Research Objective:

The objective of this project is to develop a novel laser ablation in liquid technology for surface decontamination. It aims to achieve more efficient surface decontamination without secondary contamination.

The major goals are as follows.

1. To develop novel **Laser Ablation Decontamination in Liquid (LADIL)** technology for safe removal of radioactive and/or toxic contaminants from a surface without producing dangerous secondary pollutants.

2. To obtain a data base for the basic physical processes of laser ablation on a solid-liquid interface and use the results of this basic study to improve the cleaning efficiency of surface-contaminated materials.

3. To optimize the cleaning process for efficient recycling of contaminanted materials.

4. To evaluate the feasibility of LADIL for large scale surface decontamination.

Research Progress and Implication:

After approximate 1 year of a 3 years project, we have designed, installed and tested the facility for laser ablation in liquid for surface desorption. During the past year, we have demonstrated surface decontamination with laser ablation in solution. The desorbed particle sizes have also been measured.

The facility of laser ablation in liquid has been assembled. It consists a Nd-Yag laser and an excimer laser for the light source for laser ablation. Frequency doubling, tripling and quadrupling for the fundamental frequency of the Nd-Yag laser was installed and tested. A wavelength tunable dye laser which can be pumped by the Yag laser was also used to achieve the tunability from UV to near IR region. The laser fluence from 1 mj/cm^2 to 10 J/cm^2 has been tested to compare the desorption efficiency with various power. These results will provide a guidance on the selection of laser wavelength and energy for the most efficient laser ablation in liquid for cleanup.

The size of desorbed material from the surface during the ablation is important to enrichment, collection and disposal of contaminants. Our study of the ablation of absorbing liquids showed that the surface tension and fluctuation of the acoustic field causes formation of micro-droplets with an average radius 5 to 10 μm which varies with the laser fluence used for irradiation. Similar to ablation at a liquid-air interface, ablation at a solid-liquid interface produces micro-particles rather than evaporation of the solid material. A common way to detect colloids is to observe light scattering in the solution. We used the glass cell filled with water before laser ablation of metal plates. No significant light scattering was observed for a HeNe laser beam passing through the cell. On the other hand, clear particle formation was observed from the HeNe laser beam scattering when the metal plate was irradiated for 30 min by laser pulses with a laser

fluence of 0.8 J cm^{-2} with a repetition rate of 1 Hz. Strong scattering of HeNe beam indicates the formation of a colloidal solution. However, this solution was unstable, and after a few hours it precipitated and formed sludge at the bottom of the cell.

The particle size distribution emitted by ablation at a solid-liquid interface can be characterized directly. We have carried out an experiment on cleaning of metal plate previously painted with graphite paint. The sample was analyzed using an optical microscope to determine the size and the quantity of particles ejected by ablation. The average size of particles in water was found to be about 3.5 µm. From the known density of particles in the solution and the average size, it is possible to find the total amount of material ejected. Within the accuracy of our measurements, the total volume of the particles is equal to the volume of the paint that has been removed from the plate. Since the micrometer size particles can be easily separated from the solvent by centrifuging, we consider this result indicates the feasibility of recycling solvent for re-use.

Planned Activities:

During the coming years, we will study different mechanisms for surface decontamination by laser ablation in liquid. An optimum conditions will be searched for efficient surface cleanup process. We will also evaluate the efficiencies of cleanup for different substrates and different contaminants on surfaces.