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Development of picosecond time-resolved soft X-ray XPS measurement system for studying surface dynamics

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Introduction

Recently, synchronization of short X-ray pulse of synchrotron radiation (SR) and laser pulse has gathered attention for observation of motion of atoms and molecules on solid surface at picosecond and femtosecond time scales. In picosecond time scale one can prove important processes, i.e. desorption, diffusion, and many surface chemical reactions. Time resolved pump-probe soft X-ray photoemission spectroscopy is very strong tool to investigate electron structure development in these processes. Such time resolved experiment system using laser and SR has been developed in hard X-ray region mainly (pump-probe X-ray diffraction (XRD)) On the other hand, soft X-ray needs UHV, therefore the laser-SR timing control is much more difficult than that with hard X-ray. We have developed laser-SR synchronizing and timing control system for picosecond time-resolved soft X-ray photoemission spectroscopy.

Experimental setup

We performed test of synchronizing and timing control system at BL7A and BL11A.

Laser system and timing control[1]

We prepared Ti ; Sapphire laser system. It include CW Nd:YVO_4 "millennia pro" (Spectra-Physics), Ti;Sapphire mode-locked laser oscillator "Halcyon" (KMlab's) and multi-path amplifier "Odin"(Quantronics). "Halcyon" has synchronizing circuit which synchronizes RF 500.1MHz cavity signal with multiplied 83.35MHz(6 times) that is mode-locked pulse signal. "Odin" has pulse selector (pockels cell) and 1kHz Q-switching Nd:YLF laser. Output pulse has1kHz repetition rate 30 fs width and 2.5mJ power/pulse.

We also prepared delay circuit which generate delay signals with <1 ps precision. Delayed RF signal goes to synchronizing circuit in "Halcyon" and mode-locked laser pulse is synchronized with a SR pulse.

Detector also has to synchronize to SR pulse. Laser pulses reaches sample in 1kHz and SR pulse in PF single bunch mode reaches in 1.6MHz. So detector has to ignore many SR pulses which is not right timing with laser pulse. Our delay circuit can generate delayed and divided signal. Generated 1kHz signal goes to SES-2002's gated CCD camera (Hamamatsu Photonics) as trigger signal.

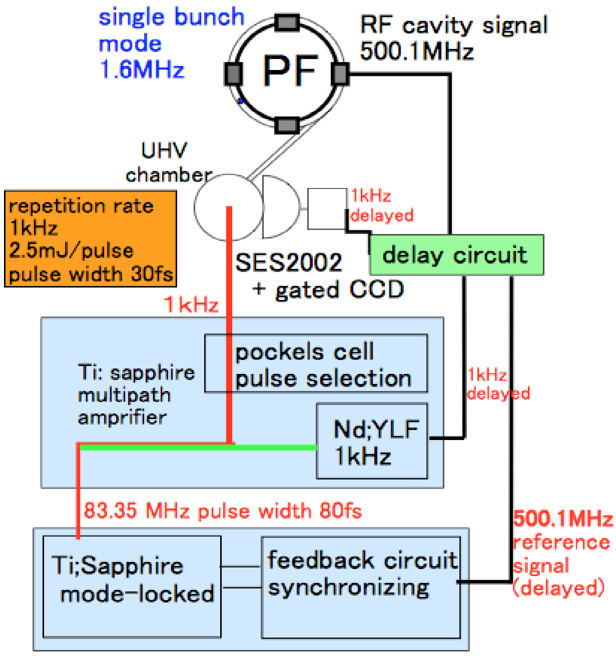

Figure 1. schematic diagram of synchronizing laser with SR and timing control

As a result, we can synchronize laser and detector with a SR pulse. Time-resolved XPS measurement was performed.

The system's schematic diagram is shown in Fig.1

Result

We confirmed synchronized laser with SR and detector with SR. But we found that phosphorous screen of detector has long life time(we measured that it is several hundreds nanoseconds).Therefore we couldn't reach picosecond time resolution with combination present our detector and PF single bunch interval (625ns). We conclude with present setup time resolution is limited to microsecond or several hundreds nanoseconds by the life time of screen and pulse interval. Now we are analyzing the date and improving our system with new detector to reach picosecond time resolution XPS measurement system.

Reference

[1] Y. Tanaka et al.,Rev. of Sci. Instrum. 71 1268 (2000).

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