“Mitigating Polarization Effects in On-Die Diffractive Optics for a CMOS Image Sensor”

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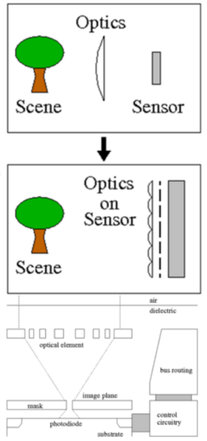
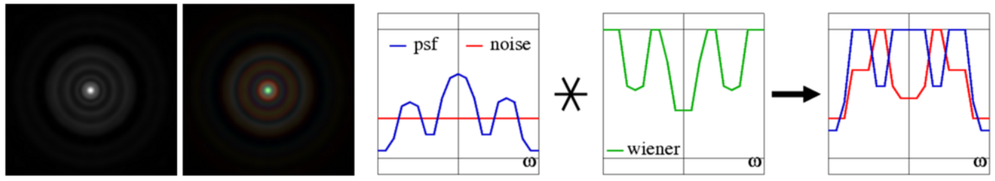
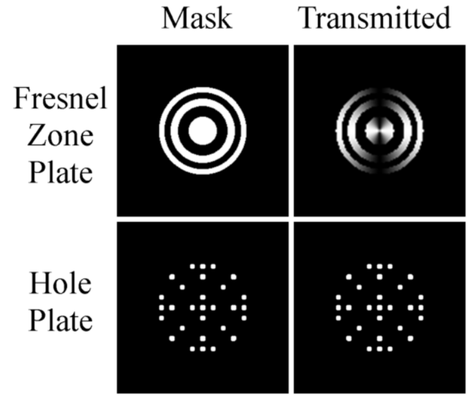
This paper discusses polarization effects in diffractive optics made using the metal layers in a standard CMOS process, and presents optical and algorithmic ways of mitigating these effects.

On-die optics are used for many applications, and have been used to create standalone image sensors that don’t need external optics. Using a metal layer to make diffractive optical elements in a standard CMOS process is attractive, as no extra mask steps are needed and the fabrication process is inexpensive. The resulting system is shown on the right.

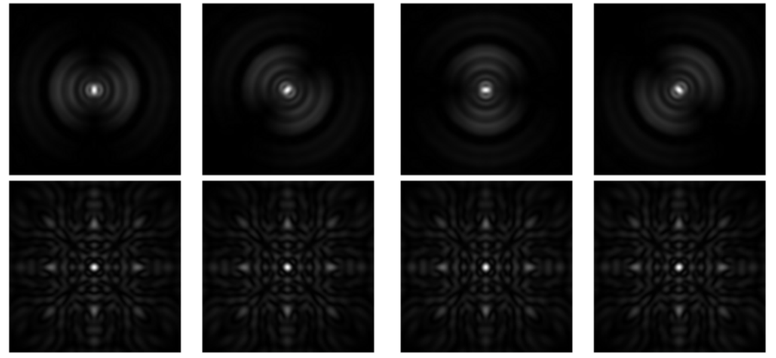


These diffractive on-die optics produce aberrations and other artifacts, depicted below. The point spread function is blurred and has fringes, due to imperfect focusing and higher-order diffraction lobes. The point spread function is also wavelength-sensitive. Both of these types of artifact can be well-characterized in advance. This allows the use of deconvolution techniques (such as Wiener filtering, illustrated below) to suppress the artifacts, as described in previous papers. Sample reconstructed images are shown on the far right.





Lastly, the metal gratings used for fabricating the optical elements act as polarizing filters, passing only some of the light striking them. The effect of this is shown above (first row). Figures on the top right (first row) depict the point spread function of a Fresnel zone plate optical element for varying illumination polarization angles. The end result is that resolution in the transmitted direction is approximately twice that of the obstructed direction. This can be ameliorated by using new optics, also shown above (second row). The hole plate has no polarizing parts, and so has a point spread function that doesn’t change with polarization (top right, second row). Deconvolved images formed by zone plates and hole plates are shown on the right.



Above:
Point spread functions for varying polarization angles.

Below:
Original images (top row) and deconvolved images (bottom row), for small and large checkerboards.