Supersonic domain wall in ferromagnetic microwires.

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Domain wall dynamics in real material:

$$m\ddot{x} + \xi\dot{x} + \alpha x = 2\mu_0 M_s H$$

If v=const. =>

$$v = (2\mu_0 M_s / \xi)\,(H - H_0)$$

H_0 - the critical propagation field - Should be low to get fast DW

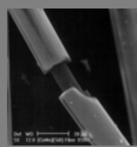
ξ-domain wall damping- should be low to get fast DW

Amorphous glass coated microwires

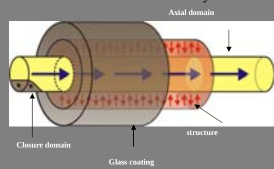
ideal material to study the single domain wall dynamics

The amorphous glass-coated materials are composite materials that consist of metallic nucleus (its diameter ranges from 0.6-20 μm) that is covered by the glass coating (thickness 2-20 μm). They are prepared by the so-called Taylor-Ulitovski method by quenching and subsequent drawing. Due to their amorphous structure, the magnetic properties of amorphous microwires are determined mainly by the magnetoelastic interaction of magnetic moments and stresses applied by quenching, drawing and stresses arising from the different thermal expansion coefficient of the metallic nucleus and glass coating.

As a result of such magnetoelastic interaction, complicated domain structure appears in amorphous wires. Particularly, the domain structure of amorphous magnetic wires with positive magnetostriction consists of one large domain in the center of the wire with magnetization oriented axially as a result of axial stresses induced by the quenching and drawing. It is surrounded by the radial multi-domain structure that results from the radial stresses induced by the quenching and different thermal expansion coefficient of the glass and metallic nucleus. Finally, small closure domains appear at the end of the microwire in order to decrease the stray fields.

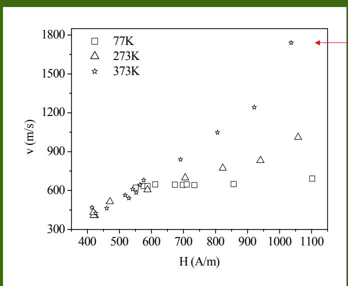


SEM microscopy image of the amorphous glass-coated microwire



Schematic domain structure of the amorphous glass-coated microwire with a positive magnetostriction

Fast domain wall, but high anisotropy



1800 m/s

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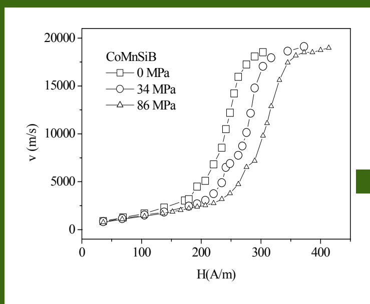
Lower anisotropy =>Faster domain wall

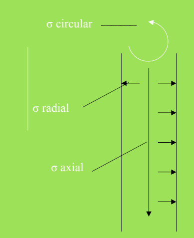


Phys. Rev. B vol.76 (2007), 132406.

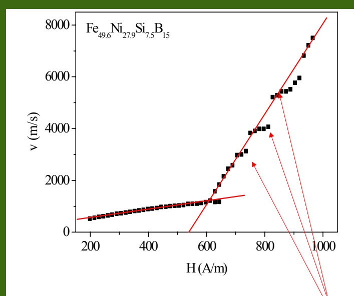
Supersonic DW

Up to 4 MACH !!!

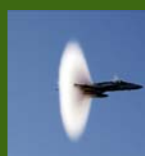
Stress distribution in microwires



Higher anisotropy => Fast domain wall because of the stress distribution



Supersonic DW



Supersonic boom – interaction of the DW with the sound wave close to the sound speed

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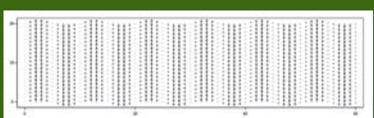
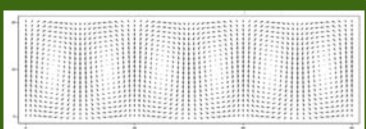
But !!!





Why 3 interactions ?

Possible sound vawes	v (m/s) in Steel, 347 stainless *	v (m/s) in microwire
Longitudinal	5790	5430
Transversal	3100	3130
Extensional	5000	4070

Conclusions:

Fast domain wall even for high anisotropy

Interaction with phonons

Advantage

- Allows one to control the fast DW velocity
- Synchronous DW circuit?