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All-glass metasurfaces for ultra-high power lasers

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The field of photonics focuses on our ability to generate, manipulate and detect light. The technologies that allow us to shape light properties have been improving, but there are still many physical and engineering obstacles preventing a more rigorous and precise control. Recently, the rise of nanophotonics has introduced the possibility of tailoring light-matter interactions at the nanoscale. In fact, the fabrication of optical materials with nanostructures has made it possible to shape the light's wavefront in amplitude, phase and polarization. Meanwhile, although the field of high-power lasers is already serving several applications, the existing optics for manipulating these lasers are still significantly limited, relying mostly on bulk optics, such as lenses and dielectric mirrors, which only provide a basic control of light. Metasurfaces are planar materials patterned with engineered arrays of nanostructures, consisting of subwavelength unit cells. When tailored specifically for high-power lasers, they could help us overcome these limitations, enabling a complete manipulation of structured light in the realm of intense electromagnetic fields. This thesis proposal aims to demonstrate such nanophotonic
technology and demonstrate high-power structured light lasers. To achieve this goal, we will develop a class of dielectric metasurfaces, primarily consisting of fused silica glass, that are specifically designed to have a high laser damage threshold. Solving this challenge will open the door to new possibilities in high-power laser microscopy, ultrafast laser machining, compact laser-plasma particle accelerators, and several other scientific and technological domains.

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