

## Mechanical properties of $\text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_{10}$ ceramics

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### Abstract

$\text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_{10}$  (Bi-2223) ceramics was synthesized by melt-quenched method at 1200 °C for 30 min and their physical properties were measured. Microstructures of the ceramics were observed by using the scanning electron microscope (SEM). The crystal structures were measured and simulated by using x-ray diffraction (XRD) technique and visualization of crystal structure (VICS) software, respectively. Elastically properties and micro-hardness were measured and evaluated by using ultrasonic sound velocity measuring device and micro hardness tester, respectively. It found that, the  $\text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_{10}$  ceramics is the amorphous behaviour confirmed by the XRD analysis. The Bi-2223 ceramics has been a good value of bulk modulus ( $K$ ), Young's modulus ( $E$ ), Shear modulus ( $G$ ) and Vickers hardness ( $H_v$ ), these properties was corresponded to the base thermoelectric materials.

### 1. Introduction

$\text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_{10}$  material is the superconductivity and thermoelectricity, high critical temperature of 110 K and high Seebeck coefficient (Von and Hoppe, 1974). The crystal structure of  $\text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_{10}$  material is the tetragonal structure, lattice parameters  $a = b = 0.3814 \text{ nm}$ ,  $c = 3.71 \text{ nm}$  (Terasaki et al., 1997). It very interesting the mechanical studies for developed to thermoelectric material.

### 2. Experimental

$\text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_{10}$  glassy precursor superconductivity samples were prepared by the melt-quenched technique. For the initial materials, high purity (99.99%) powders of  $\text{Bi}_2\text{O}_3$ ,  $\text{SrCO}_3$ ,  $\text{CaCO}_3$  and  $\text{Cu}_2\text{O}$  were mixed in an agate mortar. The mixture was melted in an alumina cup at 1200 °C for 30 min. Molten mixture was quickly poured onto a cold copper plate and pressed with another cold copper plate to obtain glassy plates in Figure 1. Rapidly quenched, dark, and approximately 1–3 mm. thick amorphous materials were obtained. (Aksan and Yakinci, 2004)

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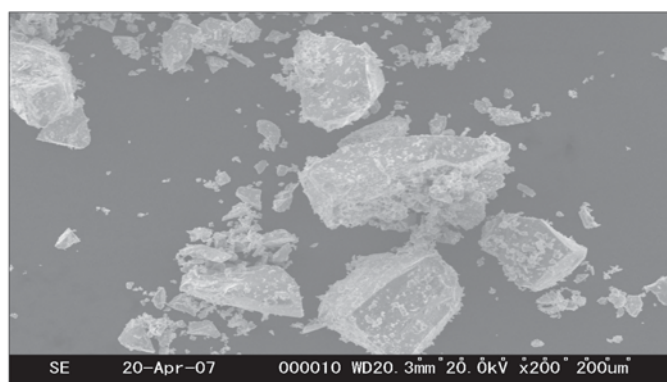
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### 3.Results and discussion

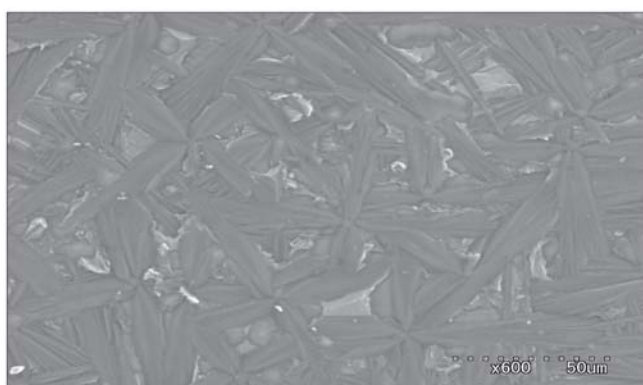
The surface morphology and microanalysis of the sample have been examined by SEM, which after melt-quenched method at  $1200^\circ\text{C}$  for 30 min in Figure 2, the ceramic powder measured  $10\text{--}100\text{ }\mu\text{m}$  and after the polish in Figure 3. to experience here meat as magnetic domain measured  $200\text{--}250\text{ }\mu\text{m}$ , to indicate the qualities of a person superconductor and thermoelectric material.



**Figure 1.** The ceramic samples with nominal compositions of  $\text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_{10}$  were melt-quenched method at  $1200^\circ\text{C}$  for 30 min.



**Figure 2.** Morphology of  $\text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_{10}$  glassy plate samples were melt-quenched method at  $1,200^\circ\text{C}$  for 30 min.



**Figure 3.** Morphology of surface  $\text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_{10}$  samples after polish

The X-ray diffraction patterns of  $\text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_{10}$  ceramic are shown in Figure 4. A large halo was obtained at around  $2\theta \cong 30^\circ$  (Aksan and Yakinci, 2004), which is a fundamental characteristics of the glass material, indicates the short-range atomic order and of periodicity in the dimensional network.

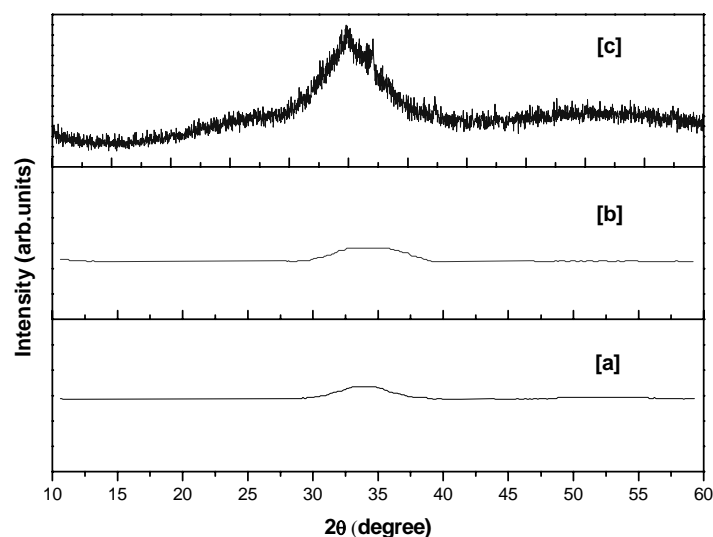
The hardness of the ceramic sample applied loads was chosen to be 0.98, 1.96, 2.94 and 4.9 N, used 15 s for the loading time. The relationship between the Vickers hardness and applied load is shown in Figure 5. The Vickers-hardness decreases with increasing applied load, indicating typical load dependence. The hardness provides the information of the resistance of the superconductor and thermoelectric material (Seetawan et al., 2005).

The shear modulus, Young's modulus were evaluated as shown in Table 1. For isotropic media,

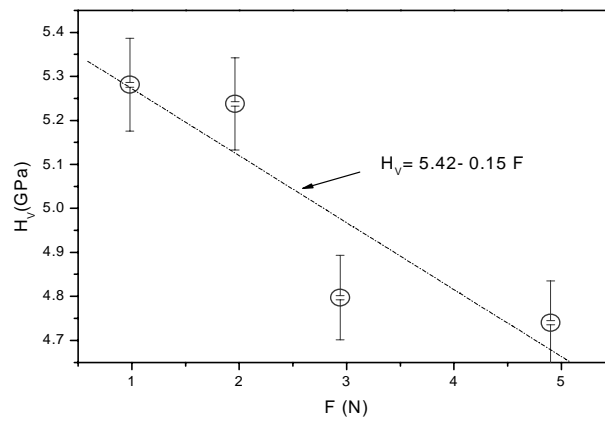
the shear modulus (G), Young's modulus (E) can be written in terms of the longitudinal sound velocity and shear velocity as (Yamada, 1997; Fukuhara et al., 1993; Inaba, 1983). The elastic moduli evaluated from the sound velocities. It seems that these phenomena correspond to the microstructure of the samples.

The Vickers - hardness was found to be proportional to Young's modulus, (Tanaka et al., 1989). We have evaluated the of the sample shown in Figure 6 are around 0.081, indicating corresponds to the ceramic characteristics

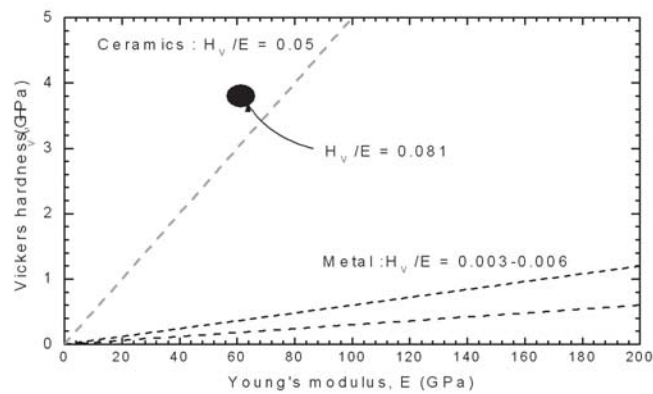
The mechanical properties of  $\text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_{10}$  were measured at room temperature shows the ceramic characteristics and the Vickers - hardness was found to be proportional to Young's modulus are around 0.081, indicate the ceramic properties. It is very interesting for thermoelectric properties studies.



**Figure 4.** X-ray diffraction patterns of  $\text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_{10}$  ceramic samples were melt-quenched method at 1200 °C for 30 min.



**Figure 5.** The relationship between the Vickers-hardness and applied load of  $\text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_{10}$  glassy precursor samples were melt-quenched method at 1200 °C for 30 min.



**Figure 6.** The relationship between the Vickers -hardness and Young's modulus of  $\text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_{10}$  glassy plate samples were melt-quenched method

**Table 1** The properties of  $\text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_{10}$  ceramics

Property	$\text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_{10}$
Density ( $\text{g}/\text{cm}^3$ )	4.6422
Weight (g)	$3.05769 \times 10^{-21}$
Longitudinal sound velocity; $V_L$ (m/s)	3981.1
Shear sound velocity; $V_s$ (m/s)	2298.5
Vickers harness; $H_V$ (GPa)	3.8022
Young's modulus; E (GPa)	61.3134
Bulk modulus; B (GPa)	40.88
Shear modulus; G (GPa)	24.53

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