Last Trends in Micromachining of Transparent Materials with Femtosecond Laser Pulses

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Due to the forever growing industrial demand for quality and fast fabrication of transparent materials, femtosecond laser systems are rapidly becoming a topic of interest in industry [1]. Femtosecond laser microfabrication differs from long pulse or CW laser fabrication systems due to nonlinear optical effects arising from high intensity (~TW/cm^2) laser radiation. At these intensity limits, transparent materials become opaque due to strong nonlinear absorption, thus enabling fabrication of virtually any type of material regardless of the wavelengths the laser is emitting. Multiphoton absorption and avalanche ionization occur in a confined space of wide bandgap material, and above some intensity could lead to laser-induced refractive index variations, which are used for creation of waveguides and diffractive gratings in bulk transparent glasses, crystals and plastics or in some range of higher fluencies nanogratings are formed in some transparent materials, which show polarization rotation futures or selectivity in chemical etching in HF or other solutions. At some fluency, which exceeds many times the fluencies required for the nanogratings formation dielectric breakdown is induced and it could be used for microfabrication of transparent materials by ablation or void formation.

In this report, brief fundamentals and original results on investigations performed at participating organizations on such topics will be presented:

a) the fundamentals of femtosecond laser pulse interaction with transparent materials and its application for micromachining,

b) microfabrication of transparent materials by nanograting formation and etching in HF and KOH solutions,

c) the review of an alternative front-side ablation technique by immersing in water the machined samples and focusing the femtosecond pulses through a low NA objective [2],

d) developed at Workshop of Photonics a break through transparent material cutting technology, which enables scribing tempered, non-tempered glass and sapphire in straight or curved lines [3],

e) femtosecond ytterbium laser systems for micromachining of transparent materials developed at Light Conversion Ltd. [4].

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[2] S. Butkus, E. Gaižauskas, D. Paipulas, Ž. Viburys, D. Kaškelytė, M. Barkauskas, A. Alesenkov and V. Sirutkaitis, Rapid microfabrication of transparent materials using filamented femtosecond laser pulses, *Applied Physics A* **114** (2014) 84-90.
[3] http://wophotonics.com/product/laser-technology-for-cutting-glass-and-sapphire/.
[4] http://lightcon.com/Products/femtosecond-lasers.html.

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