Low-Profile Terahertz Antennas for CubeSats and SmallSats

Goutam Chattopadhyay(1), Maria Alonso-delPino(1), David Gonzalez-Ovejero(2), Cecile Jung-Kubiak(1), and Theodore Reck(1)
(1) Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, USA
(2) Université de Rennes, RENNES Cedex, France

Increasingly, international space agencies are looking into CubeSats and SamllSats as viable platforms for hosting science payloads. This has opened up new avenues for antenna research and implementation as these platforms poses a unique completely different set of challenges. These difficulties are compounded at millimeter-wave and terahertz frequencies.

Emerging applications in millimeter-wave and terahertz frequencies require low-profile antennas and integrated packaging solutions for high performance and compact instruments. For space applications, there is an emphasis on antenna systems which can be part of the spacecraft walls. With the emphasis on CubeSat and SmallSat platforms in recent years, the need for low-profile antennas has become even more pronounced. Packaging of terahertz instruments with high-performance antennas is very challenging. Losses of traditional transmission lines such as waveguides, microstrips, and coplanar waveguides go up as the frequency increases. That proves to be a hindrance in integrating commonly used antenna technologies for terahertz instruments. To overcome these shortcomings, researchers have been looking into alternative technologies such as silicon micromachined waveguides and lens based leaky wave antennas which can be integrated without long length of transmission lines. The challenge is the coupling of the antenna output to the rest of the system, as the optimization of performance, loss, and reflections become too demanding. To overcome these, alternative technologies such as planar metasurface antennas, lens based leaky-wave antennas, and silicon micromachined based antennas and coupling structures are increasingly getting more attention of late.

We have developed low-profile, ultra-light, and high gain antennas that can be integrated with the front-end electronics at terahertz frequencies. One of the advantages of these antennas is that they do not require any external reflectors and associated structures. In this lecture, low-profile modulated metasurface (MTS) based antennas at millimeter-wave and terahertz frequencies will be presented. It is well known that radiation by metasurface antennas stems from the interaction of a cylindrical surface wave (SW) excited by a point source with periodically modulated impedance boundary condition. The periodic modulation of the surface wave is tailored in a way to generate leaky waves. The modulation is achieved by changing the shape and orientation of subwavelength patches printed on a grounded slab or with varying heights metal pins on a metal ground plane. At frequencies beyond 100 GHz, all-metallic structure based MTS antenna is more practical compared to dielectric based designs as the dielectrics are more lossy at higher frequencies. We have developed all-metal MTS based planar low-profile antennas at frequencies from 30 GHz to 300 GHz. The design details, fabrication challenges, and measurement results of these antennas will be presented in this lecture.

This work has been carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with National Aeronautics and Space Administration (NASA).