Simulation studies on transmissivity of silicon nitride plasma shutter for laser pulse contrast enhancement

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Tightly focused petawatt laser pulse is usually accompanied by low-energy prepulses, composed of Amplified Spontaneous Emission part and picosecond pedestal [1]. These prepulses can cause ionization and heating of the target and consequently create a low density preplasma [2] before the main pulse arrive. Mitigation of these effects, i.e., increasing the laser pulse contrast, is beneficial for several application, e.g, Radiation Pressure Acceleration in the light sail regime [3], High Harmonic Generation in the relativistic regime [4] or use of nanostructures on the target [5]. Prepulses can be reduced either by reflecting plasma media [6] or by transmitting plasma media, so-called plasma shutter [7].

In this work we study the utilisation of silicon nitride target as a plasma shutter for laser pulse contrast enhancement in the sub picosecond time domain with realistic parameters with the help of numerical 2D3V particle-in-cell simulations [8]. We focus on the dependence of the laser pulse transmission through the shutter on its thickness, the properties of the transmitted pulse (pulse shape, spectrum) and the effects of preplasma located on the front side of the shutter. When the laser pulse burns through the shutter focusing of the transmitted pulse is observed. Using thin shutter targets (less 40 nm thickness) more than 5% of energy of a petawatt class laser beam is transmitted, with transmissivity of 35% in the case of 20 nm target.

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References

[1] G. A. Mourou, T. Tajima and S. V. Bulanov, Rev. Mod. Phys. **78**, 309 (2006)

[2] F. Wagner, S. Bedacht, A. Ortner et al, Optics Express **22**, (2014)

[3] B. Qiao, S. Kar, M. Geissler et al., Phys. Rev. Lett. **109**, 029901 (2012)

[4] F. Dollar, P. Cummings, V. Chvykov et al., Phys. Rev. Lett. **110**, 175002 (2013)

[5] D. Margarone, O. Klimo, I. J. Kim et al., Phys. Rev. Lett. **109**, 234801 (2012)

[6] A. Levy, T. Ceccotti, P. D'Oliveira et al., Optics Letters **32**, 3 (2007)

[7] S. Palaniyappan, B. M. Hegelich, H. Wu et al., Nature Physics **8**, (2012)

[8] T. D. Arber, K. Bennett, C. S. Brady et al., Plasma Phys. Control. Fusion **57**, 113001 (2015)