Form birefringence, anisotropic reflection and negative index change created by fs laser pulses in transparent materials

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In recent years femtosecond lasers have proved to be of great utility for micromachining within the bulk of transparent materials [1].

Depending on the laser intensity delivered to the sample 3 different types of features can be written into the glass. We now report, for the first time, that one particular kind of damage shows negative index change besides anisotropic reflection and birefringency and we propose a consistent model which can explain all these three principal characteristics.

At lower intensity ($I \sim 10^{12}$ W/cm^2) a smooth feature showing positive index change can be achieved which has been used to realize waveguides and couplers [1]. At very high level of intensity ($I > 10^{15}$ W/cm^2) the damage consists of voids embedded into the glass, which have been exploited for data storage [2]. Finally at intermediate level of intensity a third intriguing type of feature can be realized. Indeed this kind of damage showed uniaxial birefringence [3,4]. We then observed anisotropic reflection, which we explained in terms of the formation of a self-organized nanograting within the focal volume [5] and we also demonstrated, as a possible application, embedded, large diameter, birefringent Fresnel zone plates [6]. We show here that its laser induced refractive index change is negative and we propose a model of form birefringence to explain this behaviour.

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