# Synthesis of world's largest olivine single crystals for property measurements

Kazuhiko Ito[1], # Hiroki Sato[2], Hideki Kanazawa[3], Humihiko Takei[4]

[1] Faculty of Business Administration, Southern Osaka Univ., [2] Earth and Space Sci., Osaka Univ., [3] Human and Environmental Studies, Kyoto Univ, [4] Earth and Space Sci., Osaku Univ

Olivine is the most abundant phase of the Earth's upper mantle. Production of large olivine single crystals will greatly facilitate the study of the terrestrial mantle. Particularly in the upper mantle, many geophysical observations show anisotropic physical properties. For systematic anisotropy measurements, it is essential to prepare homogeneous specimens cut for various crystallographic directions from one large single crystal. Here we show a new simple and practical method for producing a large olivine single crystal.

We synthesized an olivine single crystal by the Czochralski-pulling (CZ) method with a pure-iridium crucible of 90 mm diameter and 90 mm height. The major impurities in the single crystals come from starting reagents and stoichiometry. High-purity reagents, such as MgO, SiO2 and Fe(COO)2, have been used to synthesize olivine; however, controlling the reduction-oxidation state of FeO was often troublesome. Here we simply used natural olivine from San Carlos, USA as a source material. The Earth's upper mantle does not consist of a simple forsterite (Fo)-fayalite (Fa) solid solution, but consists of natural olivine. Synthesizing large single crystals from natural sources is particularly important for determining physical and chemical properties of earth and planetary constituents.

Before heating, lumps of natural olivine were thoroughly washed in the acetone. About 1.2 kg olivine was mounted in the crucible, and heated up to 2000C under N2 atmosphere. After olivine was completely melted, the temperature was decreased to right above the liquidus of olivine. Then a rotating forsterite seed crystal (20 rpm) was attached to the melt surface, and slowly pulled up at a rate of 5 mm/hour. A growing olivine single crystal followed up the pulling seed. After the experiment, we found no major reactions between molten San Carlos olivine and the Ir-crucible.

We will show an as-grown crystal of olivine (250 carats) growing along the [100] direction. The initial mass of the totally molten olivine was large (1.2 kg) so that a 250-carats single crystal produced here is rather homogeneous, showing a uniform color. In the crystal, no inclusions, voids or zonings were observed under stereoscopic microscope. We have also examined the thin sections of the olivine single crystal. The bulk of the crystal is generally clear, and no significant defects or inclusions are observed.

We determined Fo contents of the present olivine single crystal by EPMA. The olivine single crystal has a uniform composition of about Fo97.1Fa2.9. No iridium inclusions or compositional zonings were observed by EPMA analysis and optical microscope. We have also taken an X-ray diffraction pattern of the present olivine single crystal, showing that all the diffraction spots are sharp and clear. The EPMA and X-ray examinations demonstrate that the present olivine single crystal is homogeneous and has sufficient quality. The olivine crystal is large enough to conduct, e.g., systematic deformation experiments for various crystallographic directions. Our new attempts to use natural olivine with a wide Ir-crucible are successful, and promising to produce large olivine single crystals successively. Large single crystals of various minerals will be synthesized from natural sources, if the minerals are stable up to the liquidus temperatures at one atmosphere.

The authors thank the Material Design and Characterization Laboratory, the Institute for Solid State Physics of the University of Tokyo, for the Czochralski-pulling facilities. This work was supported by grants from JSPS (C12640467), and from the Earthquake Research Institute of the University of Tokyo (2001-A-18 and 2002-A-18).