A new EM-material comprised of nano-composite ferromagnetic oxide films

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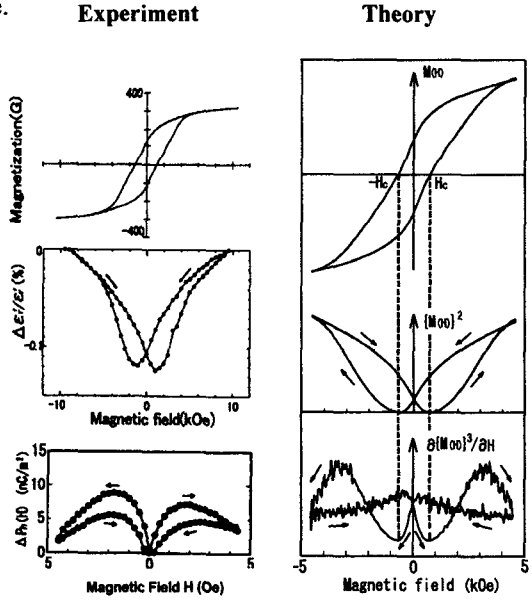
We have reported that nano-composite ferromagnetic oxide films with the Bi_2O_3-Fe_2O_3-$PbTiO_3$ system prepared by rf-reactive sputtering exhibit ferromagnetism and ferroelectricity above room temperature[1,2]. We found that these films show a kind of electromagnetic (EM-) effect, ie. the electric polarization $\Delta\mathbf{P}$ is induced by applying magnetic field $\mathbf{H}$. An example of the experimental results is shown in the left side figures for a film with $0.18Bi_2O_3$-$0.7Fe_2O_3$-$0.12PbTiO_3$ after post-annealing at 650℃ for 3h in air. The top figure is the magnetization curve, the middle one is the relative change of the dielectric permeability $\Delta\varepsilon_r'/\varepsilon_r'$ by $\mathbf{H}$, and the bottom one is $\Delta\mathbf{P}$ induced by $\mathbf{H}$, where an ac tickle field $\tilde{\mathbf{h}}(\omega)$ was applied simultaneously normal to the film plane. These experimental results are qualitatively explained by a model based on magnetization rotation of ferromagnetic nano-clusters randomly dispersed and embedded in the ferroelectric glassy matrix. The calculated results are drawn in the right side figures. The key-factors to determine $\Delta\mathbf{P}$ are summarized as : [3,4]

$$\Delta\mathbf{P}_E(\mathbf{H}) \propto \Delta\varepsilon_r'/\varepsilon_r' \propto [\mathbf{M}(\mathbf{H})]^2$$

$$\Delta\mathbf{P}_h(\mathbf{H}) \propto \partial/\partial\mathbf{H}[\mathbf{M}(\mathbf{H})]^3,$$

In calculation, we used the measured magnetization $\mathbf{M}(\mathbf{H})$ (the top figure) was used.



References

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