Microelectronics and Microsystems
Photonics

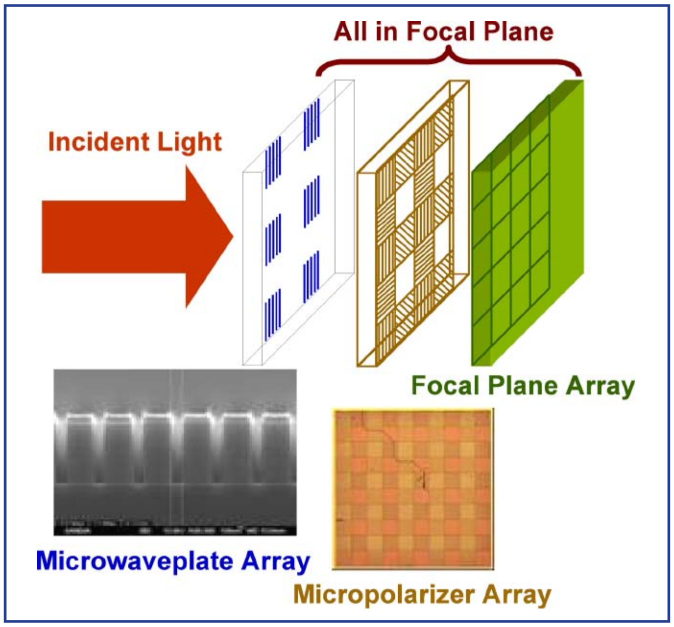

Figure 1: Arrayed components for snapshot polarimetry.

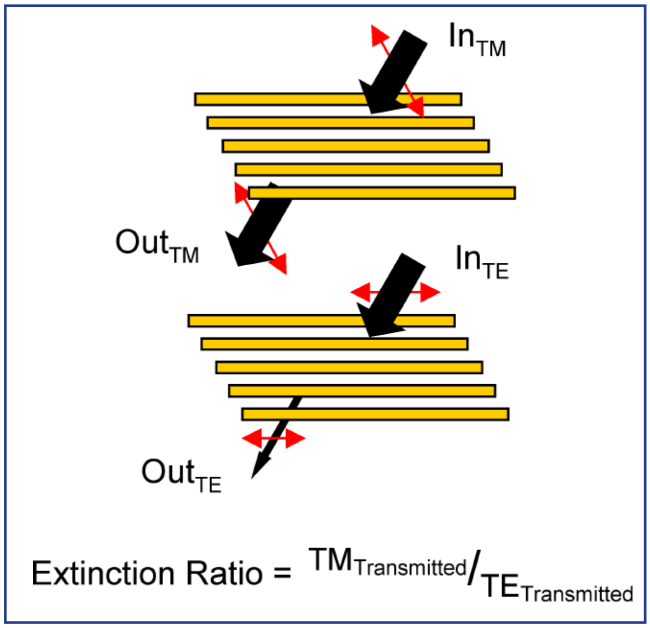

Figure 2: Subwavelength, metallic grid structure for micropolarizers and corresponding extinction ratio. TM, TE are transverse magnetic and electrical vectors of the light wave.

Simultaneous polarization information is used to classify materials and identify objects in remote sensing and military applications.

Snapshot Polarimetric Imaging in the Infrared

Polarimetric imaging measures the polarization states of light coming from all points in a scene. This information, particularly in the infrared region, can help classify materials and identify objects of interest for remote sensing and military applications. Thus there is interest in capturing and storing infrared polarization images in a similar way that intensity information is gathered, i.e., by using a pixelated focal plane array (FPA). Multiple images of a static scene are taken with a combination of oriented polarizers and waveplates in the optical path. Differences between image pairs quantify the distribution, for example, of right circularly polarized light in the scene. Traditionally, sequential polarimetric imaging sensors produce scenes with polarization information through a series of assembled images. However, sequential image capture is a problem if there is movement from one frame to the next.

Researchers at Sandia have developed a new way, "snapshot polarimetric imaging," (Figure 1) to collect the spatial distribution of all parameters simultaneously. Background noise is also eliminated. To do this, the microsystems engineering facility is used to fabricate features on the subwavelength scale that can directly manipulate the optical fields for each pixel in the FPA. The principle behind linear micropolarizers for long wavelengths is based upon the strong anisotropic absorption of light in a subwavelength, metallic grid structure (Figure 2). The grid structures are patterned with different orientations, defining the polarization axes. The extinction ratio, defined in Figure 2, quantifies micropolarizer performance.

Technical Contact:
Shanalyn Kemme, Ph.D.
505-284-4639
sakemme@sandia.gov

Science Matters Contact:
Alan Burns, Ph.D.
505-844-9642
aburns@sandia.gov

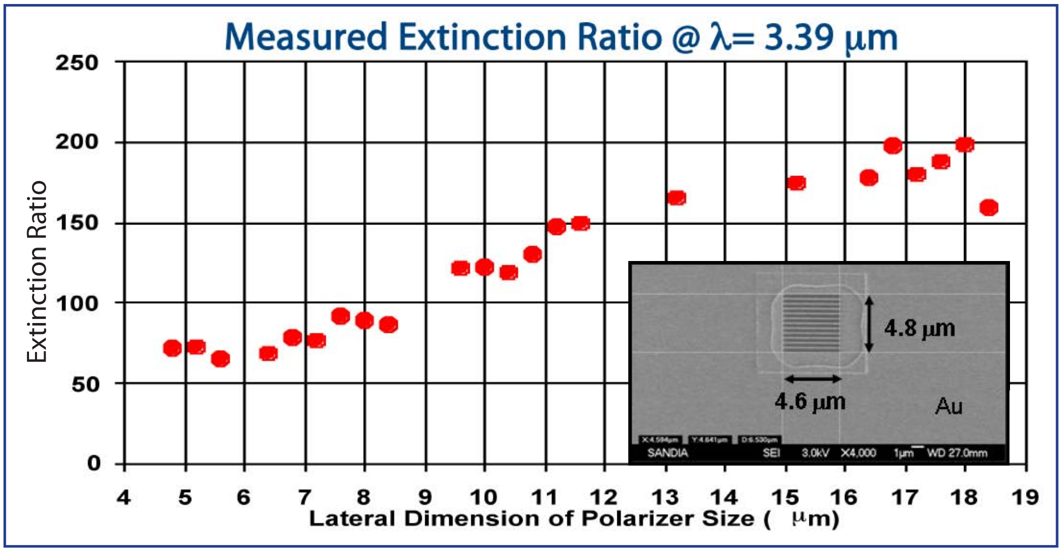

Figure 3: Measured extinction ratio of single, finite aperture micropolarizers at 3.39 microns wavelength. Inset: Scanning electron micrograph of a 4.8 micron pixel polarizer.

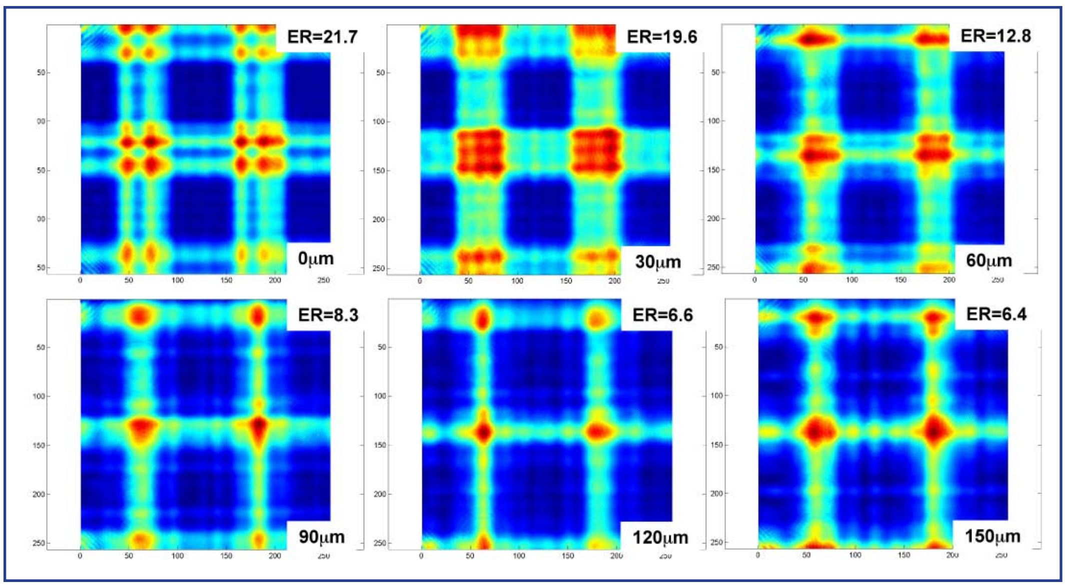

Figure 4: Measured irradiance patterns (red is highest) and corresponding extinction ratios (ER) through super pixel arrays as propagation distance is increased.

In principal, the extinction ratio of a polarizer will degrade as the component aperture decreases toward wavelength dimensions. However, Figure 3 illustrates that single pixelated micropolarizers fabricated at Sandia have measured extinction ratios still larger than 100:1 for pixel sizes as small as 9 microns. That exceeds, by seven times, previously reported extinction ratios for large area, 1 cm apertures. Equally important, the transmitted signal remains above 50%.

Overall, infrared polarimetric imaging can be accomplished with this new technique. However, due to near-field and diffractive effects of the finite component apertures, the distance between the micropolarizer array and the FPA is critical to performance of the imager. This is shown in Figure 4, where there is a substantial change in the imaged pattern and a corresponding drop in extinction ratio (ER) with propagation distance and the subsequent introduction of adjacent super pixels (crosstalk). Because of these findings, it is now recommended that only a few microns separate components in the assembly process.

Sandia National Laboratories

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