Structure dynamics study on epitaxial VO2 film by using femto-second X-ray diffraction

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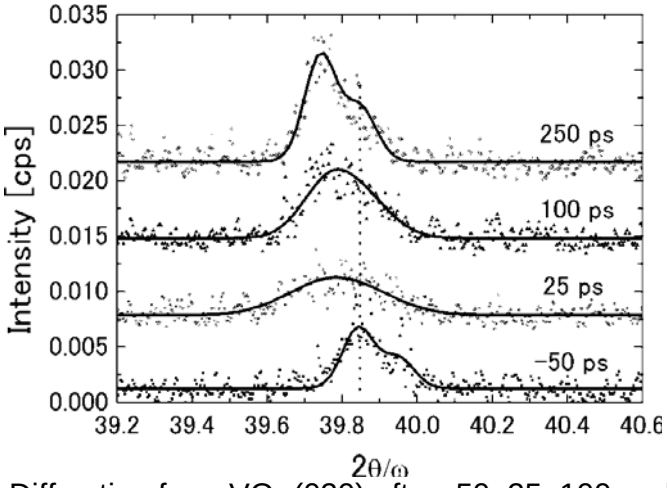
The dynamical behavior of a crystalline structure after excitation is not only of scientific interest, but also has technological importance. For instance, ultra-fast phase transition initiated with laser beam is used in digital recording devices. However, transitional mechanism in the femto-second time scale is not understood well. We have demonstrated that high-reputation rate and low peak power laser can deliver an enough amount of X-ray for diffraction experiment. This new compact X-ray source is quite useful to measure phase transition mechanisms in femto-second time scale.

Lattice motion and displacement of vanadium dioxide (VO_2) grown on Al_2O_3 have been characterized using static and time-resolved X-ray diffraction (fs-XRD). The monoclinic-tetragonal phase transition of the VO_2 and the twist motion of vanadium atoms were clearly observed after fs laser irradiation. The time-resolved XRD measurements were performed with pump(laser)-probe(X-ray) technique[1]. Typical X-ray diffraction spectra are shown in figure. The results from the time-resolved XRD measurements suggested that the unit cell of low-temperature monoclinic VO_2 transformed into the high-temperature tetragonal phase very fast, however, the atoms in the unit cell fluctuated with the center of the tetragonal coordinate within about 100 ps. The propagating time scale of 100 ps corresponded well to the previously reported time scale of shear motion measured with femto-second optical measurements or crystallography [2]. The time-resolved XRD measurements has a great potential to reveal structural dynamics of phase transition and the atomic motion in the unit cell simultaneously. We will discuss the atomic motion during the phase transition in femto-second time scale.



Time-resolved XRD Diffraction from VO_2 (020) after -50, 25, 100 and 250 ps.
The dramatic change in the diffraction spectra indicates phase transition of the crystal.

[1] M. Hada and J. Matsuo, Phys. Rev. **B82**, 153401 (2010)
[2] A. Cavalleri et al, Phys. Rev. Lett. **87**, 237401 2001.