Image contrast in ultra low voltage scanning electron microsocpy

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Recent technological development in low voltage scanning electron microscopy (SEM) has opened a new world for obtaining surface selective information. The spatial resolution reaches ~ 0.6nm at 1 kV and better than ~ 3.0 nm at 100 V. This gives quite useful for observing surface fine details such as composition and crystal topographic information from the external surface which is the most important playground for their functions. However, we have already learned that the brightness of SEM image depends on both atomic number of constituent atoms and electron landing voltage especially at voltages lower than a few kV. Then it is becoming important to separate the contribution of SE (SE1, SE2 and SE3) and BSE to SEM images.

In order to observe the dependence of the brightness of SEM image on both atomic number and electron landing voltage, a half part of the carbon sample was coated with evaporated gold with a thickness of about 200 nm was prepared. The electron landing voltage was changed between 500 V and 220 V by changing the specimen bias from 0 to 280 V while keeping the accelerating voltage at 500 V. Figure 1 (a) and (b) show FE-SEM images taken at landing voltages of 500 and 220 V, respectively, together with the integrated intensity profile obtained in the region bounded by parallel dotted lines. The relative brightness of carbon and gold was reversed between 500 V and 220 V.

Figure 2 shows AES spectra obtained under the same conditions as in Figure 1. Integrated intensities of different energy ranges are summarized in Table 1. Both the secondary electrons (SEs) and back-scattered electrons (BSEs) show higher counts for gold at the landing voltage of 500 V, while carbon shows brighter contrast than gold both in SE and BSE at the landing voltage of 220 V (b). In particular, the BSE counts of carbon was about twice as much as that of gold.This spectrum was acquired with the sample inclined by 30 ° toward electron energy spectrometer. The image contrast observed by FE-SEM (Figure 1) is consistent with the AES spectrum under the same conditions (Figure 2).

There is a difference between the integrated intensity ratio of carbon and gold in BSEs and (SE1+SE2+SE3). Some of BSEs may be consumed by other electron excitations which will be discussed at the Conference.

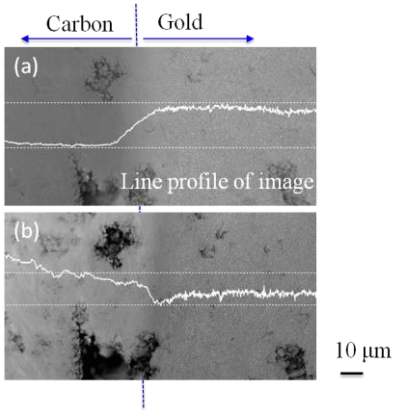

Figure 1. Relative contrast of SEM image taken with the in-column detector at WD = 4.0 mm. The relative brightness between gold and carbon dramatically changes with landing voltage 500 V (a) to 220 V (b).

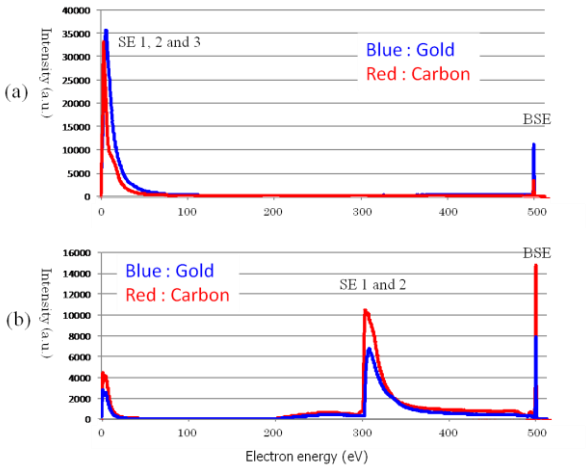

Figure 2 Auger Electron Spectroscopy (AES) spectra of emitted electrons from the same sample as in Figure 1 taken under the conditions of landing voltage 500 V (a) and 220 V (b), respectively.

Integrated intensity

(a) Landing energy: 500 eV

	0–100eV	400–500eV	0–500eV
C	1539175	79058	1907023
Au	2594265	158694	3106438
C : Au	1.0 : 1.7	1.0 : 2.0	1.0 : 1.6

(b) Landing energy: 220 eV, Sample bias voltage: −280 V

	0–100eV	200–300eV	400–500eV	0–500eV
C	221286	208699	374262	2229407
Au	134875	140890	213075	1455553
C : Au	1.6 : 1.0	1.5 : 1.0	1.8 : 1.0	1.5 : 1.0

Table 1 Comaprison of integrated intensities for different electron energy ranges