Recent progress in development of Nd:YAG laser for ITER edge Thomson scattering diagnostics

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An edge Thomson scattering system for ITER is a diagnostic system which measures electron temperature (T_e) and density (n_e) at the peripheral region in the plasma (r/a>0.9) [1]. Required measurement ranges for the electron temperature and density are 50eV< T_e <10keV and 5×10^{18}< n_e <3×10^{20}m^{-3}, respectively. The spatial and the temporal resolution are 5mm and 10ms, respectively. To satisfy the requirement, high-energy (5J) and high repetition-rate (100Hz) Q-switch Nd:YAG laser system is necessary. It has been difficult to develop the high-energy and high repetition-rate laser system due to following reasons for laser medium(laser rod), so far: (1) Limitation of output by thermal lensing effect which are caused by the temperature gradients across the active area of the laser rod, (2) Decreasing of output by depolarization which are caused by thermally induced birefringence, (3) Decreasing of output by parasitic oscillation. Recently, the high-energy and high repetition-rate laser system for Thomson scattering diagnostics was successfully developed by utilizing a stimulated-Brillouin-scattering phase conjugate mirror (SBS-PCM) in JT-60U [2,3]. The SBS-PCM well compensated and suppressed the effects above, and it was achieved that the laser energy and repetition rate were 7.46J and 50Hz, respectively. Therefore, we are developing the high-energy and high repetition-rate laser system for ITER based on the laser design in JT-60U.

Optical design of the laser system has been conducted. In the optical configuration of the laser system, MOPA (Master Oscillator Power Amplifier) configuration is adopted. The oscillator produces single-longitudinal-mode laser pulse (Energy=20mJ, repetition rate=100Hz, pulse width=30ns). The laser beam from the oscillator is divided to two beams, and each beam is amplified by an amplifier stage employing the SBS-PCM. There are two high-power amplifiers in the amplifier stage, and four amplifiers are used in the laser system. Two Nd:YAG laser rods (14mm in diameter, 100mm in length) and four xenon flash lamps are installed in each amplifier. Each laser rod is pumped by two flash lamps, the electric energy of 100J is supplied to two flash lamps at 50Hz of repetition rate. The average electric power of 10kW is supplied per one amplifier. We have developed a prototype high-power laser amplifier. From the initial test, we confirmed that the prototype amplifier was cooled by a refrigerator along the design, and the laser energy of 1.4J was extracted from one laser rod.

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