

Recent advances in ultrafast laser processing of transparent materials

Peter G. Kazansky¹, Martynas Beresna¹, Yasuhiko Shimotsuma², Kazuyuki Hirao²

¹*Optoelectronics Research Centre, University of Southampton, SO17 1BJ, UK*

²*Department of Material Chemistry, Kyoto University, Kyoto, Japan 615-8510*

E-mail: pgk@orc.soton.ac.uk

Abstract: Interaction of intense ultrashort light pulses with transparent materials reveal new interesting properties and phenomena. Recent demonstrations of 3D nanoripple formation, self-assembled 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.

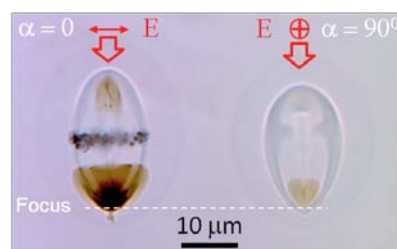


Fig. 1. Images of modified regions in glass along beam propagation direction for writing beam polarised along (left) and perpendicular (right) to the pulse intensity front normal.

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