The Application of Personal Computer in Topography Experimental Station at the BSRF

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Abstract

The topography experimental station is part of the Beijing synchrotron Radiation Facility (BSRF). Two PCs are used to build its control and data acquisition system, of which one is used for beamline and experimental station on-line control, while the another is used for x-ray topographic image capture and treatment.

1 Introduction

The x-ray topography station and attached 4W1A beamline[1] are part of the Beijing Synchrotron Radiation Facility (BSRF) to employ the synchrotron radiation from the Beijing Electron Positron Collider (BEPC). The 4W1A is a 45m long white/monochromatic wiggler beamline. When the BEPC is operated at the energy of 2.2 GeV and the magnetic field of the wiggler at 1.8T, the photon flux at 1.54Å is 6×10^{10} photons/s/mA/mrad^2/0.1%BW and the maxim beam size at the specimen point is 45(H) ×13(V) mm^2. The topography station situated at the end of the beamline 4W1A is mainly used for the study of the perfection of single crystals, high resolution multi-crystal diffraction and x-ray standing wave research. The main equipment of the station consists of a white radiation topography camera, three environmental sample chambers, an x-ray video imaging system and a four crystal monochromatic camera. These are installed inside an interlocked hutch of 3m wide and 6m long. We built its on-line control and data acquisition system by using two personal computer and some plug in cards, of which one PC is served as beamline and experimental station on-line control, while the another is mainly used for topographic image on-line and off-line treatment. The schematic of the whole system is shown in Fig.1.

2 Beam line control

The 4W1A beamline is equipped with two water cooled tunable slits driven by four-phase stepping motors to define the incident beam size, equipped with a double crystal monochromator to chose the x-ray at any energy. After the monochromator, an ion chamber is set to measure the incident beam intensity. The signal of the x-ray intensity from the ion chamber through the amplifier and discriminator become the standard TTL pulse, then into the on-line computer or NIM scalar for display.

Considering the scale of beamline, We developed a multifunctional ISA interface specially used for beamline control, which has one channel timer, three channels scalar and eight channels stepping motors controller. The motors can be used in open loop control or feedback mode, when in feedback mode, the rotating encoder can be readout by interface's scalar to correct the missed steps automatically. Currently, we use only one interface for slits control, monochromator control and ion chamber readout, but two or more interfaces can be used simultaneously if necessary.

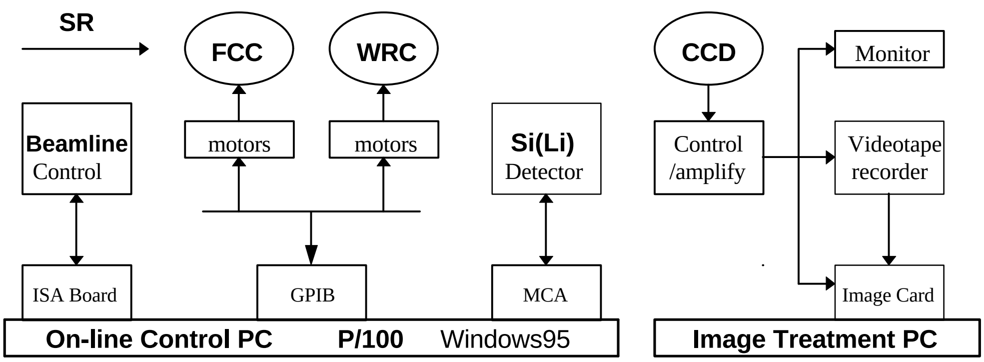

Fig.1 The schematic of control and data acquisition system at BSRF topography station.

FCC: Four Crystal Camera; WRC: White Radiation Camera; CCD: directly x-ray imaging CCD.

3 Experimental system

The topography station consists of three different experimental set-ups, so the control system is the combination of three independent programs. These programs run on Windows95 platform respectively.

3.1 White radiation dynamic topographic system

The white radiation topography camera and three environmental sample chambers are used for the dynamic topographic experiments with change of temperature, stress, electric field or other parameters[2]. The white radiation camera[3] has five axes to rotate the specimen to any orientation with the incident beam and to rotate the detector to collect the any diffracted beam. All axes are driven by stepping motors and run in open loop control. An GPIB stepping motor controller and a plug-in GPIB interface are used for motors control.

Three environmental sample chambers, including two high temperature sample chambers and one low temperature chamber, are used for different experimental requirements. One of the high temperature chamber (heavy”) is multifunctional but difficult to align, which is used for temperature over than 1000°C; while the another (light”) is simple but easy to handle, which is used for medium temperature range. A digital control power supply can ramp the electric current smoothly when starting to heat. The temperature control system is based on the Eurotherm controller (model 818) and solid state relay (SSR). By using PID control and time proportion method, the temperature stability is about 0.05°C when holding and 0.1°C when ramping. The on-line PC can set and monitor the temperature via RS-232 interface.

3.2 Four-crystal camera system

The four crystal camera[4] consists of the monochromator mounted at the end of the beamline and a double crystal diffractometer.

The double crystal monochromator comprises a pair of parallel Si perfect crystals which can be rotated to fit the Bragg angle by a Huber goniometer. The second crystal can be finely adjusted by two ways to ensure the parallel with the first crystal. The first crystal can be moved down to let the white radiation pass when the white beam experiments are performed.

The main body of the double crystal diffractometer is a precise two-axis diffractometer. A Si reference crystal or an asymmetrically cut Si standard crystal is set on the first axis; while the specimen is set on the second axis. Besides the θ_B rotating, a set of rotating system is used to align the diffractometer, including two ways rotating of the standard crystal, three ways rotating of the specimen and the whole body rotating around the incident beam. These rotating system are controllable and measurable by on-line PC via GPIB. A scintillation counter mounted at the detector axis is used to measure the intensity of the diffraction beam, which is readout via GPIB too.

3.3 X-ray standing wave research system

The x-ray standing wave (XSW) research system consists of the double crystal diffractometer (ref.*3.2*), a EG&G Si(Li) detector, a ISA bus EG&G multichannel (MCA) buffer and attached electronics. The commercial Windows based software attached with the MCA is used for fluorescence signals acquisition.

4 Topographic image treatment system

The topographic image treatment system is based on another P/100 personal computer and a new developed PCI bus plug in card, which is used for modest resolution, real time display and treatment during dynamic experiments.

The x-ray sensitive CCD(Siemens XQ1177) is used to directly convert the topographic image (x-ray diffraction pattern) into electrical signal with the spatial resolution of 25μm. The CCD control unit output three channels of standard video signal, of which one to high resolution monitor for real-time display, one to VHS recorder for recording, while the another to PC for on-line image treatment.

The schematic of the image capture/treatment card is shown in Fig.2, which can digitalis the image by standard BMP or TIF file up to rate of 25 frames/sec with the maximum digital image resolution of 768×576×8 bits. The treatment of image can be performed either on-line or post-acquisition. Some simple functions, such as contrast reverse or noise reduction by rolling integration method, can be performed by on-line treatment; while a wide range of filters is used by post-acquisition treatment to improve the quality of images recorded on VHS videotape or x-ray film. Moreover, the image can be transferred into popular commercial software such as Photoshop or Photofinish for further processing. A substantial improvement on the image quality can be achieved after the image treatment system having been used.

5 Physical results

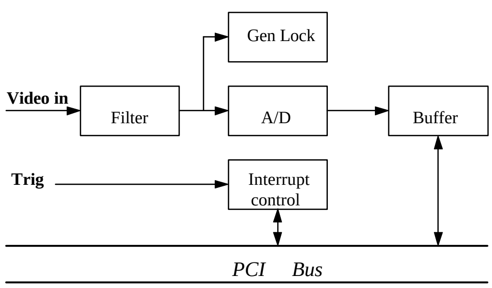

Fig.2 The sketch of image capture/treatment board.

Many physical experiments have been performed on the topography station at the dedicated time of SR. For example, the orthorhombic-tetragonal phase transition of $KNbO_3$ (a non-linear optical crystal) near 498K[5] and the metal-semiconductor phase transition of blue bronze $K_{0.3}MoO_3$ (a typical model charge-density-waves material) near 180K have been studied by ourselves. The whole process of the phase transition has been performed and recorded by the video imaging system, and the result is excellent[2].

6 Conclusion

In summary, we have built the PC based control and data acquisition system at the BSRF topography station. Instead of using CAMAC or VME, we just use some PC plug in cards and GPIB to build the system. This is the cheapest way and usually effective in small or medium scale experimental system. Currently, the whole system is only the simple combination of independent programs, we will rewrite the software next step on a suitable environment, such as LabVIEW or EPICS, to make it more friendly and standard.

References

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