Diagnostics of volumetric energy deposition and generated plasma channel parameters under excitation of the condensed medium by powerful femtosecond near-infrared radiation

In the framework of the presented work there was conducted realization of the experimental method aimed to make a complex diagnostics of femtosecond filamentation process in condensed matter under excitation by powerful femtosecond near-IR radiation. Method is based on the first time implemented photoacoustic (PA) imaging technique and shadow photography. Combination of these techniques allows to simultaneously conduct diagnostics of the energy deposition and plasma formation region. Also there was conducted acoustic signal investigation under different filamentation regimes and focusing conditions. The first set of the experiments was dedicated to realization of the PA imaging technique of a single filament in water. There was shown performance of this method and determined its spatial resolution. There was proven that PA imaging allows to visualize filament energy reservoir (that can't be achieved by any other known technique). In the second set of the experiments first time conducted acoustic study of regularized filaments. It was shown, that acoustic signal allows to resolve distance between filaments with resolution no less than 10 mcm. The third set of the experiments was dedicated to the realization of complex diagnostics method for the study of femtosecond filamentation process. It was shown, that this method allows to determine transversal energy deposition distribution averaged over filament axis, amount of energy given to the medium, electron density distribution and filamentation regime. The important feature of the method is possibility to determine energy deposition into the medium. In the performed investigations under focusing conditions $NA = 0.2$ and laser pulse energy $E = 0.29$ мДж $(P/P_{cr} = 265)$ under superfilamentation regime the maximal value of energy deposition averaged along filament axis was 330 ± 0.8 мДж/мм^3. The fourth set of experiments was directed to the determination of dependence of acoustic signal amplitude on filamentation regime and focusing conditions. It was revealed, that the most effective acoustic signal generation is realized under superfilamentation regime, that indicates the higher value of energy deposition under superfilamentation in comparison with other filamentation regimes. It was shown, that energy deposition is more effective under use of tighter focusing. Also it was proven, that under tight focusing conditions the transition of dependence of energy deposition on laser pulse energy to the region of saturation is reached at smaller energies, than in case of soft focusing conditions.