CONDENSATION ANISOTROPY OF CORUNDUM AROUND AGB STARS AND ITS EFFECT ON INFRARED SPECTRA. A. Takigawa[1], S. Tachibana[1], H. Nagahara[1], and K. Ozawa[1], [1]Department of Earth and Planetary Science, University of Tokyo, 7-3-1 Hongo, Tokyo 113-0033, Japan (takigawa@eps.s.u-tokyo.ac.jp).

Introduction: Dust formation in mass-loss winds from asymptotic giant branch (AGB) stars is a key process for acceleration of outflows. Equilibrium condensation calculations [e.g., 1] predict that corundum (Al_2O_3) is one of the first condensates around oxygen-rich AGB stars. The presence of presolar corundum grains originated from AGB stars in chondrites [e.g., 2-5] is also a strong evidence of corundum formation around AGB stars. Therefore, corundum is considered to be a possible carrier for the 13-μm feature observed in many oxygen-rich AGB stars as well as spinel ($MgAl_2O_4$) and rutile (TiO_2) [6]. However, the peak position is not completely reproduced by these minerals.

We have recently shown that an infrared spectrum of forsterite strongly reflects a specific combination of shape and crystallographic orientation, and the combination reflects dust-forming processes and conditions [7]. Thus, the morphology of candidate minerals for the 13-μm feature should be taken into account and it should reflect the formation condition of the grains around AGB stars. In this study, in order to understand the spectral features of corundum that reflect the dust-forming process (growth from gas), we conducted condensation experiments of corundum at high and low supersaturation ratios ($S = P_{AlO}/P_{eq}$) and investigated the effects of condensation conditions on infrared spectra.

Condensation Experiments: Condensation experiment were conducted in a vacuum chamber made of stainless steel with a tungsten mesh heater. The chamber was evacuated using a rotary and a turbo molecular pump to high vacuum (~10^{-4} Pa). An alumina pipe (15 mm ϕ), put in the chamber as an evaporation source, was pre-evacuated at 500°C and heated at a constant rate to 1535°C, which is the melting temperature of metallic iron. It was heated at 1535°C for 240 hours and was quenched by turning off the heater. Gas evaporated from the pipe condensed on a molybdenum substrate (20 × 20 mm^2), which was placed at the top of the pipe. Because the presence of conductance of the pipe, the pressure of gases evaporated from corundum should be higher in the inside of the tube than the outside of the pipe. Therefore, the supersaturation ratio (S) of Al-bearing gas species at the surface of the substrate was higher and lower at the inside and outside of the pipe, respectively.

The condensates were observed by FE-SEM (JEOL JSM-7000F) and determined their composition and crystallographic orientations by energy-dispersive X-ray spectroscopy (EDS) and electron back-scatterred diffraction (EBSD).

Results: Figure 1 shows the SEM images of condensates on the molybdenum substrate. EDS analyses showed that all the condensates have the composition of Al_2O_3 and EBSD analyses showed that they were corundum (α-alumina; Fig.1).

Anisotropy in condensation of corundum clearly changed with the supersaturation ratio (S). Corundum condensed at higher S had whisker-like shapes elongating along the c-axis (Fig. 1a), while hexagonal platy corundum flattened along the c-axis condensed at the lower S (Fig. 1b).

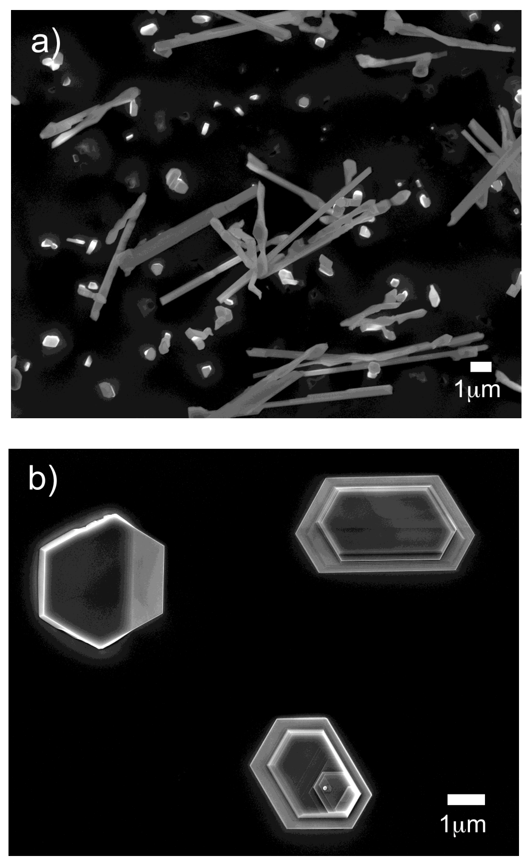

Figure 1 Corundum (α-alumina) condensed at 1535°C on the molybdenum substrate (a) at the higher supersaturation ratio and (b) at the lower supersaturation ratio.

Calculation of mass absorption coefficients of platy and needle-like corundum grains: We calculated mass absorption coefficients of oblate- and prolate-shaped corundum with different aspect ratios in the Rayleigh limit [8] with optical constants of [9] (Fig. 2). The infrared spectra of corundum grains largely depend on the combination of shape and crystallographic orientation as in the case of forsterite.

Two strong peaks at slightly shorter and longer than 13 μm (12.7 and 13.2 μm) and two very weak peaks at 16 and 20 μm are present for spherical grains. In the case of prolate particles elongating to the c-axis (Fig. 2a), the strong peak at 12.7 μm for spheres appears at an even shorter wavelength and its strength becomes weaker than that of spheres. The strong peak at 13.2 μm moves to the longer wavelength side with keeping its strength even in the case of extremely elongating prolates. The characteristic feature for prolates is the appearance of an additional strong peak at 20-24 μm. Thus, it is impossible to reproduce a single peak at 13 μm by prolate spheroids.

On the other hand, the strong peak at 12.7 μm shifts to the longer wavelength for oblate particles flattened along the c-axis (Fig. 2b). The 13.2 μm peak shifts to the longer side and its intensity deceases with increasing the degree of flattening. The strengths of other two weak peaks remain weak as long as the aspect ratio of $c_{\perp}/c_{//}$ is small. Therefore, comparison between the calculated spectra of corundum and those observed around oxygen-rich AGB stars shows that oblate-shaped corundum grains with the aspect ratio ($c_{\perp} : c_{//}$) of 1 : 0.7 well-reproduce the observed 13-μm feature (Fig. 2b). Although more systematic experiments and quantitative discussion are necessary, the present results imply that corundum grains around oxygen-rich AGB stars form by condensation at a relatively low supersaturation ratio and that understanding of anisotropy in corundum condensation is essential to reveal the forming environment of refractory dusts around AGB stars.

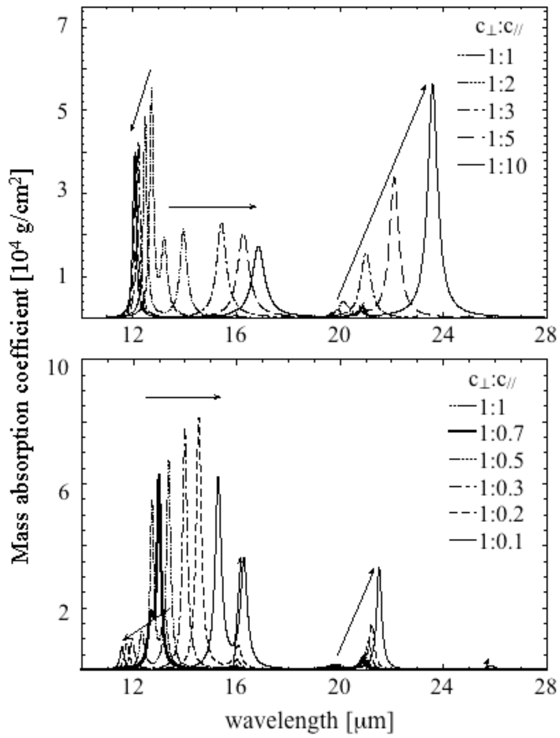

Figure 2 Mass absorption coefficients of corundum with (a) prolate spheroids elongating to the c-axis and (b) oblate spheroids flattened along the c-axis. Oblates with c⊥ : c// = 1 : 0.7 (thick-solid line in (b)) well reproduce the observed 13-μm peak position.

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