Effects of SiO_2 Coating on the Dielectric and Ferroelectric Properties of $BaTiO_3$-SiO_2 Composites

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In comparison with conventional ceramics, ceramic-glass composites have some advantages in application due to their novel properties, such as high breakdown strength and low dielectric loss. Ceramic-glass composites could be sintered from mixtures of ceramic and glass powders or core-shell like particles with ceramic core and glass shell. Chemical coating method is considered effective to prepare the core-shell like particles, which can be used as raw materials in the composites sintering process. In this paper, $BaTiO_3$-SiO_2 composites were fabricated. Firstly, core-shell like $BaTiO_3$-SiO_2 particles were fabricated by coating $BaTiO_3$ nano powders with a series of contents of amorphous SiO_2 (2.5, 5. 7.5, 10, 15 and 20 wt.%) through a wet chemical coating process named Stöber Method. Then, the as-prepared core-shell particles were used to fabricate $BaTiO_3$-SiO_2 composites by conventional ceramic process. Phase composition and microstructure of $BaTiO_3$-SiO_2 composites were characterized by X-ray diffraction (XRD) and Scanning electron microscopy (SEM). The dielectric properties in the frequency range from 100 Hz to 1 MHz and in the temperature range from -50 ^{o}C to 150 ^{o}C were determined using an HP 4294A LCR Meter assisted with an Espec ECT-2 temperature chamber. Ferroelectric hysteresis loops (P-E) and breakdown strength (E_b) were measured in silicone oil using a Radiant Precision-LC 100 system with H.V. Supply Amplifier at room temperature. The XRD patterns illustrate a typical tetragonal perovskite structure of the core-shell particles, which confirms an amorphous phase of coated SiO_2 layer. After sintering, a secondary phase, $BaTiSiO_5$, is obvious in the composites, which is caused by the interface reaction of $BaTiO_3$ core and SiO_2 shell. Furthermore, the content of $BaTiSiO_5$ phase increases with coating content of SiO_2. SEM results show that the porosity in composites could be removed by SiO_2, which can be attributed that SiO_2 works as sintering agent during the sintering process. The coated SiO_2 layer between $BaTiO_3$ cores could also acts as inhibitor in grain grown of $BaTiO_3$. It is found that dielectric constant decrease with increasing content of SiO_2 in composites and the dielectric constant peak associated with dielectric temperature dependence curve could be greatly suppressed accordingly. The P-E loop of composites gets slimmer and polarization decreases with increasing coating content of SiO_2, while the breakdown strength could be remarkable enhanced.