Amorphous-Nanocrystalline Lead Titanate Thin Films for Dielectric Energy Storage

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Source: JOURNAL OF THE CERAMIC SOCIETY OF JAPAN, Volume: 122, Issue: 1424, Pages:

250-255, DOI: 10.2109/jcersj2.122.250, Published: APR 2014

Abstract: Many high permittivity crystalline dielectric thin films have a low breakdown strength, which is unfavorable for dielectric energy storage devices. In contrast, many amorphous linear dielectrics have much lower permittivities but larger breakdown strengths. Here, composite thin films with nanocrystalline particles in an amorphous matrix were explored to increase the stored energy density of dielectrics. For this purpose, thin films of lead-rich lead titanate, Pb1.1TiO3.1, were fabricated via chemical solution deposition and heat-treated at temperatures <= 400 degrees C. Transmission electron microscopy indicated the presence of dense lead oxide nanocrystals in an amorphous lead titanate network. The films exhibit a relative permittivity of 32.6 and a low dielectric loss of 0.0008. The leakage current is approximately 10(-8)A/cm(2), with a DC breakdown strength between 2 and 3MV/cm. The 1 kHz breakdown strength exceeds 5MV/cm. At an electric field of 5MV/cm and a measurement frequency of 1 kHz, the maximum in energy storage density was similar to 28 J/cm(3). These properties suggest that nanocomposite Pb1.1TiO3.1 films may be a suitable candidate for integration into energy storage devices.