Microwave Circuit Elements with Ferroelectric and High Temperature Superconducting Thin Films

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The integration of ferroelectric (FE) and high temperature superconducting (HTS) thin films in a microstrip structure is expected to provide many advantages for microwave circuits. In this type of structure, where the FE is bounded by HTS layers, the dielectric constant can be varied by an applied electric field. Low control voltages can be used to obtain a large modulation of the dielectric constant since the FE film can be less than a micron thick. For example, the bias voltage required to achieve typical field strengths of 20-200 kV/cm for a 0.5-μm thin film (1-10 V) can be reduced by three orders of magnitude over that of a 0.5-mm thick substrate (1-10 kV). The disadvantage of this approach is that the conductor losses can greatly attenuate signals above 10 MHz. By replacing normal metals with superconductors, the losses are determined by the ferroelectric for frequencies below 20 GHz. While the loss tangent has not been measured in the microwave frequency range for thin-film ferroelectrics, measurements on bulk strontium barium titanate indicate that loss tangents of 10^{-2}-10^{-3} should be achievable. With these advantages of low control voltages and the low losses, FE films can be useful in tunable transversal filters, delay lines, real-time delay phase shifters, mixers, and other advanced signal processing functions.

To demonstrate the capability of multilayers employing ferroelectric films, a 1 cm long microstrip line has been fabricated. The microstrip line consisted of a $Sr_{0.5}Ba_{0.5}TiO_3$ ferroelectric, deposited by pulsed laser deposition, a platinum ground plane and a silver strip defining the top conductor. From the forward transmission measurements, a maximum relative dielectric constant of ~ 250 was found for the FE film near the Curie temperature of ~200 K. A 50 % modulation of the dielectric constant was achieved with an applied field of 200 kV/cm (8 Volts). These properties, while significantly different than those of bulk SBT with the same composition, are very encouraging for microwave circuits. The results obtained for HTS/FE/HTS structures will also be discussed.