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Decomposition of domain wall motion and magnetization rotation components in permeability spectra in amorphous ribbon.

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1. INTRODUCTION

The magnetic permeability of amorphous materials involves two components originating from domain wall motion and magnetization rotation. Phenomenological models for the rotational and domain wall components in the initial permeability have been proposed to predict the effects of anisotropy, stress and bias magnetic field[1]. Impedance spectroscopy has been widely adapted to characterize the frequency dependence of complex magnetic permeability, where the measured spectra were associated with the relaxation process of domain wall motion up to now[2]. In this research, we propose a new method decomposing domain wall and rotational components from total permeability of an amorphous ribbon by using impedance spectroscopy at constant current mode.

2. EXPERIMENTAL

The rectangular sample (20 μm thickness, 6 mm width and 50 mm length) of as-quenched $Co_{66}Fe_4NiB_{14}Si_{15}$ amorphous ribbon was inserted into an solenoid coil, connected to HP4192A impedance analyzer. The analyzer measures the impedance Z of solenoid coil containing the sample in frequency range f = 5 Hz – 10 MHz :

$$Z(f) = j2\pi f L(f) + R(f)$$

where $L(f)$ and $R(f)$ are the equivalent inductance and resistance, respectively, and $j = \sqrt{-1}$. The spectrum of real and imaginary part of complex permeability, $\mu^* = \mu' - j\mu''$, were obtained by the relations:

$$\mu'(\omega) = L(\omega) / L_o(\omega)$$
$$\mu''(\omega) = \{R(\omega) - R_o(\omega)\} / L_o(\omega)$$

where L_o and R_o are the inductance and resistance of empty solenoid, respectively.

3. RESULT AND DISCUSSION

As is generally known, the rotational magnetization process is faster than the domain wall motion. The magnetization by domain wall motion, which is one of main contribution to magnetization, has a threshold field to be activated due to pinning at defects and is field dependent due to unpining process. Hence we can associate two observed relaxations in low and high frequency regions with domain wall and rotational relaxation processes, respectively.

Figure 1 shows the separation process of $\mu''_{dw}(f)$ and $\mu''_{rot}(f)$ from the $\mu''(f)$ measured at $h_o = 8$ mOe, where we can see clearly two relaxation processes are involved. Hence we can separate the spectra of domain wall relaxation, $\mu^*_{dw}(h_o, \omega)$, from the superimposed spectra at high field amplitudes by subtracting $\mu^*_{rot}(\omega)$ obtained by using low field amplitudes where only the rotational relaxation remains. The domain wall and rotational components in total permeability are obtained as $\mu_{dw}(h_o = 8\text{mOe}) = 2.56$ and $\mu_{rot} = 2.84$, together with the relaxation times as $\tau_{dw}(h_o = 8\text{mOe}) = 2.8\text{x}10^{-6}$ sec and $\tau_{rot} = 1.6\text{x}10^{-7}$ sec.(τ is relaxation time)

4. REPERENCE

[1] P.T. Squir, J. Magn. Mater. 87, 299(1990).
[2] R. Valenzuela, J.T.S. Irvine and A.R. West, J. Magn. Mater. 104-107, 369(1993).

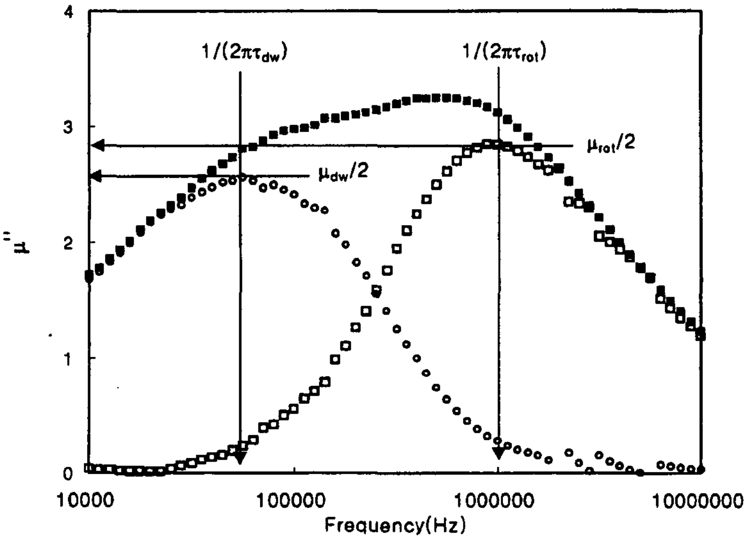

Fig.1 Separation of $\mu''_{dw}(f)$ and $\mu''_{rot}(f)$ from $\mu''(f)$ at $h_o = 8$ mOe.