Advancing the Art Femtosecond Laser Writing

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Two decades ago it has been discovered that under certain irradiation conditions subwavelength structures with record small features of tens of nanometers, can be self-organized in the volume of fused quartz [1]. The negative optical anisotropy, which results from the alignment of nano-platelets, referred to as form birefringence, is of the same order of magnitude as positive birefringence in crystalline quartz.

Anisotropy of ultrafast laser writing also reveals in phenomena of quill writing and anisotropic photosensitivity associated with spatio-temporal couplings during ultrashort pulse propagation.

The control of light polatization allows direct writing elements of flat optics with spatially variant anisotropy, which exploits the geometrical or Pancharatnam-Berry phase shift.

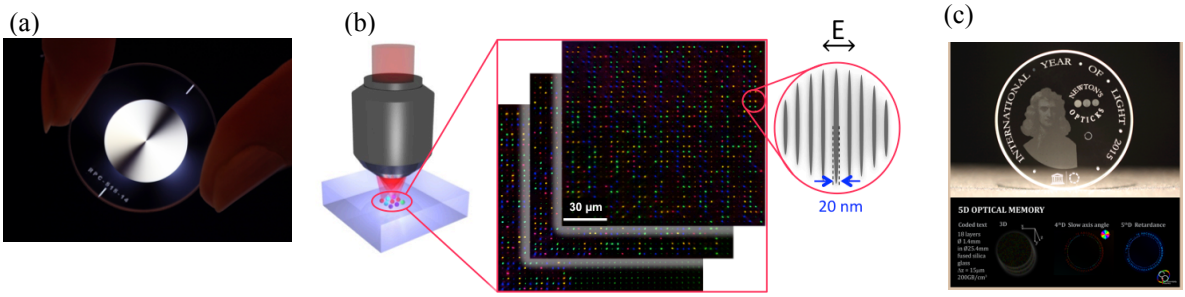

Fig. 1 (a) Femtosecond laser written S-waveplate in cross-polarized light; (b) 5 D optical storage; (c) Eternal copy of Newton Opticks imprinted in glass.

The S-waveplate (Southampton-Super-Structured-waveplate) is one example of such birefringent optical element, which can be used for creating axially symmetric polarization state, e.g. radial or azimuthal, or optical vortexes with applications ranging from material processing to optical trapping (Fig. 1a).

The two independent parameters describing form birefringence in quartz glass, the slow axis orientation (4^{th} dimension) and the strength of retardance (5^{th} dimension), are also explored for the encoding of information in addition to three spatial coordinates (Fig. 1b). The storage allows unprecedented parameters including hundreds of terabytes per disc data capacity and thermal stability up to 1000°. The demonstrated recording of digital documents, which will survive the human race, is a vital step towards an eternal archive (Fig. 1c).

The search of new material compositions for ultrafast laser nanostructuring is in progress.

References

1. P. G. Kazansky, H. Inouye T. Mitsuyu, K. Miura, J. Qiu, K. Hirao, F. Starrost, Phys. Rev. Lett **82**, 2199 (1999).