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Titre de la thèse : *« Traitement du verre avec des impulsions laser ultra courtes »*

Résumé

Set in the wide and continuously growing field of glass processing with ultra short laser pulses, this work deals with the cutting and edge shaping of glass sheets. Laser beams with elongated focal geometries have previously been used to perforate even thick glass sheets with single laser shots and thus enabled fast and clean cutting processes. These line foci so far have been limited to straight geometries resulting in sharp edges, which for many applications require an extra processing step to obtain a c-cut edge. The c-shaped Airy beam on the other hand has been employed in ablative processes to create curved edges and trenches in thin sheets of silicon and diamond. This work describes the application of the Airy beam to the micro perforation cutting process in glass.

For this, the linear propagation of the Airy beam focus is reviewed with respect to the achievable length, curvature and focal contrast that depend on the focusing conditions. With an effective numerical aperture of 0.13 volume modifications of up to more than 2 mm length are demonstrated in borosilicate glass, that follow very well the expected parabolic trajectory of the Airy beam with a bending radius of 12 mm. Applying the Airy modifications for micro perforation for the first time, glass sheets with rounded edges have been achieved after etching with a bending radius down to 727 µm in a 600 µm thick sheet.

The most crucial limitation of the Airy beam with respect to the micro perforation process is the relatively low focal contrast that leads to absorption and material damage in the side lobes of the beam. This can be observed experimentally as an effective tilt of the Airy beam due to the preferential absorption in the upper part of the glass modification and is corroborated by non linear simulation results. Adjustments of the optical setup allow the compensation of this tilt and lead to the production of a symmetric edge.

The influence of the damage in the side lobes proves particularly problematic for separation by mechanical cleaving. Further adjustments of the Airy beam can be used to align the cracks that are caused by the laser perforation process along the intended cutting direction, i.e. orthogonal to the plane of maximum curvature. Going further, the Airy beam is a promising candidate for light sheet cutting, which will enable even faster micro perforation cutting processes by replacing the focal line with a focal surface. In this work, the first sheet like in-volume modification induced by a single laser shot is demonstrated.