Image filtering in scanning electron microscopy under super low energy condition

Mikmekova, S.[1], Aoyama, T.[2] and Okuda, K.[1]

[1] JFE Steel Corporation, Japan, [2] JFE Steel Corporation, Japan

Recently, almost all commercial scanning electron microscopes have been equipped with a multiple detection system. This system achieves image filtering by selecting detection signals for each target information [1]. Microstructural differences can be observed precisely by using this method, and this information is very useful for developing high strength steel, as it is possible to distinguish phases, the morphologies of precipitates and so on. After the pioneering study of the super low energy ($E_0 \leq 20$ eV) scanning electron microscopy (SEM) by Pease [2], various SEM images under the super low energy condition have been reported. Since most of them were obtained by single detection systems, image filtering under the super low energy condition was not applied. In this study, we performed image filtering of a Au/C standard sample under the super low energy condition by using a multiple detection system. We also discussed the mechanism of the image contrast under the super low energy condition for applying to practical material.

We used a SEM system with three in-lens/in-column detectors (Scios, FEI Company). The super low energy condition is achieved by applying negative sample bias to decelerate incident electrons. The energies of the incident electrons were varied in the range from 1 to 50 eV. As the result, images taken by these three detectors showed different phenomena. By the two lower in-lens detectors (T1 and T2), gold was always observed as a darker contrast than graphite. However in the images taken by the topmost in-column detector (T3), the contrast between gold and graphite fluctuated depending on the incident energy. Since graphite shows higher intensities than gold in this energy range (≤ 50 eV) in standard Auger electron spectra [3], the fluctuation of the contrast between gold and graphite seen in the images by the T3 detector is quite unusual. This tendency is probably due to the very low take-off angle of the signal electrons of the T3 detector, as the take-off angle of the T3 detector is much lower than those of the other two detectors. Although some details of the mechanism are still unclear, we observed filtered images of the gold and graphite by using the three detectors under the super low energy condition.

Image filtering under the super low energy condition is a promising technique because signals should reflect an electronic structure, i.e. physical properties, in this energy region.

This presentation is based on the results obtained from a future pioneering project commissioned by the New Energy and Industrial Technology Development Organization (NEDO).

References

[1] Mikmeková Š., Nakamichi H., Nagoshi M., Microscopy, (2017), https://doi.org/10.1093/jmicro/dfx117.
[2] Pease R.F.W., in: Record of the IEEE 9th Annual symposium on Electron, Ion, Laser Beam Technology, San Francisco Press Inc., San Francisco, 1967, pp. 176-187.
[3] Goto K., Absolute AES spectral database. http://www.sasj.jp/COMPRO/index.html