Application of QXAFS in the Medium-Energy X-ray Absorption Spectroscopy

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Introduction

X-ray absorption fine-structure (XAFS) spectroscopy, including X-ray absorption near-edge structure (XANES) and extended X-ray absorption fine structure (EXAFS), is an important experimental method at synchrotron radiation facilities, which has been applied in scientific research and industry applications. Traditional XAFS spectrum is obtained by controlling the rotation of the monochromator by a stepper driver, then measuring the absorption coefficient of each energy point. While in quick-scanning XAFS (QXAFS), the angle of the monochromator moves continuously and quickly, greatly reducing the spectral acquisition time. It has become a powerful tool to study in-situ dynamic processes. Currently QXAFS is mainly used in hard X-ray absorption spectroscopy beamlines of synchrotron radiation facilities, here we have developed a QXAFS system in the medium-energy X-ray beamlines, which will improve the function of XAFS beamlines and extend their capabilities to a wider user community.

Device set-up

Beamline 4B7A uses a Si(111) monochromator with an energy range of 2100eV to 5700eV, the source is generated by a bending magnet with a critical energy of 3358.6eV, the flux of sulfur K-edge is 1×10^{11} and the beam spot is about $5\times3mm^2$. The QXAFS system is an independent system that uses a field programmable gate array (FPGA) module as a key logic unit to control the movement of the Bragg motor and data acquisition, it connects directly to the motor driver and directly reads the voltage signal after the conversion of the weak current, so it can replace the role of the stepping motor controllers, analog-to-digital converters (ADCs) and voltage-to-frequency converters (VFCs), the advantages of doing so are perfect time synchronization and no need to wait for responses of other devices, thus improving the time resolution greatly.

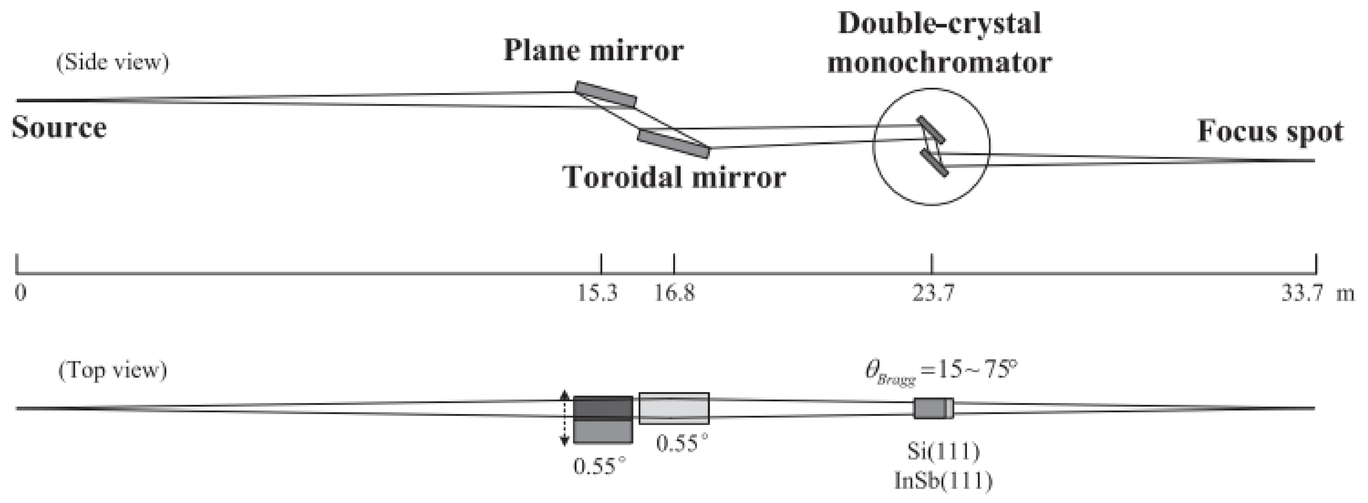

Fig.1 Schematic layout of beamline 4B7A at BSRF

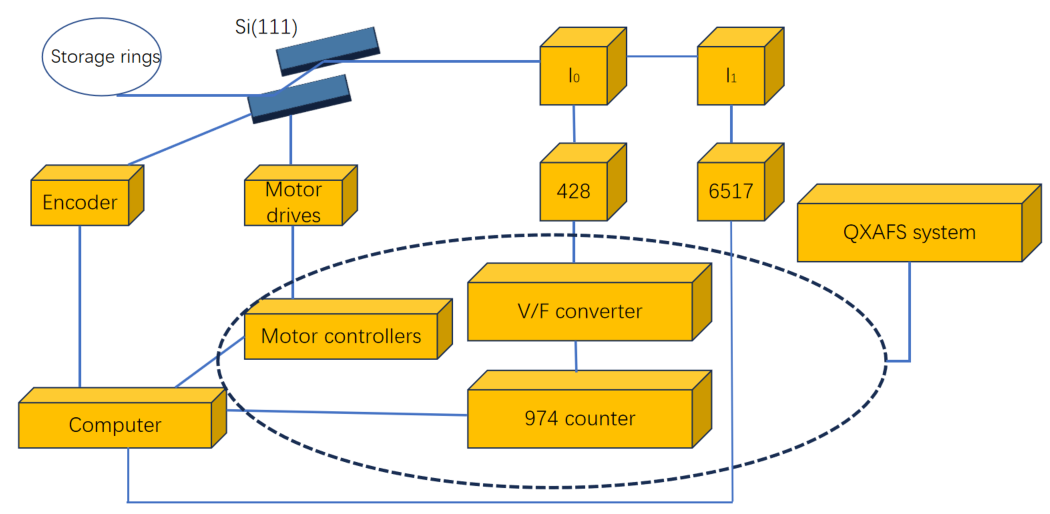

Fig.2 Schematic diagram of the QXAFS acquisition process

Result

We selected a sulfur sample loaded on an aluminum substrate to test the difference between the normal step scan and the quick scan using total electron yield method. The near-edge range of the spectrum is set at 2450eV~2500eV. The step scan mode took ten minutes to obtain the spectrum, while QXAFS just took 14 seconds at 2000 pps with similar signal-to-noise ratio. This system can be also applied in the measurement of potassium, calcium and other medium-energy elements in the second level of the dynamic process.

Further more, we have tested the effect of different rotation speed of monochromator on the quality of absorption spectrum using K_2SO_4 as a standard sample. As shown in Fig 4, the spectra are very consistent at different speeds, which means we can change the scan speed and optimize the time resolution according to the needs of the experiment.

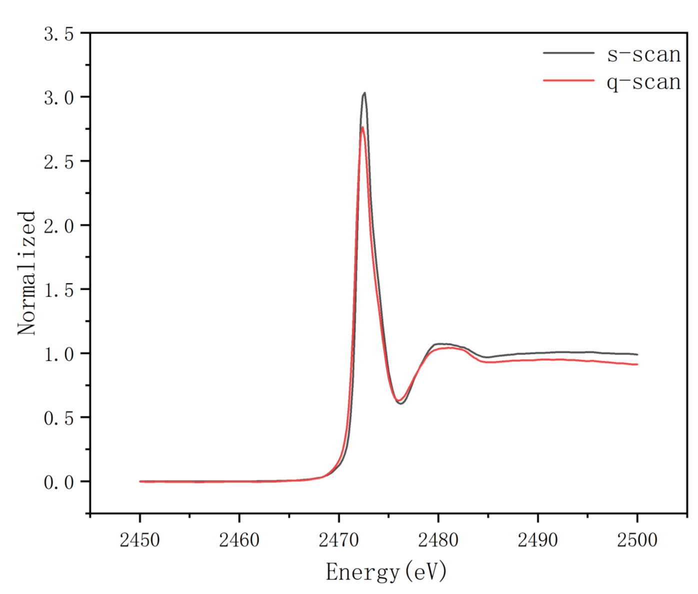

Fig.3 Comparison of step scan with quick scan

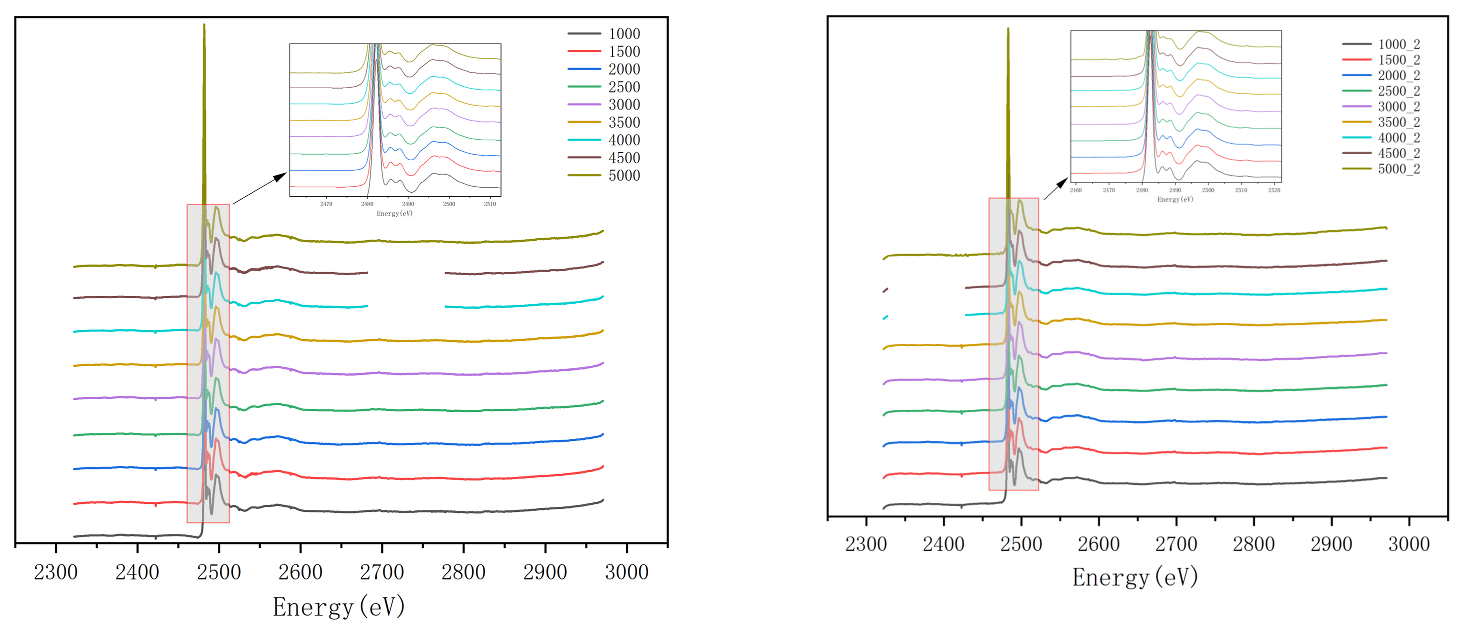

Fig.4 Comparison of different speeds under round-trip scanning

Conclusions and Outlook

We have developed a QXAFS system in the medium-energy X-ray beamlines, which will improve the function of XAFS beamlines and extend their capabilities to a wider user community. We will carry out the development of medium-energy QXAFS in fluorescence and transmission mode in the future.

References

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