Form 2

Dissertation Abstract

Report no.	(Course-based) No. 1037	Name	ROKHSAN-ARA-HEMEL
Dissertation title	Dynamics of Micro Shock Wave Induced by Laser (レーザー誘起マイクロ衝撃波の力学)		

Abstract

※ The abstract should be in keeping with the structure of the dissertation (objective, statement of problem, investigation, conclusion) and should convey the substance of the dissertation.

Propagating process of underwater micro shock wave that was induced by irradiation of single pulsed laser was observed by shadowgraph technique. The shock wave was produced by the thermo-elastic effect of thin metal film, which was coated on a flat and concave shaped glass. In the present study, in order to produce underwater micro-shock wave, two different types of shock wave emitter have been designed such as flat and concave glass, which are coated with titanium metal thin film of 100 nm thickness. In the experiment, laser irradiation intensity was changed up to 200 GW/m^2. The velocity and Mach number of underwater micro shock wave have been calculated by using a shadow graphic imaging technique for these shock emitters. In this study, it was reported that laser induced micro-shock wave propagated near the speed of acoustic wave of water for the different two shock emitters. The shock strength has been measured by pressure sensor and it was found that the generated shock wave strength decreases with respect to propagation distance in water medium. In addition, the shock focusing effect was confirmed by using concave shock emitters. Effective area of focusing was determined by the order of radius of curvature of concave surface and irradiation beam diameter. The present research on generation of micro underwater shock wave provides a fundamental kinetic data for bio or medical engineering such as drug and nanoparticle delivery into a specific target.

The present study also investigates the underwater shock wave that is related with the photo-acoustic wave propagating in a very thin metal, which was induced by a pulsed-laser irradiation. The laser irradiation induces a rapid thermal process

instantaneously. The phenomenon is interesting from the view point of micro technology with thermo-elasticity. The development of this process requires an analysis of temperature and displacement by using laser heat energy source. For the mechanics of laser energy transfer between laser and metal, a general solution of thermo-elastic wave is obtained by using Laplace transformation for the wave equation. The solution gives a very important understanding about the longitudinal wave property, and the phenomena of underwater shock wave that is induced by the traveling longitudinal wave through a thin metal, which was induced by laser irradiation. The longitudinal wave propagation has been calculated for different metals and very fast responded metal, Titanium, is used in the experiment. The experiments also carried on this phenomenon and observed the resultant shock wave with optical system. On heating the metal thin plate by pulsed laser, laser energy is absorbed, then it is found that the results in an increase in temperature. Under the experimental condition, it was found that a sharp spike of acceleration of order 10^7 [m/s^2] was propagated within 20 ps after laser irradiation through the metal film. After this high spike, acceleration wave rapidly decreased to -1×10^6 [m/s^2] within 3 ns, and then wave increases again. From this phenomenon it can be understand that the acceleration wave dominates the longitudinal wave which transfers momentum to generate underwater shock wave.

In order to clarify the momentum transport mechanics in this phenomenon, the underwater shock wave strength has been estimated theoretically. The metal region was calculated by Laplace transformation of heat conduction and wave equations, as described above and the water region was simulated by MacCormack's method. Some of boundary conditions have been examined and the acceleration condition has been adopted at the interface of metal and water. The simulated results show a good agreement with experimental result, consequently the momentum transfer mechanism from longitudinal wave to underwater shock wave has been cleared in the present research.