IONIZATION AND ACCELERATION OF HEAVY IONS IN HIGH-Z SOLID TARGET IRRADIATED BY HIGH INTENSITY LASER

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The development of ultra-short high power lasers which intensity reaches to 10^{21}W/cm^2 have opened up new schemes for ion acceleration and associated applications such as hadron radiotherapy, fusion neutron generation, ion driven fast ignition, etc., by choosing the material state properly [1,2]. Relatively lighter elements such as hydrogen, carbon, etc., which easily become fully ionized state with the largest charge-to-mass ratio *Z/A* and then are accelerated efficiently, have been widely used for such applications. On the basis of these experiences, it is worthwhile to extend the schemes to high energy acceleration of heavy elements, which explore a wider class of application especially related to nuclear physics, e.g., highly charged heavy ion beam, nucleus-nucleus collision and nuclear transmutation, extraction and acceleration of short lived exotic nuclei [3]. In contrast to such lighter elements, heavier ones irradiated by high power laser exhibit complex structure and dynamics dominated by plural physical processes such as ionization and recombination, collision and relaxation, radiation and the transport, etc. These processes have to be taken into account in the analysis simultaneously and self-consistently.

Here, we study the interaction between the solid target consisting of heavy elements and high power laser using EPIC3D (Extended Particle based Integrated Code [2]) which includes above key physical processes. Here, we present two types of target, i.e. (I) a single layer Au target (0.8μm thickness) and (II) an Al target (0.7 μm) with a thin layer of Fe or Au (0.1 μm) in front and rear surface, respectively. The target (II) is in contrast to those investigated in Ref.[3]. Here, we found the two dimensional ionization dynamics inside the solid dominated by fast time scale convective propagation of the ionization front induced by the field ionization co-propagating with localized internal sheath field and slow one by impact ionization due to heated high energy electrons coupled with nonlocal heat transport [4]. Furthermore, we also found the ionization and acceleration due to the localized external sheath field which co-propagates with Au ions constituting the high energy front in the vacuum region. Through this process, the maximum charge state and then *Z/A* increase in the rear side, so that ions near the front are further accelerated to high energy.

In the case of target (I), ions of Z=62, i.e. Au^{+62}, with the energy about 1.5MeV/u (296MeV total energy), is obtained in the rear side for the laser with 10^{21}W/cm^2 and 40fsec (pulse width). In the case of target (II), ions of higher charge state Z=69, i.e. Au^{+69}, is observed in the rear side, which is ionized by the laser field in the front surface and pass across the target. This suggests the feasibility of the extraction of highly charge state ions from the front surface or bulk.

Reference

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