Investigation of Image Contrast of Energy-Filtered BSE Image at Ultra Low Voltage

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To meet the increasing demands to clarify the compositional differences in advanced composite materials, we reported a new imaging method using energy filtered BSE signals at Ultra Low Voltages (ULV) [1][2]. This method was applied to carbon nanotube (CNT) and polytetrafluoroethylene (PTFE) composite films to confirm its ability to differentiate distribution of CNT and PTFE components at 0.3 kV as shown in Figure 1. We confirmed that the difference of surface potential affects the contrast between CNT and PTFE more strongly than the differences of average atomic number and surface morphology for this specimen. To apply this method to any other materials, it will be necessary to investigate the effect of the difference in average atomic number and surface morphology on the contrast because the signal behavior under ULV condition does not follow the conventional theory used over 1 kV [3]. In this study, we investigated the effect from the difference of average atomic number by fundamental experiments and simulation techniques.

Figure 2 shows a general view of the Hitachi SU8230 FE-SEM and a schematic of signal detection system using the deceleration mode. To control the signal detected by the top detector, an energy filter called "top filter" is used. This works as a high pass filter, so it allows only electrons with higher energy than the filtering voltage to be detected. High angle BSE (HA-BSE) signal can be detected by the top detector with an appropriate combination of landing voltage, decelerating voltage, and filtering voltage.

A fundamental experiment of the contrast caused by the difference of average atomic number on BSE imaging at ULV was carried out using a basic test specimen. This consists of four pieces of Si wafer, and 50 nm thick films of three types of materials with different atomic weights (C, Cr, Pt) are deposited on three pieces. Figure 3(a) shows a BSE image of the test specimen at 0.3 kV. In this image, the contrast between Si, Cr, and Pt is observed. Figure 3(b) shows comparison of image brightness between each material against landing voltage. The contrast does not follow the conventional theory used over 1 kV. For example, Pt has the highest Z number and it is brightest at 1 kV, but it is also the darkest at 0.3 kV. This tendency partially conforms to a previous study [3]. We will disclose more details including simulation results in the session.

References :
[1] Y. Hashimoto *et al*., Microsc. Microanal. 19 (Suppl 2), 1176-1177 (2013).
[2] Y. Hashimoto *et al*., Microsc. Microanal. 20 (Suppl 3), 34-35 (2014)
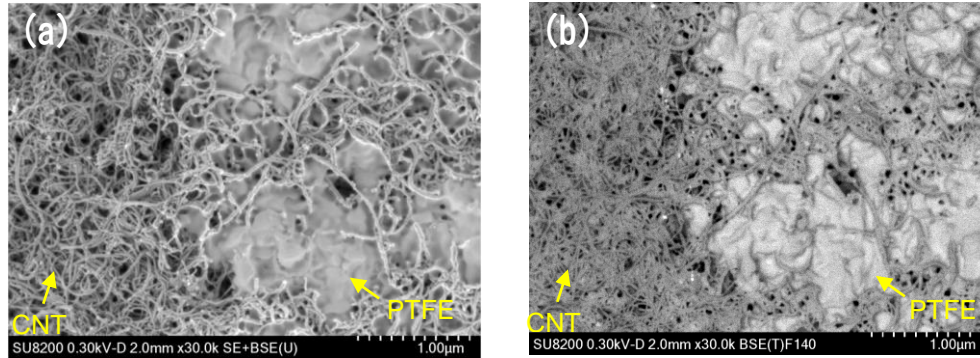[3] Ilona Müllerová, *Scanning*, 23, 379 (2001)

Fig.1 BSE images of CNT / PTFE composite film at 0.3 kV detected by (a)Upper detector, (b)Top detector
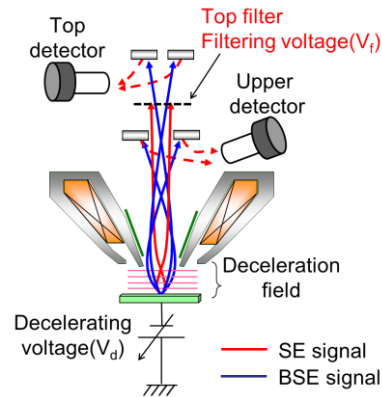

Fig.2 General view of Hitachi SU8230 FE-SEM and a schematic of signal detection system using the deceleration mode

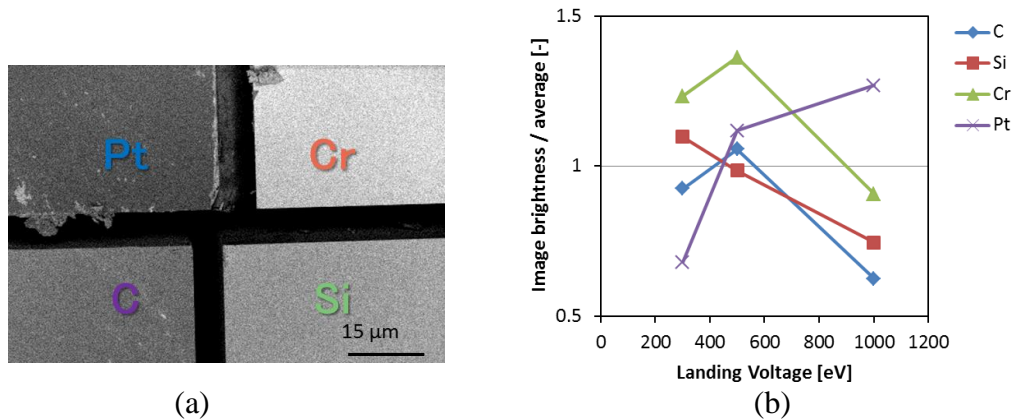(a)   (b)

Fig. 3 (a)BSE image of test specimen at 0.3 kV, (b)Comparison of image brightness between each material against landing voltage