"Novel axicon-based optical design for generation of ultrahigh aspect ratio Bessel beam and application to thick glass dicing"

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High speed dicing of thick transparent materials using ultrashort pulses remains a technical challenge since it requires both tight beam focusing and energy deposition over an extended length within the material's bulk. Non-diffractive solutions such as Bessel beams enable controlled energy deposition over an extended range because they can remain propagation-invariant even at ablation-level intensities. However from their geometry, Bessel beams hardly compromise high focusing angle and long Bessel beam length. In addition, current designs use intermediate refocussing that severely limit the maximal power and the beam length because of optical damage of intermediate optics.
Here we solve this issue with a novel design to generate a Bessel beam featuring an adjustable working distance, a high-focusing angle and an extreme high-aspect ratio (> 6000:1). The Bessel beam cone angle is as high as 26° corresponding to a central spot diameter below 660 nm FWHM. The major advantage of our design is the absence of any focusing in its upstream part, which prevents non-linear distortions of intense pulses along propagation in air and optical damage of intermediate optics. The final Bessel beam extends over several millimeters in air. We report mJ processing of glass and we achieve, as a proof-of-principle, stealth dicing of glass with thickness up to 5 mm. This work opens novel perspectives and applications for high-speed cutting of glass with ultrafast lasers.