Metacomposites: Multifunctional Metamaterial within a Structural Composites

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Materials that possess both desirable structural and electromagnetic properties are rare in nature. Metacomposites achieves this design quality by integrating electromagnetic properties into fiberglass composites. The idea of metacomposites was envisioned at Naval Surface Warfare Center Carderock Division (NSWCCD) in collaboration with University of Delaware and was inspired by recent metamaterials research. Electromagnetic functionality is added to composites through embedded sub-wavelength structures that can then be used to can create impedance matching structures, graded index structures, or guide waves.

This presentation will consist of the various design principles to consider when engineering metacomposites; that is, the fabrication of three dimensional varying electromagnetic properties and the overall electromagnetic performance. The presentation will also consist of a design example, a structural flat lens. The fabrication is achieved using a two dimensional powder dispenser. Various patterns can be generated by placing dots on a single layered pre-impregnated fiberglass resin film (pre-pregs) located on a two dimensional linear stage. Three dimensional structures are built by stacking pre-pregs with different patterns, and when the pre-pregs are cured together, the result is a metacomposite.

For a multifunctional metamaterial flat lens, the Rigorous Coupled Wave Analysis (RCWA) is used to numerically derive the effective electromagnetic properties. While RCWA is based on an infinite periodic structure, the analysis can be used to approximate the effective properties in a finite case. The flat lens is designed using the “Graded Index with Integrated Antireflective Properties” technique (Good and Mirotznik, Micro and Optic Tech Let, Vol 54 Issue 12). The technique solves for all solution spaces of possible phase shifts and corresponding front-face reflections. The minimum front-face reflection at the desired phase shifts are used to create the target phase front.