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Detection experiment of Ar emission lines for K-Ar dating using Laser-Induced Breakdown Spectroscopy

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JAXA is currently planning the lunar lander SELENE-2 project, a follow-up mission of SELENE. This project involves the dispatch of a lunar rover to investigate the lunar surface and rocks. We propose Laser-Induced Breakdown Spectroscopy (LIBS) as an instrument for mounting rovers. The LIBS conducts in-situ analysis of elemental composition.

The LIBS instrument uses a high intensity laser pulse and induced plasma. The plasma emits energy in the form of photons. The spectroscopic analysis of the plasma enables the determination of the elemental composition.

K-Ar dating is a radiometric method used in geochronology. It is based on the measurement of the product of the radioactive decay of ^{40}K into ^{40}Ar with a half-life of 1.25 Gyr. K is found in many rocks. Therefore, we can determine the solidification age of rocks by measuring the ratio of ^{40}K to ^{40}Ar in the rock. In the existing K-Ar dating method, K is measured using LIBS and Ar is measured using quadrupole mass spectrometry (QMS); thus, the method needs two measuring instruments. Our method can be applied to measure both K and Ar using only LIBS. Therefore, the instrument weight will be reduced if our method is applied successfully. The Curiosity rover, a part of NASA's Mars Science Laboratory mission, used LIBS to obtain the spectra of rocks present on the surface of Mars. The Curiosity rover's LIBS instrument detected K in the rocks. However, Ar has not been detected using LIBS. We conducted experiments to detect the Ar emission lines using LIBS.

Commonly, the temperature of plasma induced using LIBS is approximately 1eV (11600K) in the atmosphere. When temperature of plasma was 1eV, we expected that it is possible to detect the Ar emission lines at the wavelengths of 104.8nm and 106.7nm in the vacuum ultraviolet spectral range because no emission lines of neutrals and singly-charged ions of major elements exist in the range. However, as a result, we found that the plasma temperature might be several tens of eV in vacuum. We found that relative intensity of multiply-charged ions (e.g. Si(Ⅳ), Fe(Ⅱ)) emission lines is much stronger than the Ar emission lines. Therefore, we decreased the temperature of plasma in vacuum by decreasing the pulse laser intensity and conducted experiments. In addition, we conducted experiments to investigate the Ar emission lines, which we might be able to detect when the plasma temperature is higher than 1eV, in the vacuum ultraviolet (VUV)-near infrared (NIR) range in vacuum.

Keywords: LIBS, elemental compositions, K-Ar dating, Planetary Explora, Moon