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Metasurfaces for Low-Profile and Leaky-Wave Antennas and RCS Reduction

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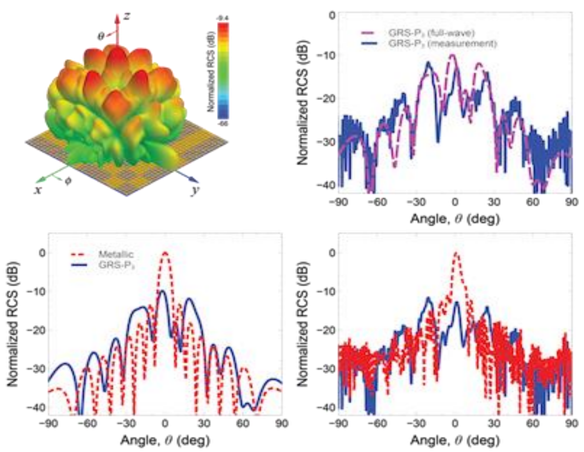

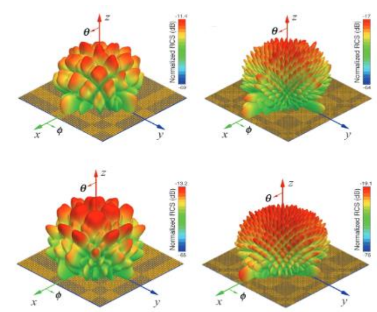

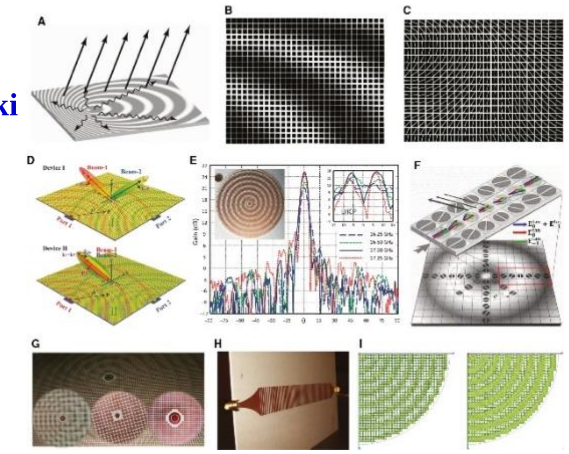

High Impedance Surfaces (HISs) have emerged as one of the advances in the modern antenna design. They have been extensively used in low-profile antenna designs because of their in-phase reflection characteristics in certain frequency band(s); hence the name EM Band-Gap (EBG) structures. HISs can also be utilized for antenna miniaturization and bandwidth enhancement, and they have also been used as attractive ground planes and checkerboard surface variations of them as radar targets for RCS reduction. The presentation we will concentrate on circularly symmetric HISs, such as loops or spirals ,and it will be shown that the unique phase profile of the circular HISs, formed by the excitation of the incident waves, provide more symmetric amplitude radiation patterns and a constructive interference between the direct and reflected waves which increases the gain by nearly an additional 3dB, compared to ideal PMC ground planes, for a total gain of about 8.5-9 dB. Holographic techniques, inspired from optical technology, are used to design HISs, often referred to as *metasurfaces*, which can be realized on dielectric covered ground planes as arrays of metallic strips or patches. Such surfaces can be designed to form Leaky-Wave Antennas (LWAs), which continuously shed/radiate energy as the surface waves propagate along these surfaces. The impedance surfaces create an impedance profile to create 1-D fan beams using metallic strips and 2-D pencil beams using metallic patches. These LWAs are ideal radiators for autonomous automotive applications as they require a simple feeding mechanism, and also can cause beam scanning, by varying the frequency. A recent design to achieve RCS reduction is to coat the radar target with checkerboard EBG designs of patches of different configurations. The incident waves on them induce surface current densities that act as antenna array elements with difference amplitude and phase excitation, and they, obtain to form constructive and destructive interference scattering patterns, to reduce the intensity of the scattered fields toward the observer; thus reducing the RCS. While symmetric square-shaped checkerboard surfaces produce four redirected lobes of the bistatic scattered fields, a hexagonal design creates six redirected lobes, which further reduce the peak intensity of the redirected bistatic lobes. Also the bandwidth of such checkerboard surfaces can be enhanced by combining two different EBG set of patches, each with different shape patches and resonant frequencies. It will be shown that the 10dB RCS reduction bandwidth, compared to a PEC plate, can be extended from nearly 40% to nearly 63%, and up to 90%.

Constantine A. Balanis (S'62 - M'68 - SM'74 - F'86 – LF'04) received the BSEE degree from Virginia Tech, Blacksburg, VA, in 1964, the MEE degree from the University of Virginia, Charlottesville, VA, in 1966, and the Ph.D. degree in Electrical Engineering from Ohio State University, Columbus, OH, in l969. From 1964-1970 he was with NASA Langley Research Center, Hampton VA, and from 1970-1983 he was with the Department of Electrical Engineering, West Virginia University, Morgantown, WV. Since 1983 he has been with the School of Electrical, Computer and Energy Engineering, Arizona State University, Tempe, AZ, where he is Regents' Professor. His research interests are in computational electromagnetics, metasurfaces, RCS reduction, low-profile and leaky-wave antennas.

He received in 2004 an Honorary Doctorate from the Aristotle University of Thessaloniki, the 2017 IEEE Rudolf Henning Distinguished Mentoring Award, the 2014 James R. James, Lifetime Achievement Award, LAPC, Loughborough, UK, the 2012 Distinguished Achievement Award of the IEEE Antennas and Propagation Society, the 2012 Distinguished Achievement Alumnus Award (College of Engineering, The Ohio State University), the 2005 Chen-To Tai Distinguished Educator Award of the IEEE Antennas and Propagation Society, the 2000 IEEE Millennium Award, the 1996 Graduate Mentor Award of Arizona State University, the 1992 Special Professionalism Award of the IEEE Phoenix Section, the 1989 Individual Achievement Award of the IEEE Region 6, and the 1987-1988 Graduate Teaching Excellence Award, School of Engineering, Arizona State University.

Dr. Balanis is a Life Fellow of the IEEE. He has served as Associate Editor of the **IEEE Transactions on Antennas and Propagation** (1974-1977) and the **IEEE Transactions on Geoscience and Remote Sensing** (1981-1984); as Editor of the **Newsletter** for the IEEE Geoscience and Remote Sensing Society (1982-1983); as Second Vice-President (1984) and member of the Administrative Committee (1984-85) of the IEEE Geoscience and Remote Sensing Society; and Distinguished Lecturer (2003-2005), Chair of the Distinguished Lecturer Program (1988-1991), member of the AdCom (1992-95, 1997-1999) and Chair of the Awards and Fellows Committee (2009-2011) all of the IEEE Antennas and Propagation Society. He is the author of **Antenna Theory: Analysis and Design** (Wiley, 2005, 1997, 1982), **Advanced Engineering Electromagnetics** (Wiley, 2012, 1989) and **Introduction to Smart Antennas** (Morgan and Claypool, 2007), and editor of **Modern Antenna Handbook** (Wiley, 2008) and for the Morgan & Claypool Publishers, series on *Antennas and Propagation* series, and series on *Computational Electromagnetics*..