Picosecond laser action on iron films: Elastic, plastic and polymorphic transformations

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The results of experimental, theoretical and numerical study of laser shock waves (SW) initiated by a picosecond (ps) pulse in iron are described. Picosecond impacts correspond to very high rates of deformation, unattainable by traditional means. Research is interesting for a number of reasons. It is important to understand how the rate of deformation affects elastic-plastic and polymorphic transformations. In particular, the study of this problem is necessary for the development of a consistent theory of ps laser hardening of metals, which is now making its first steps; although this kind of hardening approach (laser forging) is already widely used in practice. We performed a series of experiments. Modern developments in the field of SW generation and, most importantly, their experimental diagnostics are applied. Methods of theoretical interpretation of diagnostic data are developed. These methods are used for the first time in the class of ps effects. The fact is that the diagnostics of experiments only presents us with the kinematics of what is happening. Measurements of mechanical stresses (say, by means of manganin sensors) do not exist in ps experiments. Meanwhile, without data on stresses, the kinetics of polymorphic transformation remains unclear. Experiments are supported by hydrodynamic and molecular dynamics numerical simulations.