Rapid and uniform heating of matter with a laser-driven quasimonoenergetic aluminum ion beam

W. Bang[1*] , B. J. Albright[2] , P. A. Bradley[2], D. C. Gautier[2], S. Palaniyappan[2], E. L. Vold[2], M. A. Santiago Cordoba[2], C. E. Hamilton[2], and J. C. Fernández[2]

[1]1 Department of Physics and Photon Science, GIST, Gwangju 61005, Korea
[2] Los Alamos National Laboratory, Los Alamos, New Mexico 87545, USA.
**wbang@gist.ac.kr*

On the Trident laser facility at Los Alamos National Laboratory, we have used a beam of laser-driven quasi-monoenergetic aluminum ions [1] to heat solid density gold and diamond foils uniformly and rapidly above 10,000 K [2]. Although matter at such an extreme state, known as warm dense matter, is commonly found in astrophysics (e.g., in planetary cores) as well as in high energy density physics experiments, its properties are difficult to predict theoretically and are not well understood. A sufficiently large warm dense matter sample that is uniformly heated would be ideal for these studies, but has been unavailable to date. For the first time, we visualized directly the expanding warm dense gold and diamond with an optical streak camera [3]. We developed a new technique to determine the initial temperature of these heated samples from the measured expansion speeds of gold and diamond into vacuum [4]. We anticipate the uniformly heated solid density target will allow for direct quantitative measurements of equation-of-state, conductivity, opacity, and stopping power of warm dense matter, benefiting plasma physics, astrophysics, and nuclear physics.

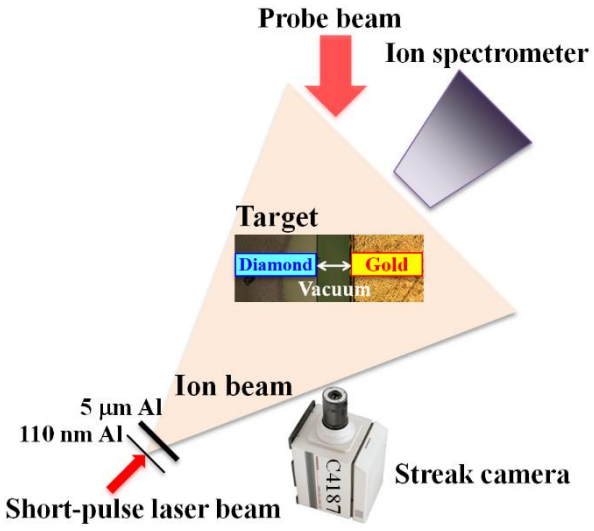

Figure 1. Schematic layout of the experimental setup (not to scale)

References

[1] S. Palaniyappan, C. Huang, D. C. Gautier, C. E. Hamilton, M. A. Santiago, C. Kreuzer, A. B. Sefkow, R. C. Shah, and J. C. Fernandez, Nat. Commun. 6, 10170 (2015).
[2] W. Bang, B. J. Albright, P. A. Bradley, E. L. Vold, J. C. Boettger, and J. C. Fernández, Phys. Rev. E 92, 063101 (2015).

[3] W. Bang, B. J. Albright, P. A. Bradley, D. C. Gautier, S. Palaniyappan, E. L. Vold, M. A. S. Cordoba, C. E. Hamilton, and J. C. Fernández, Sci. Rep. 5, 14318 (2015).
[4] W. Bang, B. J. Albright, P. A. Bradley, E. L. Vold, J. C. Boettger, and J. C. Fernández, Sci. Rep. 6, 29441 (2016).