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Dielectric and Pyroelectric Properties of La- and Pr-Modified Tungsten-Bronze Ferroelectrics

B.N. PARIDA,[1] PIYUSH R. DAS,[1,2] R. PADHEE,[1] and R.N.P. CHOUDHARY[1]

1.—Department of Physics Institute of Technical Education & Research, Siksha O Anusandhan University, Jagmohan Nagar, Jagamara, Bhubaneswar 751030, India. 2.—e-mail:prdas63@gmail.com

The polycrystalline materials $Li_2Pb_2R_2W_2Ti_4Nb_4O_{30}$ (R = La, Pr) of the tungsten-bronze structural family have been synthesized using a high-temperature mixed-oxide method. Room-temperature x-ray diffraction (XRD) analysis confirms the formation of single-phase compounds. Room-temperature scanning electron micrography of the pellet samples shows a uniform distribution of well-defined different sizes of grains on the surface of the samples, confirming the formation of single-phase compounds. Study of the frequency and temperature dependence of the dielectric constant and loss tangent suggests the existence of dielectric dispersion in the materials. The ferroelectric phase transition in the samples has been studied based on the variation of fitting parameters (calculated from a theoretical model) with temperature. Studies of pyroelectric properties [figure of merit (FOM) and coefficient] show that the materials have reasonably high FOM useful for pyroelectric detectors. The variation of alternating-current (AC) and direct-current (DC) conductivity with inverse absolute temperature (obtained from dielectric data) follows a typical Arrhenius relation. The low leakage current and negative temperature coefficient of resistance behavior of the samples have been verified from *J–E* plots.

Key words: Ceramics, dielectric properties, ferroelectricity, phase transition, powder diffraction

INTRODUCTION

Since the discovery of ferroelectricity in perovskite $BaTiO_3$[1] in the 1940s, a large number of simple and complex oxides of different structural families including tungsten bronze (TB) have been investigated to explore materials with potential use in applications. The materials with TB structure are the most important class of ferroelectrics. The TB structure consists of a complex array of BO_6 octahedra connected in such a way that three different types of tunnels exist in the unit cell. TB-structure compounds have the general chemical formula $[(A_1)_2(A_2)_4C_4][(B_1)_2(B_2)_8]O_{30}$, where the smallest triangular C interstices are empty whereas the B_1 and B_2 sites are occupied by tetra- to hexavalent ions (W^{6+}, Ti^{4+}, Nb^{5+}, Ta^{5+}, V^{5+}) and the A-site is occupied by mono- to trivalent cations.[2–6] Thus, TB ferroelectrics are complex systems with wide scope to tailor their physical properties by substituting suitable elements at different atomic sites. Among all the ferroelectric oxides examined so far, some oxides of the TB structural family have been found to be very useful for piezoelectric,[7] pyroelectric, and microwave devices at room temperature.[8,9] In the last few decades, rare-earth-containing TB ferroelectrics have particularly received considerable attention[2–4] because of their better structural stability and enhanced properties for a wide range of applications. Since the first report on the ferroelectric properties of a TB compound,[10] a large number

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