Electron irradiations onto ice-salt mixtures at low temperatures: Implications for chemical evolution and oxidant formation on Europa

*丹 秀也[2,1]、関根 康人[2]、羽馬 哲也[3]
*Shuya Tan[2,1], Yasuhito Sekine[2], Tetsuya Hama[3]

1. 東京大学大学院理学系研究科地球惑星科学専攻、2. 東京工業大学地球生命研究所、3. 北海道大学低温科学研究所
1. Department of Earth and Planetary Science, Graduate School of Science, the University of Tokyo, 2. Earth-Life Science Institute, Tokyo Institute of Technology, 3. Institute of Low Temperature Science, Hokkaido University

The ice-rich surface of Europa is known to be irradiated with high-energy particles, such as electron, accelerated by the Jovian strong magnetic field (e.g., Paranicas et al., 2009). The high-energy particle irradiations could have caused particular chemical reactions on the surface, possibly including dissociation of H_2O and subsequent oxidation of surface salts, such as chlorides and sulfates/sulfides (e.g., Carlson et al., 2009; Hand et al., 2011). In addition, sputtering of the surface ice and salts by high-energy particles is proposed to be a major source of the tenuous atmosphere on Europa (e.g., Johnson et al., 2009; Brown and Hill, 1999). However, the detailed chemical reactions on Europa’s surface have been poorly constrained.

Here we construct a novel experimental system for irradiation of electron onto ice and salt (e.g., chloride: NaCl and $MgCl_2$) mixtures at low temperatures. Laboratory experiments on electron irradiation onto NaCl salt have been conducted at low temperatures corresponding to Europa’s surface (e.g., Hand and Carlson, 2015). However, no experiments have been performed to simulate the irradiation of electron onto ice and salt mixtures on Europa. Upon electron irradiation onto ice and chloride mixtures, chloride may be oxidized into perchlorate salts. If the surface materials are provided into the subsurface ocean through crustal recycling (e.g., Hand et al., 2007), perchlorate would become an important oxidant to generated redox disequilibria in the ocean. We report preliminary results on the electron irradiation experiments using the newly-constructed system.

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