DEVELOPMENT AND FIELD TESTING OF LASER-INDUCED BREAKDOWN SPECTROSCOPY FOR IN SITU MULTI-ELEMENT ANALYSIS DURING UNDERWATER SURVEYS

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ABSTRACT

The application of laser-induced plasmas has been investigated as a method to perform in situ, multi-element chemical analysis of liquids and immersed solids at sea during marine surveys. Analytically useful spectra have been observed from plasmas generated by irradiation of a high power pulsed laser in both bulk liquids and immersed solids using a single pulse at hydrostatic pressures of up to 300atm. Experiments were performed at sea using the in situ laser-induced breakdown spectroscopy (LIBS) device I-SEA (In situ Seafloor Element Analyser) mounted on-board the remotely operated vehicle (ROV) Hyper-Dolphin of the Japan Agency for Marine Science and Technology (JAMSTEC). During the trials real-time, multi-element analysis was successfully achieved for the first time at sea using LIBS for both liquids and immersed solids at a depth of 200m.

KEYWORDS

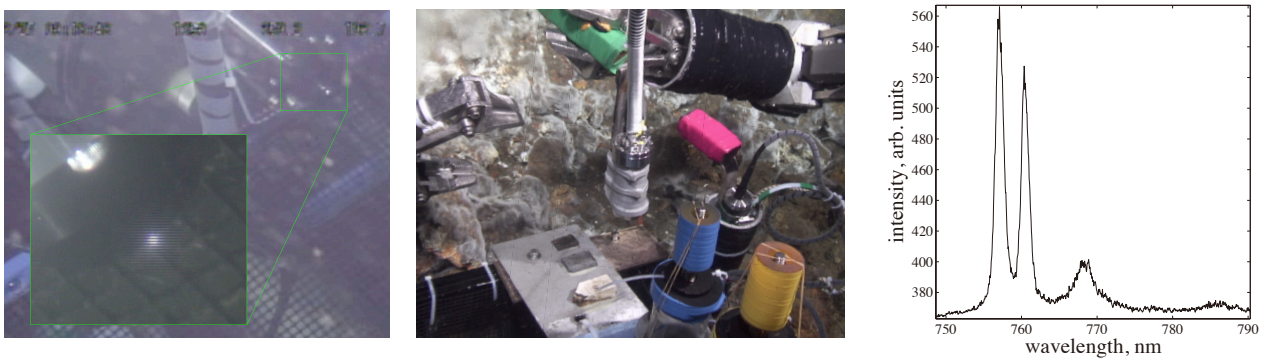
Laser-induced breakdown spectroscopy, Underwater, Element analysis, Marine survey.

INTRODUCTION

Laser-induced breakdown spectroscopy (LIBS) is a form of atomic emission spectroscopy that focuses a high power laser pulse onto a target to create a plume of excited material that emits light corresponding to the spectra of the atoms and ions that compose the plume. In this study, the authors demonstrate that well resolved emission spectra can be observed from plumes generated in bulk liquids, and on immersed solids after excitation by a single laser pulse of duration <10ns, and further demonstrated that external pressures of up to 300atm. have no significant effect on the observed line emissions. The application of LIBS at sea is demonstrated through experiments carried out using a 3000m depth rated LIBS prototype mounted on-board a remotely operated vehicle (ROV). The results of the experiments will be presented and an outlook will be given for future areas of work.

EXPERIMENT

A 3000m depth rated LIBS device, I-SEA (In-situ Seafloor Element Analyser), has been developed at the University of Tokyo, Japan, in order to perform in situ multi-element chemical analysis of both solids and liquids underwater. The device is 1.5m long with a diameter of 0.3m and weighs 110kg in air. The device has two optical setups, a direct optic and a fiber optic setup. The direct optic focuses the laser and observation optics directly into the bulk liquid via a high pressure objective lens mounted on the hull. The fiber optic setup delivers the laser through a 1000μm core diameter fiber optic cable that penetrates the hull and observes the signal through the same fiber. During operation, the direct optic measures the optical emissions of plasmas generated directly in seawater immediately in front of the device, and the fiber optic probe allows for specific targets to be selected using a ROV manipulator. The device was mounted on-board the ROV Hyper-Dolphin during the NT12-07 cruise of the R/V Natushima of JAMSTEC. During the two dives performed with the ROV, both the direct optic and fiber optic probe setups were tested and successful multi-element analysis of both liquids and solids were performed.



Testing of underwater LIBS at sea showing (left) the direct optic setup, (center) the fiber optic setup, and (right) an example of spectroscopic measurements made during the sea trials

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