Scaled Manufacturing Techniques for High Impedance Surfaces Integrated within Structural Composites

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The mushroom type high impedance surface (HIS) has become a well investigated example of an electromagnetic bandgap because of its simplicity and practical application in low profile conformal antennas. Unfortunately, the standard mushroom type HIS is ill-suited from a structural standpoint. The conductive vias, which are typically fabricated by drilling and electroplating, act as stress concentrators within the structure and, as a consequence, are points of early structural failure. In this presentation we investigated an alternative approach of fabricating a HIS to preserve its structural integrity by directly integrating it into a structural composite. The goals of this method are to; (1) preserve the electromagnetic properties observed using PCB based fabrication methods, (2) maintain the same structural properties of the composite structure without the HIS, (3) be able to scale the process to relatively large surfaces at a reasonable cost. To satisfy these goals, our fabrication technique takes advantage of the layered woven fabric architecture of structural composites, conductive screen printing, and a composite strengthening process known as z-pinning. Because of its fabric nature, woven fabric composites respond well to large scale additive techniques such as screen printing. The conductive ink is formulated of silver particle or flakes surrounded by a polymer binder which acts to provide viscosity and protect from oxidation. The viscosity of the conductive ink is high enough to reside above the fabric with little permeation through the fabric. However the polymer binder insolates the silver particles requiring the sintering of the ink to produce conductive traces. After sintering the conductivity of conductive inks have been reported to approach conductivities of bulk silver at high temperatures. Therefore, we concluded that conductive screen printing is a suitable method for depositing the patch and ground plane of the HIS. The vias were realized by the composite strengthening process known as z-pinning. Here, metallic pins are inserted into an intermediary foam structure known as a "preform". The preform is placed above an uncured composite laminate stack and driven into the stack using an ultrasonic hammer which results in drastic improvement in delamination resistance, compression strength and the conductive path necessary for surface wave suppression in the HIS. The patch and ground fabric layers are then aligned with the via- integrated stack and placed within an autoclave under high temperature and pressure to flow the resin throughout the fabric and bond the conductive layers together. The thermoset resin then undergoes a chemical change to permanently bond the structural fabric layers together forming the finished composite and integrated HIS. We used this process to fabricate several HIS test samples within the microwave frequency range. After fabrication we experimentally characterized the effectiveness of the composite HIS using the free-space focused beam approach. The measured reflection magnitude and phase were then compared against simulations using HFSS as well as HIS samples fabricated using more conventional PCB methods. We also conducted various mechanical tests such as three point short beam shear to measure the mechanical strength of our HIS samples compared to those fabricated using PCB methods (i.e. drilling and electroplating). In this presentation we will present the results and effectiveness of the embedded HIS.