laser beam smoothing by optical fiber for improvement of the target irradiation uniformity

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The system for spatial and temporal smoothing of laser radiation by multimode optical fiber [1] has been implemented at the Luch laser facility [2] in order to improve the targets irradiation uniformity. The system consists of a broadband master oscillator (MO), smoothing fiber line and preamplifiers. Master oscillator is composed of Nd-glass rod amplifier with lamp pumping and active electro-optical Q-switching. MO radiation at wavelength 1054 nm with spectrum width of 2 nm and pulse length of 20 ns is injected into the input face of the multimode fiber with core diameter of 100 μm and length of 50 m. Waveguide mode dispersion results in conversion of temporal incoherence into the mixed spatial/temporal one, and light wave field has random speckled distribution quickly time-varying at the exit of the fiber. Effective smoothing of the small-scale irradiation nonuniformity occurs because of the characteristic time of speckles positions changing (equal to coherence time) at the target is much less than the plasma response time.

After the fiber, laser radiation passes through the preamplifiers, the systems of temporal and spatial shaping and is fed in the main amplifier channel of the Luch facility. Amplified radiation at the channel’s exit converts into second harmonic and is focused on the target. The radiation spot shape in the target plane is given by the lens raster or the kinoform phase plate.

Simulations and experiments of the amplification and frequency conversion of the smoothed beam have been carried out. At the exit of the amplifier chain, the pulse energy was obtained up to 850 J with the pulse length 4 ns, the conversion efficiency made up 40% and beam divergence was equaled to 0.18 mrad.

The radiation energy density distribution at the equivalent target plane was measured: integral distribution by pulse time and with time scanning by means of the streak camera with the time resolution of 70 ps. As a result of the smoothing, speckle structure of the radiation at the target has been removed almost completely: integral by times small-scale nonuniformity was decreased to 1–2 orders of magnitude as compared with the unsmoothed beam/

References

1. D. Veron, H. Ayral, C. Gouedard, et al. Optical spatial smoothing of Nd-glass laser beam. Opt. Commun., 1988, v. 65, №1, p. 42-45.
2. S.G.Garanin, A.I.Zaretskii, R.I.Il’kaev et al. Quantum Electron*.*, 2005, v. 35(4), p.