Grain-size effect in Barium Titanate ceramics with different Ba/Ti ratios

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Barium Titanate (BT) has been widely used for capacitor applications because of its large dielectric constant (ε_r). The strong dependence of ε_r of stoichiometric BT ceramics on their grain size is repeatedly reported as grain-size effect.[1)] In this research, the grain size was controlled by changing Ba/Ti molar ratio and sintering temperature, and the dielectric and ferroelectric properties were investigated.

BT powders with three different Ba/Ti molar ratios of 0.997, 1.000, and 1.003 (BT 0.997, BT 1.000, and BT 1.003, respectively) were prepared by solid state synthesis. A mixture of $BaCO_3$ and TiO_2 powders was calcined at 1000 ^oC for 5 h. Green compacts formed after binder addition (PVB, 3 wt %) and uniaxial pressing (375 MPa) were sintered conventionally for 5 h at sintering temperatures of 1250, 1300, and 1350 ^oC (symbolled A, B, and C, respectively) for each Ba/Ti ratio. Also, to compare the effect of grain size and Ba/Ti ratio on the observed properties, BT 0.997, BT 1.000 and BT 1.003 ceramics (symbolled D) with similar grain sizes (~1 μm) were fabricated by optimizing sintering conditions, as shown in the figure. After cutting and polishing into a plate of size 4 mm x 1.5 mm x 0.4 mm, the A, B, C, and D ceramic samples were annealed for 4 h at 1000^oC. Au electrodes were deposited on both sides of the plates by sputtering, followed by annealing at 300 ^oC for 10 min, and then property measurements were carried out.

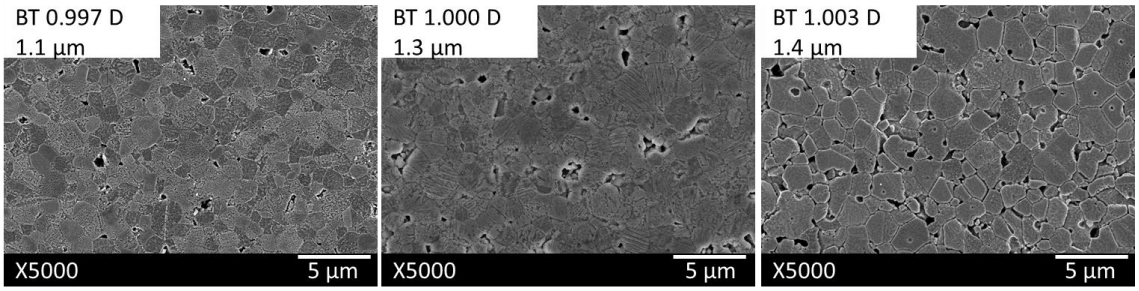

Figure: SEM pictures of BT 0.997 D, BT 1.000 D and BT 1.003 D samples with their grain sizes

The average relative densities (Archimedes method) for all the samples were more than 94% of the theoretical density of BT. XRD patterns confirmed single phase perovskite structure for all the samples. SEM images revealed unusual grain growth for BT 0.997B and BT 1.00 B samples. These samples showed uniform grain growth for A and C sintering conditions with the latter showing exaggerated grains. The unusual grain growth and exaggerated grains may be due to formation of eutectic melt around 1320 ^oC and presence of local inhomogeneity.[2)] All the samples of D sintering conditions and BT 1.003 samples showed uniform grain growth. The samples with uniform grain growth followed grain-size effect for all the three Ba/Ti molar ratios.

References

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