Time-Resolved X-ray Diffraction Measurements Using Pinpoint Structure Measurement System at the SPring-8

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The pulse characteristic and high coherent x-ray beam of the SPring-8 allow us to investigate the dynamics of chemical reactions and phase transitions of materials caused by applied field. In order to realize such direct investigation, we have been developing an x-ray pinpoint structure measurement system \cite{ref1}, which is the part of the CREST projects (2004-2008) funded by Japan Science and Technology Agency (JST). The technical targets in the first stage are set to 100-nm spatial resolution and 40-ps time resolution measurement under photo-irradiation, electric field, magnetic field and high pressure. In the present talk, we will focus on recent progress of time resolved x-ray diffraction measurements using the x-ray pinpoint structure measurement system.

Precise time control is one of the key techniques for the x-ray pinpoint structure measurement system. In order to reveal the relation between dynamic structural changes and material functions, we have developed time-resolved x-ray diffraction measurement system using a pump and probe method combining femto/picosecond laser pulses and the synchrotron radiation pulses (FWHM: \textasciitilde40 ps). The time resolved system is mainly composed of an x-ray pulse selector, a two circle diffractometer and a femto/picosecond mode-locked Ti:sapphire laser synchronized with the x-ray pulse. The laser system consists of the mode-locked Ti:sapphire laser, regenerative amplifier, pulse selector, and optical parametric amplifier. The mode-locked Ti:sapphire laser produces the pulses with a duration of 80 fs, typical energy of 10 nJ/pulse at the wavelength of 800 nm. A repetition rate of the Ti:sapphire oscillator is synchronized to 84.76 MHz which is 1/6 of a master oscillator of the RF system for storage ring acceleration (508.58 MHz). A repetition rate of the regenerative amplifier is also synchronized to 948.98 Hz which is 1/535920 of the master oscillator. Output pulses of the regenerative amplifier meet X-ray pulses on a sample. Delay time between the laser pulse and the X-ray pulse can be controlled by a high precision delay generator which is composed of in-phase quadrature (IQ) modulator and D/A converters. A striking feature of the high precision delay generator is \textasciitilde5 ps resolution for wide range of time delay. The scheme of electronic timing delay is useful for time delay scan as keeping the irradiation position, which well meets the pinpoint measurement requirement. Using this system, we succeeded direct investigation of amorphous-crystal phase change process of DVD optical memory materials. The details of the instruments and performance of the x-ray pinpoint structural measurement system will be presented.

Reference: