Millimeter-wave and Terahertz Properties of SUEX, an Epoxy-based Dry Photoresist

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Structural support and packaging materials that exhibit favorable material properties are indispensable for cost-effective realization of millimeter-wave (mmW) and terahertz (THz) sensors and systems. In particular, performance of lithographically-fabricated on-chip antennas and arrays are directly impacted by material losses, leading to extremely-poor radiation efficiencies. Polymers are a natural, cost-effective choice for structural support and packaging of microchips due to their availability and desirable chemical, thermal and mechanical properties. Among them, SU-8, a photo-sensitive, epoxy-based polymer is widely used for micro electro mechanical systems (MEMS). We recently considered SU-8 for mmW and THz-frequency on-chip phased-array applications (S. Sahin, NK. Nahar, and K. Sertel, APSURSI, 2016 IEEE) thanks to its large realizable thickness on the order of 100s of microns. However, liquid epoxy resists often suffers from key processing challenges, such as adhesion and development problems. The quality of patterned layers is highly dependent on the particular process and the re-optimization of process variables is needed when the condition of tools or the design of the microstructure change. Furthermore, non-uniformities of thickness across the wafer substantially affect the final device performance. To overcome such manufacturing challenges of liquid epoxy resists, a new line of thick dry resists, namely SUEX TDFS (Thick Dry Film Sheets) was developed recently by DJ MicroLaminates (www.djmicrolaminates.com).

In this work, we present a systematic characterization of dielectric permittivity and loss tangent of SUEX dry films for the mmW and THz bands. Several 150-μm-thick samples of green and cured SUEX were studied using two complementary measurement techniques to determine material parameters. First, the Nicolson-Ross-Weir technique (see e.g. E.J. Rothwell, J.L. Frasch, S.M. Ellison, P. Chahal and P.O. Ouedraogo, Progress In Electromagnetics Research 157: 31-47, 2016) was applied in a 2-port waveguide environment for 90-140GHz and 140-220GHz bands. In addition, the samples were also characterized using a transmission-mode time domain THz spectrometer (TPS-3000 manufactured by TeraView Inc.) for the 100GHz-2THz band. The real part of permittivity and the loss tangent were measured to be 3.08 and 0.057 for the green SUEX sample. Ultraviolet (UV)-light curing reduces the permittivity and loss tangent down to 2.86 and 0.020, respectively. SUEX films can be easily laminated onto any substrate, eliminating the spin coating and long process optimizations that are required for conventional liquid resists. As such, it is an effective alternative to commonly used epoxy-based resists, such as SU-8 while exhibiting very similar material properties. Measurement results along with the lithographic processing effects on material properties will be discussed at the conference.