0.1 Hz Sub-20 fs 4 PW Ti:Sapphire Laser

S K Lee¹,², J H Sung¹,², H W Lee², J Y Yoo², and C H Nam²,³

¹Advanced Photonics Research Institute, Gwangju Institute of Science and Technology, Gwangju, South Korea
²Center for Relativistic Laser Science, Institute for Basic Science, Gwangju, South Korea
³Department of Physics and Photon Science, Gwangju Institute of Science and Technology, Gwangju, South Korea

Contact Email: lsk@gist.ac.kr

Ultrahigh intensity lasers based on a chirped-pulse amplification technique have provided great opportunities to explore laser-matter interactions at extreme conditions. The development of multi-PW lasers has been pursued in several research projects such as Extreme Light Infrastructure, Apollon-10P, and SIOM-10 PW. At Center for Relativistic Laser Science (CoReLS) PW Ti:Sapphire lasers have been developed and utilized for relativistic laser-matter interactions. Here the development of a 4 PW Ti:sapphire laser at CoReLS is presented.

The 4 PW Ti:sapphire laser was developed by upgrading one of PW laser beamlines. Firstly, the output energy of the current 1.5-PW laser was boosted with the addition of a new booster amplifier. The amplifier was pumped with Nd:glass lasers delivering 180 J in green at 0.1 Hz repetition rate. The amplified energy reached 112 J with the input energy of 34 J, giving an amplification efficiency of 47%. Secondly, the laser spectrum was broadened in order to obtain the pulse duration of 20 fs. Such short pulse duration has not been achieved yet in PW Ti:sapphire lasers because an amplified laser spectrum becomes seriously narrowed due to strong gain depletion at PW amplifiers. To overcome the spectral narrowing, the spectrum of the seed pulse was controlled. An optical parametric chirped pulse amplifier (OPCPA) was thus employed to shape the spectrum of the seed beam. The cross-polarized wave (XPW) generation technique was also employed to broaden the spectral width of the OPCPA seed beam and to enhance the contrast ratio. Four large-aperture gold-coated gratings were newly installed for the pulse compression, and the transmission efficiency of the pulse compressor was 74%. We obtained the pulse duration of 19.6 fs, being minimized by the dispersion control with a feedback system (Wizzler). As a result, 4-PW laser pulses with sub-20 fs duration and 83 J energy was achieved at 0.1-Hz rep. rate. After commissioning the 4 PW Ti:sapphire laser, experimental campaigns on relativistic laser-matter interactions will be carried out in the unprecedented intensity regime.