MICROFLUIDIC DEVICES FOR OCEAN SCIENCE AND EXPOLORATION

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ABSTRACT

Microfluidic devices have been applied to realize functionally integrated and compact *in situ* chemical and biochemical analyzers that can be operated in deep-sea environments. PDMS-based microfluidic devices are connected with miniature pumps, valves, and flow-rate sensors to enable *in situ* detection of biomolecules or trace elements. The *in situ* analyzers can be mounted on a variety of underwater platforms such as remotely operated vehicles, autonomous underwater vehicles, and manned submersibles. Development, evaluation, and *in situ* operation processes of the *in situ* analyzers will be introduced together with practical operation results.

KEYWORDS

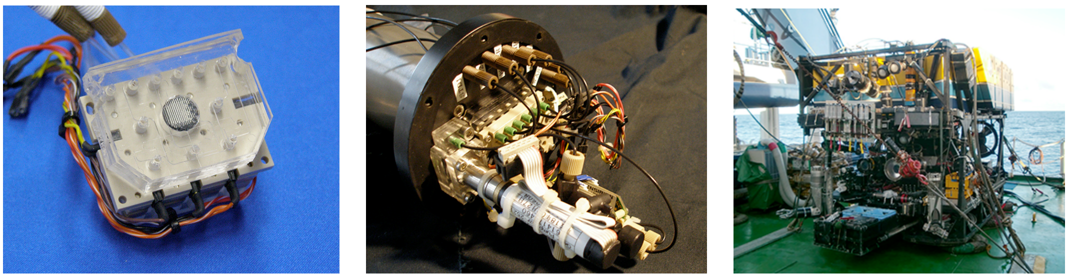
Marine survey, *in situ* measurements, Gene, ATP, Manganese, pH

INTRODUCTION

For the purpose of ocean sciences, natural resource surveys, and environmental assessment missions, development of compact *in situ* chemical/biochemical sensors or analyzers has been demanded. A series of Integrated *In Situ* Analyzer (IISA) utilizes a microfluidic device as a core functional element for chemical or biochemical analysis in ocean environments. IISA-Gene can detect targeted microbial genes based on a PCR method [1]. Microbial biomass can be estimated using IISA-ATP (adenosine triphosphate) that can perform a luciferin-liciferase bioluminescence assay *in situ* [2]. IISA-Mn can quantitatively detect manganese (Mn) ion as one of the trace metal contents of seawater using a luminol chemiluminescent assay [3]. A microfluidic device was also integrated with an ion-sensitive field-effect transistor (ISFET) to realize *in situ* calibration of a pH sensor (IISA-pH) [4]. All of IISA apparatuses have been operated *in situ* for system evaluations and practical operations.

EXPERIMENT

IISA-Mn equipped with a microfluidic device that has four microvalves, a flow-rate regulator, a mixer, and an optical detection flow-cell was operated in the deep-sea environment for practical survey of underwater hydrothermal sites. IISA-Mn was mounted on a remotely operated vehicle (ROV) “HYPER-DOLPHIN” (JAMSTEC). As a result of survey missions at the depth of 500 to 700 m at the Okinawa Trough area, distinct anomalies on manganese concentration were detected and novel hydrothermal sites were successfully discovered.



A PDMS microfluidic device with a PMMA flow-manifold for manganese detection (left), fluidic components of IISA-Mn (center), and ROV “HYPER-DOLPHIN” with IISA-Mn (right)

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