Filamentary deposition of of laser energy in glasses with Bessel beams

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The controlled laser energy deposition in dielectrics is a key technological issue for applications that require drilling or structuring glass materials in the bulk. High angle Bessel beams delivered by a femtosecond laser have been used for extremely high aspect ratio nanochannels drilling and microstructuring in glass with a single laser shot [1,2]. Several types of filamentary damages were obtained with high angle Bessel beams and were reported to depend on laser pulse duration and energy [2]. I will address the question of optimal laser parameters for nonlinear absorption of laser energy in the bulk of dielectric materials, along the focal line of a Bessel beam.

A semi-analytical model was developed for modeling the generation of a plasma column with femtosecond and picosecond laser pulses focused by a conical lens in dielectrics. The associated nonlinear absorption of energy was calculated so as to highlight the influence of the pulse duration, laser pulse energy and cone angle, on laser energy absorption. From a map of the density of nonlinear absorption of laser energy in BK7 as a function of pulse duration and peak fluence, a specific pulse duration is shown to correspond to the highest nonlinear absorption at given pulse energy and cone angle. This duration corresponds to a transition between two propagation regimes of the laser pulse featured by uniform or non-uniform laser energy deposition in the Bessel zone. A uniform energy deposition is obtained in the absence of pulse temporal dynamics.

I will show that transmission measurements in BK7 are qualitatively well reproduced by the results of the semi-analytical model, which is also in agreement with numerical simulations of the nonlinear pulse propagation.

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[2] M.K. Bhuyan, P. K. Velpula, J. P. Colombier, T. Olivier, N. Faure and R. Stoian, Single shot high aspect ratio bulk nanostructuring of fused silica using chirp-controlled ultrafast laser Bessel beams, Appl. Phys. Lett. 104, 021107 (2014).