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Effect of anisotropic crystallization on the IR absorption spectra of silicates

Keisuke Murata[1]; Hiroki Chihara[2]; Takashi Takakura[1]; Chiyoe Koike[3]; Akira Tsuchiyama[1]

[1] Earth and Space Sci., Osaka Univ.; [2] Dept. of Earth and Space Sci., Osaka Univ.; [3] none

Characteristic 11.2 micron band of olivine ($(Mg, Fe)_2SiO_4$), the most diagnostic feature in mid-IR observations, has been observed around circumstellar environments of both evolved and young stars and comets. The band position has provided a diagnostic means to determine the iron content of the olivine crystals from spectroscopic observations.

In order to investigate anisotropic crystal growth of olivine, we calculated IR spectra of oblate forsterite particles shorten along the one axis and prolate forsterite particles elongated along the one axis. Our spectral calculations indicated that the 11.2 micron band is very sensitive to anisotropy of each crystal axis of forsterite.

In our previous laboratory experiments, the IR spectra of olivine crystallized from amorphous silicates show peak shifts of the bands of olivine to longer wavelength during the crystallization process. For confirmation of the correlation between the IR spectral peak positions of olivine and the Mg/Fe ratios, we estimated both peak positions and atomic Mg/(Mg+Fe) ratios of olivine contained in the heated amorphous silicates using IR absorption spectroscopy and synchrotron X-ray diffraction. From comparison with the previous study on the IR spectra of olivine, the peak position of the 11.2 micron band in the present study shifts very widely due to not only the atomic Mg/(Mg+Fe) ratio but also the crystallization process of olivine. Compared with the calculation result, it is considered that anisotropic crystal growth of olivine induced peak shift of the 11.2 micron band. Our study suggests that anisotropic crystallization affects crystalline silicate features observed in astronomical spectra.