependence has been analyzed jointly with the dc axial field induced transformation of the MOKE jumps. The general growth of the velocity with dc axial field is observed. Nevertheless, three specific parts of the dependence could be marked out. There are two pars with clearly defined increase of the velocity – in the beginning and in the end of the of the curve. Also the local decrease of the velocity value exists in the middle part of the field dependence.

We consider that the first part of the field dependence is related to the DW transformation form inclined one to DW perpendicular to the wire axis, that confirmed by the MOKE signal transformation. When the dc axial field is high enough the magnetization inside the transformed DW is directed probably more along the axial direction that decelerates the motion of DW between two circular domains. The successive DW acceleration observed in the final part of the curve is clearly related to the field induced decrease of the angle of the turn of the magnetization in the DW. Finally, DW collapses when this angle is reduced to zero.

In frame of the task of the miniaturization of active elements of magnetic sensors the investigation of the magnetization reversal has been performed in nano-scale amorphous microwires for the first time. The arrays of glass covered microwires (nominal composition $(Fe_{97}Co_{3})_{75}B_{15}Si_{10}$, diameter of metallic nucleus 1000 nm) have been studied by magnetic and magneto-optical techniques. The results of PPMS magnetic (4 microwires array) and longitudinal magneto-optic Kerr effect (10 microwires array) experiments are presented in the Figs. 2(a) and 2(b). The clear jumps of magnetization could be observed in volume and surface hysteresis loops. These jumps are related to the giant Barkhausen jumps associated with the magnetization reversal in single microwire as a consequence of the interaction between the microwires. Based on the obtained results we can conclude that the magnetic behaviour of the glass covered microwires with such extremely tiny diameter keeps magnetically bistable and could be considered in the frame of core-shell model.

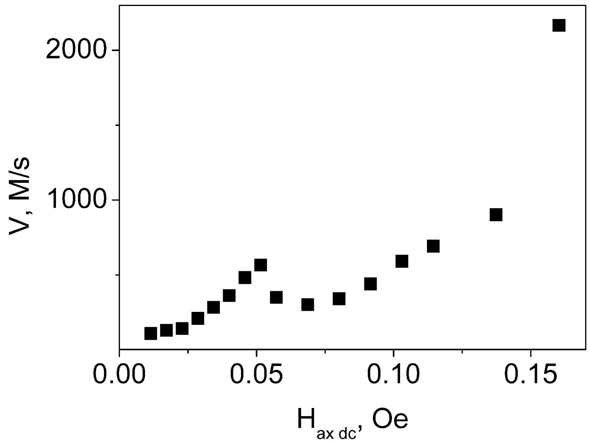

Fig.1. Dependence of the velocity of the circular surface domain wall on dc axial magnetic field. The value of the pulsed circular magnetic field is 0.2 Oe.

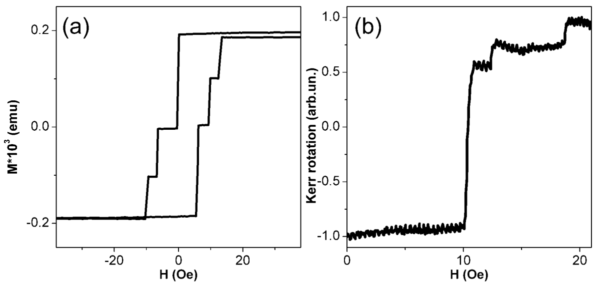

Fig. 2. Magnetization reversal curves obtained by magnetic (a) and magneto-optic (b) techniques.

References

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