

Crystal Structure of NaCl on Europa's Subsurface Originated from Subsurface Ocean: Based on Plasma Irradiation Experiments

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Europa, an icy satellite of Jupiter, has an interior ocean that is expected to be habitable for life. Since material transport between the ocean and surface layer has been suggested (Schubert et al. 2004), understanding the chemical composition of the surface layer could provide insights into the chemistry of the ocean. However, the surface material composition is still unknown because it must be altered immediately after the transport from the ocean due to exposure to Jupiter's magnetospheric plasma and other elements. The telescopic data showed absorption signatures in the solar reflectance spectrum at wavelengths of 450 nm and 230 nm in the Tara Regio (Doggett et al. 2009; Trumbo et al. 2022), which is over 1,000 kilometer-wide area of the Chaos Terrain and is likely an active in the eruption of the ocean materials (Roth et al. 2014). These are consistent with the absorption structures in the reflectance spectra generated by electron irradiation of NaCl in laboratory experiments, which would be 'color centers' corresponding to lattice defects in the NaCl crystal (Trumbo et al. 2022). However, the relationship between the spectral absorption depth of the color centers and irradiation conditions is still unresolved, which leads to difficulty for the crystal structure estimation from the spectral observation. Therefore, the alteration state of NaCl in the Europa surface layer has not been unveiled.

Here we attempted to relate the color center absorption, irradiation conditions, and crystal structure for the first time based on the irradiation of NaCl samples with energetic electrons and multiple optical analyses. Pelletized powder NaCl was irradiated at room temperature (300 K) with electrons at an irradiation energy of 10 keV with a flux of $8.51\text{E}+14/\text{s}/\text{cm}^2$ for 90 min and 5 min, and the UV-visible reflectance spectra were measured (Hoshino et al. in prep.). The data analysis of these reflectance spectra showed that no absorption at 230 nm was observed, unlike the previous study by Brown et al. (2022), while absorption structures at 460 nm, 720 nm, and 580 nm were identified as in Cerubini et al. (2022). The correlation between the absorption depth and total irradiance (fluence) indicated positive correlations for the absorptions at 460 and 720 nm, while a negative correlation at 580 nm. The 580 nm absorption corresponds to Na colloids (Sugonyako. 2007), so our result can be interpreted that Na colloids in the crystals are more abundant for less total irradiation in the $2.55\text{E}+17 - 4.60\text{E}+18 / \text{cm}^2$ range if the initial condition is $2.55\text{E}+17/\text{cm}^2$. In the future, we are going to investigate the dependence of the absorption's depth and flux. The crystal structure of NaCl samples after irradiation will be directly evaluated using the cathode luminescence method developed by Sadgrove et al. (2022), which is a crystal structure analysis that suppresses the sample alteration. In this presentation, we will report the current status of our experiments.

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