THERMAL RELEASE AND DIFFUSION OF HELIUM-4 IMPLANTED INTO LUNAR SIMULANTS

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Introduction: Noble gases and various isotopes in lunar sample and meteorites provide unique and extensive information about a broad range of fundamental questions [1, 2]. Diffusion properties of noble gases are important in the interpretation of such noble gases data. In addition, 3He in the lunar soil is one of the most valuable resources as a fusion fuel. Knowledge of trapping mechanisms and diffusion characteristics of implanted noble gases will enable the optimization of the processes to extract 3He from lunar soil [3]. Here we report 4He implantation and extraction experiments. 4He release pattern and diffusion mechanism in lunar simulants grains were studied.

Experiments: We performed an experiment of solar wind ions implantation and 4He extraction. High-Ti mare soil simulant (CAS-1) [4], highland lunar soil simulant (NAO-1) [5], and Panzhihua ilmenite are irradiated in the experiments. The energy of 4He ions is 50 keV. The irradiation dose is 5×10¹⁶ ion/cm², five times of irradiation saturation dose [6, 7]. After implantation, the samples were analyzed in noble gas mass spectrometry. The samples were heated from 200 to 1500 °C, with 100 °C stepwise interval.

Results: Lunar simulants, CAS-1 and NAO-1, display similar 4He release patterns in curve shape as lunar soil, but release temperatures are little lower. This is probably a consequence of long-term diffusion after implantation in lunar soil grains. Panzhihua ilmenite displays a different helium release pattern with lunar simulants. Helium release temperatures of Panzhihua ilmenite are higher than those of lunar simulants. Based on the data, we calculated the helium diffusion coefficient (D) and activation energy (Ea) using the equation in [8]. In the Arrhenius plots, we note variation of diffusion parameters of CAS-1 and NAO-1 as temperatures were increasing. It is not consistent with simple thermally activated volume diffusion. The variation could be attributed to physical transformation during high temperature. Activation energy of 4He in Panzhihua ilmenite is apparently higher than Ea of CAS-1 and NAO-1, especially at low temperature range. This result confirms that ilmenite is more retentive for noble gas than other lunar materials.