Abstract: An advent of powerful sources producing intense and ultrashort laser pulses containing high-energy photons opened up a wide range of possibilities to conduct experiments formerly achievable only through theoretical calculations and models. This thesis provides a complex overview of processes which occur right after arrival of the first photons, through lattice heating, up to resolidification and formation of irreversible changes. Irradiated spots and craters formed in various materials are examined employing a wide range of microscopic and spectroscopic methods which provide a deep insight into laser-induced modifications such as detachment of a graphene layer from SiC substrate or thermally-induced diffusion of tellurium inclusions through CdTe lattice. An increased emphasis is placed on beam characterization utilizing ablation and desorption imprints in suitable solids. A proper knowledge of the beam fluence profile may serve for evaluation of diverse damage thresholds as well as for modelling of the pulse propagation or consequent retrieval of otherwise unmeasurable opacity of warm dense aluminium plasma heated to temperatures exceeding tens of thousands of Kelvins. Moreover, the method of desorption imprints is extended to accurate characterization of pulses delivered at MHz repetition rate. This work aims to contribute to general understanding of interaction between short-wavelength laser pulses and matter at different time scales.