A new fabrication technique for the development of flexible mosaic substrates for conformal RF devices

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As technology matures, the quest for multifunctional devices with competing performance specifications increases for many conformal RF (Radio Frequency) applications including miniaturized antennas. Conformality, large bandwidth, and miniaturization are only few of these requirements. Majority of existing design efforts to address these needs still rely on design expertise and/or offer restricted design freedom, hence offer limited solutions. To overcome these limitations, , recent efforts focused on creating a new class of artificial composite materials using systematic, versatile and powerful topology optimal design techniques. The novelty of these multi-functional materials is a direct result of their multi-material volumetric distribution. Although many ceramic-polymer composite substrates are presently available for RF applications, a manufacturing process capable of producing such composite substrates satisfying both high-dielectric constant with possibly low loss for miniaturization purposes and flexibility/pliability desired by conformal applications is needed. To address this need, the objective of this paper is to develop a method suitable for the effective fabrication of conformal material composites which are composites of dielectrics, magnetic oxides and polymer materials, combined to produce new electromagnetic property tensors and previously unobtainable figures of merit. To compromise between high dielectric constant and flexibility, in this study a new hyrbid method based mainly on two earlier techniques proposed by the authors, namely DPD and tape casting will be investigated. Earlier success in producing in an automated fashion textured monolithic ceramic substrates for SATCOM antennas via the former and high-k ceramic-polymer composites via tape casting will be investigated. The former is based on the use of LTCC powders and the latter relies on their mixture with organic binders (polymer solution) to produce deformable films. Automated grid based texturization will be investigated to decrease the loss observed in films produced via tape casting earlier and increase their limited resolution of their mosaic counterparts. Dielectric properties of resulting material films are measured by an Agilent 16451B impedance analyzer and their microscopic behavior are examined by scanning electron microscopy. Results show that flexible mosaic films display improved dimensional acuraccy and improved loss behavior when compared with earlier films produced via tape casting only. Also, printing on these flexible mosaic antenna substrates will be demonstrated based on techniques such as CVD (Chemical Vapor Deposition). Resturn loss measurements of the printed antenna on resulting mosaic film substrates with 3D material variation will be presented. Initital results of the proposed hybridized manufacturing technique shows that it is capable of producing flexible substrates with high dielectric constant up to 30% of the ceramic constituent with loss tangent of less than 0.01 and satisfactory resolution of material constituent cells. By reducing size and adding functionality to a conformal radiator element, avenues will be opened for many new and practical conformal phased array applications such as RF sensing, flexible miniaturized transceivers and covert RF tags to mention a few. This process will serve as a general example for a new approach for creating designed flexible metamaterials, useful for other functional conformal materials.