# Laser-induced breakdown detection (LIBD) of uranium and silica colloids

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## Introduction

Laser-induced breakdown detection (LIBD) is a well established technique using plasma formation in the high irradiance of a focused laser beam for measuring small size of colloidal particles in an aquatic environment. Over the last decades, several different LIBD systems which adopt different detection schemes by using a piezoelectric transducer, a charge-coupled device camera, and an optical probe beam were developed. These LIBD systems enable to detect extremely low concentration of nanoparticles. Thus, the LIBD technology can be applied in various fields such as, *in situ* observation of colloid mediated transport of polluants and measurement of solubility of radio-active elements.

Although LIBD methods allow one to determine a particle size in principle, until now, particle sizing capabilities in most LIBD experiments were inspected only for polystyrene particles of a well-defined size as a reference material. Therefore, it should be certified that these LIBD methods are whether suitable or not to determine the particle size for different materials.

## Discussion of Results

In the present work, particle sizing capability using LIBD has been investigated for three different materials: uranium, polystyrene, and silica nanoparticles. It was observed that spatial distribution of breakdown events generated by laser pulse of 532 nm wavelength along the laser beam propagation axis was directly correlated with particle size for uranium and polystyrene, while there was no correlation between the spatial distribution of breakdown events and particle size for silica. The reason for these phenomena is understood based on the ionization potential (IP) of each material. IPs of these materials are about 6.17, 7.8, and 11.7 eV for $UO_2$, polystyrene, and $SiO_2$, respectively. When a focused laser pulse of 532 nm wavelength is used to generate laser-induced plasma, simultaneous three or four photon absorption is required to induce multiphoton ionization (MPI) of uranium and polystyrene. However, at least five photon absorption is required to induce MPI of silica. The result suggests that determination of particle size of silica particles with the aid of calibration curve obtained from the polystyrene reference particles may give incorrect values.

# Seismic anisotropy produced by serpentine in the mantle wedge

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Trench-parallel seismic anisotropy has been observed in many subduction zones in the upper mantle. In this study, crystal-preferred orientation (CPO) and seismic anisotropy of natural serpentine from Val Malenco in northern Italy and Punta Bettolina in western Italy were studied. It is found that [001] axes are aligned subnormal to the foliation but [010] axes of serpentine are aligned subparallel to the lineation which is significantly different from that produced in a recent high-pressure experiment. I show that the CPOs of serpentine found in this study can be used to explain trench-parallel seismic anisotropy in the mantle wedge, not only for serpentine deformed at high angles greater than 45° from the surface but also for serpentine deformed at low angles such as in horizontal shear, demonstrating that the CPO of serpentine has much broader implications for interpreting the seismic anisotropy than previously thought. It is also found that seismic anisotropy caused by the CPO of serpentine depends on the degree of serpentinization and flow geometry. Current data suggest that trench-parallel seismic anisotropy in the forearc mantle wedge in subduction zones can be attributed to the CPO of serpentine.