Nonlinear optical interaction of 1030-nm ultrashort laser pulses with biocompatible polymers

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An optimized z-scan method is proposed for the correct estimation of the samples nonlinear absorption parameters with possible defects formation under the influence of ultrashort laser pulses [1]. It is shown that at peak intensities $I_0 < 0.65\mathrm{TW/cm^2}$ the attenuation mechanism of 1030- nm femtosecond laser pulses in polymethylmethacrylate (PMMA) can be described as fourphoton absorption with a coefficient of $\beta_4 = 35 \pm 5\,\mathrm{cm^5/TW^3}$, and in polydimethylsiloxane (PDMS) at $I_0 < 0.27\mathrm{TW/cm^2}$ - five-photon absorption with $\beta_5 = 750 \pm 90\,\mathrm{cm^7/TW^4}$. It has been established that the dependence of absorption on pulse duration is nonlinear: increase at $\tau = 250 - 450\,\mathrm{fs}$, followed by a decrease at $\tau = 450 - 1500\,\mathrm{fs}$ and a weak dependence at $\tau > 1500\,\mathrm{fs}$. The maximum nonlinear refraction is observed at $\tau \approx 450\,\mathrm{fs}$ and the values of the nonlinear refractive index and the corresponding self-focusing critical powers are estimated: for PMMA $n_2 = 7.6 \pm 0.4 \times 10^{-4}\,\mathrm{cm^2/TW}$ and $P_{\mathrm{cr}} = 1.4 \pm 0.1\,\mathrm{MW}$, for PDMS $n_2 = 4.6 \pm 0.5 \times 10^{-4}\,\mathrm{cm^2/TW}$ and $P_{\mathrm{cr}} = 2.4 \pm 0.2\,\mathrm{MW}$. The correspondence of the theoretical estimation of the nonlinear focus shift based on them to the modified regions positions in PMMA is shown. The results obtained are relevant for the tasks of precision modification of transparent biocompatible polymers. This research is supported by Russian Science Foundation (project no. 25-22-00488).

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