Single pulse laser-induced breakdown on the target in water

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Laser induced breakdown spectroscopy (LIBS) currently represents the only choice for direct elemental analysis of bulk liquids and submerged targets [1]. In order to have precise and reliable LIBS analysis, thorough understanding of laser induced breakdown (LIB) in water, or any other liquid is needed. That has proven to be very challenging, both for theoretical and experimental investigations, due to many factors influencing the process.

In this work, complex phenomena that arise during single pulse LIB on submerged solid target in the distilled water are studied by different experimental techniques, fast schlieren and shadow photography, optical emission spectroscopy and transmission and scattering measurements . Nd:YAG laser source operated at 1064 nm, with 20 ns pulse duration and 50 mJ energy was used for the plasma initiation. Laser beam was focused using two lenses, where the second lens was built in the chamber wall directly. Lenses were aligned in the manner that the laser beam induces breakdown on the surface of solid target placed perpendicularly to the laser beam and vertically inside a chamber filled with distilled water. Chamber was equipped with two quartz windows mounted on the opposite chamber walls. Target was placed in the target holder and translated after each laser shot.

Transmission and scattering measurements were performed under illumination of HeNe laser and green diode laser, respectively. Photomultiplier tube (PMT) with interferential filter (IF) for corresponding illumination was used for signal detection.

In the case of shadowgraphy and schlieren imaging, area above the target surface was illuminated with the white light source. Illuminated area above the sample was further imaged with the lens placed after the chamber exit window. Final image was formed using objective lens mounted on the iCCD camera. To perform schlieren imaging additional vertically mounted knife-edge was positioned in the focus of the lens to monitor refractive index gradients perpendicular to the sample.

For spectroscopic measurements 1:1 image of the plasma plume was projected, by means of optical mirrors, on the entrance slit (100 μm width) of the 0.5-m Ebert-type spectrometer with the grating of 1180 grooves/mm. The plasma radiation was recorded with the ICCD detector mounted on the exit slit plane of the spectrometer. The ICCD was operated by a pulse generator (DG-535, Stanford Research Systems), allowing the choice of gate width and delay time after the laser pulse for the time resolved data acquisition.

References

[1] V. Lazic, S. Jovićević, Laser induced breakdown spectroscopy inside liquids: Processes and analytical aspects, Spectrochim. Acta Part B, 101 (2014) 288-311