

Thermal expansion of forsterite (Mg_2SiO_4), corundum ($\alpha\text{-Al}_2\text{O}_3$), and platinum (Pt) to 1713K

Akira MIYAKE^{*1}, Masaki TAKAYA¹, Yu Kodama¹, and Shugo OHI²

¹Department of Geology and Mineralogy, Division of Earth and Planetary Science, Graduate School of Science, Kyoto University, Kitashirakawa-Oiwakecho, Sakyo-ku, Kyoto, 606-8502, JAPAN;

²Department of Interdisciplinary Environment, Graduate School of Human and Environmental Studies, Kyoto University, Sakyo-ku, Kyoto, 606-8501, JAPAN

Introduction

High-temperature synchrotron powder diffractometry is a powerful method to study crystal structure and phase transformation at high temperatures and enables the precise determination of unit-cell parameters. The angular resolution in synchrotron powder diffractometry could be much higher than that in conventional laboratory-based X-ray powder diffraction measurements. Yashima et al. (2005, 2006) designed and fabricated the high-temperature furnace to measure the high-resolution synchrotron powder diffraction data at the BL-4B2 experimental station of the Photon Factory, Tsukuba. In particular, at the BL-4B2, the multiple-detector system with six detector arms was constructed by Toraya et al. (1996) to measure the high-resolution synchrotron powder diffraction data. We report the cell parameters and thermal expansion of platinum (Pt), corundum ($\alpha\text{-Al}_2\text{O}_3$), and forsterite (Mg_2SiO_4) using this system.

Experiment

Powder XRD experiment from room temperature to 1715 K at atmospheric pressure was carried out with synchrotron X-ray in order to identify the diffraction pattern in high resolution. It was performed by using a multiple-detector system and a compact furnace (Toraya et al., 1996, Yashima et al., 2005, 2006) at the BL-4B2 beam line of the Photon Factory (PF), High Energy Accelerator Organization (KEK) in Tsukuba.

A little Pt powder was sprinkled on corundum (Sample 1) or forsterite (Sample2) and was not contacted to sample holder, which is composed of Pt/Rh (10%). The wavelength of the X-ray beam was 1.197547(5)Å in the experiments for Sample1 and 1.19766(1)Å in those for Sample2. The step interval for scanning was 0.01° and the diffraction angle (2θ) ranged from 15.00 to 150.00°. Cell parameters of Pt, corundum, and forsterite in Sample 1 and 2 were refined by the Rietveld method from the X-ray diffraction data with RIETAN-FP (Izumi & Momma, 2007).

Results and Discussion

Refined cell parameter at room temperature (297K) of Pt is $a=3.92310(19)$ Å, those of corundum are $a=4.75846(32)$ Å and $c = 12.98969(63)$ Å, and forsterite are $a = 10.19570(62)$ Å, $b = 5.98087(36)$ Å, and $c = 4.75487(29)$ Å. This result is good agreement the cell parameter

of Pt is 3.92374 Å at 297 K calculated from Arblaster (2006).

The thermal expansions of cell parameter and molar volume in Pt, corundum and forsterite can be well described by the quadratic functions in angstrom unit in the temperature range between 298 and 1715 K. The temperatures were estimated from a control thermocouple.

Pt:

$$a(T) = 5.480 \times 10^{-9} \times T^2 + 3.200 \times 10^{-5} \times T + 3.913$$

$$V(T) = 2.795 \times 10^{-7} \times T^2 + 1.455 \times 10^{-3} \times T + 5.992 \times 10^1$$

Corundum:

$$a(0) = 6.275 \times 10^{-9} \times T^2 + 2.877 \times 10^{-5} \times T + 4.749 \times 10^0$$

$$b(T) = 1.926 \times 10^{-8} \times T^2 + 8.684 \times 10^{-5} \times T + 1.296 \times 10^1$$

$$V(T) = 1.124 \times 10^{-6} \times T^2 + 4.718 \times 10^{-3} \times T + 2.532 \times 10^2$$

Forsterite:

$$a(T) = 2.164 \times 10^{-8} \times T^2 + 1.100 \times 10^{-4} \times T + 1.016 \times 10^1$$

$$b(T) = 1.154 \times 10^{-8} \times T^2 + 5.769 \times 10^{-5} \times T + 5.963 \times 10^0$$

$$c(T) = 7.271 \times 10^{-9} \times T^2 + 3.125 \times 10^{-5} \times T + 4.745 \times 10^0$$

$$V(T) = 1.789 \times 10^{-6} \times T^2 + 7.682 \times 10^{-3} \times T + 2.875 \times 10^2$$

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* miya@kueps.kyoto-u.ac.jp