“Design of Metamaterial and Metasurface Components”

Prof. Zvonimir Sipus
University of Zagreb, Croatia

Abstract:
In recent years, the development of various metamaterial surfaces has inspired new antenna applications and technological solutions. Whether these surfaces are metamaterials, electromagnetic bandgap (EBG) surfaces, artificial high-impedance surfaces or simply “metasurfaces,” the idea behind their design is to provide an electromagnetic effect not attainable using classical materials. In this presentation, metasurface concepts will be employed to design Luneburg lens antennas. Using an array of size-varying circular patches on a dielectric substrate within a parallel-plate waveguide (PPW) structure, a variable surface impedance is obtained to realize the equivalent refractive index of a Luneburg lens. The obtained lens has good bandwidth characteristics and significant fabrication advantages with respect to conventional dielectric lenses. Based on this PPW lens, an H-plane antenna has been designed.

Gap waveguide technology (i.e., waveguides with metamaterial layers) represents an alternative technology for the development of components in the GHz and THz frequency ranges. This technology was recently proposed and developed at several European universities: Gothenburg (Chalmers), Valencia, Madrid (Carlos III), Siena and Zagreb. In order to design real-word engineering components, an efficient and accurate analysis tool is needed. The proposed analysis method is based on solving integral equation using the method of moments. In the analysis procedure, appropriate Green’s functions are constructed that rigorously take into account the metamaterial layer. This approach provides clear physical insight into the operation of the considered device (as opposed to commonly used ‘blind’ optimization methods).

Metamaterial and metasurface based devices are usually designed using transformation electromagnetics, i.e., the designed structure is described in terms of space-varying permeability and permittivity tensors. However, there still exists a large gap between the desired permeability and permittivity distribution and reality: the actual electromagnetic parameters of different metamaterial and metasurface structures. Due to their complexity, it is not possible to design them without a good strategy (i.e., we cannot simply use the optimization features of a commercial electromagnetic solver). Therefore, we proposed a procedure for designing metamaterial-based devices. The procedure starts with the ideal design obtained using some physical method like transformation electromagnetics, i.e., we search for the metamaterial realization of a complex multilayer anisotropic structure. In order to design “real” metamaterial structures in an efficient way, we propose an intermediate step in which an equivalent planar anisotropic multilayer structure is defined and which is realized using the metamaterial approach. The main reason for introducing an intermediate step is that planar periodic structures can be rapidly analyzed (and designed) using commercial electromagnetic solvers since a single unit cell only needs to be designed. After designing an equivalent planar structure, we need to go back and map the structure to the desired shape. In order to do that, we consider an efficient approach based on conformal mapping.

Speaker’s Biography:
Zvonimir Sipus was born in Zagreb, Croatia, in 1964. He received the B.Sc. and M.Sc. degrees in electrical engineering from the University of Zagreb, Croatia, in 1988 and 1991, respectively, and the Ph.D. degree in electrical engineering from Chalmers University of Technology, Gothenburg, Sweden, in 1997.

From 1988 to 1993, he worked at Rudjer Boskovic Institute, Zagreb, Croatia, as a research assistant, involved in the development of detectors for explosive gases. In 1994, he joined the Antenna Group at Chalmers University of Technology as a Ph.D. student. In 1997, he joined the Faculty of Electrical Engineering and Computing, University of Zagreb, where he is now a Full Professor (since 2008). From 1999 to 2003, he was also an Adjunct Researcher at Chalmers University of Technology. Since 2006, he is participating as a lecturer in the European School of Antennas. His main research interests include numerical electromagnetics with application to antennas, microwaves, and optical communications. He is an author or co-author of more than 40 scientific papers published in scientific journals. He received the annual national science award in 2006 for research of conformal antennas and periodic structures.

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