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Development of the Plasma Mirror for Contrast Improvement of Ultra Short Intense Lasers

高強度短パルスレーザー高コントラスト化用プラズマミラーの開発

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To develop the plasma mirror to improve the contrast of short pulses generated from a CPA laser system we have studied the reflectivity from a silica based glass plate. The reflectivity of 80% has been obtained at the laser intensity of 10^{15}~10^{16}W/cm^2 with 10-degree incidence. No much difference between p- and s-polarizations has not been seen.

1. Introduction

A short pulse generated from a chirped-pulse-amplification (CPA) laser system is generally composed of long (ns-order) tail ahead of the main pulse (called "pre-pulse"). For the intense laser-matter interaction studies this pre-pulse deforms the matter from its initial state [1-3]. For instance, the laser-solid interaction is easily reduced to that of laser-plasma (long-scale expanding plasma). To quantify the pre-pulse, the contrast ratio is defined as I_p/I_0, where the I_p and I_0 are the intensities of the main pulse peak and the pre-pulse, respectively. Ideally (no pre-pulse) the ratio is infinite, but usually is $10^{7\text{-}8}$. For the pulse with peak intensity of 10^{20}W/cm^2, the matter is exposed in the field of $10^{12\text{-}13}$W/cm^2, high enough for the matter to be in plasma state. For technology development of ultra-high intensity lasers, the high contrast pulse generation is one of the key issues. A method is "plasma mirror". When a pulse is irradiated on an optical transparent plate, the pre-pulse part transmits through the plate, while the main pulse make the plate surface to plasma and is reflected from the plasma surface, consequently the reflected pulse can be free from pre-pulse. The plasma mirror has been studied intensively [4-7] since the intense lasers become available. However, it is not yet devoted to steady operation for the laser system. The performance of the plasma mirror is defined by the contrast improvement and reflectivity. The improvement of $10^{2\text{-}3}$ has been reported, but the reflectivity is up to 70-80%. The use of two mirrors to improve the contrast reduces the reflectivity to so small 50% [5]. For the plasma mirror we can find no physical reason to limit the reflectivity and contrast improvement, and therefore we are developing it with the performance of 80%-reflectivity and 10^3-contrast improvement for single mirror. In this report, we study the reflectivity characteristics plasma surface produced by pre-pulses.

2. Experiments

To optimize the laser irradiation conditions for the plasma mirror, we have measured reflectivity for different incident angles with changing laser intensity. Intense short pulses from a CPA Ti:sapphire laser (duration 150fs, wavelength 800nm, energy 120mJ) were focused by an off-axis-parabolic mirror (*F*/5.6) and irradiated on a silica based glass plate with the configuration of p- and s-polarizations. The energy of the reflected laser was measured by a pyroelectric energy meter. The incident angles are 10, 30, 45 and 60 degrees. The laser intensity on the plate is changed by moving the plate.

3. Results

Figure 1 shows the dependence of reflectivity on laser intensity for different incident angles. The smaller the incident angle is, the higher the reflectivity is. For 10-degree incidence the maximum reflectivity of 80% is obtained at the intensity of 10^{15}~10^{16} W/cm^2. Comparison of p- and s- polarizations is shown in Fig. 2. The incident angle is 10 degrees. No much difference between p- and s- polarizations can be seen in Fig. 2. The results suggest that the laser light is not

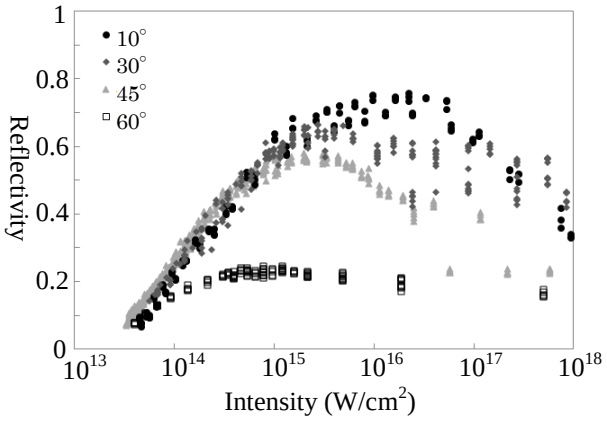

Fig.1. Dependence of reflectivity on laser intensity for different incidences

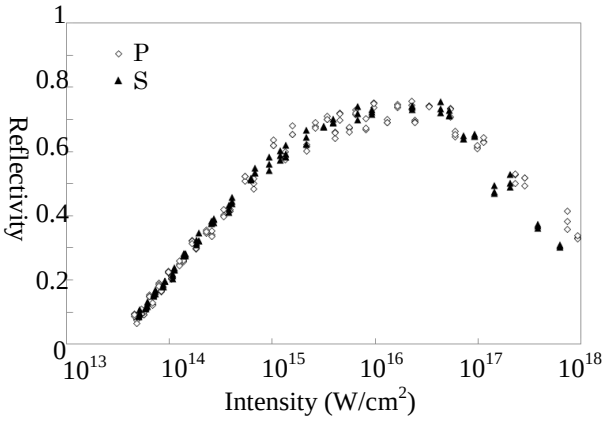

Fig.2. Reflectivity for p- and s- polarizations at 10-degree incidence

absorbed by resonance absorption but inverse-Bremsstrahlung, which decrease as the laser intensity increases.

4. Conclusion

We have measured the reflectivity of a silica based glass plate for intense femtesecond laser pulses. The dependence of reflectivity on laser intensity for different incidences has been studied. To obtain high reflectivity the laser intensity of 10^{15}~10^{16} W/cm^2 and the incidence of 10-degree are optimized for any polarizations.

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