

New Phenomena in Ultrafast Laser Interaction with Matter

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Abstract— Modification of transparent materials with ultrafast lasers has attracted considerable interest due to a wide range of applications including laser surgery, integrated optics, optical data storage, 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, 3]; 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 [4]. The phenomenon has been interpreted in terms of anisotropic plasma trapping and heating by a tilted 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 that inked with the bygone quill pen [5]. 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 we have observed that in a non-centrosymmetric medium, modification of the material can be different when light propagates in opposite directions (KaYaSo effect) [6]. Non-reciprocity is produced by magnetic field (Faraday effect) and movement of the medium with respect to the direction of light propagation: parallel (Sagnac effect) or perpendicular (KaYaSo effect). We anticipate that the observed phenomena will open new opportunities in laser material processing, laser surgery, optical manipulation and data storage.

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