OPTICAL EMISSION FROM SILICON PLASMA UNDER PRESSURE 70–510 GPA

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The thermal radiation from the shock wave front in silicon can be directly registered by optical pyrometry technique, due to transparency window in the infrared region (1.2–8 microns), where modern photodiodes, based on InGaAs, can work. Shock compression of single–crystal silicon up to pressure 70–130 GPa was realized using the flyer plates, accelerated by traditional 1-D explosive generators. Cylindrical Mach-type cumulative generators make possible to achieve pressures up to 510 GPa. Silicon shock Hugoniot was determined by impendance matching—the measurement of wave velocities in reference material (single–crystal quartz) and silicon sample. Optical emission from the shock wave front was registered by a four–channel infrared optical pyrometer with a fiber input. Registration bands, centered at wavelengths 1.3, 1.5, 1.6, and 1.8 microns were used. Shock compressibility data, obtained at 280–510 GPa range, demonstrates significantly soft Hugoniot in comparison with Pavlovsky, 1968 data at 80–196 GPa, and good agreement with laser experiment by Henderson, 2021. The optical emission of shock front in silicon and brightness temperature in the infrared transparency window of spectrum were measured. The significant difference of experimental and calculated temperature (experimental is 2–5 times lower) was found at pressures of 200–510 GPa; a similar phenomenon was observed in the experiments by Lower in 1998. Appearance of the electron–hole plasma layer before shock wave front due to the electron thermal conductivity and photoionization process does not allows to describe this phenomena. A satisfactory agreement was obtained between experiment and plasma model, including the kinetics of ionization and formation of the electron concentration gradient at shock front. The model gives the estimation of the ionization rate and gradient layer thickness, which prove to be of the order of $2 \cdot 10^9$ s^{-1} and 10 microns correspondingly.