Improved Embedded Antenna Design using Subwavelength Anti-reflective Surfaces

Brandon Good and Mark Mirotznik
Department of Electrical Engineering
The Catholic University of America
Washington, DC 20064

Embedding planar antennas, or antenna arrays, in a protective dielectric cover can have the beneficial effects of prolonging the antenna's lifetime, increasing antenna gain and reducing antenna size. However, one of the main issues with embedded antennas is the introduction of trapped surface waves that can generate undesirable sidelobes and mutual interference artifacts. These undesired sidelobes and mutual interference artifacts can especially interfere with arrays. Rather than modeling the antenna array strictly for the dielectric, the array design is created based on the surface waves caused by the boundary between the dielectric and air. To reduce surface waves in embedded antenna structures we investigated the use of broadband antireflective (AR) surfaces. The goal of the AR surface is to create a smooth impedance transition from the dielectric cover to free-space and, as a consequence, reduce reflected energy that may subsequently manifest itself as a trapped surface mode. To create the AR boundary we investigated the use of moth-eye surfaces machine directly onto the top surface on the dielectric cover. The moth-eye surfaces are created using a periodic array of subwavelength features whose effective electromagnetic properties create its AR performance. Optimization algorithms were used to create the moth-eye pattern that generated the least reflected energy over the band of interest. The moth-eye surfaces were designed using a combination of custom electromagnetic design codes and Ansoft's HFSS. Experimental surfaces were constructed using a computer numerical control (CNC) milling machine. We investigated arrays of embedded monopoles with and without AR surfaces. Simulation and experimental results in the Ka-Band will be presented that illustrate the usefulness of this approach.