Ultra-short Pulse Laser Drilling of Glass with Modified Bessel Beams

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Non-gaussian beam profiles, such as Bessel beams are of interest for laser material processing due to their ability to generate unusual focal volume profiles. Bessel beams, typically generated using an axicon lens, exhibit a distinctive characteristic of an extended focal depth along the axis of propagation. This depth of focus can be in the order of magnitude of centimetres with a micron-sized focal spot which allows for the fabrication of high-aspect ratio holes due to the longer non-diffracting beam length; a stark contrast to the much shorter focal depth of gaussian beams which is typically in the order of microns. For processes involving transparent materials such as, microchannel fabrication, waveguide inscription and laser drilling these extended depths of focus have potentially significant advantages.

Despite their ability to produce higher-aspect ratio holes, standard quasi-Bessel beams produce an asymmetric intensity profile along the axial direction, resulting in variations in the holes shape along its depth [1]. By manipulating the incident light throughout the system using custom refractive optics, we demonstrate the ability to redistribute the axial intensity of a beam focussed by an axicon. Enabling control over the intensity distribution in the third dimension allows for the development of more sophisticated laser processing methods with novel beam shapes, such as beams with uniform intensity distributions in the propagation axis.

This study explores the use of quasi-Bessel beams with a modified axial intensity profile for laser hole drilling in glass (fused silica) using ultra short pulses. Our experimental setup incorporates custom refractive optics and in situ diagnostics such as shadowgraphy. By comparing the effects observed with standard gaussian and quasi-Bessel beams, we assess the impact on the generated hole, allowing us to investigate the various parameters and scanning strategies providing insights into optimizing the process.

[1] O. Jedrkiewicz, D. Valetti, P. Di Trapani, Etching and drilling of through-holes in thin glass by means of picosecond Bessel beams, SN Applied Sciences, 1 (2019) 1267.