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A Progress on Nanostructured Array Targets in Nano-plasmas Research

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Nano-plasmas generated by intense radiation encompass elements of both high energy density physics and nanoscale science, which leads to the many interesting and unusual physical effects.[1] Interactions of short-pulse, high-intensity relativistic lasers with nanometer-scale targets are actively studied to generate high-energy ions, extreme UV, and coherent radiation. This Colloquium paper explores a recent progress on the array nanostructure targets and their applications in high intensity beams and energy interactions. Ultra-high electron energies and densities have been reported in many literatures which achieved through high-intensity irradiation of oriented nano-array structures.[2-5] We discuss and analyse the mechanism and related enhanced effects by using nanostructure array targets generated from laser-produced plasma, such as the large surface area and thin nanowall structure enlarges the region of interaction with the laser pulse, the nanospaces in array structure promote electron oscillation and ion collisions, and the low thermal conductivity increases plasma temperature, etc. For nano-array targets, the effect of photo-excitation lead to generate hot electrons and strong magnetic fields. Through the interactions of non-equilibrium, many-body coulomb interaction, thermal and non-thermal effect, nanostructured array targets have been widely used in the field of particle accelerators, compact syncrotrons, sources of THz, infrared, X-ray radiation, etc..

Our research group in Research Center of Laser Fusion (RCLF) has set up a physically self-assembled Oblque Angle Deposition (OAD) and Glancing Angle Deposition (GLAD) technique with dynamic shadowing growth (DSG) in physical vapor atmosphere. We have designed and fabricated different lightweight nanostructured array targets with the characterized properties for their interactions with intense radiation, such as nano-rod/nano-column and triangular patterned array targets with band-gap turing, porous structure, low density, different distance, doping and composite multilayer 3D nanostructures. Under the irradiation of 50 fs 3×10^18 W/cm^2 intense laser pulse, we compared the difference of high intensity beams and energy interactions by using generally Cu foil film and nanostructured array Cu targets by glancing angle deposition technique. The experimental results show that the intensity of Kα X-ray and laser-energy conversion efficience can be transferred more effectively to the electrons in the well-separated and oriented nanostructure array targets.

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