The Removal of Auger Signals from ELS Signal and Its Estimation

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(Recieved September 1, 1991)

We tried to remove Auger spectrum overlapping on a fine structure by applying modulation voltage to both the sample and the analyzer. This method is one of important techniques to measure the spectrum of SEELFS.

The peak-to-peak of Auger spectrum as a function of phase angle shows good agreement with the caluculated results.

Key words : SEELFS, ELS, AES, ZnTe, CMA

1.Introduction

The analysis of surface extended energy loss fine structure(SEELFS) has been developed by M.De Crescenzi et al[1]-[5]. As SEELFS uses incident electrons of less than several KeV, it is considered that this method is a useful technique for analysis of surface structure. Though electron loss spectroscopy(ELS) is used for getting a fine structure, we can not obtain the accurate fine structure in the range where Auger spectra overlap. Therefore, it has been necessary to choose the suitable energy of an available incident electron to avoid overlapping of the Auger spectrum on the fine structure.

In this letter, we tried to remove the Auger spectrum overlapping on the fine structure by applying modulation voltage to both the sample and the analyzer. At the same time based on the experimental results thus obtained,we discussed quantitatively about the influence of phase shift.

2.Results and Discussion

Though the idea of this method has already been reported by Matsuura et al[6], the connecion position of their phase shifter is different from the one of our system. That is, their phase shifter is connected to the modulation voltage circuit which is applied to the analyzer. When we carried out experiment by their arrengement, we found that the phase of the signal simulataneously shifts during the adjustment of phase between the sample and the analyzer. To decrease the shift of the phase, We changed the position of our phase shifter to the sample side.

Figure 1 shows the schematic diagram of the present SEELFS system. The modulation voltage was applied to both a sample and a analyzer with the same phase.

We used a single pass CMA in the measurement of SEELFS. Modulation frequency and amplitude were 1.1kHz and 8eV$_{p-p}$, respectively. A single crystal ZnTe was used as asample. Every spectrum was measured at energy of incident electron 970eV. A personal computer was introduced into the measuring system for setting the sweep voltage and averaging the sum of data points in order to improve the signal-to-noise ratio. The data was stored on a floppy disk. The samples were measured in the same UHV chamber at 2×10^{-7}Pa. Figure 2 shows the spectra obtained by this system. In this figure, horizontal axis shows loss energy. Zn-$M_{2,3}$,M_1 edges at the near 80eV and 130eV can be observed at about 470eV. The upper spectrum was measured by applying the modulation voltage to both the sample and the analyzer, whose phase angles are changed from -360° to -180°. The shape and energy position of M2,3 and M1 loss spectra did not cange even if we change the phase angle between the sample and the analyzer, as shown in Fig.2. On the other hand, O-KLL Auger

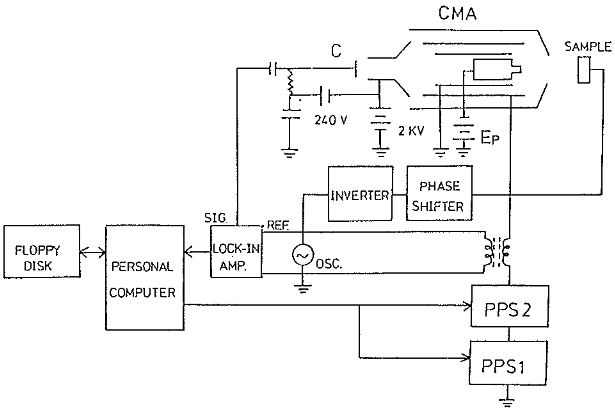

Fig.1 Schematic diagram of our measuring system to obtain SEELFS removing AES signals.

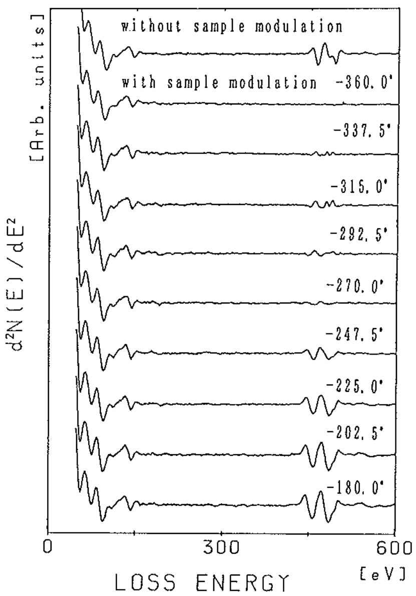

Fig.2 Spectra are measured above the Zn-$M_{2,3}$ peak of the single crystal ZnTe. Upper spectrum is measured by applying modulation voltage to only analyzer. Other spectra are measured by applying modulation voltage to both sample and analyzer, whose phase angles are changed from -360° to -180° .

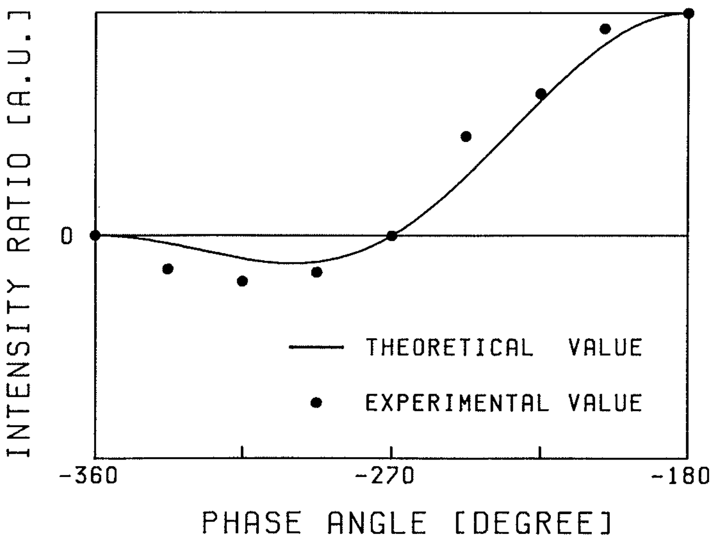

Fig.3 The intensity ratio of O-KLL AES signal is shown as a function of phase angle between the sample and the analyzer.

spectrum appeared in opposite phase, as compared with the topmost spectrum. The intensity of Auger spectrum showed the increase up to -315°. After that, its intensity decreased. After -270° to -180°, the shape of Auger spectrum showed the tendency of monotonic increase and finally became the original shape. The peak-to-peak of O-KLL Auger spectrum is shown in Fig.3 as a function of the phase angle between the sample and the analyzer. A closed circle shows the experimental value. A solid line shows the calculated one.

The calculated result was obtained from the equation described below. Taylor series till the second expansion is shown as follows.

$$P(V+\Delta V)=P(V)+P'(V)\Delta V+1/2(P''(V)\Delta V^2) \quad (1)$$

Though the ELS signal was only affected by the modulation voltage of the analyzer, the Auger signal was affected by the modulation voltage of both the sample and analyzer. The modulation voltage between the sample and the analyzer is written as

$$\Delta V=V_{\square}(\sin wt-\sin(wt+\phi)), \quad (2)$$

where ϕ is a phase shift between the sample and the analyzer. Substituting the eq.2 into the eq.1 , we can obtain the following equation

$$P(V+\Delta V)=P(V)+P'(V)V_{\square}(\sin wt-\sin(wt+\phi))$$
$$+1/2(P''(V)(\sin wt-\sin(wt+\phi))^2 \quad (3)$$

When we pay attention to the third term described at eq.3, the third term is expanded as follows.

$$(\sin wt-\sin(wt+\phi))2=$$
$$1-\cos\phi+1/2(2\cos\phi-\cos2\phi-1)\cos2wt$$
$$+1/2(\sin2\phi-2\sin\phi)\sin2wt \qquad (4)$$

The coefficient of cos2wt can be detected as the second derivative signal. Figure 3 shows the coefficient of cos2wt as a function of the phase shift ϕ. This calculated result shows the satisfactory agreement with the experiment result. On the other hand, by shifting the phase angle of signal by 90°, the coeficient of sin2wt will be able to be obtained as the signal.

3.Sumary

As a sumary, Auger spectrum could be removed by applying the modulation voltage to the sample and the CMA by using the measuring system shown in Fig.1. The peak-to-peak of Auger spectrum as a function of phase angle shows good agreement with the calculated results.

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