L.9: Generation of collimated MeV electrons in grazing incidence laser solid interaction

Controlling fast electron emission parameters viz. the divergence and emission angle in ultrahigh intensity laser matter interaction is of outmost importance for the success of fast ignition concept related to ICF. Laser parameters including intensity, irradiance angle, polarization and laser pre-pulse play a very important role in fast electron generation and their emission direction from target surface. Typically electron beams in the laser solid interaction have wide divergence angle with broad energy spectra and are emitted at widely different angles. Recently some studies have been performed to explore the fast electron emission by irradiating the target surface at nearly grazing incidence. They observed the fast electron beam along the target surface direction. It has been shown in the theoretical studies that the acceleration mechanism in such geometry depends on the preplasma present ahead of the target. A control on the electron emission and beam divergence may be achieved by varying the preplasma conditions.

We here report experimental study of the dependence of amplified spontaneous emission (ASE) prepulse on MeV fast electrons generated during grazing incidence laser solid interaction. A 200 mJ, 45 fs laser beam was focused at an intensity of ~ 3 10^{18} W/cm^2 on to a thick planar Al target at an incidence angle of 70°. The intensity of the ASE prepulse was measured to be ~10^{-6} times the magnitude of the main pulse intensity. The duration of the pre-pulse was varied from ~ 1 ns to 5 ns (without affecting the main pulse energy and stability). The electron beam emanating from the target surface was recorded in a single laser shot directly on a phosphor screen imaged on to a CCD camera. The cut-off energy of the electrons reaching the phosphor screen was ~ 60 keV. A magnetic spectrograph was implied for measuring the distribution of the fast electron beam energy at an angle of 30° from the target surface.

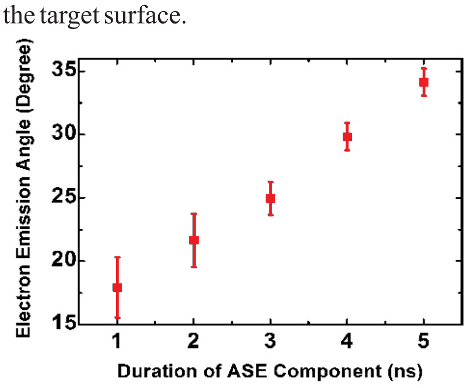

Fig. L.9.1: Electron emission angle for different duration of ASE component

The electron emission angle was observed to be highly sensitive to the duration of ASE prepulse (Fig.L.9.1). The angle of emission of the electron beam increases from 17° to 34° from the target surface on increasing the duration of ASE component from 1 ns to 5 ns. The typical observed divergence angle of the electron beam emanating from the target surface was estimated to be ~23°±2° which is much smaller than the non-grazing interaction case. The total charge contained in the electron beam increases ~ 2.5 times on increasing the duration of ASE from 1ns to 5 ns (Fig. L.9.2) due to increased laser absorption in the preplasma leading to higher electron flux and energy.

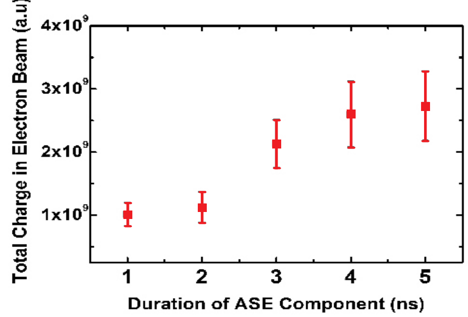

Fig. L.9.2: Variation of total charge contained in the electron beam for different ASE level

Emission of the collimated electron beam in grazing incidence laser solid interaction is due to the guiding of fast electrons under the influence of intense quasi-static surface fields along with the presence of reflected laser in a larger interaction area. Presence of longer duration ASE prepulse spoils the formation of large surface fields therefore reducing the guiding of the electron beam.

The typical energy spectrum of electron beam for ASE pulse duration of 4 ns is shown in Fig. L.9.3. It shows that the electron beam generated with larger duration ASE prepulse has continuous energy distribution with energy reaching greater than MeV. However, a further study is required to optimize the preplasma conditions and higher laser intensity to achieve Monoenergetic electron beam.

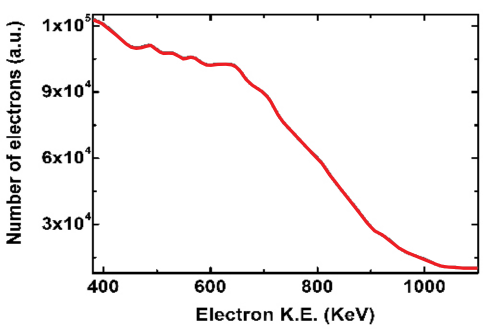

Fig. L.9.3: Electron energy spectra for 4ns ASE level

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