Characterizing Bragg Diffraction Efficiency for Plasma Transmission Gratings of Various Lengths

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Plasma optics offers a promising approach to the advancement of high power laser systems, which is currently limited by damage thresholds of solid optical components. By temporally overlapping and interfering two femtosecond pulses, a plasma density structure with periodic refractive index modulation is created through ionization to form a transmission plasma grating. In this work, we diffract a probe beam (linearly polarized, 800 nm, 25 fs, 0.26 mJ) from a plasma transmission grating formed by crossing two pump beams (linearly polarized orthogonal to probe, 800 nm, 25 fs, 0.69 mJ and 0.39 mJ) inside a gas cell filled with CO_2 gas. We show that the Bragg diffraction efficiency initially increases with grating length up to an observed maximum. Grating length ranges from ~0 mm to ~3 mm and is controlled by using gas cell window plugs of different lengths. The diffracted probe beam is captured with a camera after passing through the gas cell and scattering from a Teflon screen. The grating structure is observed using shadowgraphy and the plasma density inside the gas cell is measured with a Mach-Zehnder interferometer. These results show the comparability of Bragg diffraction in plasma optics and conventional optics, while demonstrating the advantage of plasma optics in high power laser systems.

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