Optical Parametric Synthesis of Waveform-Controlled 4.3 fs Pulses at the 100 TW Level

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Ultrahigh peak power laser systems with tens of femtoseconds pulse durations are widely used as drivers for compact particle and light sources. Conversely, lasers with shorter (a few-femtoseconds) pulse durations and lower peak powers, enable the generation of isolated attosecond light pulses to study nature with unparalleled temporal resolution. In this work, we integrate these characteristics in a robust optical parametric synthesizer (OPS) system, achieving a peak power of about 100 TW and a pulse duration as short as 4.3 fs with waveform-control. This system coherently synthesizes the corresponding spectrum from visible to near-infrared regions through three OPS stages, each housing two optical parametric amplifiers that serially enhance two complementary spectral gain regions. The resulting light transients are carrier-envelope phase stabilized to $<$300 mrad, are focused to an intensity of 10^{21} W/cm^2 and possess an outstanding high dynamic range temporal contrast, making them optimal even for the most demanding relativistic laser-plasma experiments. Utilizing temporal super-resolution the pulses are shortened to sub-4-fs duration. This OPS is dedicated to advance the frontiers of attosecond electron and X-ray sources.