Editorial

High Energy Density Physics

States of matter that correspond to an energy content of 10^{11} J/m^3 or equivalently 1 Mbar pressure, and above, are classified as High Energy Density (HED) states. The subject of HED physics spans over very wide areas of basic and applied physics including, for example, astrophysics, planetary sciences, geophysics, plasma physics, inertial fusion, fluid dynamics, radiation hydrodynamics, magnetohydrodynamics, material sciences, condensed matter physics, interaction of intense radiation with matter, atomic and molecular physics and many others. In addition to that, this field has great potential for numerous lucrative industrial applications. A study of the fundamental properties of HED matter, especially its thermophysical and transport properties, is therefore of considerable scientific importance as well as of great technological interest.

The traditional methods of generating HED states mainly involve shock compression of matter. Pressures in 10 Mbar range have been produced employing high power explosives, light gas guns and Z-pinches [1-5]. Much higher pressures in Gbar range have been generated using underground nuclear explosions [6] and powerful lasers [7-10]. Isobaric expansion (IEX) technique that involves explosion of thin metallic wires that are strongly heated by the passage of very high current [11], is an alternative approach. Compression of matter in diamond anvil cell (DAC) [12, 13] is another popular method to study this problem. A new technique that involves isochoric and uniform heating of a sample material using laser generated high energy proton beams [14] as well as accelerator generated intense heavy ion beams [15,16] has recently been proposed. Another novel proposal to study this field is to use future short-pulse tunable soft X-ray free electron laser based on self-amplified spontaneous emission [17].

In this special issue we present four specialized papers on selected topics in HED physics. The first paper by Deutsch *et al.* presents a comprehensive overview of the theory of stopping of energetic ions in dense targets to generate HED states in matter. This problem is specially of great importance to heavy ion driven inertial fusion. The second paper by Fortov and Lomonosov thoroughly deals with the Equation of State (EOS) of HED matter, which again, is an extremely important problem for inertial fusion and HED physics studies. The third paper by Lopez Cela *et al.* describes how the material properties like the yield strength of materials in HED state can be deduced from the experimental studies of the Rictmyer-Meshkov instability. The last paper presents experimental results on the measurement of the energy loss of energetic particles in laser-produced plasmas. This is a very valuable contribution to this filed as most of the available energy loss data so far has been measured in cold matter.

We believe that the papers presented in this special issue will provide a very good introduction to the field of HED physics and the large number of the references quoted therein would assist the readers to get more detailed information about the relevant problems.

REFERENCES

[1] McQueen RG, Marsh SP, Taylor JW, Fritz JN. In: Kinslow R, Ed. High velocity impact phenomena. New York: Academic Press 1970; pp. 293-417.
[2] van Thiel M, Ed. Compendium of Shock Wave Data, Lawrence Livermore Laboratory Report, UCRL-50108 1977.
[3] Marsh SP. Ed. LASL Shock Hugoniot Data, University of California Press, Berkeley, Los Angeles, London 1980.
[4] Zhernokletov, MV, Zubarev VN, Trunin RF, *et al*. Experimental data on shock compression and adiabatic expansion of condensed materials at high energy density. (IPCP RAS, Chernogolovka, 1996) [in Russian].
[5] Knudson MD, Hanson DL, Bailey JE, Hall CA, Asay JR, Anderson WW. Equation of state measurements in liquid deuterium to 70 GPa. Phys Rev Lett 2001; 87: 225501-1.

1876-5343/10 2010 Bentham Open

[6] Vladimirov AS, Voloshin NP, Nogin VN, Petrovtsev AV, Simonenko VA. Shock compressibility of aluminum at a pressure of 10-Mbar. Sov Phys - JETP Lett 1984; 39: 85.
[7] Löwer TH, Zigel R, Eidmann K, *et al*. Uniform multimegabar shock waves in solids driven by laser-generated thermal radiation. Phys Rev Lett 1993; 72: 3186.
[8] Cauble R, Phillion DW, Hoover TJ, *et al*. Demonstration of 0.75 Gbar planar schocks in x-ray driven colliding foils. Phys Rev Lett 1993; 70: 2102.
[9] Koenig M, Faral B, Boudenne MJ, *et al*. Relative consistency of equations of state by laser driven shock waves. Phys Rev Lett 1995; 74: 2260.
[10] Batani D, Balducci A, Beretta D, *et al*. Equation of state data for gold in the pressure range < 10 Tpa. Phys Rev B 2000; 61: 9287.
[11] Gathers GR. Dynamic methods for investigating thermophysical properties of matter at very high temperatures and pressures. Rep Progr Phys 1986; 49: 341.
[12] Narayana C, Lou H, Matsubara S, *et al*. No evidence for an alkali metal. Nature 1998; 393: 45.
[13] Mao HK, Hemley RJ. Ultra-high transitions in solid hydrogen. Rev Mod Phys 1994; 66: 671.
[14] Patel PK, Mackinnon AJ, Key MH, *et al*. Isochoric heating of solid density matter with an ultrafast Proton beam. Phys Rev Lett 2003; 91: 125004.
[15] Tahir NA, Kain V, Schmidt, *et al*. The CERN large hadron collider as a tool to study high energy density matter. Phys Rev Lett 2005; 94: 135004.
[16] Tahir NA, Deutsch, Fortov VE, *et al*. Proposal for the study of thermophysical properties of high energy density matter using current and future heavy ion accelerator facilities at darmstadt. Phys Rev Lett 2005; 95: 035001.
[17] Lee RW, Baldis HA, Cauble RC, *et al*. Plasma based studies with intense x-rays and particle beam sources. Laser Part Beam 2002; 20: 527.

Naeem A. Tahir
(***Guest Editor***)
Gesellschaft für Schwerionenforschung Darmstadt
Planckstrasse 1
D-64291
Darmstadt
Germany
E-mail: n.tahir@gsi.de