

The importance of laser-generated bubble expansion and cavitation erosion mechanisms for pulsed laser interactions and nanoparticle formation in liquid

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Pulsed laser ablation in liquids (PLAL) is known to be one of the promising methods used for nanoparticle formation. The main advantages of this procedure are the possibilities to fabricate various alloy nanoparticles and the fact that the particles are chemically clean since no aggressive chemicals are typically employed. The mechanisms involved are, however, extremely complex involving laser propagation, ablation, ionization, formation and expansion of a cavitation bubble, instabilities, condensation and aggregation, etc. In numerous experiments, it was demonstrated that PLAL creates an oscillating bubble in water, which collapses generating acoustic effects and surface erosion. Models of this process are often limited by the numerical solutions to the well-known equations, such as Gilmore, Rayleigh-Plesset or Keller and Miksis [1-4] ones, depending on the degree of the required accuracy. Herein, firstly we propose a more complete bubble model accounting for plasma formation, evaporation and semi-empirical mass transport. The developed model provides a much more realistic bubble oscillation dynamics that better agrees with the available experiments than the ones obtained in the previous studies. Secondly, we introduce the process of the cavitation surface damage taking place when a bubble collapses in the vicinity of a solid surface. Since pressures up to GPa can be generated, such damage easily leads to the erosion of the laser-preheated surface, crater formation and surface material ejection into liquid. These effects explain several puzzling experimental facts, for instance that laser radiation should be focused above the surface to produce nanoparticles by PLAL and that the typical laser fluences required for nanoparticle generation that are often much smaller than the ones required for laser surface ablation in liquids.

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