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Short communication

Sintering behavior of bulk $SrBi_2Ta_2O_9$ prepared by solid-state reaction

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Abstract

The conventional solid-state reaction method has been used to prepare bulk $SrBi_2Ta_2O_9$ ceramics. The sintering behavior and decomposition of bulk $SrBi_2Ta_2O_9$ ceramics have been investigated. Higher sintering temperature (>1200 °C) and longer sintering time (>7 h) can result in decomposition of $SrBi_2Ta_2O_9$.

Keywords: Solid-state reaction; $SrBi_2Ta_2O_9$; Sintering temperature; Sintering time

Much attention has been paid to $SrBi_2Ta_2O_9$ thin films due to their potential applications in ferroelectric random access memories [1–4], while relatively little research on bulk $SrBi_2Ta_2O_9$ ceramics has been performed. However, studies on the characteristics of bulk $SrBi_2Ta_2O_9$ ceramics can enhance understanding of $SrBi_2Ta_2O_9$ thin films. In addition, for some processes such as RF sputtering and laser deposition, the preparation of dense $SrBi_2Ta_2O_9$ target ceramics is important. The bulk density, preferred orientation and stoichiometry of the target will affect the deposition rate, phase content and homogeneity of the thin film [5,6]. Thus in this paper the sintering behavior and decomposition of bulk $SrBi_2Ta_2O_9$ ceramics prepared by the conventional solid-state reaction have been investigated.

The starting materials were high purity tantalum pentaoxide (>99%), strontium carbonate (>99%) and bismuth oxide (>99%). The chemicals were mixed in equal molar ratio with deionized water and ball-milled for about four hours using zirconia balls. The obtained slurry was dried at 100 °C and calcined at 1000 °C for 2 h. In order to study the sintering behavior and decomposition of bulk $SrBi_2Ta_2O_9$ ceramics in detail, the prepared $SrBi_2Ta_2O_9$ powders were uniaxially pressed into pellets and sintered at different temperatures for different times. Then the densities were measured (Archimedes principle).

Fig. 1 shows the shrinkage versus temperatures diagram of the $SrBi_2Ta_2O_9$ pellets. Up to 700 °C the thermal expansion is nearly linear and the curve reaches a maximum at about 700 °C. From this point the pellets shrink as the temperature increases, firstly at a relatively slow rate, until about 800 °C, and then with a continuously increasing rate. A sudden step occurs at 1350 °C.

In order to better understand the shrinkage of $SrBi_2Ta_2O_9$ during heating, the derivatives of Fig. 1 are shown in Fig. 2. Shrinkage starts at about 700 °C. Beyond 700 °C several valleys can be found and the rate is a step like function of the temperature.

The density of bulk $SrBi_2Ta_2O_9$ ceramic as a function of sintering temperature is shown in Fig. 3. The density tends to increase as the sintering temperature increases. At 1200 °C the density reaches its maximum which is about 90% of theoretical density. SEM fractographs of the $SrBi_2Ta_2O_9$ pellets are presented in Fig. 4. The surface of the pellets sintered above 1100 °C were examined by XRD. As shown in Fig. 5, decomposition starts at 1200 °C and almost all the $SrBi_2Ta_2O_9$ disappears at 1300 °C.

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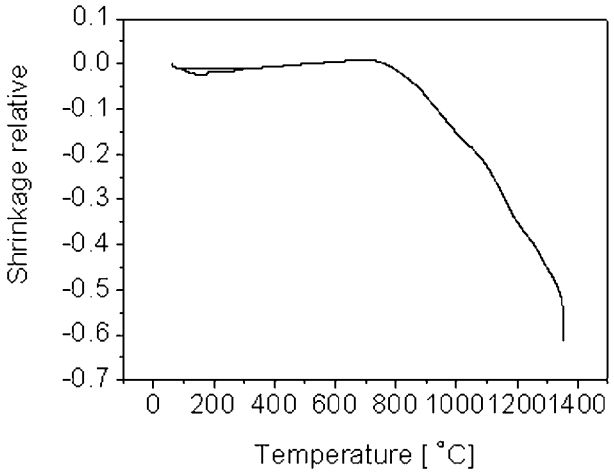

Fig. 1. The shrinkage diagram of the $SrBi_2Ta_2O_9$ pellets.

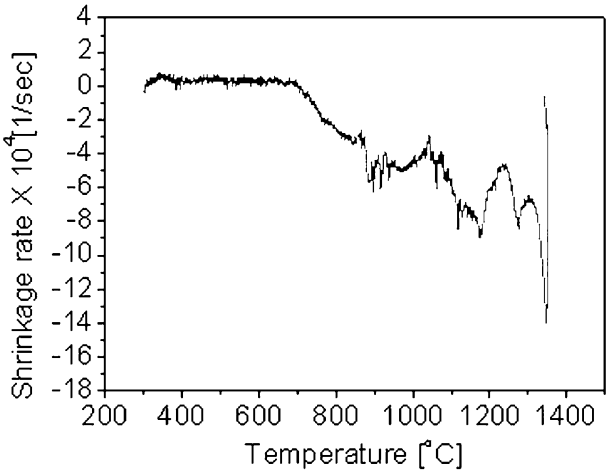

Fig. 2. The shrinkage rate diagram of the $SrBi_2Ta_2O_9$ pellets.

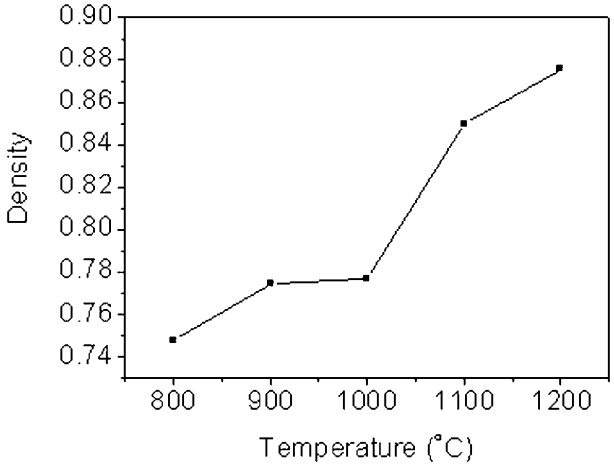

Fig. 3. Density of the $SrBi_2Ta_2O_9$ pellets as a function of sintering temperatures while the length of sintering time are 2 h.

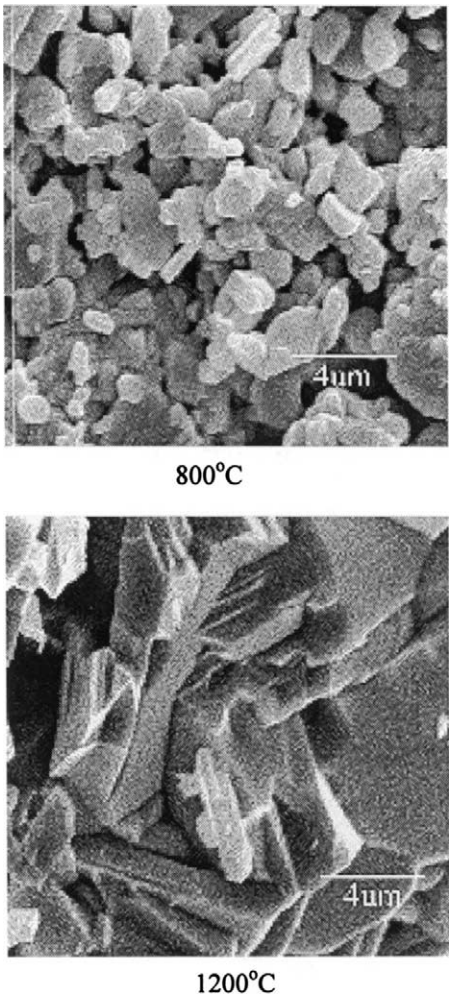

Fig. 4. SEM fractographs of the $SrBi_2Ta_2O_9$ pellets sintered at 800 and 1200 °C while the length of sintering time are 2 h.

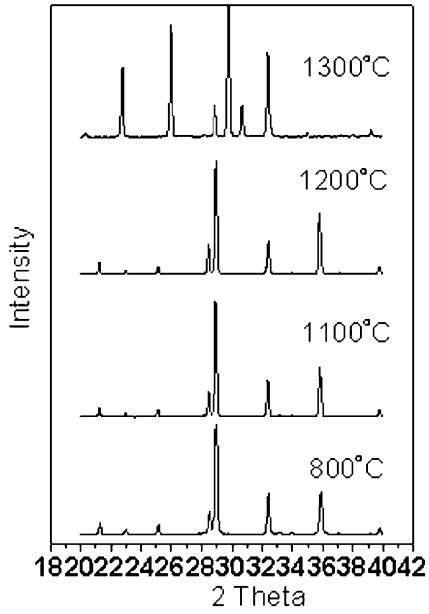

Fig. 5. XRD patterns of the $SrBi_2Ta_2O_9$ pellets sintered at 1100–1300 °C while the length of sintering time are 2 h.

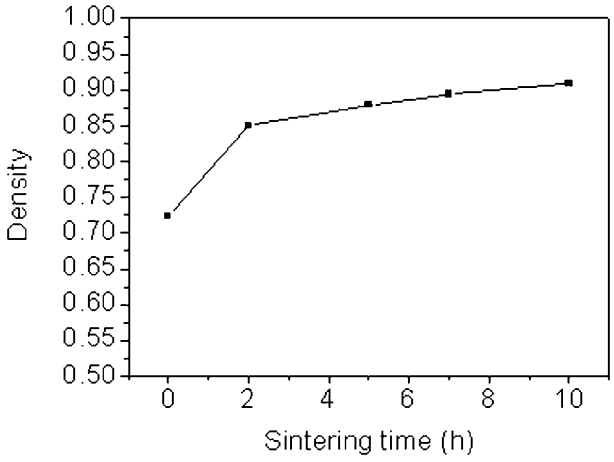

Fig. 6. Density of pellets as a function of sintering time while the sintering temperature is 1100 °C.

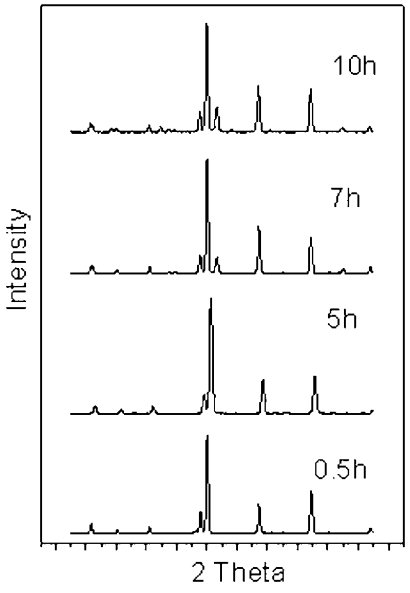

Fig. 7. XRD patterns of the $SrBi_2Ta_2O_9$ pellets sintered at 1100 °C for different length of sintering time.

In order to know the effect of the length of sintering time on the decomposition of bulk $SrBi_2Ta_2O_9$ ceramics, the pellets were sintered at 1100 °C for different times. Density versus sintering time is graphed in Fig. 6. It shows density increases from 70 to 85% of theoretical density within 2 h, then remains approximately constant and reaches 90% after 10 h. The surfaces of the pellets are also examined by XRD which is shown in Fig. 7. The results show that sintering for longer than 7 h results in decomposition of $SrBi_2Ta_2O_9$.

In conclusion, bulk $SrBi_2Ta_2O_9$ ceramic can be prepared by solid-state reaction and its density is about 90% of theoretical density at 1200 °C. Higher sintering temperature (>1200 °C)and longer sintering time (>7 h) can result in decomposition of $SrBi_2Ta_2O_9$.

Acknowledgements

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