MS39-03 | Time-Resolved Structure Analysis of Piezoelectric Crystals Resonantly Vibrating Under Alternating Electric Field

Aoyagi, Shinobu (Nagoya City University, Nagoya, JPN); Osawa, Hitoshi (Japan Synchrotron Radiation Research Institute, Hyogo, JPN); Sugimoto, Kunihisa (Japan Synchrotron Radiation Research Institute, Hyogo, JPN); Nakahira, Yuki (Hiroshima University, Hiroshima, JPN); Moriyoshi, Chikako (Hiroshima University, Hiroshima, JPN); Kuroiwa, Yoshihiro (Hiroshima University, Hiroshima, JPN); Takeda, Hiroaki (Tokyo Institute of Technology, Tokyo, JPN)

Piezoelectric crystals are widely used in many applications such as oscillators, sensors, and actuators. The mechanisms of piezoelectricity could be explained from atomic displacements under a static electric field. However, atomic displacements under a static electric field are usually too small to be detected by conventional X-ray diffraction (XRD) measurements. The small atomic displacements can be resonantly amplified by mechanical vibrations under an alternating electric field with the resonant frequency. We have recently succeeded in detecting the small atomic displacements of resonantly vibrating quartz (SiO_2) and langasite-type ($La_3Ga_5SiO_{14}$ and $Nd_3Ga_5SiO_{14}$) piezoelectric crystals by the time-resolved synchrotron radiation XRD measurements under an alternating electric field [1-3].

The time-resolved crystal structure analyses of the quartz and langasite-type crystals revealed that bridging angles of oxygen tetrahedra are deformed with displacements of specific oxygen atoms along the applied electric field during the resonant vibrations. Deformations of specific oxygen tetrahedra were also observed in the langasite-type crystals. GaO_4 and $Ga_{0.5}Si_{0.5}O_4$ tetrahedra in the langasite-type crystals are more deformable than SiO_4 tetrahedra in the quartz crystal. This seems the reason why the piezoelectric constants d_{11} of the langasite-type crystals are larger than that of the quartz crystal.

[1] Aoyagi, S. et al. (2015). Appl Phys. Lett. 107, 201905
[2] Aoyagi, S. et al. (2016). Jpn. J. Appl. Phys. 55, 10TC05
[3] Aoyagi, S. et al. (2018). Jpn. J. Appl. Phys. 57, 11UB06