

Harmonics Generation in VUV Spectral Region Driven by a NIR Ti:Sapphire Laser in Rare Gases

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A subpicosecond VUV seed beam at 126 nm has been produced by the nonlinear frequency up-conversion of a near infrared femtosecond Ti:sapphire laser at 882 nm in rare gases. We obtained the maximum output of the 7th harmonic at 126 nm in Xe at the pressure of 2.5 Torr among three rare gases, Ar, Kr, and Xe. The 126 nm seed beam will be amplified by an optical-field-induced ionization amplifier, which could result in high-power sub-picosecond VUV pulses at 126 nm.

We have been developing a vacuum ultraviolet (VUV) rare gas excimer lasers. Among the rare gas excimers, the shortest wavelength at 126 nm was obtained in Ar₂^{*} medium. We had developed an e-beam pumped Ar₂^{*} laser and obtained a high power output of 16 MW by single shot operation [1]. We now develop a practical VUV laser system with high-intensity output pulses at high repetition rates, which will be driven by tabletop high-intensity lasers.

A sub-picosecond VUV radiation at 126 nm was produced by nonlinear frequency up-conversion in rare gases using a near infrared (NIR) Ti:sapphire laser operated at 882 nm. Characteristics of the harmonic radiation were examined in terms of rare gas media, their pressures and pump laser intensities. The NIR laser was focused into three rare gases (Ar, Kr, and Xe) at the intensity of 8×10^{13} W/cm² by use of a $f = 500$ mm lens. The VUV 7th harmonic intensity at 126 nm in Xe was much higher than those in Kr and Ar. It was qualitatively explained by the classical dispersion theory. A negative dispersion was provided in the Xe gas around 126 nm, which satisfied the phase matching conditions. The harmonic intensity was optimized at the Xe gas pressure of 2.5 Torr. When the pumping NIR laser exceeded the intensity of 5×10^{13} W/cm², the saturation of the harmonic intensity was observed. The saturation intensity was well correlated with the intensity, at which ion currents measured by a Faraday-cup and the Xe⁺ emission intensity in visible appeared. The result indicated that the plasma production by the high intensity pump laser destroyed the phase matching condition and inhibited the increase of the harmonic intensity.

Sub-picosecond pulse measurements by use of two-photon absorption in a fluoride crystal and energy measurements are under investigation. The low-output-power VUV seed beam should be amplified to obtain a sufficient output energy and an average power for applications by a novel Ar₂^{*} amplifier pumped by high-intensity laser-produced electrons, which could lead to an output energy on the order of 1 μ J at 126 nm at a repetition rate of 1 kHz.

[1] Kurosawa K., Takigawa Y., Sasaki W., Okuda M., Yoshida K. and Kato Y., IEEE J. Quantum Electron. **QE-27**(1), 71-76 (1991)

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