Science with the Alpha Ray Detector on-board SELENE

Masayuki Itoh[1]; Toshisuke Kashiwagi[2]; Takeshi Takashima[3]; Shoji Okuno[2]; Kenji Yoshida[2]; Kunishiro Mori[4]; Kosuke Saeki[1]; Jun Nishimura[5]

[1] Faculty of Human Development, Kobe Univ; [2] Faculty of Engineering, Kanagawa University; [3] ISAS/JAXA; [4] CLEAR PULSE Co.; [5] ISAS

Alpha Ray Detector (ARD) will be on-board SELENE. Primary target is the alpha particles emitted by 222Rn and 210Po. 222Rn is produced by the decay of 238U in the lunar ground and emitted from the lunar surface through crustal alteration and diffusion. The radon nuclei are trapped by the gravity of the Moon. With the half life of 3.8 days, 222Rn decays emitting alpha particle with the energy of 5.490 MeV. Since the emission of daughter nuclei is isotropic, half of them emitted upward escape from the Moon gravity, and the rest are deposited on the lunar surface. The daughter nuclei experience sequence of decays, and 210Po emits alpha particle with the energy of 5.305 MeV. The time span of the decay sequence is dominated by 210Pb of which half life is ~22 yr. Thus, comparison of the intensities of the alpha particles from 222Rn and 210Po provides us with the information on the variation of gas emission from the lunar surface with the time scale of tens of years.

Scientific objective of the ARD experiment includes (1) global mapping of the radio-active material, (2) identifying the gas emission location, (3) study of the gas emission mechanism and the origin of the lunar atmosphere, (4) obtaining information on the crustal alteration. For the human activities in the future, information on the locations of gas emission probably including N2, CO2, and H2O will be valuable.

Measurements of the alpha particles on the Moon were carried out by Apollo 15 and 16 in the early phase of the lunar exploration and recently by the Lunar Prospector (LP). The latter produced a global map of the alpha particle intensity. Their results indicate that the gas emission has considerable temporal variability and positional dependence. The alpha particle intensity was 2 to 3 orders-of-magnitude lower than the terrestrial value, which implies difference in radon gas transport processes.

The ARD consists of 48 silicon SSD chips each of which has 26 x 26mm2 area and 100 micron thickness. Requirement for the energy resolution is 100keV to clearly resolve the alpha particles from 222Rn and 210Po, which is enabled by the development of high-capacity low-noise pre-amplifier. The total sensitive area amounts to 326 cm2, which is 20-30 times larger than the detectors of the Apollo and LP. The field of view of the detector is limited to ~70 degrees with collimators, which corresponds to ~150km on the lunar surface. High background-rejection efficiency of more than 90% will be achieved by the anticoincidence method. The mission period is close to the solar minimum, which also contributes to reduce the background level. We expect the cosmic-ray background level of ~0.2 ct/min (in 200keV band) while the background due to the albedo protons will be ~0.9 ct/min. Estimate of the average count rate is ~2 ct/min for 222Rn and ~10 ct/min for 210Po. After the mission period of one year, the accumulated event numbers for 100km square area will be ~160 for 222Rn and ~800 for 210Po at the location around the equator where the exposure is minimum. The S/N is expected to be 15 times better than the LP case.

In summary, the large area, low background, and long observing period will give us data with high S/N and allow us detailed mapping of the alpha particle intensity to deepen our understanding of the problems mentioned above. We can investigate time variation of the gas emission with the time scale between one month and one year during the mission period as well as with the time scale of years through direct comparison with the previous missions. Joint analysis with other instruments such as the Gamma-Ray Spectrometer and Lunar Rader Sounder will be useful.

The detector fabrication is close to completion, and preflight tests are under way. Some of the sensors of the ARD were tested with the heavy ion beam facility at the National Institute of Radiological Science. We confirmed that the sensor chips have expected performance.