

# Recent advances in ultrafast laser processing of transparent materials

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**Abstract:** Interaction of intense ulrashort light pulses with transparent materials reveal new interesting properties and phenomena. Recent demonstrations of 3D nanoripple formation, self-assemled form birefringency and ultrafast laser calligraphy are reviewed.

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Modification of transparent materials with ultrafast lasers has attracted considerable interest due to a wide range of applications including laser surgery, integrated optics, 3D micro- and nano-structuring [1]. Three different types of material modifications can be induced with ultrafast laser irradiation in the bulk of a transparent material, silica glass in particular: an isotropic refractive index change (type 1); a form birefringence associated with self-assembled nanogratings and negative refractive index change (type 2) [2-6]; and a void (type 3). In fused silica the transition from type 1 to type 2 and finally to type 3 modification is observed with an increase of fluence. Recently, a remarkable phenomenon in ultrafast laser processing of transparent materials has been reported manifesting itself as a change in material modification by reversing the writing direction [7]. The phenomenon has been interpreted in terms of anisotropic plasma heating produced by a tilted intensity front of the ultrashort laser pulse. Moreover a change in structural modification has been demonstrated in glass by controlling the direction of pulse front tilt, achieving a calligraphic style of laser writing which is similar in appearance to quill pen writing [8]. It has also been a common belief that in a homogeneous medium, the photosensitivity and corresponding light-induced material modifications do not change on the reversal of light propagation direction. More recently it has been observed that in a non-centrosymmetric medium, modification of the material can be different when light propagates in opposite directions (KaYaSo effect) [9]. Moreover a new phenomenon of ultrafast light blade, representing itself the first evidence anisotropic sensitivity of isotropic medium to ultrashort pulse laser irradiation has been recently discovered (Fig.1) [10]. We anticipate that the observed phenomena will open up new opportunities in laser material processing.

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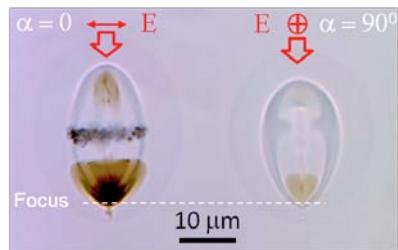


Fig. 1. Images of modified regions in glass along beam propagation direction for writing beam polarised along (left) and perpendicular (right) to the pulse intensity front normal.