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Study on quantitative analysis for Au thin films using XAS

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Introduction

A quantity of x-ray absorption by an absorption edge follows Lambert-Beer law so it can be a method for quantitative analysis of an element in various materials without destruction if the coefficient is exactly determined. It had been considered to be difficult to measure XAS of thin films with some nm thickness by transmission mode. However, recent progress in optical techniques using synchrotron radiation source made it possible. In the present report, we have determined absorption edge jump coefficients on various elements and done quantitative analysis for gold thin films with 1 – 50 nm thickness by the edge jump method in XAS successfully.

Experimental

XAFS spectra of K-edge for an elemental series from Sr(38) to Nd(60) of the 5th and 6th periods in the periodic table and L3-edge for Pt and Au in standard solutions (1000 mg/dm^3 standards for Atomic Absorption Spectrometry by Wako Pure Chemical Industries, Ltd.) in transmission mode were measured at Photon Factory using precise quartz cells with 0.5, 1, 2, and 5 cm thickness which are certified by Japan Quality Assurance Organization using the three-dimensional measurement system (Carl Zeiss UMM550) traceable to national standard of Iodine-stabilized He-Ne laser (NMIJ). The error was below 3 μm in 4 points on optical windows at 293 K.

Results and Discussion

An absorption edge jump of excitation cross section of a specific core electron of an isolation atom is in proportion to the number of atom on optical path. The absorption edge jump per an unit of optical density of element (1 g/cm^2) is defined as absorption edge jump coefficient, CΔμ (cm^2/g), relation of Δμ=CΔμD, where Δμ is a quantity of the absorption edge jump of the element, D is the optical density of the element (g/cm^2).

Figure 1 shows the CΔμ vs. the atomic number (Z) obtained by measurements of some standard solutions. The results indicate that the CΔμ can be expressed first order exponential function of the Z. The result of a least square fitting was

CΔμ =exp(7.62 - 0.07916 Z).

The newly measured elements in the 6th period were also following this equation. This indicates that we can estimate a value by interpolation and extrapolation on the element that a standard sample is not provided.

Figure 2 shows XAS of a 5 μm Au foil and a Au evaporated film to be 1 - 50 nm thickness on SiO_2 obtained by transmission mode. The results of quantitative analysis are shown in Table 1. It indicates that quantitative analysis by XAS can be applicable to ultra thin films in a nm-scale.

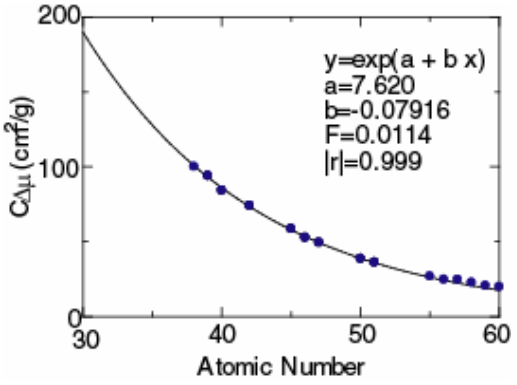

Fig.1 Coefficient parameter of absorption edge

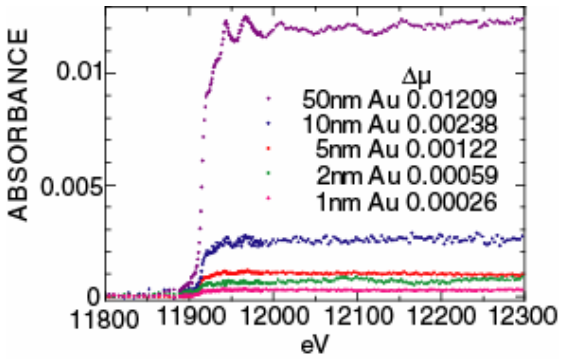

Fig.2 XAS of Au L3 of gold thin films on glass.

Table 1 Results of quantitative analysis of Au thin film using absorption edge jump coefficient CΔμ=119.79 cm^2/g

	Δμ	μg/cm^2
50nm Au/SiO_2	0.01209	100.9
10nm Au/SiO_2	0.00238	19.9
5nm Au/SiO_2	0.00122	10.2
2nm Au/SiO_2	0.00059	4.9
1nm Au/SiO_2	0.00026	2.2

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