Strong electric field tuning of magnetism in multiferroic heterostructures

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Abstract: Magnetoelectric coupling can be realized in multiferroic composites, which has led to novel devices, such as the electrostatic tunable microwave signal processing devices, magnetic field sensors, etc. The performance of these devices based on multiferroic composites is critically dependent on the strength of the ME coupling, which however has been weak in at microwave frequencies. In this work, we report on novel multiferroic heterostructures which show strong ME coupling at microwave frequency. Electric field induced large changes in ferromagnetic resonance (FMR) frequencies were observed in FeGaB/Si/PMN-PT (lead magnesium niobate-lead titanate) multiferroic heterostructures, which exhibited a large tunability of the FMR frequency of Δf =900 MHz or Δf/f = 58%. We have also investigated a whole series of spin-spray deposited ferrite/ferroelectric heterostructures, including Ni0,23Fe 2.77O4(NFO)PZT (lead zirconium tinatate), Ni 0.26Zn0.1Fe2.63O4(NZFO)/ (011) cut PMN-PT, Zn0.1Fe2.9O4(ZFO)/ (011) cut PMN-PT, Fe3O4/PZT, Fe3O4/ (011) cut PMN-PT, and Fe3O4/ (011) cut PZN-PT (lead zinc niobate-lead titanate). Strong atomic bonding was observed at the interface of the spin-spray deposited ferrite/ferroelectric heterostructures, which could lead to strong ME coupling. Electric field induced giant magnetic anisotropy fields were observed in these ferrite/ferroelectric multiferroic heterostructures, which resulted in a giant electrostatically tunable FMR field range of ΔHr=860Oe in Fe3O4/PZN-PT, corresponding to a large microwave ME coefficient of 108 Oe cm/kV Static ME interaction was also investigated for these multiferroic heterostructures, which agreed well with the ME coupling at microwave frequencies. In addition, a significantly enhanced tunable ferromagnetic resonance field of 1450 Oe was demonstrated in the Fe 3O4/ (011) cut PZN-PT heterostructure by utilizing the anisotropic piezoelectric coefficient of the (011) cut single-crystal PZN-PT. These novel multiferroic heterostructures with giant electric filed induced tunable ferromagnetic resonance fields and ferromagnetic resonance frequencies provide great opportunities for electrostatically tunable microwave multiferroic devices.

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