Information Depth Estimation for Electron Yield and Fluorescent XAFS Measurement Methods

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[Purpose] **XAFS analysis of thin film materials is frequently required in industrial use of SR.**

Electron yield (EY) and fluorescent yield (FY) methods are applied to examine thin film materials.

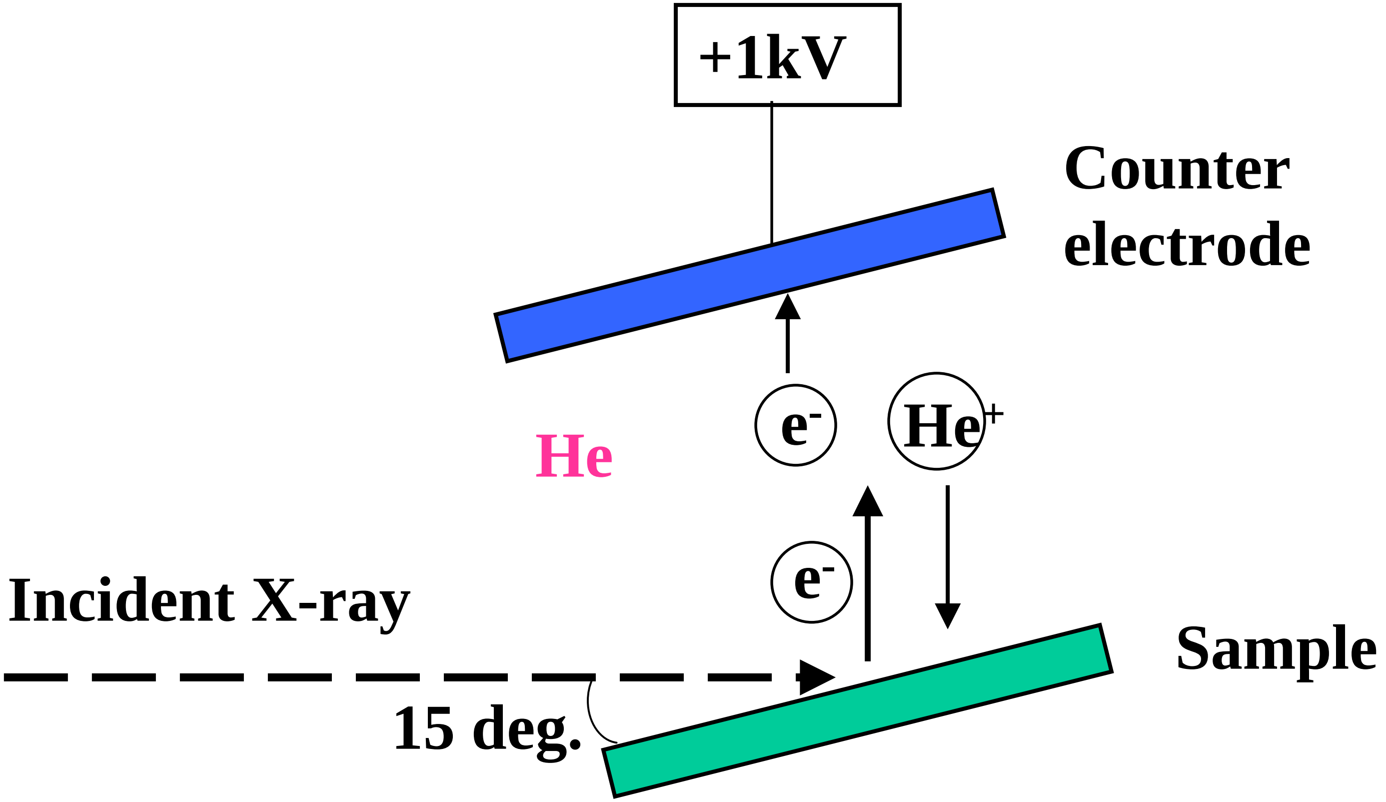
It is necessary to know the information depth of those methods.

[Sample] **PtPd films deposited on Si substrate (20nm～467nm thick)**

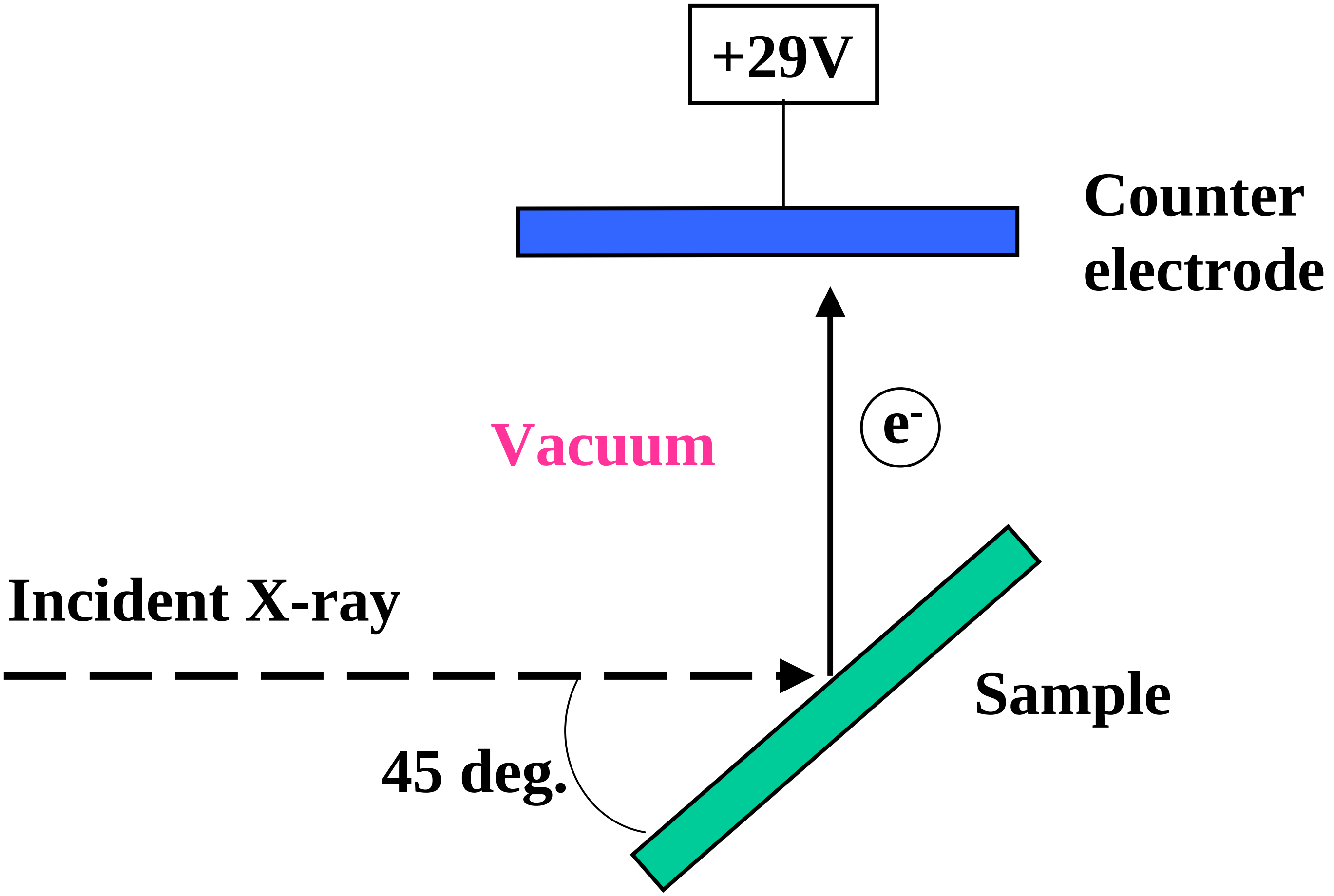
[Experiment] **Measuring edge jump of Pt L_{III} by conversion electron yield (CEY), total electron yield (TEY) and fluorescent yield (FY) methods.**

The information depths were derived using relationship between film thickness and edge jump value.

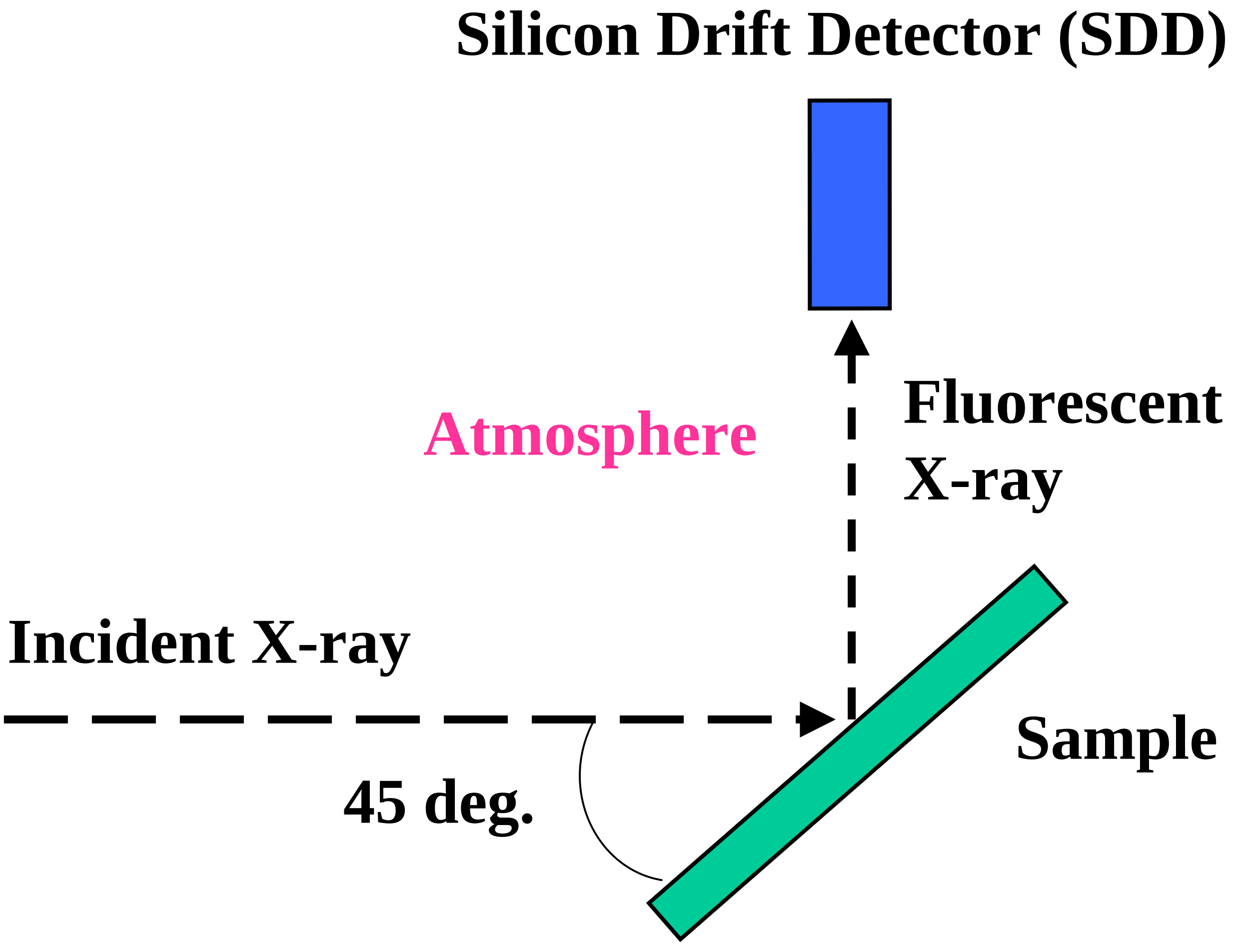
Experimental Arrangement (CEY)



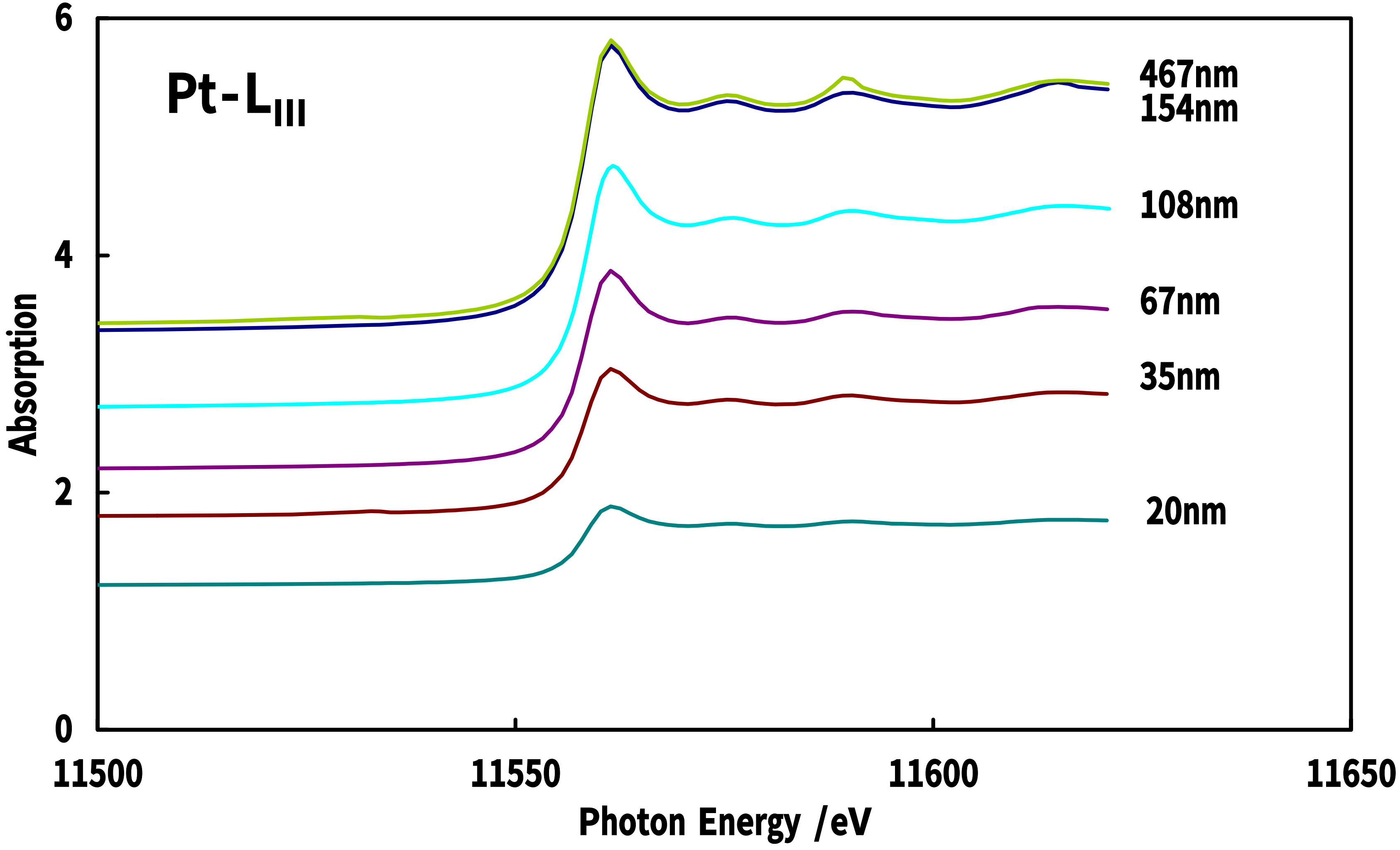
Experimental Arrangement (TEY)



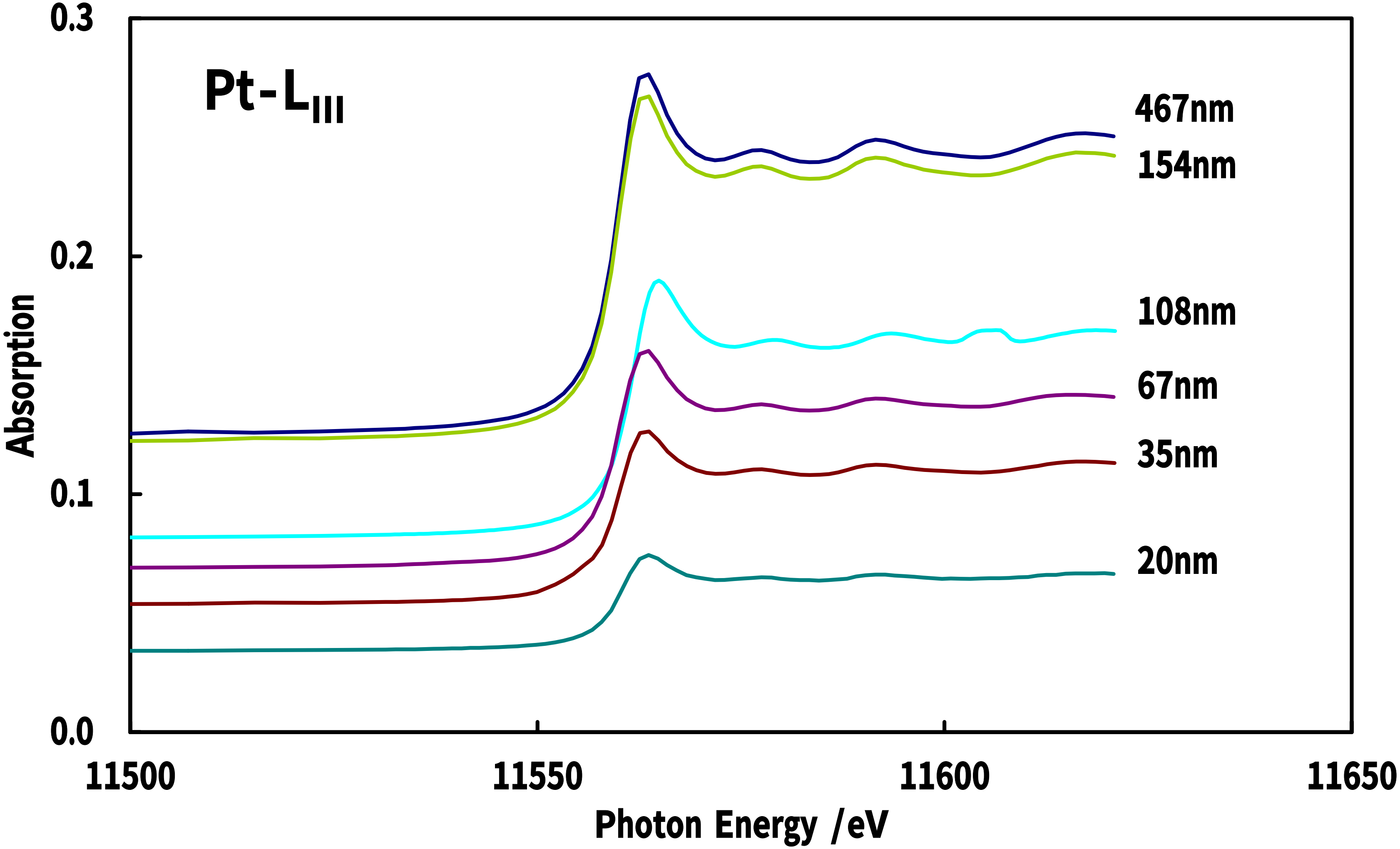
Experimental Arrangement (FY)



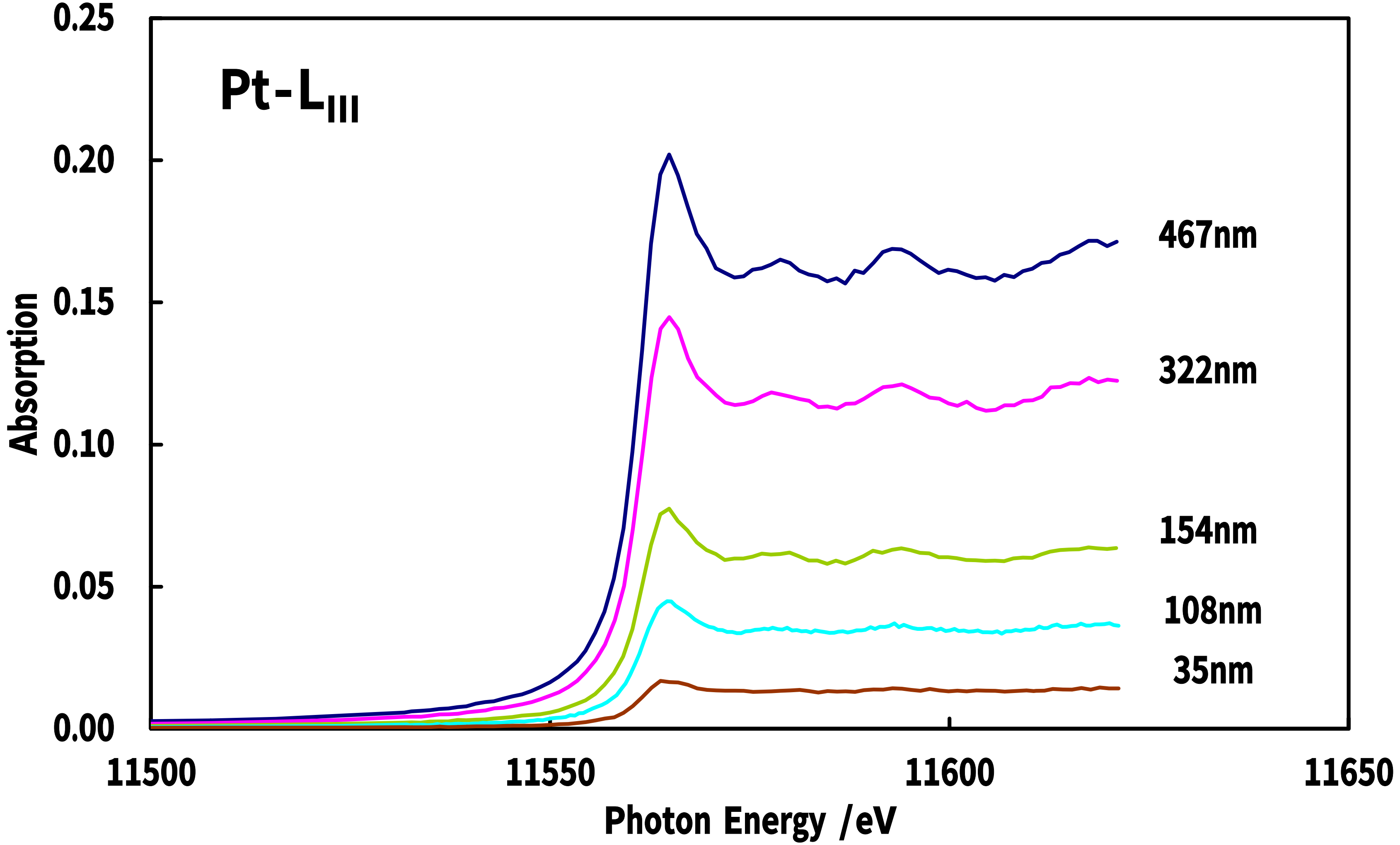
XANES Spectra (CEY)



XANES Spectra (TEY)



XANES Spectra (FY)



Estimation of Information Depth (1)

(Attenuation of incident X-ray was ignored.)

$$\phi(z) = c\ \exp(-z/\lambda)$$

$\phi(z)$: **Emission Depth Distribution Function**

λ : **Escape Depth**

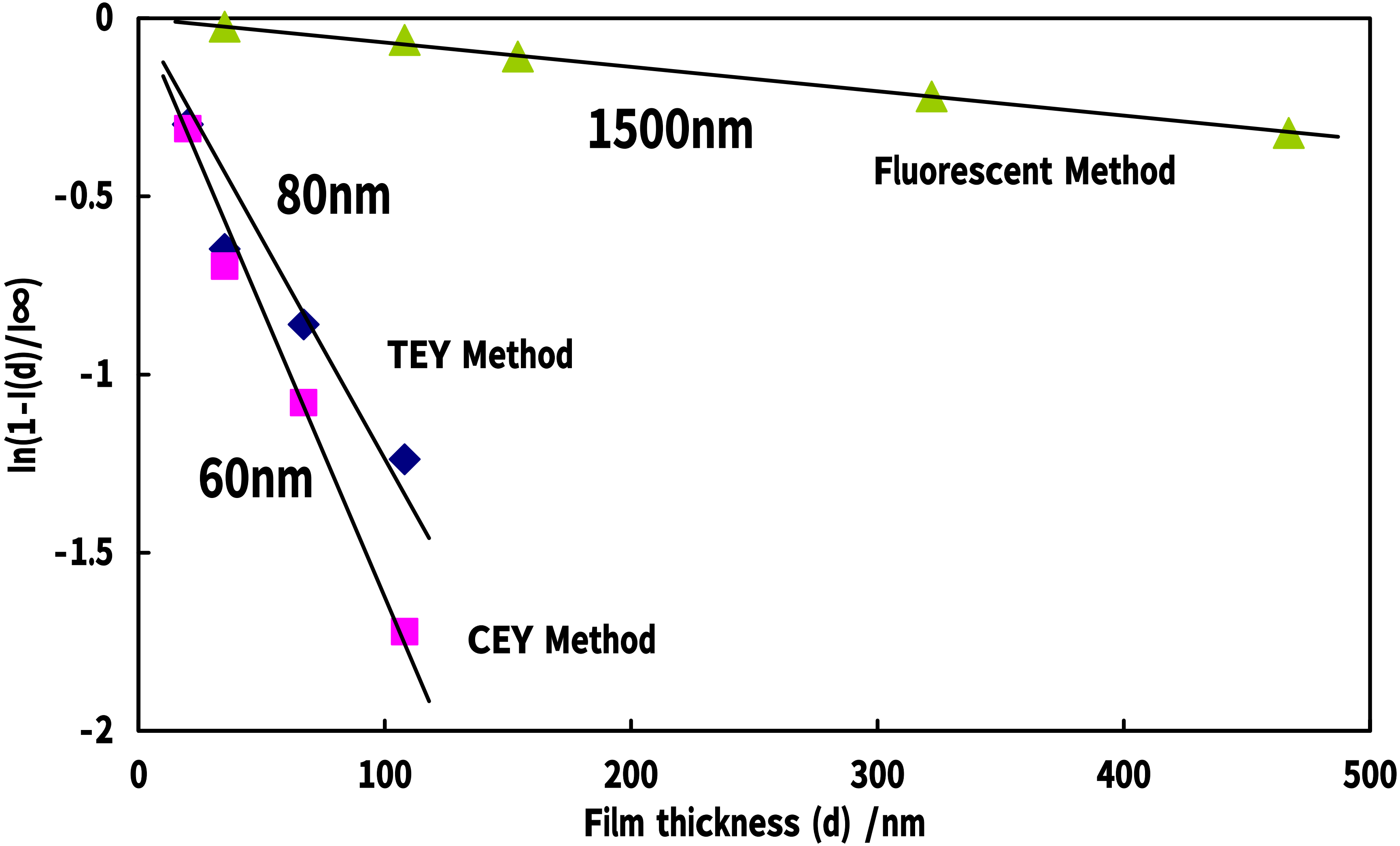
$$\frac{I_x}{I_\infty} = \frac{\int_0^x \phi(z)dz}{\int_0^\infty \phi(z)dz} = 1 - \exp(-\frac{x}{\lambda})$$

I_∞ : **Measured value of 467nm sample for CEY and TEY.**

: **That of Pt foil for FY.**

The edge jump value is 1-1/e of *I* when the thickness (*d*) is equal to λ.

Result for Each Method



Estimation of Information Depth (2)

(Attenuation of incident X-ray was taken into account.)

$$\phi(z) = c\exp(-z/\lambda)\exp(-\mu z)$$

$$\frac{I_x}{I_\infty} = 1 - \exp(-\mu - \frac{1}{\lambda})\,x$$

CEY

$$\frac{I_x}{I_\infty} = 1 - \exp(-\frac{\mu_i}{\cos\theta_1} - \frac{1}{\lambda})\,x$$

TEY

$$\frac{I_x}{I_\infty} = 1 - \exp(-\frac{\mu_i}{\cos\theta_1} - \frac{1}{\lambda\cos\theta_2})\,x$$

FY

$$\frac{I_x}{I_\infty} = 1 - \exp(-\frac{\mu_i}{\cos\theta_1} - \frac{\mu_c}{\cos\theta_2})\,x$$

θ_1 **Angle between incident X-ray and the sample normal**

θ_2 **Angle between the detector and the sample normal**

μ_i **Attenuation coefficient for incident X-ray**

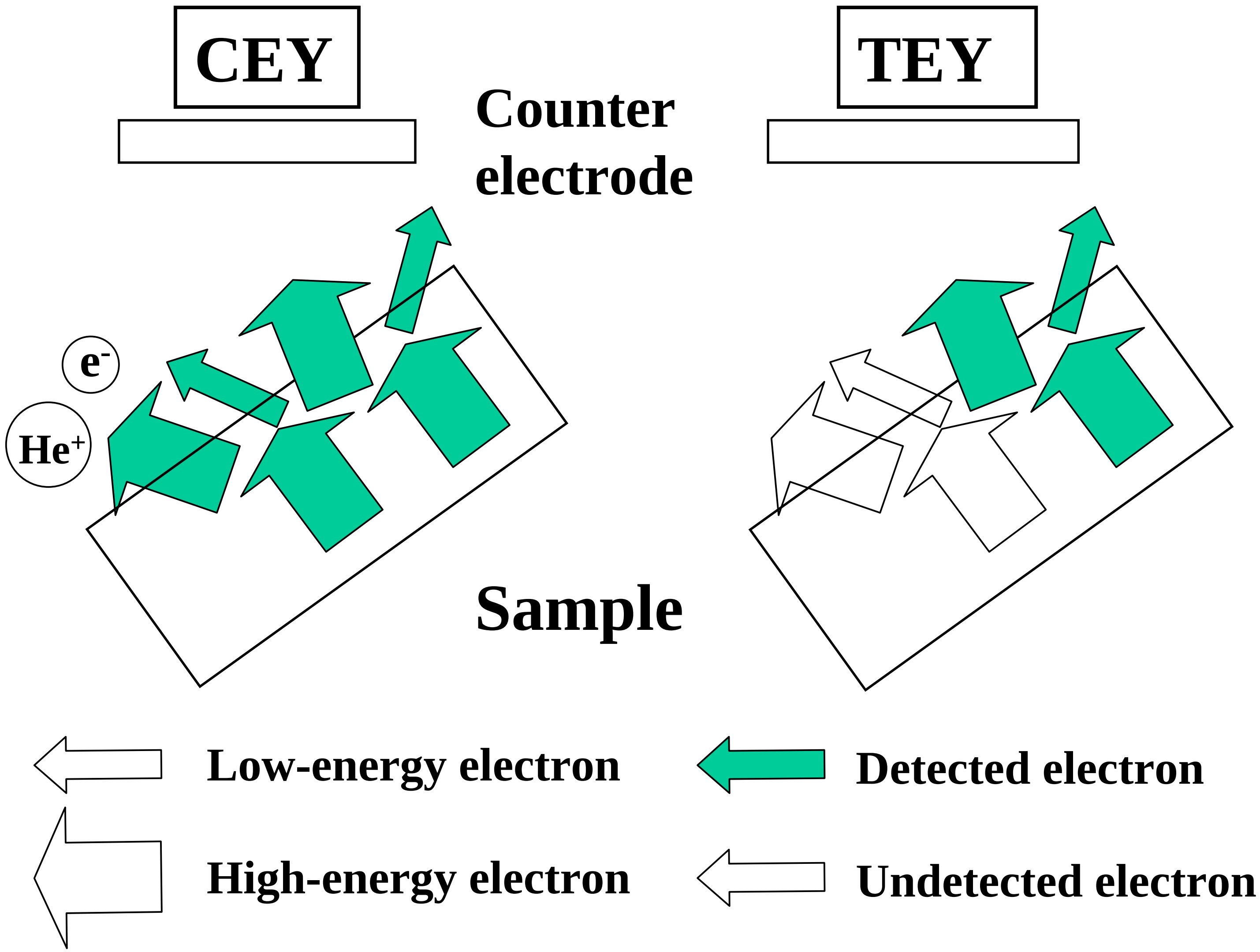
μ_c **Attenuation coefficient for fluorescent X-ray**

Calculation Results

	Attenuation of incident X-ray was ignored	Attenuation of incident X-ray was taken into account
CEY	**60nm**	**66nm**
TEY	**80nm**	**84nm**

The difference is not so remarkable.

Why the information depth of TEY is larger than that of CEY?



Low-energy electrons are generated by scattering of high-energy electrons (Pt LMM etc.) that are emitted from the deep region.

CEY is more sensitive for high-energy electrons than low energy electrons, because the number of ionized He atoms increases with the kinetic energy of electrons.

High-energy electrons only emitted toward counter electrode are detected in TEY.

Average kinetic energy detected by TEY is lower than that detected by CEY.

⇒ The information depth of TEY is larger than that of CEY.

Conclusions

At the energy range around Pt L_{III}-edge

1. **Information depth of the electron yield methods are in the range of several tens nm.**
2. **Information depth is not significantly influenced by attenuation of incident X-ray.**
3. **Information depth of CEY is deeper than that of TEY.**