Cold Sintering and Electrical Characterization of Lead Zirconate Titanate Piezoelectric Ceramics

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This paper describes a cold sintering process for $Pb(Zr,Ti)O_{-3}$ ceramics and the associated processing-property relations. $Pb(Zr,Ti)O_{-3}$ has a very small, incongruent solubility that is a challenge during cold sintering. To circumvent this, a $Pb(NO_3)(2)$ solution was used as the transient liquid phase. A bimodal lead zirconate titanate powder was densified to a relative density of 89% by cold sintering at 300 degrees C and 500 MPa. After the cold sintering step, the permittivity was 200, and the dielectric loss was 2.0%. A second heat-treatment involving a 3 h anneal at 900 degrees C increased the relative density to 99%; the resulting relative dielectric permittivity was 1300 at room temperature and 100 kHz. The samples showed well-defined ferroelectric hysteresis loops, having a remanent polarization of 28 mu C/cm(2). On poling, the piezoelectric coefficient d(33) was similar to 200 pC/N. With a 700 degrees C 3 h post-annealing, samples show a lower room temperature relative permittivity (950 at 100 kHz), but a 24 h hold time at 700 degrees C produces ceramics where there is an improved relative dielectric constant (1050 at 100 kHz).