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Pyroelectric properties of $BiFeO_3$ ceramics prepared by a modified solid-state-reaction method

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Abstract $BiFeO_3$ (BFO) ceramics were prepared by a modified solid-state-reaction method which adopts a higher heating/cooling rate during the sintering process than usually used. It was found that the calcination temperature T_{cal} (from 400 to 750°C) does not influence the BFO phase formation, while the sintering temperature T_{sin} (from 815 to 845°C) dominates the phase purity. The optimum sintering temperature was in the range from 825 to 835°C. The optimized samples exhibit saturated ferroelectric hysteresis loops with a remnant polarization of 13.2 μC/cm^2. The measured piezoelectric coefficient d_{33} was 45 pC/N. No remnant magnetization was observed in all of the samples. The pyroelectric properties were studied as a function of temperature and frequency. A pyroelectric coefficient as high as 90 μC/m^2 K was obtained at room temperature in the optimized sample. An abrupt decrease of the pyroelectric coefficient was observed at temperatures between 70 and 80°C. On the basis of our results, BFO may have the potential for pyroelectric applications.

1 Introduction

Magnetoelectrics are the class of materials exhibiting coexistence of magnetic and ferroelectric ordering in a certain temperature range. These materials have the potential for applications in magnetic as well as ferroelectric devices. Bismuth ferrite (BFO) compound is one of the few known magnetoelectric systems. It exhibits antiferromagnetic ordering with the Neel temperature $T_N \sim 370$°C and ferroelectric behavior with a high Curie temperature $T_C \sim 830$°C [1]. Despite possessing a high Curie temperature, bulk BFO samples were reported to exhibit weak ferroelectric behavior, e.g., a remnant polarization as small as $P_r \sim 3.5$ μC/cm^2 [2]. Recently, a large P_r in the range of 90–100 μC/cm^2 has been observed in thin films as well as crystals at room temperature [1, 3], which is consistent with the theoretical predictions [4]. New processing techniques have been developed to synthesize single-phase BFO ceramics, and the most well-known one is rapid liquid phase sintering (RPS) [5, 6]. The P_r in these RPS derived BFO ceramics was increased to 11.6 μC/cm^2 [5]. In the RPS method, a single-step firing approach was adopted: the green ceramic samples were heated to the sintering temperature of about 855°C with an extremely high heating rate of 100°C/s. Then after soaking for a short period of time, the samples were cooled down to room temperature [5, 6]. Such a high heating rate is only feasible in a rapid thermal processing (RTP) furnace, and the dimensions of the samples are limited if one considers the heat propagation in the samples. In the present work, a simple modified conventional solid-state-reaction method was proposed to produce high quality BFO ceramics. The pyroelectric coefficient and the remnant polarization of these BFO ceramics are larger than those obtained from the RPS method.

Among various properties exhibited by ferroelectric materials, the pyroelectric effect is of fundamental interest as well as important for applications. A material to be suitably used in a pyroelectric detector should have a high pyroelectric coefficient, high resistivity, small dielectric constant and low thermal capacity [7]. BFO bears many

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