Influence of tensile stress on the surface magneto-optical hysteresis loops in amorphous and nanocrystalline ribbons

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Objectives

The fabrication of the special sample holder, as a part of the magneto-optical (MOKE) differential intensity setup, enabling to apply the tensile stress in the axis of amorphous and nanocrystalline ribbons prepared by the planar flow casting (PFC) method.

The investigation of the influence of tensile stress on the ribbons surface magnetic properties and magnetic anisotropy using the MOKE hysteresis loops.

The practical demonstration of the holder in the case of field-annealed Co₆Fe₄Si₃B₁₀ and as-quenched Fe₁₋ₓSiₓB ribbons.

Principle of operation

The sample (ribbon) is placed in specially designed non-magnetic sample holder and is fixed by screwing the circlet with the hole in the middle (for incidence and reflection of the light).

Rotation of the micrometric stage causes the movement of the central part of the holder in the forward and backward directions. In this way the tensile force F in the range of 0 - 50 N can be applied in the ribbon axis.

Actual value of the force is monitored by the tensiometer and displayed by the digital controller.

Results

Field-annealed Co₆Fe₄Si₃B₁₀ ribbons

1 mm wide and 20 μm thick, prepared by the PFC technique

annealed for 8 h at temperature of 380°C, magnetic field of 3 Oe was applied along the ribbon axis

value of bulk magnetostriction : \( \lambda_b = 2.1 \times 10^{-5} \)

Surface hysteresis loops of field-annealed Co₆Fe₄Si₃B₁₀ ribbons as a function of applied tensile stress \( \sigma \) measured on the shiny side.

Detection of two magnetically hard crystalline phases.

The separation of both phases due to the material (different response coming from both phases) or depth (incident light changes the phase due to the existence of the surface oxide layer originated after ribbon annealing) sensitivity.

The influence of tensile stress on the separated individual phases:

Soft crystalline phase consists mainly of Co₆Fe₄Si₃ phases.

While stressed, the slope of loop decreases indicating the negative magnetostriction. \( (H = H_s) \)

The value of coercive field about 50 Oe.

As-quenched Fe₃₋ₓSiₓB₁₀ ribbons

5 mm wide and 20 μm thick, amorphous in the bulk as well as on both surfaces

value of bulk magnetostriction : \( \lambda_b = 3.2 \times 10^{-5} \)

The influence of tensile stress in two different places on the surface:

Two magnetic phases, FeSi and Fe₅B₆, clusters, are clearly visible at loop measured without loading.

With increasing tensile stress the changes in anisotropy, demonstrated by increasing slope in MOKE loops of both phases, are detected.

For \( \sigma = 140 \) MPa the preferred axis of both phases has the direction parallel to the applied stress and magnetic field.

Calculated values of \( \lambda \), of both phases (tens of ppm) are well comparable with the bulk magnetostriction.

Different shapes of MOKE loops in comparison to the first place.

Anisotropy and magnetostriction of both phases differ in every place on the surface, where the light is focused.

For \( \sigma = 120 \) MPa the clusters are already not distinguished at measured loops and magneto-elastic effect slowly saturates.

Positive magnetostriction of both phases is observed also in this place.