Cold Sintering--Rethinking What We Thought We Knew in Electroceramics

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For over 30,000 years, the general practice of sintering ceramics has involved a high temperature thermal treatment to drive the transport processes to densify the particles and minimize the surface energy of the material. Typical sintering temperatures consider 0.6 to 0.8 of the melting temperature (T_m) for many oxides; this means we sinter around 800 ^{o}C to 1200 ^{o}C for 2 to 10 hours. Here we introduce a broad body of systems that utilize a transient aqueous based liquid phase (1 to 10 wt%) that sinters under a uniaxial pressure, while being heated from room temperature to 250 ^{O}C, over a time period of 10 to 60 minutes.

Given the massive drop in sintering temperature of the ceramic, this offers many new opportunities in material design, especially in composites. We will show three different types of polymer ceramic composites with high percentages of ceramic, 100% to 60%, with the thermoplastic polymers for dielectric applications, ionic electrolytes, and semiconducting composites. We will give insights into the mechanisms that control the Cold Sintering process. It will be shown that multilayer structures and printable electronics are all possible with this technique. We will consider the impact in the ferroelectrics and transducer fields. Furthermore, these manufacturing approaches and routes will be discussed.