Journal Article Volume 309, Materials Chemistry and Physics pages 1 – 15

Effect of sintering temperature on dielectric and electrical properties of bio-waste derived beta-dicalcium silicate

Abstract

Beta-dicalcium silicate ceramics were synthesized by mechanochemical-assisted solid-state reaction route using rice husks and chicken eggshells as silica and calcium oxide sources. The ceramics were sintered at 900, 1000, and 1100 °C for 2 h in air. The effect of sintering temperature on these ceramics' morphological, breakdown strength, dielectric, and electrical properties was investigated. It was found that the ceramic sintered at the optimized temperature of 1100 °C formed the pure β-dicalcium silicate (β-Ca2SiO4). Scanning electron micrographs showed that with the increase in sintering temperature, the average grain size and pore size of the sintered ceramics increased while the grain boundary density decreased, which promoted the breakdown path and resulted in a decrease in breakdown strength. The dielectric behavior examined from 25 to 300 °C and in a frequency range of 4–5 MHz found that the dielectric constant and loss tangent decreased with increasing frequency. Nyquist plot of impedance confirmed a non-Debye type relaxation, and grain and grain boundary contributions were revealed from equivalent circuit fitting. Variations of impedance spectroscopy reflect the positive and negative temperature coefficient of resistance behavior for these ceramics. Electric modulus spectra revealed that with the sintering temperature increase, the samples' conductivity activation energies increased from 0.35 to 0.46 eV. All the sintered samples attained low dielectric loss ($0.004 < \tan\delta < 0.1$) above 103 Hz, which makes them suitable materials for capacitor application.

Keywords

Dicalcium silicate; Dielectric properties; Electrical properties; Microstructure; Sintering