Generation of self-organized high energy density plasma by the interaction between high intensity laser and *structured medium*

Y. Kishimoto[1,2], D. Kawahito[1], R. Matsui[1,4], W. Feng[1,],
T. Okihara[1], H. Sakaguchi[2], K. Fukami[3], A. Ishizawa[1], Y. Fukuda[4]

[1]*Graduate School of Energy Science , Kyoto University, Uji, Kyoto, Japan, 611-0011*
[2]*Institute of Advanced Energy, Kyoto University, Uji, Kyoto, Japan, 611-0011*
[3]*Graduate School of Engineering, Sakyou-ku, Kyoto, Japan,* 606-8501
[4]*Kansai Photon Science Institute, National institute for Quantum Radiation and Technology, Kizu, Kyoto, Japan, 619-0215*
E-mail: kishimoto@energy.kyoto-u.ac.jp

Interaction between high power laser and various types of target has been investigated aiming at innovative application, e.g. collisionless shocks and particle acceleration [1], magnetic turbulence and self-organization, formation of a scaled interstellar plasma jet, etc. The characteristics of plasma produced by such interaction, e.g. the structure and dynamics, the state and life time, are of specific importance. So far, the generation of high energy density plasma in a confined manner, such as magnetically confined plasma, has not been achieved ascribed to the strong pressure inhomogeneity, which easily leads to a destruction of the state. To sustain such a plasma exceeding inertia time, a new concept is requited in target design and control the interaction.

Here, we propose a new concept, which we refer to it as ***structured medium***, consisting of plural different materials and/or mediums contacting each other across boundary layer. As the example, clusters or a lattice-like assembly with sub-μm size are immersed in a gas or strong magnetic field. Such a designed assembly has been made by combined technologies of beam lithography and chemical etching. A series of simulation has been organized to study the interaction.

When the medium with ambient gas is irradiated by the short laser of $10^{18\text{-}22}$W/cm^2, a collision-less electrostatic shock, lunched at the Coulomb explosion front, is found to compress and reflect the gas ions in a fast time scale, allowing a high energy gas ion spectrum with a limited energy spread. More interestingly, a high energy density plasma state with a clumpy structure is found to be sustained via kinetic pressure balance as a Bernstein-Greene-Kruskal (BGK) type equilibrium in a course of the relaxation process of the shock. Similar structure is seen in the plasma sheet boundary layer in the Earth's magnetotail [2]. For the medium immersed in kilo-Tesra level magnetic field, it is once scrambled by the laser field, leading to a magnetic turbulence with power low spectrum. The generation of turbulent wind is expected as one of astrophysics applications. The state is found to be self-organized to a coherent structure consisting of magnetic vortices, which is sustained over inertia time [3]. The explosive blow-off across confinement boundary is observed in both gas and magnetic field cases, which are expected to measure in future experiment.

The linear and nonlinear optical properties have been also investigated [4]. The structured medium can widen the class of application. A possible experimental set-up is discussed.

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