Polarization Independent Broadband Metasurface Edge Detector

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Image processing is of fundamental importance for many emerging technologies such as AR/VR glasses, autonomous driving, and biometric identification. Conventionally, image processing tasks are performed by digital computers. However, the processing time and power consumption of digital computers become a limiting factor with the increasing demand for real time, continuous data processing. With the advent of metamaterials and metasurfaces, optical computing platforms emerged as promising candidates to perform such image processing tasks. In recent years, numerous examples based on spin Hall effect, Pancharatnam–Berry phase, photonic crystals, and surface plasmons were realized. These studies have shown that metasurfaces offer real time image processing with low to none power consumption. However, the previous demonstrations suffer from one or few of the several limitations that are requiring angled incidence, polarization dependence, requiring additional polarizers, narrow operation band, being limited with 1D processing, requiring coherent light, and requiring digital post-processing.

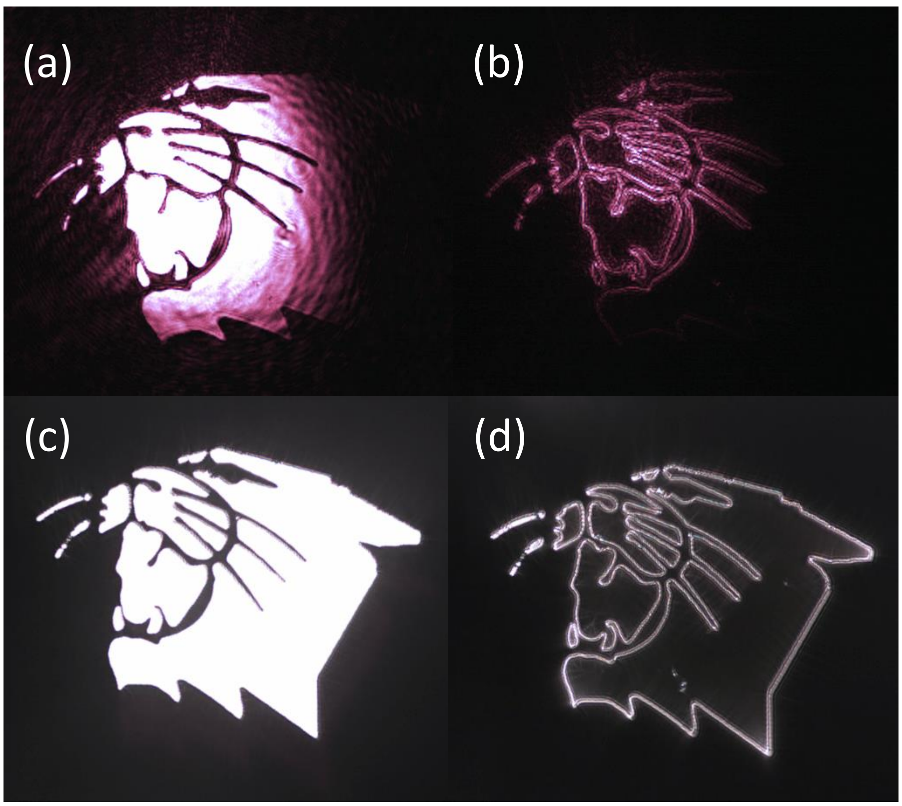

Fig. 1 Experimentsl edge detection under; (a-b)coherent (HeNe Red laser) and (c-d)non-coherent (Xe light bulb) illumination .

Here, addressing these problems, we propose and demonstrate metasurfaces for 2D isotropic and polarization independent edge detection based on Fourier optics principles. We designed sub-wavelength metallic metasurfaces to perform edge detection. The metasurface consist of co-centric metallic rings that create a spatial transmission profile matching the Fourier transformation of the second order differentiation. We experimentally confirm polarization independent, broadband edge detection with high transmission efficiency under both coherent and non-coherent illumination along the visible range as seen in the Figure 1. By further simulations and measurements, we show that the operation range of the metasurface also covers the 800 nm to 1600 nm wavelength range in the near IR. Our results constitute an important step towards the application of metasurfaces for real-life image processing tasks.