Abstract:

Since 2003, Phoebus Optoelectronics has enabled custom R&D solutions in the fields of metamaterials, plasmonics, antennas, and sensors. We work closely with our customers throughout device development, from product realization to small volume manufacturing. Our R&D portfolio spans the spectral ranges of visible light, infrared, terahertz, and microwave radiation, for applications in high resolution infrared imaging systems, wavelength and polarization filtering, tunable optical components, beam forming and steering, solar cells and renewable energy devices, and chemical and biological toxin sensors. Our agile team makes extensive use of the resources at the CNF for our nano/micro fabrication and testing, to provide cost efficiency and rapid turnaround. In this report, we discuss the ongoing development of a metamaterial-based pixelated focusing polarizer.

Summary of Research:

Extraordinary optical transmission (EOT) is a phenomenon in which light is transmitted through apertures much smaller than the incident wavelength, at anomalously large intensities relative to the predictions of conventional aperture theory. EOT was first observed by T. W. Ebbesen in 1998 [1], setting off a flurry of research into metamaterials and anomalous transmission, into which Phoebus Optoelectronics was an early entrant. For over 10 years, Phoebus has successfully incorporated metasurfaces into devices used to perform light filtering [2-3], photon sorting [4-5], polarimetric detection [6], high speed optical detection [7], optical sensing of biological and chemical toxins [8], and other light controlling tasks. In the present report, we present recent developments toward the development of a metamaterial-based pixelated focusing polarizer.

The current industry standard for pixelated polarizers is a wire grid geometry. However, this decades-old technology has been developed to its full potential, in that the further optimization of wire grid pixels is limited by optical physics itself. Each wire grid diffracts light very strongly, so that as the transmission of individual pixels increases, the cross talk between neighboring pixels increases as well, which decreases resolution.

We have developed an on-chip pixelated polarimeter device that sidesteps this fundamental tradeoff between cross talk and transmission, by using metasurfaces in place of wire grids, to simultaneously minimize diffraction and better collimate the transmitted light. In our first-generation IR polarimeter, which is currently commercially available, each pixel has the structure shown in Figure 1, with four arrays of wires oriented at 0°, 45°, 90°, and 135° to each other. Each array is capable of acting as a graded index lens to focus and collimate transmitted light. At the same time, the phase delay produced by the four arrays together allow the pixel as a whole to behave as a polarizer to control the phase of the light. A higher magnification image of a typical array (Figure 2) illustrates the high aspect ratios and smooth sidewalls that are essential for the high-quality performance of our metasurface structures.

We are currently developing additional metasurface structures, such as the second generation design shown in Figure 3, which are tailored to operate in other spectral ranges.

Preliminary computer simulations, shown in Figure 4, demonstrate the ability of our metasurface structures to simultaneously deliver higher transmittance and lower cross talk between pixels than the current generation of wire-grid-based pixelated polarimeters. Our metastructures combine the advantages of extremely high extinction ratios (>10000:1), high transmission, and lower cross talk between pixels than the current state-of-the-art wire grid technology.
References:


