Natural Ferromagnetic Resonance in Microwires

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Abstract **- The investigation of ferromagnetic metal microware with an amorphous core structure by ferromagnetic-resonance method is reviewed. This method can be used in investigation the residual stress and the micro- and macroscopic heterogeneity of amorphous materials. The theoretical basis of the method in this case is considered.**

Index Terms **- ferromagnetic-resonance method, cast amorphous glass-coated microwires, residual stress.**

1. INTRADUCTION

A microwire was considered as ferromagnetic cylinder with small radius r_m. For its characterization we introduce following parameters:

1. The depth of the skin layer is:

$$\delta = [4\pi(\mu\mu_0)_e\Sigma\omega]^{-1/2} = \delta_0\,(\mu)_e^{-1/2},$$

$(\mu\mu_0)_e$ - is the effective magnetic permeability, and Σ - is the microwire electrical conductivity. In the case of our magnetic microwires, with the relative permeability $|\mu|$ near resonance of the order 10^2, ($\omega \sim$ (8 - 10) GHz) δ changes from 1 up to 3 μm.

2. The size of the domain wall (according to Landau-Lifshits theory) is:

$$\Delta = \pi(A/K)^{1/2} \sim 10 - 0{,}1\ \mu m,$$

where A is the exchange constant and K is the energy anisotropy of microwire.

3. Radius of single domain (according to Brown theory) is:

$$a = (1{,}84/M_s)(A/2\pi)^{1/2} \sim 0{,}1 - 0{,}01\ \mu m,$$

where M_s is the saturation magnetization of microwire.

According to the frequency of the NFMR is:

$$\left(\frac{\omega}{\gamma}\right)^2 = (H_e + 2\pi M_s)^2 - (2\pi M_s)^2 \exp\{-2\delta/r_m\},$$

where γ is the gyromagnetic ratio ($\gamma \sim 2{,}8$ MHz/Oe). The anisotropy field is $H_e \sim 3\lambda\sigma/M_s$, where λ is the magnetostriction constant; and σ is the effective residual stress originated from the fabrication procedure

2. CONCLUSION

For the frequency of NFMR in simple approximation formula can be written as:

$$\omega(GHz) \approx \omega_o\left(\frac{0.4x}{0.4x+1}\right)^{1/2}, \qquad (1)$$

x is ratio of the glass - metal cross-sectional area,

$$\omega_o(GHz) \approx 1{,}5\left(10^6\lambda\right)^{1/2}$$

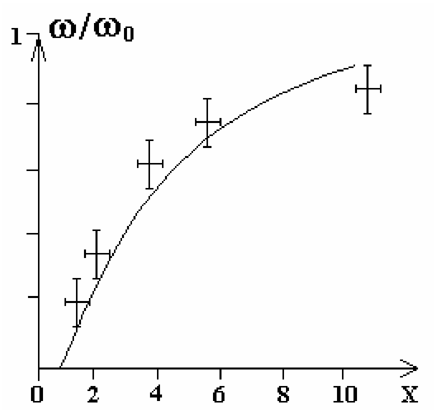

Fig.. Theoretical curve (continuous curve) of FMR frequency as a function of x according to Eq. (1), for zero external field and experimental data for dependence of FMR frequency on parameter x (crosses)