Status and Performance of the Gamma-Ray Spectrometer on the KAGUYA (SELENE)

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Remote-sensing gamma-ray spectroscopy of the bodies is extremely powerful technique for the surface measurement of the elemental abundance. Gamma-ray spectrometer (GRS), on board KAGUYA (SELENE) spacecraft launched on September 14, 2007, employed a Ge detector which has the highest energy resolution as the main detector [1]. Using the GRS observation data, we are able to measure the abundances of many elements, O, Mg, Al, Si, Ca, Ti, Fe, K, Th and U, on the Moon surface with higher precision than the past Apollo missions and Lunar Prospector had done.

The regular observation of the Moon by the KAGUYA GRS began on December 14, 2007. The high voltage (HV) applied to the Ge detector at first was 3.1 kV. After an eclipse of the Moon in February, 2008, the noise in the signal of the Ge detector became serious. The GRS stopped its observation, and the investigation of the cause was conducted for four months. The GRS resumed its observation in July, 2008, with the HV value of the Ge detector set to 2.5 kV and is continually observing lunar gamma rays except eclipses of the moon or the maintenance of the spacecraft or special operations of the GRS, which are background (BG) measurement and the Ge detector annealing (see below). For the details about scientific discussion of observation data please see Karouji et al.[2] and Kobayashi et al.[3].

The measurement of BG gamma rays is required for the quantitative evaluation of the lunar surface material. Twice background gamma ray measurement was performed while the spacecraft was pointed away from the Moon for a number of orbits. In these BG measurement operations, the GRS sensor head mounting surface sees only deep space, and the spacecraft body is between the Ge detector and the Moon.

In the first BG measurement implemented in July, 2008, we found that gamma rays from K, U, Ti and Al, which are contained in the spacecraft body and the instrument structure was emitted at significant strength. In particular the contribution of BG gamma rays from Al is significant because most parts of the spacecraft and instrumental structure are made of Al, therefore most intense gamma ray peak of Mg has the same energy with one of Al, 1368.6 keV. Accordingly the BG gamma rays from Al interfere with ones from Mg, which is very important to derive Mg#.

In the second BG measurement in December, 2008, we took sufficient time to acquire BG data so that we are able to identify the 1368.6 keV gamma ray from lunar surface even in the area where the strength of the 1368.6 keV gamma ray is the weakest. Accumulation time of BG data is about 37,000 seconds in total.

The Ge detector of the KAGUYA GRS has been exposed to high energy cosmic rays and lunar albedo neutron in transition to the Moon and lunar orbit. Therefore the Ge detector has suffered from radiation damage but it would have any deterioration in energy resolution if the detector was kept below 100K. However, the cryocooler was stopped frequently until August, 2008, serious deterioration of the energy resolution of the Ge detector was seen. It was necessary to anneal the Ge detector at a high temperature to remove the deterioration of the energy resolution by the radiation damage in the Ge detector.

We had an operation of the Ge detector annealing, conducted in December, 2008. In the operation, the Ge detector was maintained at 80 degrees Celsius for 48 hours, for high temperature annealing. After the annealing, the performance of the Ge detector was checked with HV=2.5 kV. It was found that the tails of peaks became small by comparing with the tails before annealing. The energy resolution seems to have been improved to the one at the beginning of the mission.

[1] N. Hasebe et al. *Earth Planets Space*, **60**,299-312, 2008.
[2] Y. Karouji et al. (This meeting).
[3] S. Kobayashi et al. (This meeting).