MS38- X-Ray diffraction on the micro-s and ps time scale

Chairs: Dr. Gergely Katona, Dr. Ullrich Pietsch

MS38-P01

Current status of time-resolved X-ray crystallography beamline TPS 09A at Taiwan photon source

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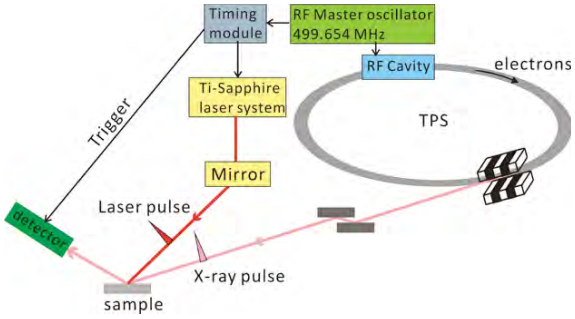
The TPS 09A beamline of Taiwan Photon Source (TPS) is designed for time-resolved laser pump X-ray probe crystallography experiments. TPS 09A has opened to general X-ray scattering users since September 2016. TPS is a third generation synchrotron source which operate at 3.0 GeV, 400 mA (design gold 500 mA), with beam emittance of 1.6 nm rad. The source of TPS 09A beamline is delivered from two IU22 undulators which provide temporal coherence X-rays of 5.6-25 keV. Follow the double crystal monochrotromator (DCM with two Si(1 1 1) crystals) is a horizontal focusing mirror. The beam size at the entry of experimental hutch is about 700 mm x 600 mm (H x V). Inside the hutch, the X-ray focus by a compound reflection lens, a Juelich chopper (the chopper will be delivered in the summer of 2019) and a Huber 9-circles diffractometer. Server detectors can be choiced for X-ray scattering, such as Pilatus 200K, Perkin Elmer XRD 1611 xP, and CsI point detector. A new area detector is now planning. A Ti-Sapphire with 35 fs pulse laser is located at the second hutch and can bring the 800 nm or 400 nm pulse laser to sample position. The synchrotron X-ray bunch length is about 35 ps. For lack of the Juelich chopper, we have test a las er pump X-ray probe time resolve X-ray diffraction experiment by using single bunch injection at TPS. The electron current is maintained at about 2 mA with top up injection for every 8 mins. The diffraction intensity and position of Si (111) is monitored during different laser pumping time. The FWHM of the intensity variation is about 250 ps. It demonstrated that the time scale of laser pump X-ray probe can be determined in 100 ps time scale. The structure of the excited sates of some organic and inorganic luminesce compounds are under investigations.



Keywords: Time-resolved X-ray Crystallography, Laser Pump X-ray Probe, Synchrotron Radiation

MS38-P02

Sub-na and sub-ps time resolved diffraction at cristal beamline - SOLEIL synchrotron

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The study of out-of-equilibrium dynamics in crystalline solids has become an important topic of modern condensed matter physics. Out-of-equilibrium states are obtained by irradiation with ultra-short laser pulses in the optical range, which induces electronic transitions on a timescale at which the lattice is considered to be frozen. Such photo-induced dynamics are studied experimentally in the so-called 'pump-probe' scheme, in which the sample is excited (pumped) by a fs optical laser pulse and probed by a pulse of an eventually different wavelength such as X-rays. Pulsed hard X-ray sources open the possibility to use diffraction and X-ray absorption to study photo-induced transitions in condensed matter under non-equilibrium conditions, and thus uniquely give access to precise information on the dynamics of atomic structures at the Å-scale.

In laser pump - X-ray probe experiments, the time resolution is in practice limited by the X-ray pulse duration. SOLEIL synchrotron, in its standard mode of operation, provides pulses of typically 80 ps FWHM [1]. X-ray pulses as short as 10 ps and 100 fs are also produced, in the "low-α" mode of operation [2] and with the femto-slicing source [3], respectively.

The undulator-based diffraction beamline CRISTAL enables studies of ultrafast structural dynamics using those short X-ray pulses. The sample is excited by 800 nm, 25 fs FWHM laser pulses provided by a regenerative Ti:Sa amplifier (max. output power 6 mJ @ 1 kHz). The subsequent changes in the sample's atomic structure are studied in the time domain Dt, by measuring its diffraction out of a monochromatic incident beam. The X-ray flux available at sample, which depends on the aimed time resolution, ranges from 6.10^8 ph/s for 7 keV, 70 ps FWHM X-ray pulses at a repetition rate of 1 kHz, to 1.10^6 ph/s for 7 keV, 100 fs FWHM X-ray pulses at the repetition rate 1 kHz. A 2D, gateable detector is used to collect the scattered intensities, which gives access to a large portion of reciprocal space for each single measurement. Various sample environnements have been made available, including a near-ambient temperature Peltier cell, a 5 K cryostat, and a 30 K N_2/He blower.

The poster will present the instrumentation developped at CRISTAL beamline for pump-probe diffraction experiments, as well as recent exemples of measured ultrafast structural dynamics.

References:

[1] C. Laulhé et al., Acta Phys. Polonica A 121, 332 (2012).
[2] C. Laulhé et al., Eur. Phys. J. Special Topics 222, 1277–1285 (2013).
[3] M. Labat et al., J. Synchrotron Rad. 25, 385–398 (2018).

Keywords: Diffraction, synchrotron, time-resolved