INV 22

MAGNETIC SWITCHING OF FERROELECTRIC DOMAINS AT ROOM TEMPERATURE IN A NEW MULTIFERROIC

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We have prepared sintered ceramic specimens of ball-milled ceramics of formula $Pb(Fe,Ta,Zr,Ti)O_3$ and measured their electrical and magnetic properties.[1] This perovskite oxide is prepared by mixing 30-40% $PbFe_{1/2}Ta_{1/2}O_3$ ["PFT"]with 70-60% $PbZr_{1/2}Ti_{1/2}O_3$ ["PZT"] and gives a single-phase crystal with very high-temperature ferroelectricity. Although pure PFT exhibits long-range magnetic ordering onlyup to 150K, it is known to have weak ferromagnetism due to Fe clustering up to ca. 400K. As a result, single-phase mixtures of PFT/PZT are multiferroic at room temperature. There is only one other known room-temperature multiferroic – BiFeO3 – and our new material exhibits far lower electrical conductivity and dielectric loss (ca. 1%) for device applications. Several other materials such as CuO are multiferroic slightly below room temperature, sometimes requiring a small dc field.

We have carefully analyzed our specimens via EDX (Fig.1), TEM (Fig.2), Raman spectroscopy, and other techniques and confirm than any second phase must be in amounts << 1%. This is too small to explain the measured magnetization at 295K and cannot explain the switching results below. In our initial work we were unable to see either a linear magnetoelectric effect or magnetoelectric switching, due to the measurement area extending over many domains. However, in the present work (Fig.3) we demonstrate good magnetoelectric switching at room temperature: In particular the ferroelectric domains measured via PFM are switched using a very small bar magnet (rare earth, ca. 0.1 Tesla). The direction of H was normal to the plane of the domains.

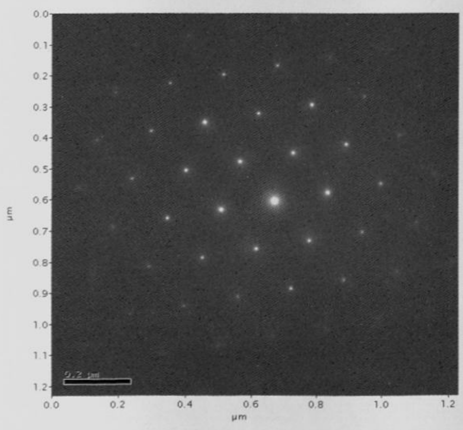

Fig. 1. X-ray diffraction pattern.

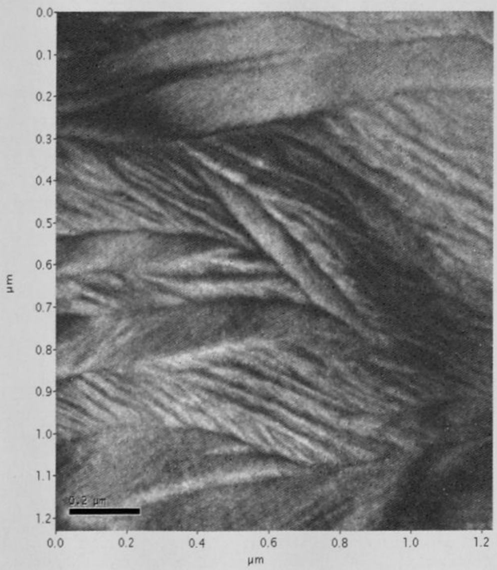

Fig.2. TEM pattern.

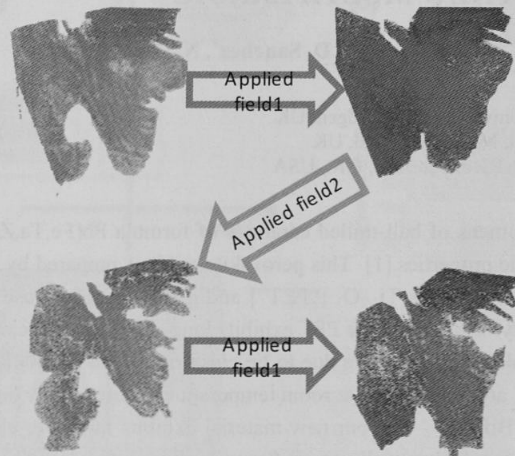

Fig.3: Magnetic switching:

Dark areas of PFM images. Apply field 1 and cause dark area to grow

Apply opposite field to cause dark area to shrink

Can cause 'switching' of dark area by using different magnetic field.

[1] D. Sanchez, N. Ortega, A. Kumar, R. S. Katiyar, J. F. Scott, AIP Adv. 1, 042169 (2011) .