Low Loss Tunable Dielectric Constant Materials on Intragrain Concentration Gradient (Ba,Sr)TiO\(_3\) Ceramics.

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Miniaturization of electronic devices has led to an urgent need for ceramics with a dielectric constant at microwave frequencies that is tunable by means of an external field, and with a reasonably small dielectric loss. Both tunability and high dielectric loss originate from non-harmonic behavior of ions in the lattice and are maximum near the ferroelectric transition. The search for materials that combine large tunability and low loss has hitherto focused on the chemical composition[1] of homogeneous material and on the use of composites of such materials [2].

We suggest a radical new approach, i.e., material with a graded composition within each grain. Due to the graded composition the ceramics do not show any specific dielectric relaxation frequency. Instead, we observe gradual decrease of the dielectric constant with frequency, while the loss tangent remains practically unchanged (below 0.02 everywhere within the frequency range 0.0003-3 GHz). The tunability of the ceramic decreases with frequency but remains about 10 \% at 3 GHz. Because of the graded composition the elastic modulus of the material is not constant with in the grains. This results in a suppression of the ferroelectric resonance of the grains and decreases the loss at microwave frequency.

We also identified that the significant contribution in the high frequency losses of (Ba,Sr)TiO\(_3\) ceramics comes due to the presence of the low melting point (<1400 °C) impurities. We suggested simple sol-gel process that tolerates up to 1\% (Ba,Sr) : Ti error and leads to the formation of the (Ba,Sr)TiO\(_3\) particles that do not show any traces of low melting impurities.

We also expect that the concept of intragrain concentration gradient ceramic materials may be useful of other electronic materials.
