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Atomic columns in rock-forming mineral using Cs-corrected STEM

Akira Miyake[1*], Shoichi Toh[2], Keiichi Fukunaga[3]

[1]Kyoto Univ., [2]Kyushu Univ., [3]JFCC

A high angle annular dark field (HAADF) scanning transmission electron microscopy (STEM) has become widely used in the filed of materials sciences such as studies on ceramics, semi-conducting material and metals, because of high-resolustion capability and easily interpretable image contrast, which is roughly proportional to square of atomic number Z (Z^2). Howerver, the HAADF-STEM image sometimes gives lack of light element because the signal scales strongly with Z: when heavy elements are present, light elements are varely visible if at all. Recently, Okunishi et al (2009) & Findlay et al. (2009, 2010), presented a novel imaging mode for STEM which uses an annular detector spanning a range within the illumination cone of the focused electron beam. It was shown that the resultant images enable one to determine the location of columns containing light elements. This imaging mode was called annular bright field (ABF) imaging. The framework of most of rock forming minerals is composed from oxygen elements, and cation such as silicon, aluminum, magnesium, ..., is included in the framework. In this study, atomic columns in rock forming minerals were directly observed using Cs-corrected STEM. STEM specimens were made using focused ion beam (FIB, FEI Quanta 200 3DS) at Kyoto Univ. and HAADF- & ABF-STEM observation were performed using JEM-2400FCS (JEOL) at JFCC with an annular bright field and dark field detectors as well as a spherical aberration correction system for STEM. HAADF-STEM image of forsterite parallel to a-axis shows the magnesium atom columns and the columns which alternately formed of silicon and oxygen atoms. On the other hand, the ABF-STEM image shows the oxygen atom columns in addition.