Mechanisms of the post-perovskite transformation in $NaNiF_3$

Koyumi Yamashita[1], *Tomoaki Kubo[1], Yoshinori Tange[2], Yuji Higo[2]

1. Kyushu Univ., 2. JASRI

Strong seismic anisotropy has been observed in the D” layer at the bottom of the lower mantle. This is possibly attributed to lattice preferred orientation (LPO) of bridgmanite (pv) and/or post-perovskite phase (ppv) induced by mantle flow, however their interpretations are still under debate. In particular, the ppv transformation exhibits topotaxy (having crystallographic relationship between pv and ppv) at least a certain condition in analogue material ($NaNiF_3$), which may cause LPO transition, and thus should be considered when interpreting seismic anisotropy (Dobson et al., 2013). However, topotaxy in the ppv transformation has been found in the single crystalline sample only at large overpressure and low temperature condition that is far from the equilibrium boundary. It is likely that the transformation proceeds near the equilibrium boundary in the D” region, where incoherent grain-boundary nucleation and growth mechanism may be dominant without topotaxy. In this study, we conducted the ppv transformation experiments in polycrystalline $NaNiF_3$ to investigate the dominant transformation mechanisms in the D” layer.

The starting material is equi-granular polycrystalline $NaNiF_3$ pv (~5-10 μm grain size) that was synthesized from a powder mixture of NiF_2 and NaF at 2 GPa and 750-800℃ for 40-60 min using a DIA-type high-pressure apparatus (MAX 90D) at Kyushu University. Transformation experiments were carried out by using Kawai-type high-pressure apparatus with the quenching method at Kyushu University (QDES) and with in-situ X-ray observation method at BL04B1 of SPring-8 (SPEED 1500). In the latter case, the phase transition was observed by time-resolved X-ray diffraction measurement using the energy dispersive method. Au was used as a pressure marker, and the overpressure (dP) of the phase transition was estimated based on the equilibrium boundary determined by Shirako et al. (2012). Transformation textures in the recovered samples were examined by SEM and EBSD.

In the case of the in-situ X-ray observation, we observed the transformation during the isothermal pressurization (~2.8 GPa/h) at 400°C, 600°C, 800°C, and 1000°C. The dP needed for the initiation of the transformation drastically increases with decreasing temperature. For example, the transformation started at dP of 1.5 GPa and 1000℃, however it did not occur even at the dP of 15 GPa and 400℃. Dobson et al. (2013) reported the intracrystalline lamellar nucleation of ppv phase in single crystalline pv with having crystallographic relationships at 700℃ and dP of ~9 GPa. Our study demonstrated that the ppv transformation can proceeds at much smaller dP conditions. We observed lamellar textures implying topotaxy in the recovered samples even at such small dP conditions. This is a typical feature for the ppv transition that is not seen in the olivine-spinel and post-garnet transformations. This may suggest that topotaxy generally occurs in the D” region. On the other hand, the lamellar spacing and width drastically increases with decreasing dP. We found that, after the nucleation stage at high T and small dP conditions, the ppv phase largely grow in the a-axis direction outside the parental pv grain, resulting in the formation of large rod-like crystal over the parental grains. The fast growth by rod-like ppv crystals likely occurs by the migration of incoherent interface, which may erase the texture induced by topotaxy.

Keywords: post-perovskite transformation, topotaxy, seismic anisotropy

