Planar High Performance Antennas at Terahertz Frequencies

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Design, fabrication, and testing of antennas at millimeter- and submillimeter-waves is somewhat different than at microwave frequencies. Traditional metal machining of horn antennas gets increasingly difficult to fabricate due to the tolerance requirements as the frequency increases towards millimeter and higher wavelengths. Planar antennas such as microstrip, patches, and even reflect arrays are lossy due to both metal and dielectric losses at these frequencies. Moreover, millimeter- and submillimeter-wave radiometric, spectroscopic, and imaging systems for astronomy, planetary, Earth science, and other applications are increasingly moving towards large focal plane arrays. All these make design and fabrication of antennas at these frequencies extremely challenging.

We developed different approaches to design and fabricate terahertz antennas and related optical elements. One approach is to construct silicon optics by stacking flat patterned wafers for developing lenses as well as antennas. The starting point is a multilayer optical design incorporating both an axial gradient in the refractive index for antireflection and a radial index gradient for focusing. For each optical layer, an aperiodic hole pattern is used to achieve the required effective index of refraction. Using a novel multilayer etching procedure, several layers of the optical structure are fabricated on a flat wafer. Several individually patterned wafers are stacked and bonded together to produce the completed optics. Although the component technologies are mature, they have not been previously combined this way. We developed a technique for fabricating novel silicon optics with integral achromatic antireflection (AR) layers by bonding stacks of etched silicon wafers.

Another approach is to use modulated metasurfaces (MTS) to design and fabricate antennas at these frequencies. MTS can be applied to the design of very high gain antennas. One of the major advantages of MTS based antennas that they can be used for beam shaping, on-surface control of the aperture fields, pointing and scanning, and all these accomplished with a low-profile and compact envelope.

In this paper, an overview of different planar antennas and optical components such as flat mirrors developed by stacking and bonding together thin, flat, patterned silicon wafers to produce compound optical elements, at terahertz frequencies will be presented. It will compare different design and fabrication approaches for planar terahertz antennas and optical elements.

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