SHOCK WAVES IN CONDENSED MEDIA: EXPECTED AND UNEXPECTED PHENOMENA

V. E. Fortov

Institute for High Energy Densities (IHED), Russian Academy of Sciences, Izhorskaya 13/19, Moscow, 127412 Russia, e-mail: fortov@ficp.ac.ru

High energy densities in matter can be generated by different methods. Review of modern experimental techniques, such as methods of shock compression, multi-step shock compression, electrical and laser heating and others is given. A special attention is pointed out to possibilities of short pulse heating in high-energy-density matter research. The physical properties of strongly coupled matter at high energy densities are analyzed in a broad region of the phase diagram. The theoretical and experimental methods of hot dense matter investigations are discussed. Intense shock, rarefaction and radiative waves in gaseous, solid and porous samples, explosion and bulk electron and ion heating were used for generation of extremely high temperatures and high pressures. The highly time-resolved diagnostics allow us to measure the thermodynamical, radiative and mechanical properties of high temperature condensed matter in the broad region of the phase diagram from compressed condensed solid states up to the low-density gas range. Theoretical estimations of the dielectrization pressure range for some elements at ultra-megabars are presented and compared with the experiments. Shock Hugoniots of liquids were measured up to the pressures about one megabar and are in a good agreement with the zone theory of condensed matter.

The phase diagrams at high pressures and high temperatures are under consideration – from the compressed condensed solid state (through melting and evaporation) up to a low density gas range, including high pressure evaporation curves with near-critical states of metals, strongly coupled plasma and metal-insulator transition regions. These states were achieved by fast shock wave loading, pulse electrical heating and fast laser pulse heating (femtoseconds). Femtosecond laser pulses were used for investigations of condensed matter: thermal and nonthermal melting; ablation in metals, semiconductors and dielectrics; compression of matter up to ultrahigh pressure (≥ 1 Gbar).

New thermophysical data for metals were obtained for solid state, liquid, for the region higher critical point. Using exploding wire technique, the electrical conductivity was measured in a continuous transition from condensed to gaseous state for W, Al, Fe at 10-100 kbar pressure range and 10-50 kK temperature range. A maximum in the temperature dependence of the Al resistivity along isochores were detected in the so-called metal-nonmetal transition region.