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Electrical and Pyroelectric Properties of $K_2Pb_2Gd_2W_2Ti_4Nb_4O_{30}$ Ferroelectrics

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A polycrystalline sample of $K_2Pb_2Gd_2W_2Ti_4Nb_4O_{30}$ was prepared by a high-temperature solid-state reaction method. The formation of the single-phase compound (at room temperature) was confirmed by preliminary x-ray structural analysis. The surface morphology recorded by scanning electron microscopy at room temperature exhibits a uniform grain distribution on the surface of the sample with few voids. Studies of the (i) variation of dielectric parameters with temperature (27°C to 430°C) and frequency (1 kHz to 5 MHz) and (ii) temperature dependence of polarization confirmed the existence of ferroelectricity in the material below the transition temperatures. Two dielectric anomalies observed at 304°C and 378°C suggest the existence of phase transitions in the material. The temperature and frequency dependences of electrical parameters of the material exhibit a strong correlation between microstructure and properties of the material. The temperature dependence of the direct-current (dc) conductivity shows the typical Arrhenius and negative temperature coefficient of resistance (NTCR) behavior of the material. The variation of the alternating-current (ac) conductivity with frequency obeys Jonscher's universal power law. The current variation with temperature shows that the material has high pyroelectric coefficient and figure of merit, and thus it is useful for pyroelectric sensors. Even with a small piezoelectric coefficient (4.5×10^{-12} C/N), the material is confirmed to be ferroelectric.

Key words: Ceramics, ferroelectricity, phase transitions, electrical properties, pyroelectricity

INTRODUCTION

Although a large number of ferroelectric oxides of different structural families (including perovskites) have been studied for various applications, some oxides belonging to the tungsten–bronze (TB) structural family have attracted much attention from the scientific community because of their wide-ranging industrial applications such as in transducers, multilayered capacitors, microwave dielectric resonators, pyroelectric detectors, actuators, etc. Materials possessing the TB structure usually have moderate dielectric constant and low tangent loss, and hence they can be useful for many applications as stated above. The complex and disordered TB structure has arrays of distorted BO_6 octahedra sharing corners in such a way that three different types of interstices (A–C) are available for substitution of a wide variety of cations in the general formula $[(A_1)_2(A_2)_4(C)_4][(B_1)_2(B_2)_8]O_{30}$ or $[(A_1)_2(A_2)_2(A_3)_2(C)_4][(B_1)_2(B_2)_4(B_3)_4]O_{30}$. The A_1 and A_2 (also A_3) sites are usually occupied by mono–trivalent cations and the B_1 and B_2 (also B_3) sites by W^{6+}, Ti^{4+}, Nb^{5+}, Ta^{5+} or V^{5+} ions, whereas the C site (being small) often remains empty. It is possible to make different ionic substitutions at the above-mentioned sites so as to tailor the physical properties

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