

## Dielectric Phase Gradient Metasurfaces for Classical and Quantum Optics Applications

### Abstract:

In recent years, various optical functionalities have been demonstrated using metasurfaces which have attracted tremendous attention. Metasurfaces being diffractive optical components, show greater flexibility, including compactness, lightweight, arbitrary wavefront addressing capabilities exceeding those of refractive optical components. However, in terms of efficiency refractive components perform better and further optimization is required for metasurfaces in this direction. Considering this, here we design hybrid optical devices to combine the advantages of both the components. First, it is demonstrated how the dispersion of a simple optical element such as a prism can be mitigated using a metasurface. By employing phase gradient metasurfaces, the outgoing wavevectors can be controlled and hence the diffractive dispersion of metasurface. Utilizing this property, metasurfaces with relatively small phase gradients are designed and prism dispersion mitigation is experimentally demonstrated. Extending the same principle to lenses, metasurface to correct for lens chromatic aberration is designed in the wavelength range of 550-800nm. Also, it is shown that monochromatic aberration such as spherical aberration can also be corrected by designing an appropriate phase gradient for the metasurface. Analytical calculations, large area metasurface fabrication and comprehensive experimental characterization are done to demonstrate aberration correction of commercially available lenses. These developments are promising for future compact imaging systems.

Realizing the potential of metasurfaces in classical optics, they are also used for Quantum optics applications. However, only a few works have been done in this direction. Hong Ou Mandel experiment, which is one of the basic experiments of Quantum optics, demonstrates quantum interference. Here, we propose to modify the original setup by replacing the beam splitter with a phase gradient metasurface. A novel metasurface is designed for this purpose called 'Dual Gradient Metasurface' which imparts additional functionality along with the beam splitter functionality. The nanofabrication of the metasurface is optimized to realize 50/50 transmission in the two diffracted orders to imitate a beam splitter. The superior control that metasurfaces offer over the phase, polarization and amplitude of light can be quite beneficial for manipulating the quantum states of light. This opens doors for harnessing the potential of metasurface for quantum technologies.

**Keywords :** Phase gradient, Dispersion compensation, Aberration correction, Hybrid components, Meta-corrector, Nanopillars, Pancharatnam-Berry phase, Two-photon interference, Anti-bunching