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저에너지 플루언스(fluence) 레이저 어블레이션(ablation)을 통한 표면오염제거과정에서의 나노입자의 생성에 관한 연구

Investigation of Nanoparticle Generation during Surface Decontamination by Low-Energy-Fluence Laser Ablation

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During the cleanup of US Department of Energy facilities, contaminated materials, toxic and hazardous radionuclides (e.g., Th, Cs, and U) and heavy metals (e.g., Cr, Hg, Pb, and Ni)-laden ultrafine particles are generated. The size of the particles is up to about 200 nm. Understanding of the production of these nanometer size particles is critical in determining the surface cleaning efficiently. In addition, nanoparticles have the ability to penetrate the upper respiratory tracts of human lungs and can cause adverse health effects when exposure occurs. As a part of the particle characterization study, investigation of particle generation by low-energy-fluence laser ablation was performed.

Nd:YAG laser, which emits up to 200 mJ of energy/pulse with a 3-5 ns pulse width at wavelengths of 1064 nm, was employed in the ablation. Using harmonic generators, 532 and 266 nm laser pulses were generated from the laser with up to 110 mJ and 25 mJ energy/pulse, respectively. The laser pulses irradiated the surfaces of rotating sample targets placed inside an air-tight chamber. Concrete, stainless steel, and alumina blocks were used as the targets, and nanoparticles were generated from the target surfaces by low energy fluence laser ablation. Using an ultrafine condensation particle counter and a scanning differential mobility analyzer system, the generated particle concentrations and their size distributions were recorded with respect to sets of variables such as the energy and wavelength of the laser, target materials, etc.

At a given laser fluence, our experimental results show that alumina produces the least amount of particles while stainless steel produces the most. More detailed analysis results of the experimentally observed relationships among the particles, target materials, and laser beam characteristics will be presented. Also, theoretical consideration for particle generation mechanism will be discussed.

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