THE CONTROL SYSTEM OF BSRF TOPOGRAPHY STATION
BASED ON PC

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The topography station is part of Beijing Synchrotron Radiation Facility (BSRF), which use two personal computers for its control and data acquisition. One computer is used for beamline and experimental station on-line control, while another computer is used mainly for X-ray topography image capture and processing.

1. INTRODUCTION

The X-ray topography station and attached beam line 4W1A are part of the Beijing Synchrotron Radiation Facility (BSRF) to employ the bright synchrotron radiation from the Beijing Electron Positron Collider (BEPC). The main purposes of the station are used for the study of the perfection of single crystals, high resolution multi-crystals diffraction and X-ray standing wave research. The intense power and small angular divergence of synchrotron radiation (SR) \(^{[1]}\) allow the setting of the specimen to a longer distance from the source and a shorter exposure time, to gain better spatial resolution in imagine. The use of large sample chamber allows in-situ studies of the change in crystals with temperature, stress, electric or magnetic field. The real time imaging system can provide a direct observation of the dynamic process in the condensed matter system.

The arrangement of control system is shown in Figure 1, which is established based on two personal computer and some plug in cards. One computer serves as experimental facility control and data acquisition, while another is used for on-line and off-line X-ray image processing. The every part of this system will be described in following paragraphs.

2. BEAM LINE

The experimental station \(^{[2]}\) is located at the end of the wiggler beam line 4W1A. When the BEPC is operated at the energy of 2.2Gev and the magnetic field of the wiggler at 1.8T, the photo flux at 1.34Å is \(6 \times 10^{10} \text{ photos/s/mA/mrad}^2/0.1\%\text{BW}\) and the electron beam size at the source point is \(2.2 \times 0.8\text{mm}^2\). For a distance of 50mm from specimen to film, the spatial resolution is about \(3\mu\text{m(H)} \times 1\mu\text{m(V)}\).

![Diagram of BSRF topography station control system](image)

The beam line equipped with two water-cooling tunable slits used for define the incident beam size, with an ionization chamber used for monitor the incident beam intensity. The slits are driven by four-phase stepping motors and controlled by SMC-2 interface \(^{[3]}\). The signals of X-ray intensity through the amplifier and discriminator become the standard TTL pulses...
then into the SMC-2 interface too. The SMC-2 interface is a standard ISA bus interface developed by ourselves, which has one channel timer, three channels scalar and can control eight motors simultaneously.

3. EXPERIMENTAL SYSTEM

The major parts of experiment system consist of a white-radiation topography camera, a versatile environment chamber, an X-ray video imaging system and an image processing system. These are installed inside an interlocked hutch of 3m wide and 6m long. Two Personal computers communicated through local net are used for control and data acquisition.

3.1 On-line control and data acquisition

A P/100 personal computer is used for on-line control, including beamline control and monitoring, topography camera control, temperature control and fluorescence measurement. Most of the tasks are run on Windows 3.1 platform respectively.

The station equipped with a white radiation camera and a four-crystal camera[3] used for white beam topography, multiple crystal topography and high resolution diffraction. The white radiation camera made in UK has five rotary axes and the four-crystal camera has six rotary axes. These axes are used for coincident with the incident beam and carry the specimen and detector to known position. All axes are driven by stepping motors and run in open loop control, the rotary speed can run up to 90°/sec for dynamic experiments. An IEEE-488 stepping motor controller and a plug-in IEEE-488 interface are used for motors control.

The station is equipped with a high temperature and a low temperature environmental chamber for in situ studies of the physical and chemical effects of the structural imperfection in crystals. The high temperature chamber consists of a furnace, a sample holder, a vacuum chamber, a pumping system and a digital control power supply for ramp the electric current smoothly(maximum 30VAC, 20A). The temperature control system is based on an Eurotherm controller (818) and solid state relay(SSR). By using PID control and time proportion method, the temperature resolution is about 0.05°C at hold range and 0.1°C at ramp, dwell range. The temperature control system is communicated through RS-232 with the on-line computer for temperature set and monitoring.

The on-line computer is also used for fluorescence measurement for X-ray standing waves research, which consists of a Li(Si) detector, electronics, a plug-in multichannel buffer (EG&G) and its attached window-based software.

3.2 Image acquisition and analysis system

A Pentium/100 computer is used for topography image processing system, which consist of an X-ray direct image CCD detector, a high resolution monitor and a high speed image capture card(PCI bus), which is used for modest resolution, real time display and processing during dynamic experiments. System functions include real-time image subtraction, image plot, and a wide range of image processing filters. The image can be captured by standard BMP or TIF file up to rate of 25 frames/sec.

The Siemens CCD(type XQ1177) converts the X-rays directly to electrical signals with spatial resolution of 25µm. The CCD control unit output three channels of standard video signals, of which one to monitor for real-time display, one to VHS recorder for image recording, while another to computer for on-line and off-line image processing.

The schematic of image capture/processing card is shown in Figure 2. The digital image resolution is 768×576×16 bits. The software is written on Windows by ourselves, which offer simplicity and easy of operation and supports windows DDE and OLE, enabling data to be exported into popular software programs such as Photoshop or Photofinish for further processing. A substantial improvement on the image quality can be achieved when using image processing system.
4. PHYSICAL RESULTS

The control system has been put into operation and runs stably. The efforts are doing to make the software more standardization and easy to use.

During the past years, many experiments have been performed at BSRF topography station on KNbO₃ nonlinear optical crystals, HgCdTe multielement linear array(MLA) infrared detectors and MBE-grown InₓGa₁₋ₓAs/GaAs strained-layer superlattices(SLS)². For example, Potassium niobate KnbO₃ (KN) exhibits outstanding nonlinear-optical and electro-optical properties. KN crystal is subjected to a ferroelectric phase transition as follows:

trigonal(363K)--orthorhombic(498K)--
tetragonal(708K)--cubic

The whole process of the phase transition has been performed and recorded by the video imaging system, which confirmly shown the evolution of the contrast of ferroelectric domain in the crystals during heating.

REFERENCES
