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Effects of Sintering Temperature on Structure and Properties of 0.997(KNN-LS-BF)-0.003V_2O_5 Lead-Free Piezoelectric Ceramics

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0.997(KNN-LS-BF)-0.003V_2O_5 lead-free piezoelectric ceramics were prepared by a traditional sintering method. The effects of sintering temperature on the structure and properties of the 0.997(KNN-LS-BF)-0.003V_2O_5 ceramics were studied. The results show that the sintering temperature exerts a distinct influence on the phase structure and properties. With the increase in sintering temperature from 1040°C to 1060°C, the main crystallographic phase changes from the orthorhombic symmetry to the tetragonal phase, and the optimum dielectric and piezoelectric properties of samples can be obtained when sintering at 1060°C. However, the dielectric and piezoelectric properties of the samples deteriorate when the sintering temperature exceeds 1060°C.

Key words: Piezoceramics, KNN-LS-BF, V_2O_5 doping, sintering temperature, properties

INTRODUCTION

Lead oxide-based piezoelectric ceramics, such as lead zirconate titanate (PZT), have been widely used in piezoelectric actuators, sensors, and transducers due to their excellent piezoelectric properties.[1,2] However, utilization of lead-based materials not only causes serious environmental pollution, but also comes with the instability of composition due to its volatilization at high sintering temperature. Therefore, in the past decade, research on lead-free piezoelectric materials has drawn remarkable attention.[3,4]

In recent years, increasingly considerable attention from researchers has been focused on $K_{0.5}Na_{0.5}NbO_3$ (KNN)-based solid solutions.[5,6] However, in previous KNN-based studies, generally ceramics were sintered at high temperatures of over 1100°C,[7,8] resulting in oxygen deficiency and high electronic conductivity.[5] The formation of liquid phase is beneficial for densification, but the evaporation of Na_2O and K_2O during the sintering process at high temperatures degrades the piezoelectric properties of KNN ceramics. Thus, oxides, such as ZnO, MnO_2, and CuO, were introduced into the sintering body to prevent pre-evaporation of Na_2O and to lower the sintering temperature.[9–11] Recently, Jiang et al.[12] reported that 0.996(0.95$Na_{0.5}K_{0.5}NbO_3$-0.05$LiSbO_3$)-0.004$BiFeO_3$ (KNN-LS-BF) lead-free piezoelectric ceramics possess good piezoelectric properties. However, the sintering temperature of the reported KNN-LS-BF material is above 1100°C, and the KNN-LS-BF system has greater potential for further improvement in dielectric and piezoelectric performance.

The phase structure and electrical properties of KNN-based ceramics are sensitive to preparation process variables, especially sintering temperature. Hence, in this work, 0.3 mol.% V_2O_5-doped 0.997(KNN-LS-BF)-0.003V_2O_5 ceramics were prepared by a conventional sintering technique, and the effects of sintering temperature on the structure and properties of the 0.997(KNN-LS-BF)-0.003V_2O_5 piezoelectric ceramics were explored.

EXPERIMENTAL PROCEDURES

0.997[0.996(0.95$Na_{0.5}K_{0.5}NbO_3$-0.05$LiSbO_3$)-0.004$FeBiO_3$]-0.003V_2O_5 [0.997(KNN-LS-BF)-0.003V_2O_5]

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