
# Success in Capturing Instantaneous Atomic Movement Induced by Application of Voltage for Millionths of a Second

Scientists from Hiroshima University (President, Toshimasa Asahara), in cooperation with scientists from The University of Tokyo (President, Junichi Hamada), Japan Synchrotron Radiation Research Institute (JASRI; President, Tetsuhisa Shirakawa), and RIKEN (President, Ryoji Noyori), successfully observed the instantaneous atomic movement during the piezoelectric vibration of crystals for the first time in the world by the structural measurement of crystals at a level of one-millionth of a second. This study was carried out as a Power User Project of SPring-8.

Piezoelectric crystals macroscopically expand, contract, and deform upon the application of an electric field. This phenomenon was discovered by J. Curie and P. Curie in the late 19th century. Today, piezoelectric devices utilizing this phenomenon are indispensable to our everyday lives; for example, they are used to control the ejection of ink in ink-jet printers and in the touch panels of cell phones. Several mechanisms underlying changes in the exterior of piezoelectrics have been discussed; however, it is necessary to examine how atoms are displaced in crystals upon the application of a voltage at the microscopic level to understand the essence of the mechanism. The atomic displacement is too small to be detected; even the movement of a crystal lattice has not been clarified thus far.

In this study, by combining two advanced measurement techniques, i.e., single crystal diffraction using high-energy X-rays and a high-speed time-resolved measurement technique, the research group succeeded in the *in situ* observation of a change in the crystal-lattice size of piezoelectric crystals with time of microsecond order during piezoelectric vibration for the first time in the world. The achievements of this study are expected to lead to developments in research on the dynamics of atomic displacement of nanosecond or picosecond order and enable the observation of atoms in an electronic device during operation. Also, this technology is considered to be applicable to the development of new materials for electric storage devices, such as capacitors and batteries.

The results of this study were published in the September issue of *JJAP*, and the paper was selected as a spotlight paper recommended by the editors of *JJAP*.

Reference: "Synchrotron Radiation Study on Time-Resolved Tetragonal Lattice Strain of $BaTiO_3$ under Electric Field"
C. Moriyoshi, S. Hiramoto, H. Ohkubo, Y. Kuroiwa, H. Osawa, K. Sugimoto, S. Kimura, M. Takata, Y. Kitanaka, Y. Noguchi, M. Miyayama
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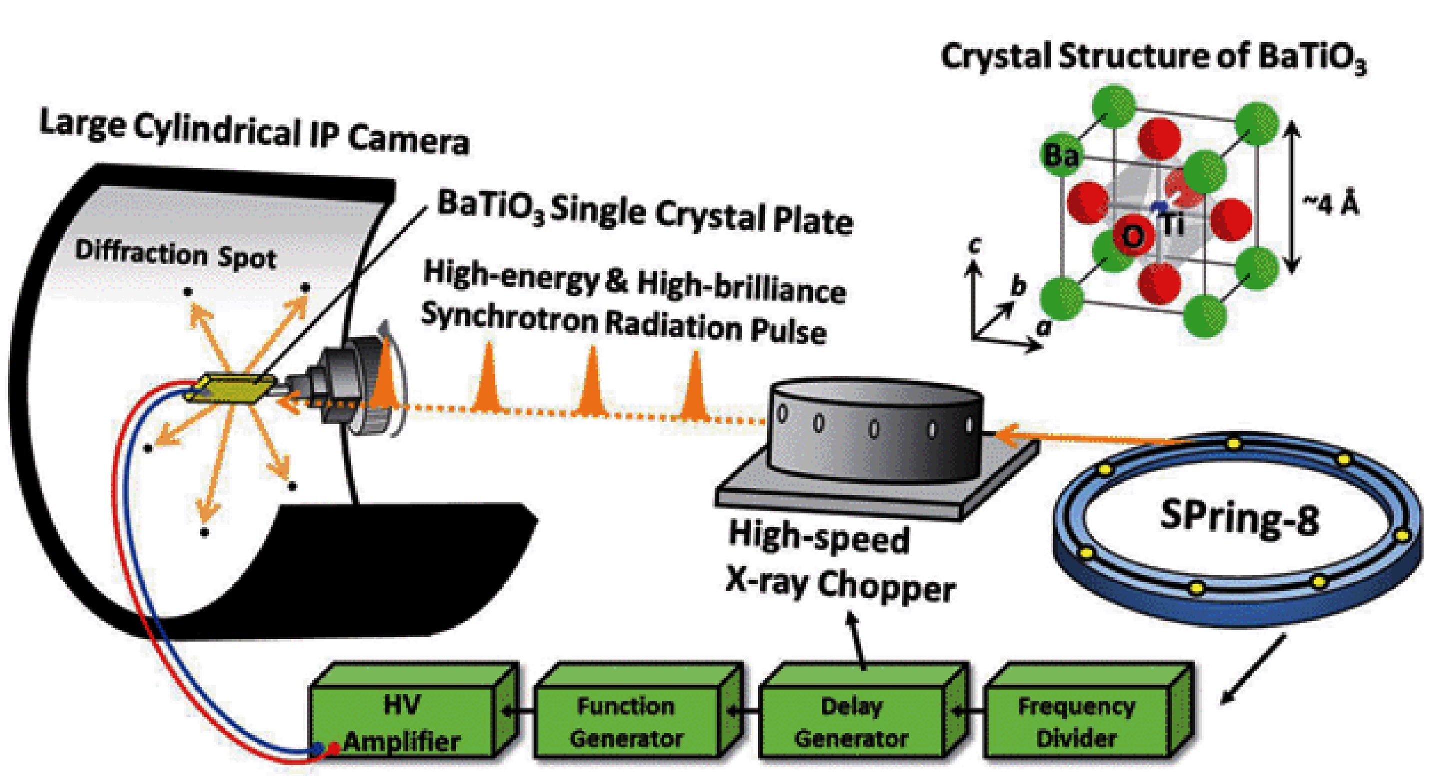


**Fig. 1 System for collecting diffraction images using dynamic synchrotron radiation X-rays installed in SPring-8 BL02B1**

The synchrotron radiation is chopped using an X-ray chopper so that it is synchronized with the waveform of the external voltage. There is a timing adjuster between the X-ray chopper and a voltage pattern generator.

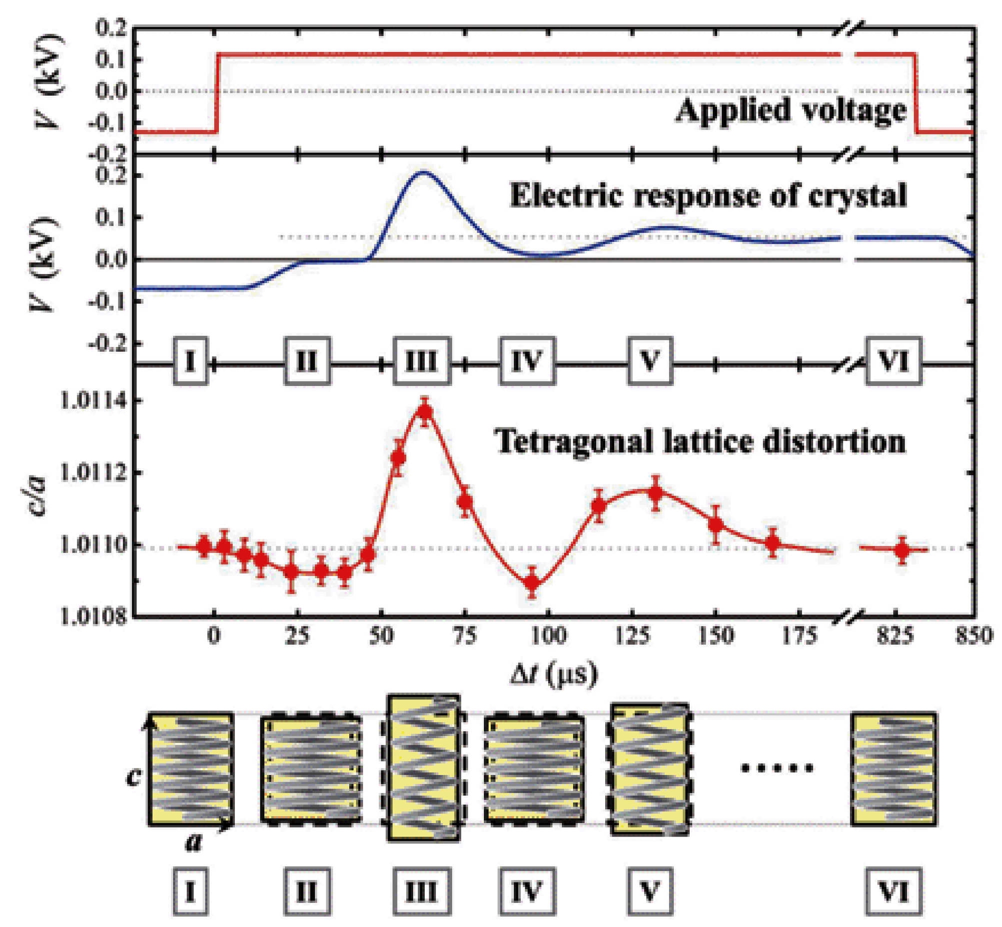


**Fig. 2 Change in tetragonal lattice ratio *c/a* with respect to time when an electric field (*E*) is applied to the *c-axis* direction of a barium titanate single crystal**

When the applied voltage is changed from negative (I) to positive, polarization reversal occurs (II), and the crystal slightly contracts in the *c-axis* direction. When the polarization reversal is complete (III), the crystal can significantly expand in the *c-axis* direction. *c/a* oscillates with decreasing the amplitude, and finally returns to its original value (III-VI). This behavior is similar to the damped oscillation of a spring.