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MINIATURIZED SUBMERSIBLE FOR EXPLORATION OF AQUEOUS ENVIRONMENTS ON EARTH AND BEYOND

Abstract

Some of the most likely environments to support extraterrestrial life in our solar system are the ice-covered moons, such as Europa, thought to harbor a liquid ocean underneath its frozen crust. Exploration, however, necessitates an ice-penetrating cryobot, or a long and narrow borehole, and the subsequent deployment of a small submersible, a hydrobot, with severe size restrictions imposed on its scientific payload. As a stepping stone for exploration of such environments, a small instrument-ladened submersible vehicle is currently under development.

Employment of a large set of instruments capable of characterizing the aqueous environment, imaging the surroundings and collecting microorganisms is essential for the determination of habitability. Despite the submersible being only 20 cm in length and 5 cm in diameter, a high degree of functionality is facilitated here through the use of miniaturization technologies. For instance, a compact laser-illuminated diffractive optical element, paired with a high-resolution camera, enable photogrammetry and the reconstruction of objects' shapes in 3-D space. Also for imaging, the world's smallest side-scanning sonar has been developed to acoustically image, either where water is too turbid for the camera, or where longer range is necessary. Currently, the sonar exhibits centimeter resolution and ranges over 30 meters. On the sensor

side, a most vital oceanographic instrument, the CTD, used to measure the conductivity, temperature, and depth of water, has been heavily miniaturized and preliminary evaluated. Additionally, a water sampler combining integrated selection and enriching capabilities to filter out and accommodate, e.g., microbes in the size range of 1-10 μm, is under development. Among other parts, its high-pressure valves and microfluidic acoustic traps have already been realized.

For remote operation and upload of measurement data or images, or even live streaming of video, the submersible will be tethered with a bi-directionally transmitting fiber optic cable, also capable of charging the onboard batteries for long missions. The one kilometer long fiber will be fitted within the hull, and by reeling out the fiber from the submersible, drag will be reduced.

Herein, test results and images of the vehicle and its complete, and continuously developed, subsystems are presented. The vehicle, and its subsystems as stand-alone instruments, will enable the exploration of previously unreachable analog environments on Earth, vital to the field of astrobiology, and act as a forerunner to a submersible hydrobot that can explore ice-covered oceans elsewhere in our solar system.