MAGNETOELECTRIC MULTIFERROIC COMPOSITES: PHENOMENA AND DEVICES

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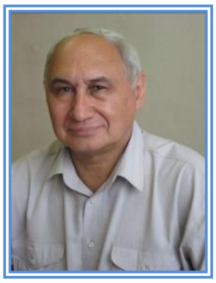

Magnetostrictive-piezoelectric composites exhibit magnetoelectric (ME) property through elastic interactions occurring at the interface of these two phases. In the last few years, strong magneto-elastic and elasto-electric coupling has been achieved through optimization of material properties and proper design of transducer structures. These developments have led to magnetoelectric structures that provide high sensitivity over a varying range of frequency and DC bias fields enabling the possibility of practical applications. Layered magnetostrictive-piezoelectric structures are multifunctional due to their dual-responsiveness to mechanical and electromagnetic forces. Here, we discuss studies of magnetoelectric (ME) interactions in ferrite-lead zirconate titanate (PZT) and metglas, Ni, Terfenol-PZT material couples. Key findings include: the observation of a giant low frequency ME effect in the layered systems; data analysis based on our model for low frequency ME effects; observation and theory of enhanced ME coupling at the electromechanical resonance (EMR); and theory and measurements of microwave ME effects, at the ferromagnetic resonance (FMR) of ferrites. Layered structures are potential candidates for sensors, gyrators and microwave devices. Low frequency sensors are feasible with excellent sensitivity to minute magnetic field variations. One could also realize composite based FMR devices, such as resonators, filters and phase shifters with electric field tunability for use at microwave range.

Studies on layered samples of ferrite/ferromagnet-PZT show evidence of strong ME interactions. We will discuss detailed mathematical modeling approaches that are used to describe the dynamic behavior of ME coupling in magnetostrictive-piezoelectric multiferroics at low frequencies and in EMR region. Our theory predicts an enhancement of ME effect that arises from interaction between elastic modes and the uniform precession spin-wave mode. The peak ME voltage coefficient occurs at the merging point of acoustic resonance and FMR frequencies. The electric tuning of ME devices would facilitate high-speed operation, small size and compatibility with integrated circuit technology.