Design and fabrication of surface relief diffractive optical elements

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Surface relief diffractive optical elements (DOE) are flat devices that modulate the phase of the incoming wavefront by locally altering the optical path. DOE applications have evolved greatly from spectroscopy and diffractive lenses [1], to holography, beam shaping [2] and more recently augmented reality [3]. Iterative Fourier transform algorithms (IFTA) have facilitated the design of DOEs to produce any arbitrary computer-generated intensity pattern [4]. However, the complexity in the design and fabrication increases dramatically as larger diffraction angles are desired, requiring higher pixel resolution, and precise multilevel depth control to optimize diffraction efficiency, and considering distortions in the modelling [5]. Here we present the ongoing development of an IFTA-based design tool to generate arbitrary DOE phase masks, considering microfabrication constraints. Microfabricated transmissive surface relief ($\Delta z \approx 1$ µm) binary DOEs were demonstrated on a glass substrate for 1 µm to 5 µm pixel resolutions and evaluated using a green laser source. The phase mask was defined with direct write laser on photoresist, followed by SiO_2 glass substrate etching. The binary phase mask results in a mirrored replica of the pattern around the zero order, and geometrical distortions are observed for higher diffraction orders. The zero order is accentuated due to the mismatch of the topography depth from the expected π-phase. DOEs with multilevel phase topography enable not only higher diffraction efficiency, reducing the zero order, but also elimination of the mirrored image. These optical devices may be mass replicated using nanoimprint or embossing techniques onto polymeric substrates or coatings, significantly reducing production costs. For high power applications, such as to increase throughput of laser structuring and texturing, the DOEs may be etched onto fused silica glass for improved thermal stability and robustness. These preliminary results validate the design and fabrication process of custom DOEs. Future work consists in introducing distortion compensation for large diffraction angles in the design tool, and non-binary DOE microfabrication and replication.

REFERENCES

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FIGURES

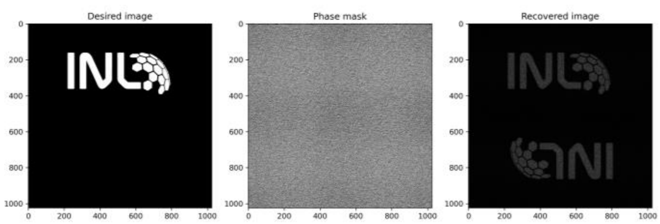

Figure 1: Results of the DOE design tool used to generate binary and multilevel phase masks and evaluate the expected projected pattern intensity.

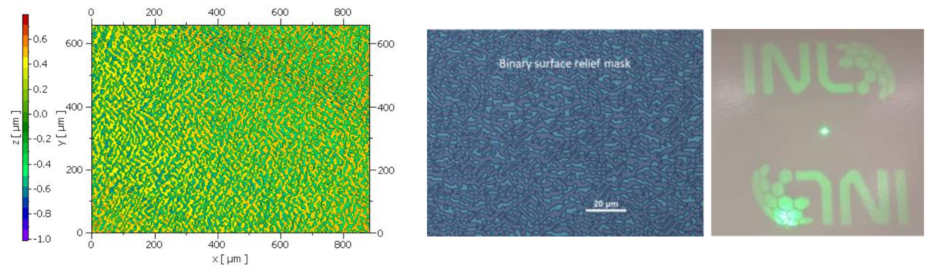

Figure 2: Experimental (left) topography and (middle) microscope measurements of binary DOE devices and (right) projected pattern on a white screen using a green laser source.