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イトカワ粒子の宇宙風化産物の STEM 観察と N2 パージ環境の重要性
STEM observation of space weathering products on the Itokawa dust particles and importance of N2 purge environment

野口 高明 [1*], 木村 眞 [1], 橋本 隆仁 [2], 今野 充 [2], 中村 智樹 [3], Zolensky Michael[4], 田中 雅彦 [5], 藤村 彰夫 [6], 安部 正真 [6], 矢田 達 [6], 向井 利典 [6], 上野 宗孝 [6], 岡田 達明 [6], 白井 慶 [6], 石橋 之宏 [6], 上椙 真之 [6], 唐牛 譲 [6], 岡崎 隆司 [7], 土山 明 [8]
NOGUCHI, Takaaki[1*], KIMURA, Makoto[1], Takahioto Hashimoto[2], Mitsuru Konno[2], NAKAMURA, Tomoki[3], ZOLENSKY, Michael[4], TANAKA, Masahiko[5], FUJIMURA, Akio[6], ABE, Masanao[6], YADA, Toru[6], MUKAI, Toshifumi[6], UENO, Munetaka[6], OKADA, Tatsuaki[6], SHIRAI, Kei[6], ISHIBASHI, Yukihiro[6], UESUGI, Masayuki[6], KAROUJI, Yuzuru[6], OKAZAKI, Ryuji[7], TSUCHIYAMA, Akira[8]

[1] 茨城大学, [2] 日立ハイテクノロジーズ, [3] 東北大学, [4]NASA/JSC, [5] 物質材料研究機構, [6] 航空宇宙研究開発機構, [7] 九州大学, [8] 大阪大学
[1]Ibaraki University, [2]Hitachi High technologies Co., [3]Tohoku University, [4]NASA/JSC, [5]NIMS, [6]JAXA, [7]Kyushu University, [8]Osaka University

Surfaces of airless bodies exposed to interplanetary space gradually have their structures, optical properties, chemical compositions, and mineralogy changed by solar wind implantation and sputtering, irradiation by galactic and solar cosmic rays, and micrometeorite bombardment. These alteration processes and the resultant optical changes are known as space weathering [1, 2, 3]. Our knowledge of space weathering has depended almost entirely on studies of the surface materials returned from the Moon and regolith breccia meteorites [1, 4, 5, 6]. Lunar soil studies show that space weathering darkens the albedo of lunar soil and regolith, reddens the slopes of their reflectance spectra, and attenuates the characteristic absorption bands of their reflectance spectra [1, 2, 3]. These changes are caused by vapor deposition of small (less than 40 nm) metallic Fe nanoparticles within the grain rims of lunar soils and agglutinates [5, 6, 7].

Structure of nanoparticle-bearing rims by the initial analysis of the Itokawa dust particles are as follows. Sulfur-bearing Fe-rich nanoparticles exist in a thin (5-15 nm) surface layer (zone I) on olivine, low-Ca pyroxene, and plagioclase, suggestive of vapor deposition. Sulfur-free npFe exist deeper inside (less than 60 nm) ferromagnesian silicates (zone II). Their texture suggests formation by amorphization and in-situ reduction of Fe2+ in ferromagnesian silicates [8]. On the other hand, nanophase metallic iron in the lunar samples is embedded in amorphous silicate [5, 6, 7]. These textural differences indicate that the major formation mechanisms of the metallic nanophase iron are different between the Itokawa and the lunar samples.

Eleven of them were embedded in epoxy resin and ultramicrotomed into about 100 nm-thick ultrathin sections. Four of them were preserved in N2 purge environment from the curation facility at ISAS/JAXA through ultramicrotomy at Ibaraki University to STEM observation at Hitachi high-technologies Co. Six samples were enclosed in thin (a few micrometer thick) epoxy resin at the curation facility to avoid long-haul exposure to the earth's atmosphere during experiments at Spring-8 and KEK-PF. Although these six samples ultramicrotomed in the earth's atmosphere, dehydrated ethylene glycol was used as trough liquid instead of distilled water to avoid unnecessary contact with water. Total exposure time to the earth's atmosphere was less than a few hours for these samples. One sample was kept in a desiccator for about one month at Osaka University, which means that it was kept in earth's atmosphere for a month. To evaluate the effect of long exposure to the earth's atmosphere, ultrathin sections were prepared for this sample by using the same procedures of the above six samples. All the samples were investigated using a spherical aberration corrected scanning transmission electron microscope to investigate space weathering products on the samples.

STEM observation of these particles revealed that some nanoparticle-bearing rims are vesiculated. Different from vesicular rims on the surface of lunar samples [5, 6], vesiculation occurred at the boundary between zone I and zone II or within zone II. We found that two samples without nanoparticle-bearing rims by have quite thin (2-3 nm) surface layers with elements that are not included in the substrate minerals, suggestive of vapor deposition from the surrounding minerals. We think that the quite thin layers are the immediate-early product of space weathering.

References: [1] Hapke, B. (2001) JGR, 106, 10039-10073. [2] Clark, B. E. et al. (2002) In Asteroids III, Tucson, Univ. Ariz. Press. [3] Chapman, C. R. (2004) Ann. Rev. Earth. Planet. Sci., 32, 539-567. [4] Hapke, B. Moon, 13, 339-354. [5] Keller, L. P., McKay, D. S. (1997) GCA, 61, 2331-2341. [6] Noble, S. K. et al. (2005) MAPS, 49, 397-408. [7] Pieters, C. M. et al. (2000) MAPS, 35, 1101-1107. [8] Noguchi, T. et al. (2011) Science, 333, 1121-1125.

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