A study of the behavior of SE and BSE in Ultra low landing voltage condition

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Studies in ultra low voltage condition have been reporting the interesting phenomena such as the mismatch of the proportional relationship between the image contrast and the atomic number[1], the possibility that the information source size of BSE is shallower than that of SE[2], some of which don't follow the general logic to interpret the SEM image based on the traditional SEM principles.

In the study, we set our motivation to consider the mechanism to explain such an interesting phenomena particularly happened at the ultra low voltage situation. At first we gathered a set of SE and BSE images simultaneously at ultra low voltage condition from various kinds of specimen. Second, we compared the SE and BSE image to investigate the difference. A simulation results by CASINO [3] was also applied for the theoretical consideration. In the study the recent cold FE-SEM (Hitachi SU8000) is used. The SEM is offering the SE/BSE filtering capability even at ultra low voltage condition as shown in Fig.1.

Fig.2 shows SE and BSE image of Au foil at the landing voltage of 100V and 300V.The residue on Au foil was revealed to be present at 100V SE image (Fig.2(a)) and the Au grains under residue layer became visible at 300V SE image(Fig.2(b)).
At the same time, BSE images both of 100 and 300V show the topography of the sample (Fig.2(c)(d)). The fine convex shaped topography with the height of 1 or 2 nm are clearly visible at 100V(Fig.2(c)) as well as a few nanometers' micro asperity of Au grains. In case the residue consists of organic materials, BSE scattering depth is simulated less than 1nm, which implies the BSE spatial resolution for Z direction, corresponding with the experiment.

Reverting to SE images, all SE is emitted without any loss because PE scattering region is extremely shallow like as imaging by the landing voltage less than a few hundred volts. SE will be emitted from almost the entire PE scattering region so that the information changes between 100V and 300V.

We also report some examination results to acquire the spatial resolution of SE and BSE.

[1] Ilona Müllerová, Scanning, 23, 379, (2001)
[2] D C Joy, Electron microscopy and analysis, 175, (1987)
[3] http://www.gel.usherbrooke.ca/casino/

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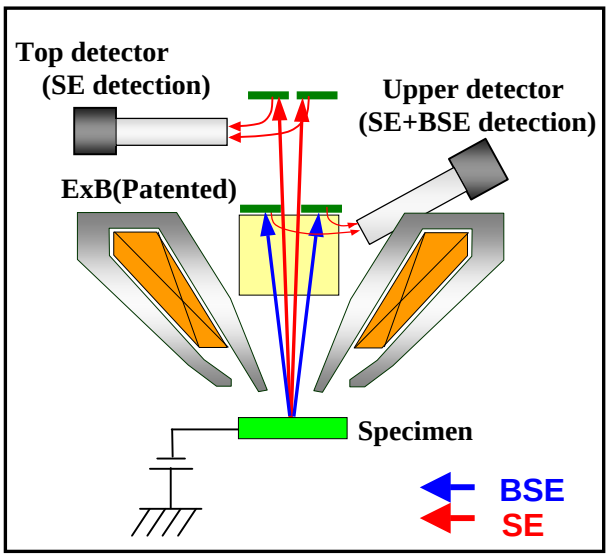
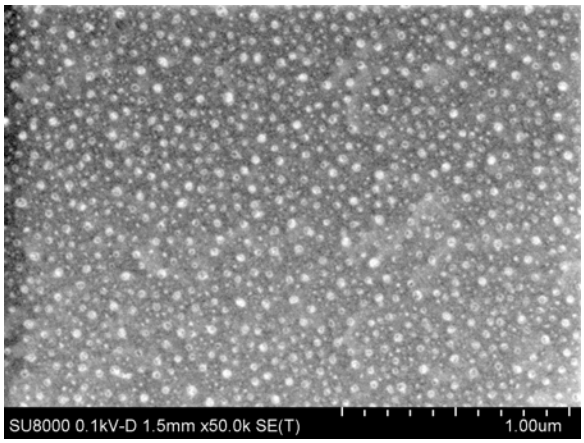
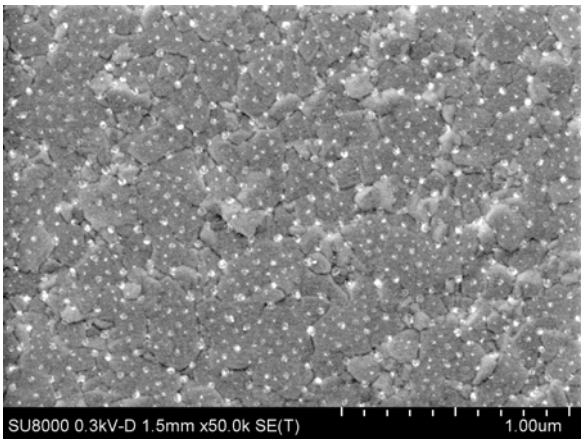


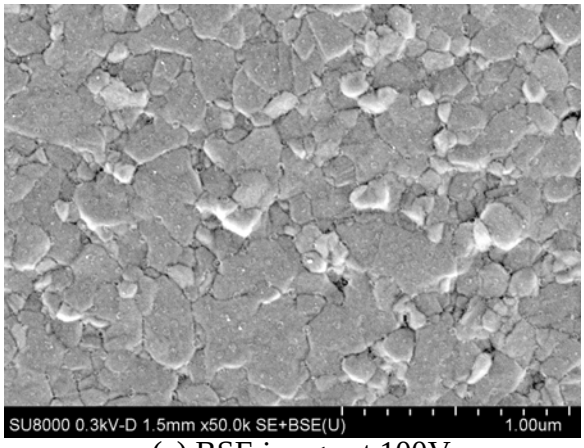
Figure 1 SE/BSE filtering function in SU8000 FE-SEM



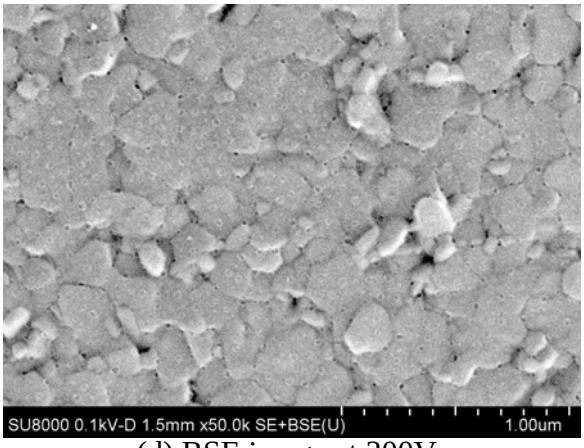
(a) SE image at 100V



(b) SE image at 300V



(c) BSE image at 100V



(d) BSE image at 300V

Figure 2 SE and BSE imaging of Au foil at the landing voltage of 100V and 300V

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