# 論文内容の要旨

氏　名　　Nguyen Thi Phuong Thao

Focusing an intense, short laser pulse onto a rigid target surface produces high-pressure plasma, which drives a shock wave into the surrounding environment during its expansion. This process is called laser ablation. When the laser ablation is carried out under liquid, the liquid phase acts as a restricting medium to restrain the plasma expansion and induces a much stronger shock in comparison to ablation in normal atmospheric condition. In this regime, the vapor-generated by plasma forms a cavitation bubble, which oscillates over hundreds of microseconds and exerts additional mechanical effects to the process. Under-liquid laser ablation attracts much interest because of its wide potential applications such as nanoparticle synthesis, medical and biological applications, micromachining, laser cleaning and laser peening. Deeper understanding of the behavior of laser-induced shock process (LSP) in under-liquid laser ablation is required to evaluate and optimize its mechanical effects. Fundamental aspects of the sequences happening in an under-liquid LSP, their dependences on the ablation conditions as well as their contribution to the mechanical effects exerted into the solid target still remain poorly understood. We thus have been motivated by the need to carrying out deep investigations into the dynamics of under-liquid LSP and its dependence on the ablation conditions.

LSP is by nature a transient phenomenon, and is coupled with complicated phenomena such as plasma formation, which makes it difficult to observe and quantify the propagation of the laser-induced shock and stress waves. In this study, a custom-designed imaging system which utilizes photoelasticity technique in the bright-field mode has been developed. With this technique, the processes in the liquid phase and the solid phase can be observed simultaneously and the strength of laser-induced stress can be monitored directly by the images.

This thesis presents a research on the dynamics of under-liquid LSP and its dependence on the ablation conditions using the custom-designed time-resolved photoealsticity imaging technique. The effects of an absorptive coating, focal conditions, liquid properties, liquid layer thickness on the dynamics of shock wave, stress wave and cavitation bubble were investigated. It was found that even at energy densities in the $GW/cm^2$ range, an absorptive coating helped to induce a stronger shock by enhancing the energy absorption by plasma in the laser ablation process. When the surface was located close to the focal point, the breakdown that occurred on the solid-liquid interface resulted in reduced laser-induced stress. At positions above the focal point, the stress-wave intensity was mainly determined by laser pulse energy, but not by fluence. Impurities in liquids initiated breakdowns at multiple sites along the light path and reduced stress-wave intensity. A heavy, hard to compress, high shock impedance liquid can provide a better confining medium to the plasma, thus enhance the strength of laser-induced stress wave**.** There was a minimum value of liquid layer thickness needed to obtain the similar effects of bulk liquid. Below this threshold, the laser-induced stress was weaker with thinner layers. The threshold thickness of liquid layer required to induce the same stress as in fully immersed case increased with laser pulse energy. The cavitation bubble was elongated when approaching the free surface and its lifespan was shortened as the liquid depth decreases. The interaction of bubble and the free surface led to the formation of a toroidal bubble, of which the collapse is strongly unstable, resulting in the emission of multiple shock waves from different locations along the torus.

This work contributes to the better understanding of under-liquid LSP by providing detail knowledge of the dependence of shock process on ablation conditions. This understanding would be useful for an optimal condition choice for each particular application of under-liquid laser-induced ablation.