High intensity ultrafast Bessel beam shaping

F. Courvoisier, R. Meyer, J. Hoyo, L. Froehly and R. Giust

Institut FEMTO-ST, Université Bourgogne Franche-Comté, 15B Avenue des Montboucons, 25030 Besançon cedex, France;

e-mail: francois.courvoisier@femto-st.fr

Transparent dielectrics, particularly glass, are becoming ubiquitous in technology. They are used in a large number of applications belonging to different fields such as electronics, consumer electronics, automotive or lighting. However, most of the applications require deep drilling which is very demanding for conventional lithography techniques. Ultrafast infrared laser pulses are ideal to process glass and sapphire because nonlinear ionization allows for depositing laser energy straightforwardly within the bulk of the material. In this context, Bessel beams provide novel opportunities for laser processing with high aspect ratio.

Bessel beams are generated by an interference of an infinite set of plane waves distributed along the generatrix of a cone [1]. When the cone angle is sufficiently high, the propagation of intense ultrafast Bessel beams can be stationary [2]. In this case, a single laser pulse creates a high density plasma along a nanometric cylinder with high aspect ratio. The plasma relaxation creates a microexplosion opening a void even within the bulk of hard material such as sapphire [3,4].

We will review recent results concerning the development of high aspect ratio Bessel beam shaping with high quality. We have demonstrated Bessel beams with very large focusing angle, up to 35° and high quality [5]. These beams, used in combination with a femtosecond laser source, allowed the drilling in single shot of vias with 100 nm diameter in glass, opening novel perspectives for nanofluidics applications. A second key advance is the increase of the Bessel beam length up to several millimeters while preserving the high focussing angle and avoiding optical damage in the shaping optics [6]. We designed a novel beam shaper capable of handling very high energies, at the Joule level and demonstrated applications to single-pass stealth dicing of glass for thickness up to 1 cm.

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