CRYSTALLOGRAPHIC STUDY OF ITOKAWA PARTICLE, RA-QD02-0127 BY USING ENERGY-SCANNING X-RAY DIFFRACTION METHOD WITH SYNCHROTRON RADIATION.

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Introduction: The petrographic study of Itokawa particle, RA-QD02-0127 has been performed by SEM-EDS and optical microscope observations [1]. The purpose of this study is to understand better the metamorphic and impact shock history of asteroid Itokawa, and other S-class asteroids.

Experimental: The sample particle has been embedded in epoxy glue for optical microscope and FEG-SEM observations. Because of the unsuitable form for X-ray diffraction, we studied it by energy-scanning X-ray diffraction method with synchrotron radiation [2]. The stationary sample method is advantageous, because the irradiated area of the sample is always same and fixed, meaning that all diffraction spots occur from the same area of the sample. We employed the intense X-ray source of SPring-8, Hyogo, Japan. At beam line BL37XU an undulator is installed and white undulator radiation is further monochromatized using a Si (111) double-crystal monochromator. A Kirkpatrick and Baez mirror is equipped at upstream of the sample giving the beam size of ~ 0.7(V) x 2(H) μm^2 on the sample position. The analyzed sample was attached on the XYZ-stage, and the target point was adjusted on the micro-beam position under an optical microscope. Three points with different composition observed by EPMA were analyzed. They are olivine, low-Ca pyroxene and plagioclase [1]. We applied X-ray energies from 30.00 to 20.00 keV (wave length $\lambda = 0.4133$-0.6199 Å) at steps of -0.04 keV with each exposure time being 0.5 seconds. Then, 251 diffraction patterns were measured on the two-dimensional detector (CMOS Flat panel detector, Hamamatsu Photonics K.K.) without rotating the sample. Because several diffraction spots were saturated in spite of shorter exposure time, an attenuator (Al plate: thickness 5 mm or 10 mm) was equipped at upstream of K-B mirror and similar measurements were performed. The instrument parameters such as camera distance were calculated from the coordinates on the Debye-Scherrer rings in the diffraction pattern of Si powder (NIST 640c) taken at 30 keV and the values were used for further analysis.

Analysis and Result: The diffraction images collected from olivine domain were analyzed. A Laue pattern obtained by superimposing 251 diffraction images is complicated. This means multiple domains exist in the irradiated area. Almost all diffraction spots were sharp. Several weak diffuse diffractions were observed around the several strong diffractions. Such sharp diffraction spots are consistent with relatively low shock grade (S2) indicated by optical microscope observations [1]. The weak diffuse diffractions indicate that the small fragments were formed by cracks around the surface of large domains. Except for weak diffuse diffraction, 93 diffractions spots were analyzed. Intensities of the spots are changed corresponding to the energy of the incident X-ray, and we can determine the energy of each diffraction spot with maximum intensities. The positions (x, y) of the diffraction spots at their maximum intensities were determined as those of the top of the diffraction profile fitting with the 2-D Gaussian function. Then, d-values are derived from the set of diffraction spots with positions on the detector and X-ray energies. In order to assign indices, it was necessary to classify the attribution of diffraction spots to each domain. The diffraction spots accompanied by diffuse diffractions were assigned to the same domain. Several spots of them were successfully indexed based on d-values calculated by the olivine unit cell. We ran a simulation of the diffraction patterns using the positions obtained from the olivine cell, and then a total of 34 diffraction spots were indexed as domain 1. A new domain was found following the same procedure. Finally, we found four domains following the same approach. All of 93 diffraction spots were indexed, 34, 29, 19 and 11 diffraction spots are assigned to domain 1 to 4, respectively. The cell parameters of domains 1 and 2 are refined based on the d-values. The observed cell parameters, domain 1: a=4.7779(8) Å, b=10.2808(13) Å, c=6.018(2) Å and domain 2: a=4.7774(7) Å, b=10.272(3) Å, c=6.0163(9) Å. These values give a composition of $Fo_{68.4}$, $Fo_{70.1}$, $Fo_{66.5}$ for domain 1 and $Fo_{69.2}$, $Fo_{73.2}$, $Fo_{68.4}$ for domain 2, respectively by the Vegard's law [3]. The average value ($Fo_{69.6}$ for domain 1 and $Fo_{70.3}$ for domain 2) is close to the value obtained by EPMA [1].

References: [1] Komatsu M. et al. 2015. Abstract #1884. 46th Lunar & Planetary Science Conference. [2] Hagiya K. et al. 2010. Abstract #5083. *Meteoritics & Planet. Sci.,* 45. [3] Akimoto S. and Fujisawa H. 1968. *Journal of Geophysical Research* 73:1467–1479.