Infrared Antennas

Glenn D. Boreman
College of Optics & Photonics/CREOL
University of Central Florida
4000 Central Florida Blvd.
Orlando, FL 32816-2700 USA
boreman@creol.ucf.edu

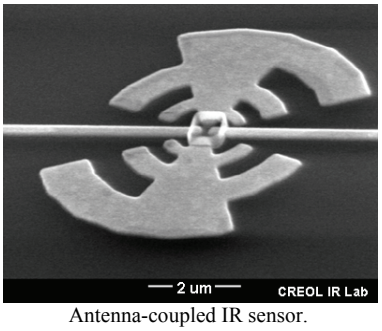
Abstract: Radiofrequency components such as antennas, transmission lines, phased arrays, frequency-selective surfaces, reflectarrays and meanderline waveplates are demonstrated in the infrared. Usual design methodologies apply, providing that IR material properties are used in the computations.

OCIS codes: (040.3060) Infrared ; (040.2235) Far Infrared and THz

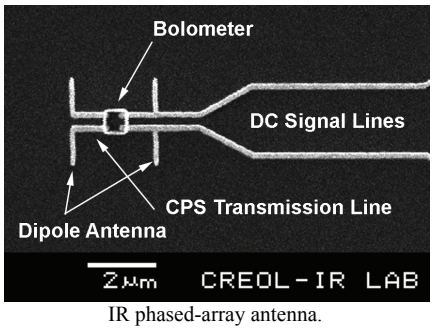
We fabricate nanoscale antenna structures resonant at infrared (IR) frequencies using direct-write electron-beam lithography. Antennas facilitate electromagnetic coupling to sub-wavelength sized sensors (e.g., bolometers, Schottky diodes), with resulting spectral and polarization response determined by the dimensions and arrangement of the antenna arms. Along with single-element antennas, we have demonstrated both incoherent and coherent antenna arrays, with co-phased response verified by measurements of the angular reception patterns. In phased-array configurations, beam shifting and beam narrowing are noted, in agreement with classical antenna theory. Dual-dipole antennas can also be used to measure the magnitude of the spatial coherence of the incoming radiation, at the location of the two antennas.

Frequency selective surfaces (FSS) are two-dimensional arrays of metallic antennas with subwavelength periodicity. Depending upon the geometry of the antenna arrangement, these have been demonstrated as spectral reflectance or transmittance filters in the IR and THz. They have also been configured as selective absorbers, to control the IR spectral emissivity of a surface by means of Kirchhoff's law. One extension of the IR FSS concept is the reflectarray, which is a quasi-periodic array of antennas for which the phase shift on reflection depends on the local unit-cell geometry. Varying the antenna dimensions across the surface of an array can be used to produce a flat surface with optical focusing power. We have demonstrated these in the IR, at wavelengths as short as 1.5 micrometers. Another extension of FSS technology is the meanderline waveplate. These have been demonstrated in the 3-5 and 8-12 micrometer IR bands, and allow implementation of a quarter-wave, half-wave, or arbitrary retarder. Unlike the usual crystalline waveplates, the meanderline device has a thin aspect ratio and significant angular and spectral bandwidths.

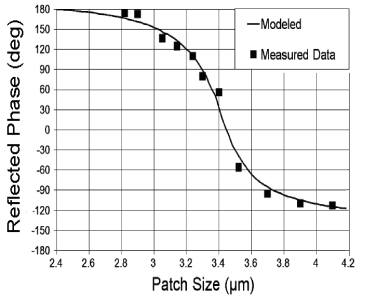
In the design of these devices, accounting for the spectral variation of the real and imaginary parts of the permittivity is crucial to obtain accurate agreement between numerical models and measured results. This is particularly important for thin (typically 100 nm) metallic films, for which inadequate tabular data are available in the literature. Material properties are measured as a function of frequency with an IR variable-angle spectroscopic ellipsometer, and then imported into full-wave electromagnetic models for design and analysis.



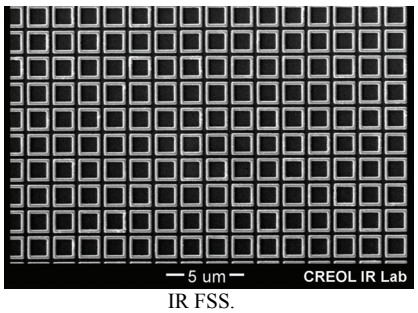
Antenna-coupled IR sensor.



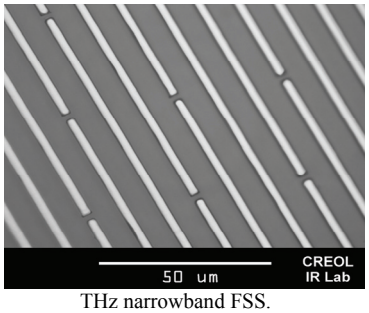
IR phased-array antenna.



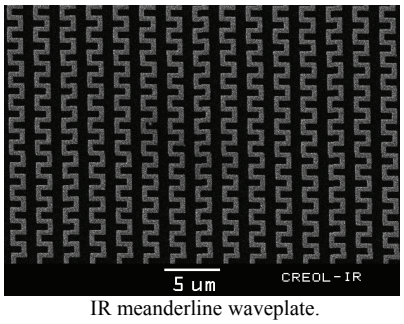
Refl. phase vs patch size - IR reflectarray.



IR FSS.



THz narrowband FSS.



IR meanderline waveplate.