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Development of the survival module for temperature control of scientific instruments on the lunar surface

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The lunar surface is a severe environment for the instruments especially because of its temperature and vacuum conditions. The absence of convective cooling by atmosphere makes the ground surface temperature variable in the wide range of -200 to 100 degC in which the space electronics can hardly survive. The independent devices must have a thermal control structure to regulate inner temperature into operable ranges of the instruments for a long-time measurement, such as 1 month or longer beyond the lunar nights. The objectives of this study is to develop the thermal control system (lunar survival module) for the future SELENE-2 mission.
The lunar landing mission SELENE-2 is being planned by Japan Aerospace Exploration Agency (JAXA) as the post lunar orbiter mission SELENE (Kaguya). Scientific objectives of the SELENE-2 are research for inner structure of the Moon, geological investigations and research of the lunar surface environment. This mission consists of the three main modules of the orbiter, the lander and the rover. In the mission, some scientific devices (seismometer, magnetometer, heat flowmeter, and radio source for VLBI) are proposed to be placed on the lunar ground, being thermally indepent from the lander and the rover.
The lunar survival module for SELENE-2 mission is required to be developed with some limitations; First, the module must be low power consumption, small size, and light mass in the same manner as common space instruments. Second, noise sources for the science instruments (e.g. movable or magnetic devices) should be excluded. The subsystems of communication, data processing, and power management are also required in the module. We conducted so far the concept design of the thermal module and computed its thermal model on the assumption of use for a lunar seismometer. The basic concept of the thermal module is a heat insulating shell compartment surrounding the scientific device. An emissivity-variable radiator is placed on the top of the module. The hill shape insulator retains heat in the regolith soil in the daylight, and it can keep the device warm in the night. The results of the model calculation indicated the high potential of the long-time survival. A bread board model (BBM) was manufactured and its thermal-vacuum tests were conducted to determine in detail thermal binding parameters which were assumed in the computed thermal model. The situation of the lunar surface was simulated by glass beads paved in a vacuum chamber, and a temperature-controlled insulated cylinder. The thermal parameters were finally determined by measuring temperature of any parts of the BBM in thermal cycling tests. Some of parameters of the lunar thermal model were updated, but there was no critical effect on the survivability.

Keywords: Moon, Planetary Exploration, SELENE-2, Thermal control, Thermal design