Basic development of miniaturized CNT-FE x-ray tube for in-situ x-ray analysis of lunar surface material

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We have been developed a X-ray fluorescence spectrometer / diffractometer (XRF/XRD) for Japanese future lunar landing mission. A new lunar investigation project called SELENE-2 is being planned as a post-SELENE mission by Japan Aerospace Exploration Agency (JAXA). The main scientific objective of the mission is in-situ investigations of geological futures around the landing site, which will be chosen in scientifically important area such as the central peak of impacts, polar region, South-Pole Aitken basin, or else. Some scientific analyzers called Science Instrument Package is mounted on the unmanned lander, and will analyze the samples brought by associated rover vehicle. XRF/XRD will be equipped on the lander as one of science instruments, and perform analyses of chemical composition and crystal structure of the samples.

XRF/XRD requires probe x-ray source to obtain fluorescent and diffract x-rays from samples. we adopt x-ray tube for the probe source, which is typical x-ray generator in laboratory. However, x-ray tube has never been embedded on spacecraft because conventional x-ray tubes have large mass and size. In the past planetary missions radioactive isotope is used for the x-ray source, which is less large size and easier to be mounted while generates less intensity of x-rays than x-ray tubes. Therefore radioactive isotope requires long measurement time to obtain significant amount of data. X-ray tube is able to make the measurement time drastically with hundreds times of x-ray intensity as high as the radioactive isotopes. For instance, same measurement of Mars Exploration Rovers (MER) fluorescent x-ray analysis, which needs some hours, will be operated only a few minutes with the x-ray tube.

SELENE-2 XRF/XRD includes a new type of x-ray tube based on the electron field emission (FE) from carbon nanotubes (CNT) to achieve miniaturizaed strong x-ray source. The CNT is the powerful electron source which needs neither additional heating nor micro fabrication, and has large electron current and long lifetime. Using the CNT cold cathode as the electron gun in x-ray tubes allows cutting off large cooling system of conventional x-ray tubes, generating enough intensity of x-rays. Finally, size of 1 cm x 1 cm x 2 cm miniaturized x-ray tube which still has high intensity of x-rays and weight light enough to be carried on spacecraft will be achieved. The objective of this study is to validate the possibility of the CNT-FE x-ray tube to be carried on spacecraft by experimental methods. In the past study, we have developed the experimental setup for evaluations of the electron field emission from CNT cathode, and performed some evaluation tests for a future miniaturized X-ray tube. As a result, the electron emission from CNTs and subsequent X-rays were confirmed, and have large possibility for miniaturization with high performance. Currently, a prototype of the CNT-FE x-ray tube is being developed for more evaluations and considerations of actual application on the future XRF/XRD. We would like to show results of our experiments of CNT-FE x-ray tube, and actual application methods of the miniaturized x-ray tube.