Modeling of plasma plume formation induced by a laser beam

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Abstract

High intensity laser beam material processing is accompanied by evaporation of irradiated substrate. At certain conditions, the evaporated material starts to ionize, and absorption coefficient in plasma increases, causing increase of laser beam energy absorption in the plasma plume. Therefore, portion of laser beam energy does not reach the substrate surface and, consequently, heating of the substrate is decreased. The proposed model of plasma plume formation includes the basic thermal phenomena caused by interaction of laser beam with material: heating, melting, evaporation, ionization of evaporated material and plasma plume formation. An important parameter of this process is the absorption coefficient of the plasma, which is described by three different mechanisms of absorption: the inverse bremsstrahlung process, photoionization process and absorption process of light induced by small condensed clusters. Based on the model, numerical solutions are given for KrF laser beam irradiation (wavelength of 248 nm) impinging on a nickel substrate. In the model, laser pulses with duration 50 ns and fluence range from 2.5 to 10.5 J/cm2 are considered. Results of the proposed model show that the portion of absorbed laser beam energy in the plasma plume increases with the increase of laser beam fluence. The acquired results of our model are compared with an experimental example from the literature.