Preferred orientation in $CaIrO_3$ formed by the plastic deformation under pressure

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INTRODUCTION

Since the discovery of "post perovskite" phase in $MgSiO_3$, numerous arguments have been made to explain the characteristic property of D" layer assuming the existence of this phase at the bottom of the lower mantel. Based on theoretical calculations, strong elastic anisotropy is expected to exist in the post perovskite phase of $MgSiO_3$. Therefore if the preferred orientation of crystal is formed under plastic deformation, the bulk property of the post perovskite phase will be anisotropic as well and many features of the seismic observations, which were difficult to understand so far, can be explained. However, there is no experimental evidence for the formation of preferred orientation. In the present study, we have studied the plastic property of post perovskite phase using model material, $CaIrO_3$, which is regarded to be a prototype of the post-perovskite structure.

EXPERIMENT

$CaIrO_3$ with post-perovskite structure was synthesized from a stoichiometric mixture of CaO and IrO_2 at 4 GPa and 1473K using cubic-anvil type high-pressure apparatus. The recovered powder sample was a single phase of an orthorhombic post-perovskite structure with an unit cell of a=0.3147(1)nm, b=0.9863(2)nm, c=0.7299(1)nm. This powder sample was placed in a hole of the "X-ray transparent gasket", which is made of a combination of amorphous boron and Kapton sheet. The assembly was then compressed using diamond anvil cell(DAC) and powder X-ray diffraction experiments were performed with increasing pressure. Very thin X-ray beam of about 30micron in diameter was irradiated to the sample perpendicular to the compression axis of DAC. Diffracted X-rays were recorded using imaging plate. Intensities of the diffraction lines with various indexes were integrated every 10 degrees along each Debye ring and compared as a function of angle relative to the compression axis. X-ray experiments were carried out at BL13A of the Photo Factory, KEK, Tsukuba. Compression experiments were made up to about 6 GPa at room temperature.

RESULTS AND DISCUSSION

Starting sample had a needle like morphorogy but no preferred orientation was observed when loaded in the sample chamber. By squeezing it using diamond anvil, the pressure was increased and the sample chamber was deformed. It was compressed along the compression axis while elongated in radial directions perpendicular to the compression axis. The crystals were crushed into fine grains and preferred orientation was formed gradually so that the b-axis of the crystal aligned in the direction of compression axis. This result is in harmony with the idea that the post-perovskite structure consists of a stacking of SiO_6 layers (in the present model material IrO_6 layers) along the b-axis and the a-c plain is easy to slide. Although the present experiment was made on the model material, deformation property is mainly determined by the crystal structure and not so sensitive to the chemical composition. It can be expected that the post-perovskite phase in the Earth has similar property. At the bottom of the lower mantle, if there is any flow related to the subducting slab, it is likely that the strong preferred orientation of post-perovskite phase is formed.