Compositionally Tailored Material Properties To Enable Performance Enhanced Tunable Microwave Devices

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Abstract

Electronically scanned phased array antennas (ESAs) provide the means to achieve high data rate, beyond line of sight, on-the-move (OTM) communications. The phase shifter is a key component of ESAs, and recently BaSrTiO3 (BST) thin film technology has been acknowledged as the premier candidate for achieving affordable high performance phase shifter elements. However, there is significant concern that in practical applications the antenna performance will be compromised due to the temperature dependence of the phase shifter/device capacitance. The capacitance of the BST phase shifter is strongly influenced by temperature changes because the dielectric constant of a uniform composition BST films follows the Curie-Weiss law; $K = C_{curie}/(T - \theta)$ where K is the dielectric constant, C_{curie} is the curie constant, T is the temperature, and θ is the Curie temperature. Thus, spurious changes in the phase shifter capacitance that stem from ambient temperature fluctuation will disrupt the phase shifter performance via device to device phase shift and/or insertion loss variations leading to beam pointing errors and ultimately communication disruption and/or failure in the ability to receive and transmit the information. This seminar will present recent ARL research data focused on compositionally stratified BST thin film material design and optimized process science protocols which results in low loss, highly tunable and temperature stable thin film heterostructures. Our results show that the compositionally stratified BST thin films possessed higher permittivity, lower dissipation factor and higher tunability with respect to both uniform composition paraelectric BST films fabricated via the same processing method and the relevant literature values for compositionally graded BST films. In addition, our findings revealed that the temperature dependence of the dielectric response for the compositionally stratified BST film design exhibited minimal dispersion over a broad temperature range. The status of these results suggest that this compositionally stratified material design is an excellent candidate for tunable devices which require

both enhanced dielectric response and performance consistency in harsh operational temperature regime.

Biographical Sketch

M.W. Cole is a senior researcher and Team Leader of the Active Materials Research Group at the US Army Research Laboratory in APG, MD. She performs and directs research in the area of materials development for wireless communications applications. Her research focuses on identifying structure-process-property relationships, which are utilized to develop a fundamental understanding of the complex relationship among materials, process, and design that affects performance and reliability. M.W. Cole conducts numerous collaborative R&D projects, technically supports Army programs in mobile wireless communications, e.g., OTM phased array antennas & JTRS, and directs several SBIR and STTR programs. M.W. Cole holds a research sabbatical position (Adjunct Professor) in Applied Physics & Mechanical Engineering at Caltech and is actively involved in several joint university-industry-government research projects related to materials development for communications systems.

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