Spatial configuration of fast ion source created in femtosecond laser plasma of cluster targets studied by ion pinhole imaging method

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A plasma induced by high-intensity femtosecond laser is considered for a long time as versatile compact source of fast ion beams for micromachining, precision microsurgery, proton radiography of ultrafast plasma phenomena, etc. In this context, the use of gas cluster targets provides a set of definite advantages such as the absence of debris and wide-angle ion emission. However, the spatial configuration of the ion source formed in fs laser-cluster target interaction has not been studied well yet. Ion pinhole imaging method is proposed and applied for the first time to study the processes of fast ion acceleration in the interaction of $10^{17}$–$10^{18}$ W/cm² 35 fs laser pulses with CO₂ cluster target. It was obtained the region with highest fast ion yield is spatially separated from that one with peaked yield of x-rays. This fact is most likely associated with the destruction of clusters by laser prepulse at the best laser focus. This assumption is consistent with time-resolved optical shadowgraphy data showing the formation of the plasma channel in the vicinity of the best laser focus prior the arrival of the main laser pulse. The anisotropy in the ion source spatial configuration was examined for different laser focusing position inside the gas cluster cloud.