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MICROWAVE CHARACTERIZATION AND APPLICATIONS OF FERROELECTRIC THIN FILMS

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The development of new technologies for the deposition of metal oxide films has resulted in renewed interest in ferroelectric materials for microwave device and circuit applications. The properties of bulk ferroelectric materials have been known for decades. By utilizing the technology of pulsed laser deposition (PLD), it is possible to deposit thin films of these materials with electronic and physical properties that are compatible with microwave technology. The high electric field dependent dielectric constant of these materials can result in very compact, low power, variable reactance devices. Potential applications include VCO's, phase shifters, tunable filters and antennas.

Employing a target containing the stoichiometric ratios of $SrTiO_3$ and $BaTiO_3$ desired, thin films (~0.5 μm thick) are deposited on a variety of substrates. Post-deposition annealing and selective doping of these films can greatly improve their microwave properties. Interdigitated capacitors, consisting of 1-μm-thick silver electrodes are deposited via standard photolithography and metal-liftoff patterning. These interdigitated capacitors are used to study the microwave properties of the ferroelectric thin film as well as develop alternative technologies for VCOs.

Microwave reflection measurements of the interdigitated capacitors are used to characterize the ferroelectric film properties in the frequency range from 50 MHz to 20 GHz under a variety of dc electric field biases. Bias-dependent capacitance tuning greater than 4:1 has been observed in some films. Losses in some devices at 10 GHz that are comparable to those of state-of-the-art semiconductor varactors. Models to extract the ferroelectric film properties from measured data are based on an extension of a pseudo-static approach (S. Gevorgian, et. al, IEEE Trans. on MTT, 44, 896-904, 1996) to account for electrical size effects. Studies are in progress to understand the correlation of these microwave losses with film composition, deposition conditions, post-annealing profiles, impurities, grain size, and other microscopic film properties.