Chemical State Analysis of SiO_2/Si by Wavelength-Dispersive X-Ray Fluorescence

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The chemical states of a SiO_2/Si govern the conductivity of an oxide film, the hot-carrier resistance, and the breakdown characteristic. In order to improve characteristics of a very thin gate oxide film, it is necessary to analyze this chemical state.

It is difficult for WD-XRF in laboratory system to perform a chemical state analysis of a thin film. WD-XRF equipment for chemical state analysis has been developed and installed in the BL16XU Industrial Consortium ID Beamline at SPring-8.

The information acquired from EXEFS (Extended X-Ray Emission Fine Structure) resembles XAFS (X-ray Absorption Fine Structure). As a chemical state analysis for thin films, EXEFS was applied to SiO_2 films (15A and 100A). These spectra were showed in Fig. 1. Quartz and Si were showed in same figure, as standard. The spectrum for a very thin SiO_2 film of 15A, like a SiO_2 film of 100A, reflects the chemical state of quartz.

SiKb of SiO_2/Si was measured for the depth profile of these chemical states, changing an incidence angle. As an incidence angle becomes small, these chemical states are changing from Si to SiO_2.

The element scattering by the high flux SR was observed at BL40XU of SPring-8. In order to find out the measurement conditions suitable for the chemical state analysis, the action of the oxygen of pyrex glass was investigated against the energy and the flux of excitation X-rays.

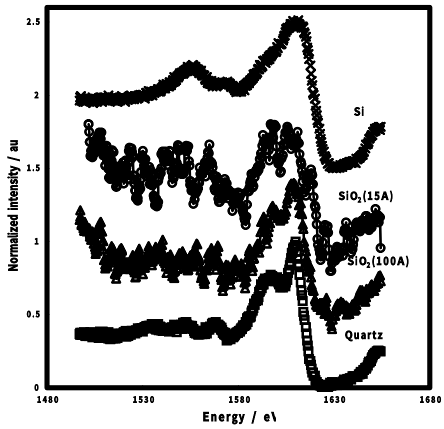

Fig.1 EXEFS spectra of SiO_2/Si

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1.1 Introduction

- The chemical states of a SiO_2/Si govern the conductivity of an oxide film, the hot-carrier resistance, and the breakdown characteristic. In order to improve characteristics of a very thin gate oxide film, it is necessary to analyze this chemical state.
- It is difficult for WD-XRF in laboratory system to perform a chemical state analysis of a thin film. WD-XRF equipment for chemical state analysis has been developed and installed in the BL16XU Industrial Consortium ID Beamline at SPring-8.

Figure WD-XRF Equipment

1.2 Experiment

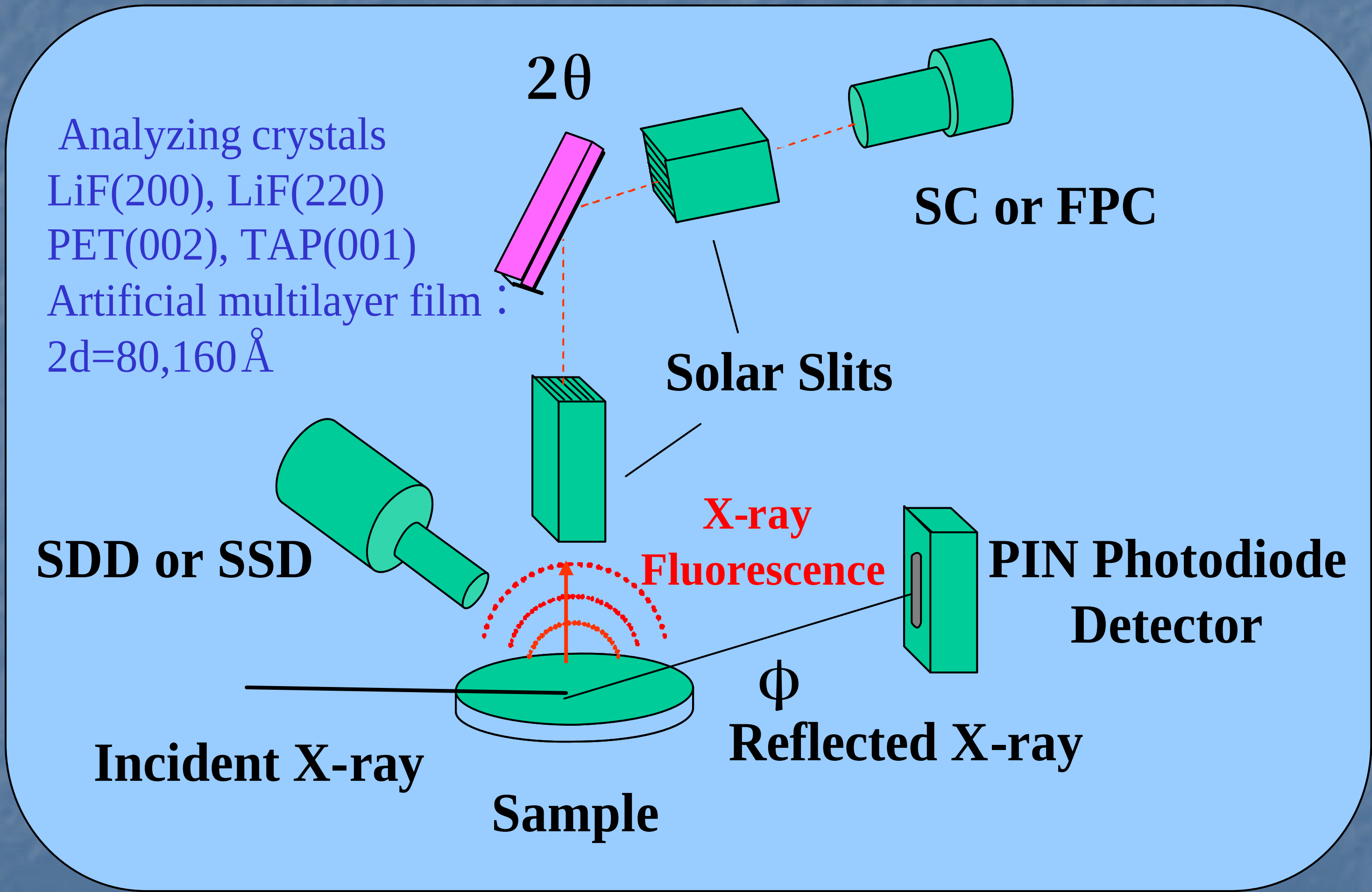

Figure WD-XRF Equipment

2.1 High Resolution Spectra of SiKb

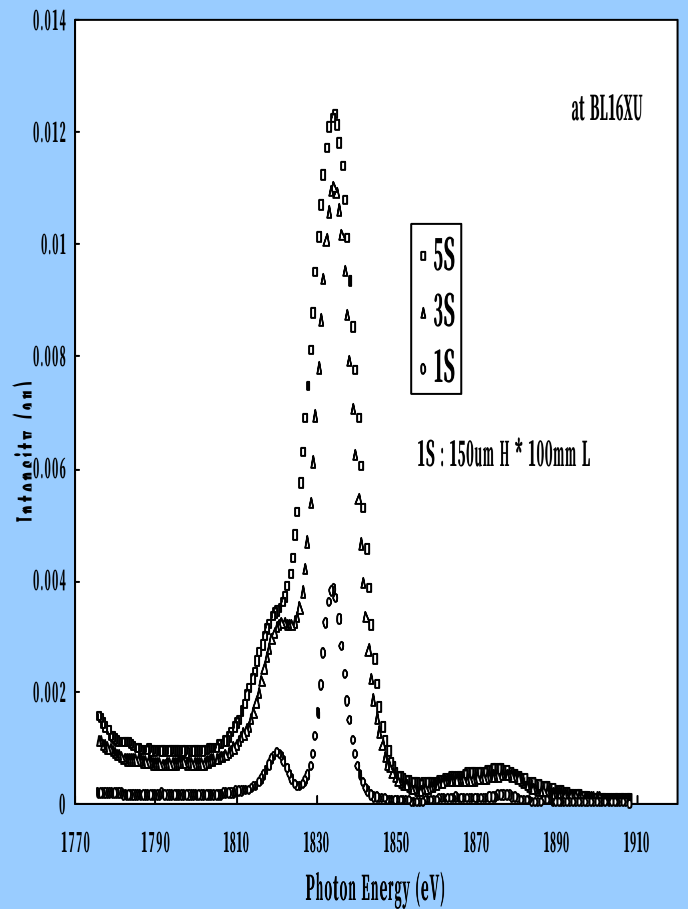

Fig.1 Si Kb Spectra of Quartz
: Solar Slit 1S, 3S and 5S

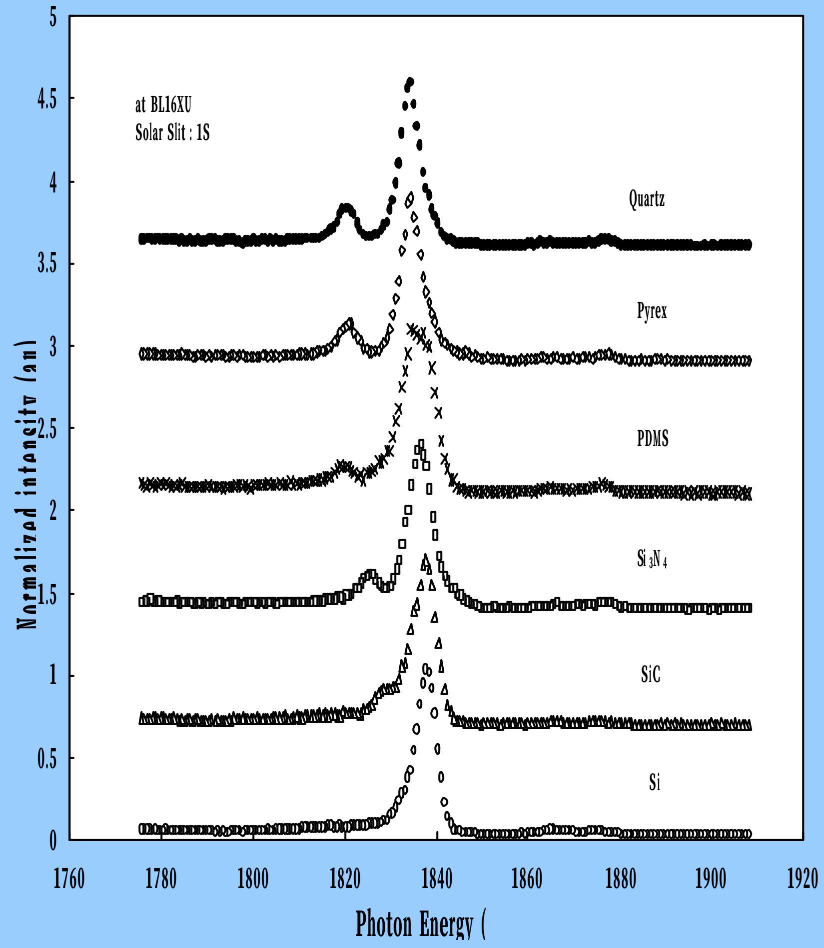

Fig.2 Si Kb spectra of Si compounds

2.2 Depth Profile of Chemical States for SiO_2 /Si

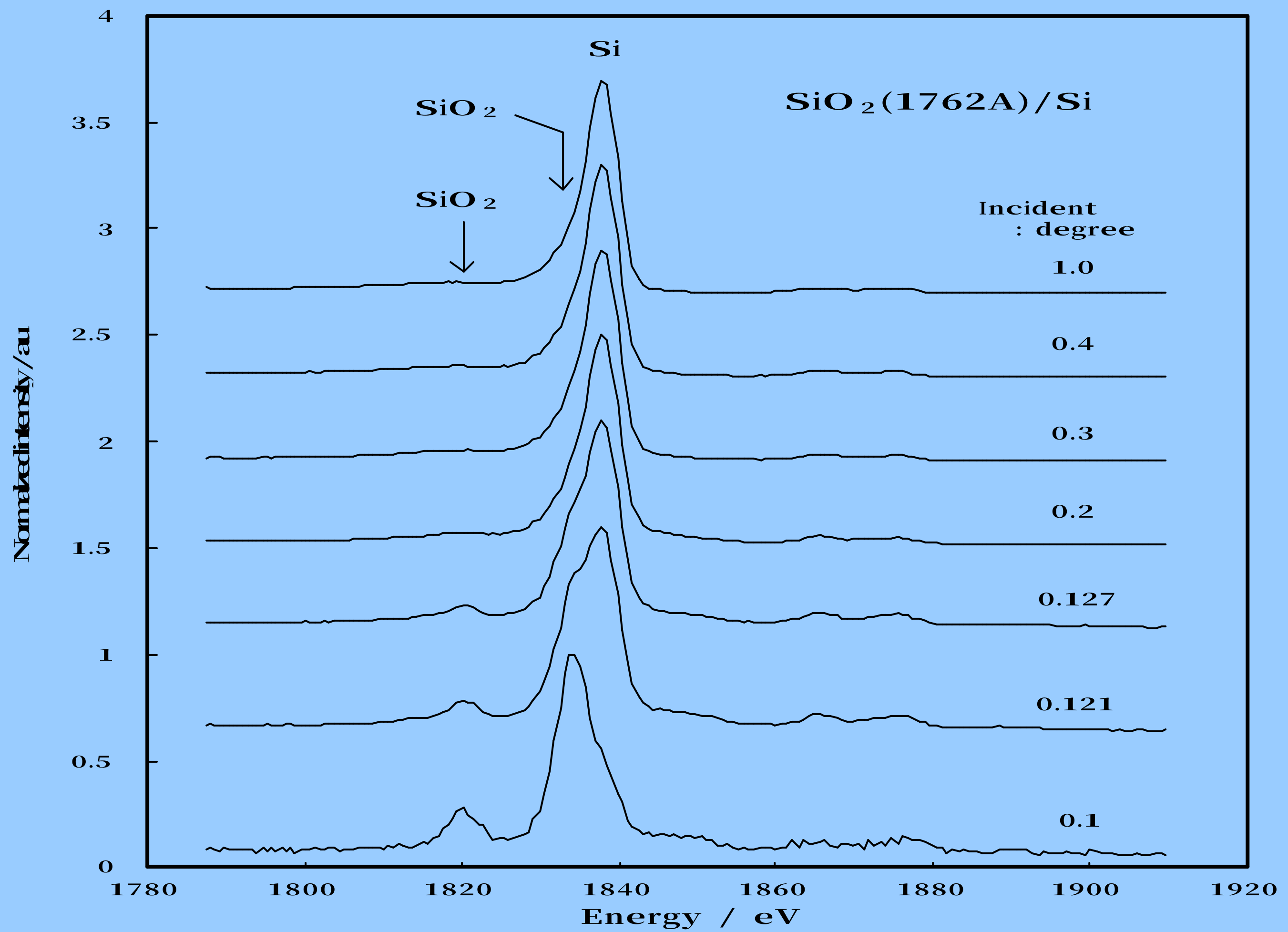

Fig.1 Incident angle dependence of SiKb spectra of SiO_2(1762A)/Si

3.1 EXEFS Spectra of Si and Quartz

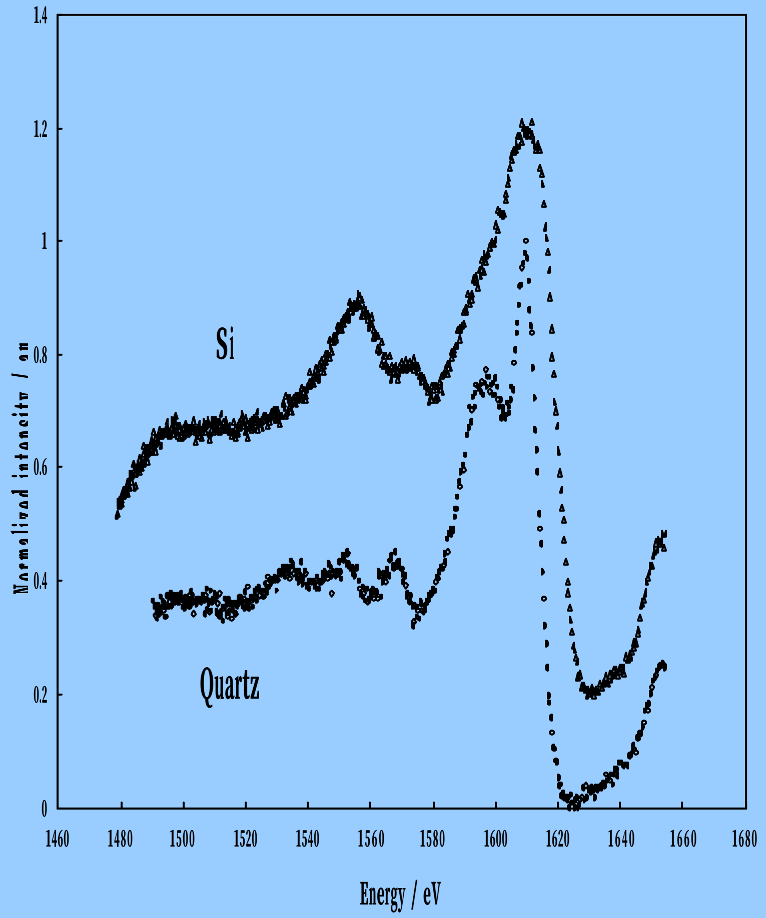

Fig.1 EXEFS spectra of Si and Quartz

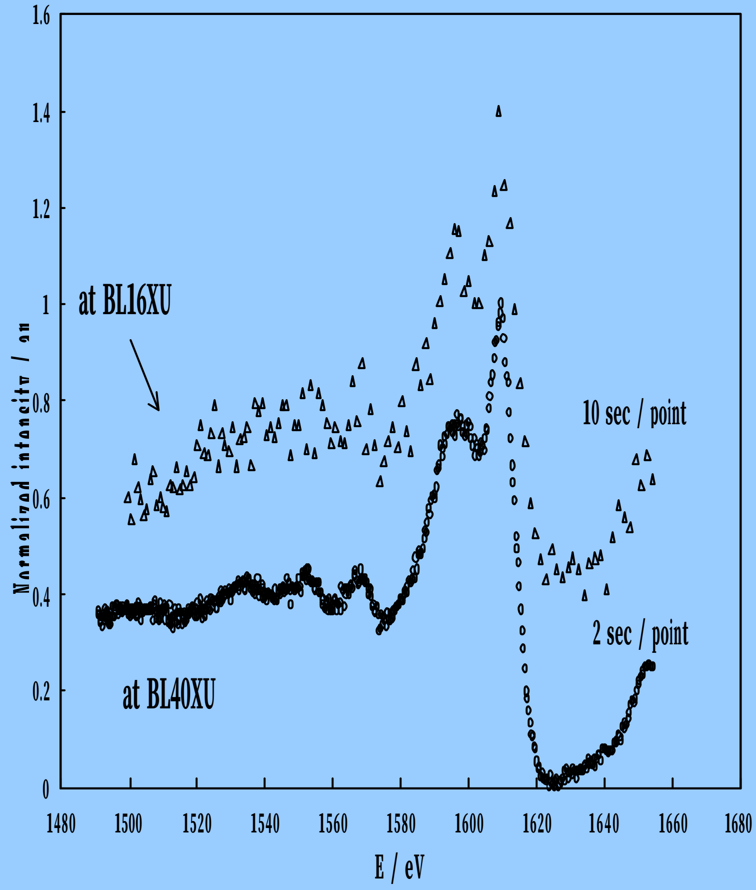

Fig.2 EXEFS of Quartz at BL40XU and BL16XU

3.2 EXEFS Spectra of SiO_2/Si

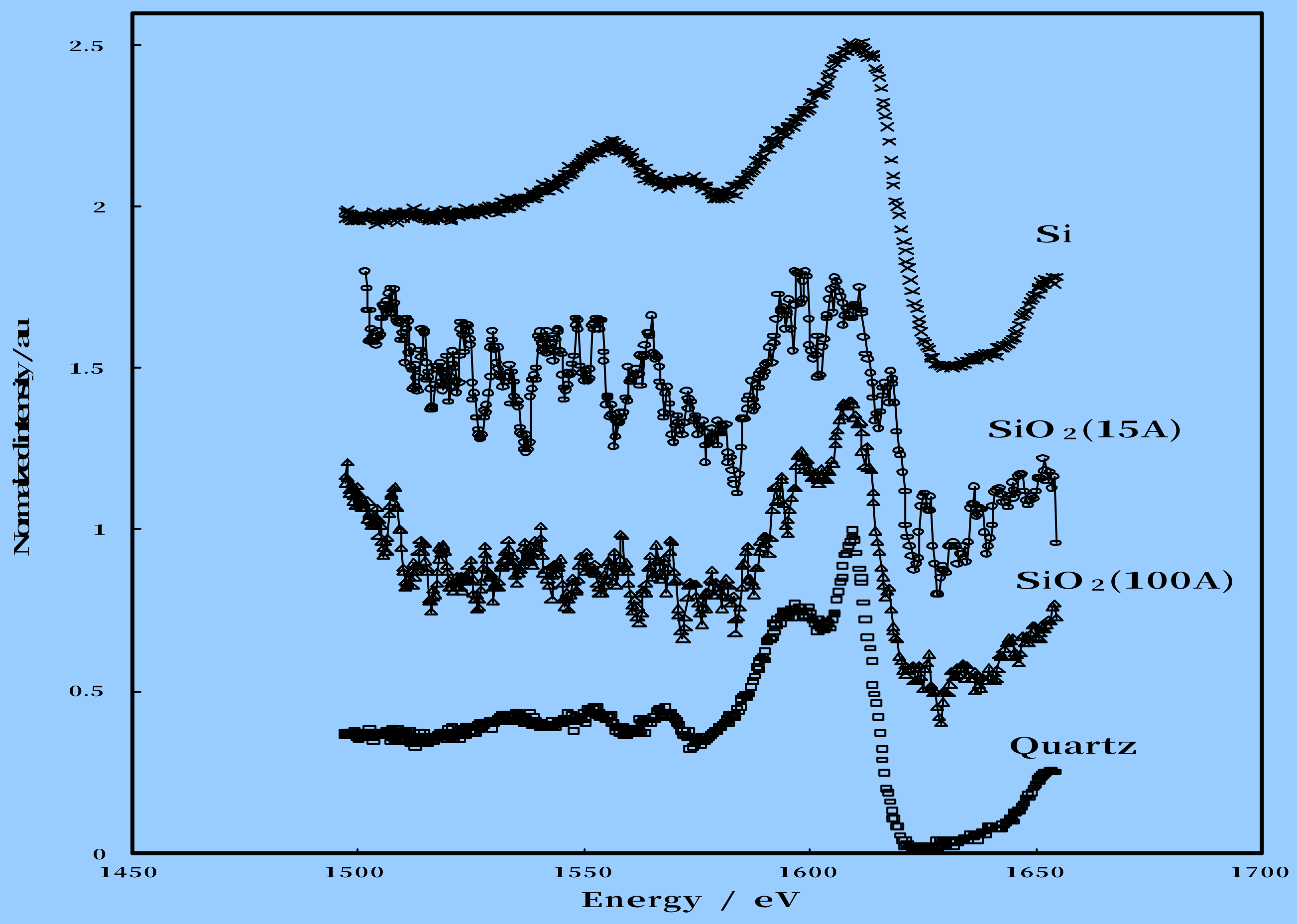

Fig.1 EXEFS spectra of SiO_2/Si

4.1 Damage of High Flux X-ray

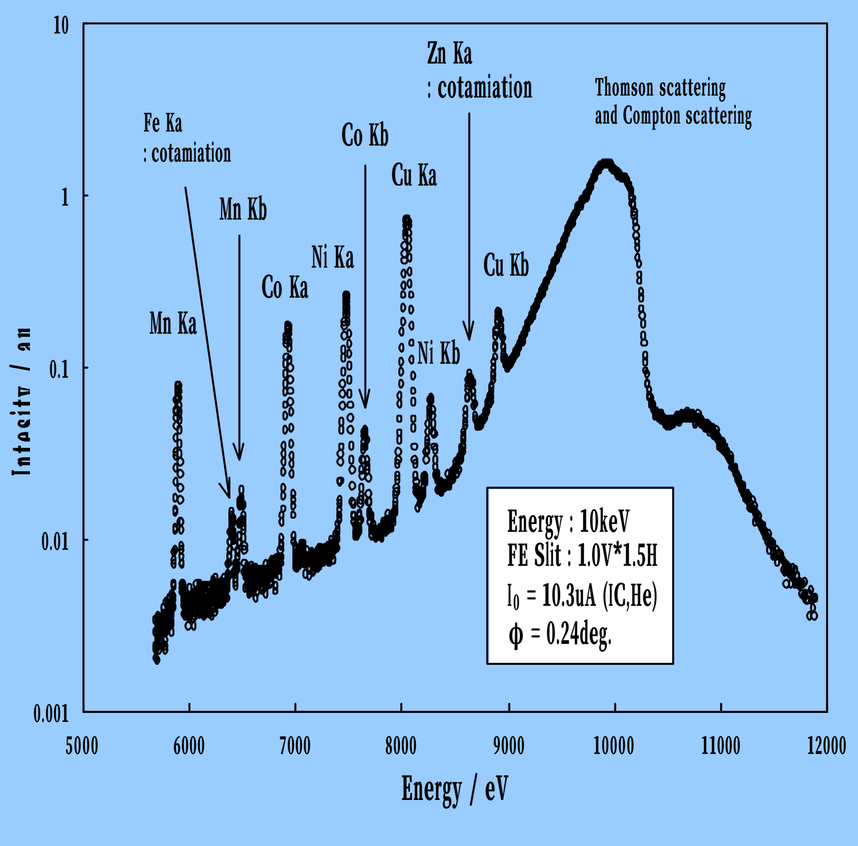

Fig.1 WD TXRF spectra of 200pmol Cu,Ni,Co,Mn on Si

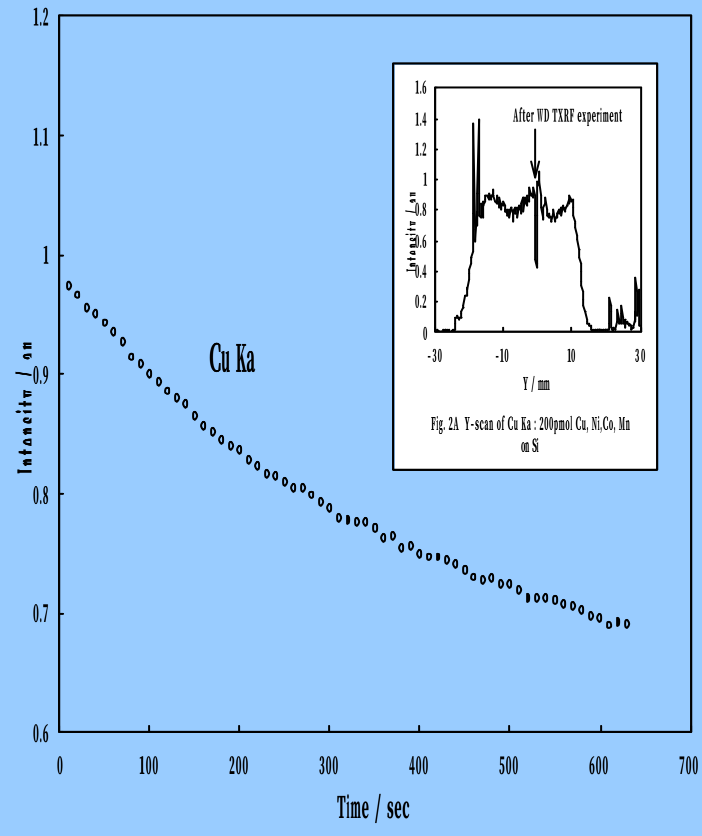

Fig.2 Time dependence of Cu Ka : 200pmol Cu,Ni,Co,Mn on Si

4.2 The Condition of X-ray for less Damage

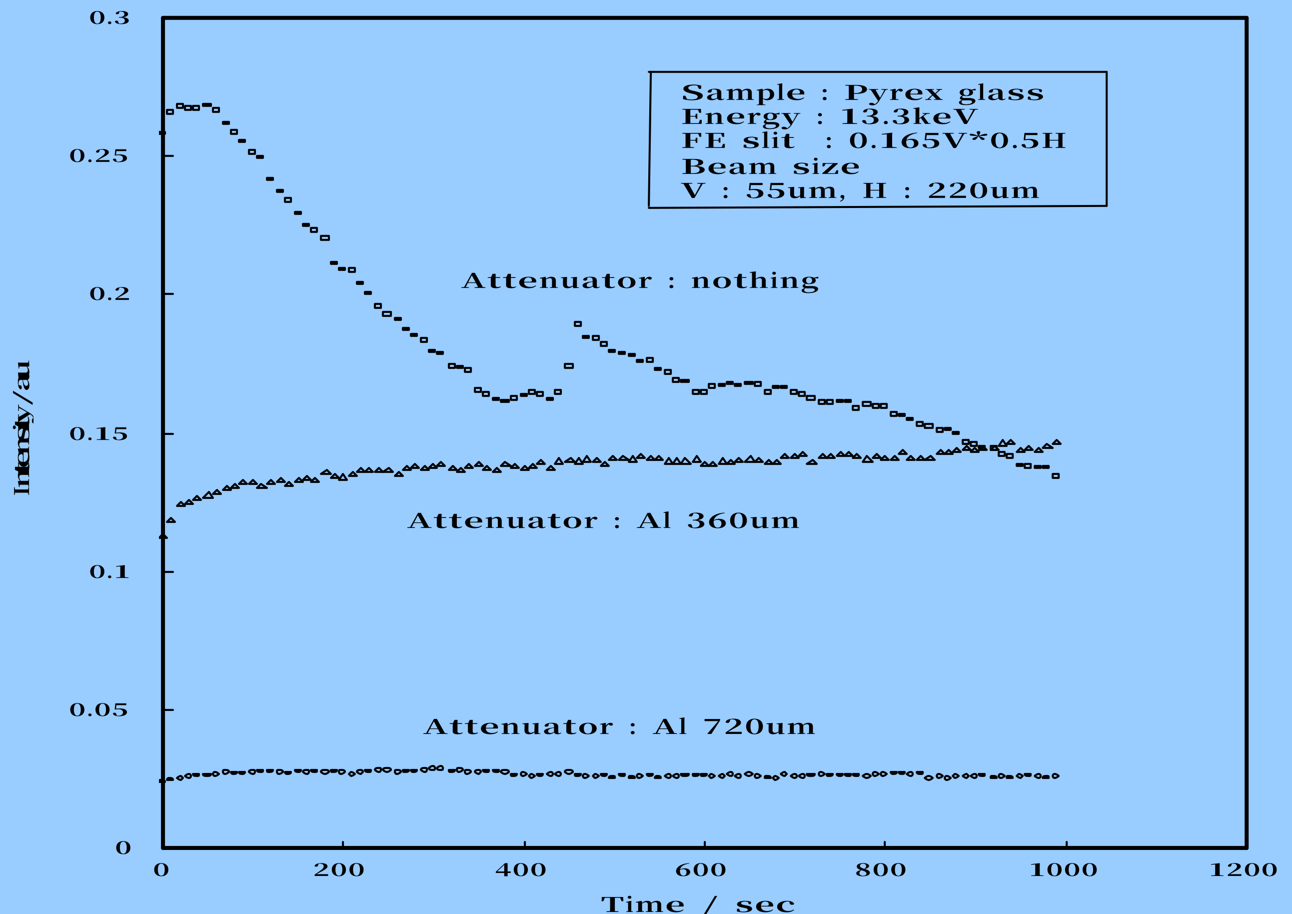

Fig.1 Time dependence of OKa intensity of Pyrex glass

Summary

- The information of acquired from EXEFS resembles XAFS. EXEFS spectrum for a very thin SiO_2 film of 15A on the Si substrate, like a SiO_2 film of 100A, reflects the chemical state of quartz.
- SiKb XRF spectra of SiO_2 /Si was measured for the depth profile of these chemical states, changing an incidence angle. As an incidence angle becomes small, these chemical states are changing from Si to SiO_2.
- The element scattering by the high flux was observed at BL40XU of SPring-8. In order to find out the conditions suitable for the chemical state analysis, the action of the oxygen of Pyrex glass was investigated against the energy and the flux of excitation X-rays.