A 10-Hz short pulse CO_2 laser system for extreme ultraviolet source

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Abstracts: *We produced 3−15 ns pulses at 10.6-μm wavelength required to driver an efficient short wavelength in extreme ultraviolet (EUV) and soft x-ray emission. A master oscillator power amplifier (MOPA) laser operated at a repetition rate of 10 Hz was built on transversely excited atmospheric pressure (TEA) CO_2 mediums with a Q-switched oscillator and a multi-pass amplifier. An optical semiconductor switch was employed to slice the pulse from the oscillator, in order to produce short pulses less than 15 ns. The output energies of the MOPA were 150 and 50 mJ per pulse at the pulse durations of 15 and 3 ns, respectively.*

The great interest of laser-produced high-*Z* plasmas is that the overlap in adjacent ion stages could yield intense unresolved transition arrays (UTA) lying within reflectance bandwidth of a multilayer mirror. This scheme can realize a powerful micro light source with a short wavelength. The ion stage distribution and density play a crucial role in the transport of radiation through the plasma due to opacity effects. The production of low-density plasma by use of CO_2 (carbon dioxide) laser-produced plasmas (LPPs) has been proposed. However, behavior of CO_2 LPP sources has been investigated with a long pulse duration longer than 15 ns. In this study, we generate 3−15 ns pulses CO_2 laser at 10.6-μm wavelength in order to investigate LPP sources for high resolution lithography and lab-scale soft x-ray imaging systems.

We show the production of short pulse CO_2 laser based on TEA gain mediums. The laser system consists of a *Q*-switched master oscillator and 14-pass amplifier, and operates at a repetition of 10 Hz. These laser units were modified by replacing internal cavity mirrors with ZnSe windows. The oscillator is an electro-optic (EO) *Q*-switched ring cavity with a TEM_{00} beam as the seeder for the multi-pass amplifier. In order to produce the short pulse less than 15 ns, the pulse slicing technique was used by the optical switching in the Ge substrate, which is coupled the short pulse solid-state laser at a wavelength of 1 μm for carrier production on the surface of Ge substrate. Two Nd:YAG lasers have been operated at 1064 nm produced maximum pulse energies of 5 mJ for a pulse duration of 150 ps (FWHM) and 40 mJ at a pulse duration of 10 ns (FWHM), respectively, with the pulse separation time of 40−100 ns between each peaks, keeping the plasma shutter lifetime. It is noted that the typical recombination time is the order of 50 ns. To overcome the short plasma mirror lifetime, two lasers should be irradiated to the Ge substrate. The output energies of the amplifier were 150 and 50 mJ per pulse at the pulse durations of 15 and 3 ns (FWHM), respectively, keeping a high quality beam of the MOPA system. This laser output provides the power density of the order of 10^{12} W/cm^2 and was sufficient to produce the EUV emissions at 13.5 nm and 6.*x* nm.