# Design, Fabrication, and Performance of Terahertz Antennas

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Millimeter- and submillimeter-wave spectroscopic and imaging systems for astronomy, planetary, and Earth science applications are increasingly moving towards large focal plane arrays. The relatively long wavelengths together with focal ratios encountered imply mm-sized pixels with hundreds to thousands of pixels. In many applications, especially for space-based systems, one will require vacuum windows 10s of cm in diameter for these large arrays.

A wide range of such applications in the terahertz (THz) frequency band would benefit from silicon optics with broadband antireflection treatment. Silicon's high refractive index and low loss make it an ideal optical material at these wavelengths. Antireflection treatment of silicon optics is essential, however, and has proven a major challenge for the 15 cm to 100 cm diameter optics required for current and future applications. Moreover, multilayer antireflection treatments are necessary for wide spectral bandwidths, with wider bandwidths requiring more layers. It is difficult to find low loss dielectrics with the correct refractive index and other properties to match silicon well, especially if more than one layer is required. Textured surfaces are an attractive alternative to dielectric antireflection coatings. Both the innermost layers of multilayer structures and antireflection structures for submillimeter wavelengths require finer features that require lithographic techniques.

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.

In this paper, an overview of the terahertz optical components such as flat mirrors developed by stacking and bonding together thin, flat, patterned silicon wafers to produce compound optical elements. We will present our design and measured results for an 850 GHz system.

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