## Magnetoelectric properties of ferrite-PZT multilayer thin films

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Lamellar type 2-2 composite structure of various ferrite films deposited onto either rhombohedral Pb(Zr0.52Ti0.48)O3 or tetragonal Pb(Zr0.3Ti0.7)O3 thin film was prepared in an attempt to investigate the magnetoelectric properties of magnetic-piezoelectric composite materials.<sup>1-5</sup> PZT films were spincoated on (111)-oriented Pt/Ti/SiO2/Si<100> substrate utilizing the wet sol-gel technique. The ferrite films studied included CuFe2O4, CoFe2O4, and (Ni,Zn)Fe2O4, which possessed varying values of magnetic susceptibility and magnetostriction coefficients. A thin Pt layer, which was deposited by ion beam sputtering method, was inserted between the magnetic and the piezoelectric layers in order to suppress diffusion at high processing temperatures and thereby to prevent possible interfacial reactions between magnetic and piezoelectric layers. Ferrite layer was then deposited using pulsed laser deposition method (PLD). The resulting film structure is tri-layered type, where the bottom PZT layer covered the whole substrate, while Pt and ferrite layers were deposited through circular shadow masks to measure ferroelectric and magnetoelectric properties. The structural properties of the films were investigated by Xray diffraction (XRD) and field-emission scanning electron microscopy (FE-SEM). Ferroelectric and magnetic behaviors were analyzed by measuring polarization and magnetization – electric and magnetic field hysteresis, utilizing the ferroelectric test system and the vibrating sample magnetometer. The possible effect of annealing on the film microstructure and multiferroic properties was then investigated using thin film stacks heat-treated at temperatures ranging from 550 to 650C. Magnetoelectric coefficients were calculated by measuring magnetoelectric voltages using magnetoelectric measurement system. Both the magnetoelectric properties and the coupling effect of ferrite/Pt/PZT films on magnetic and magnetoelectric properties are discussed as a function of heat-treatment temperature. In this paper, the effect of annealing temperature on the magnetoelectric coupling in various ferrite/Pt/PZT multilayer thin film is discussed in detail.

## References

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