Dependence of contrast on pressure using segmental ionization detector in environmental SEM

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Ionization detector is often used for the detection of signal electrons in environmental scanning electron microscope (ESEM). This detector is based on the principle of signal electron amplification by the process of impact ionization in the specimen chamber with gaseous environment. The grounded specimen forms one electrode of the parallel electrode detection system [1]. The second electrode is placed above the specimen, and it is connected to the appropriate potential that causes impact ionization of secondary electrons. A hole in the upper electrode allows primary electrons to pass to the specimen and this electrode also detects amplified signal electrons.

The electrode system of the segmental ionization detector was constructed by printed circuit board technology. In the experiment the upper electrode was divided into three concentric annular segments. The outer diameters of the individual segments are 3.5 mm (segment A), 7 mm (segment B) and 14 mm (segment C). The spaces between the segments are 0.5 mm, as presented in Figure 4. The electronics of the segmental detector makes it possible to connect one or more segments to ionization potential, and consecutively the signal is detected from these segments. Segments without ionization potential can be either grounded or unconnected.

Dependences of signal levels of gold, copper, aluminium and carbon foils on the water vapor pressure in the specimen chamber were analysed from the specimen micrographs. The ionization potential was 400 V, the primary beam current was 30 pA, accelerating potential of the primary beam was 20 kV and the working distance between the specimen and the upper electrode was 4 mm. The contrast C_X was interpreted as the difference of signals S_X and S_C obtained from the metal foil (Au, Cu, Al) and from the carbon foil, respectively:

$$C_X = S_X - S_C \ ,$$

where $X=Au$, $X=Cu$ or $X=Al$. Some experimental results of the pressure dependences of the contrast are shown in Figures 1, 2 and 3. As the change of the signal from the carbon foil with the pressure was very low, these pressure dependences of the contrast C_X are similar to the ones of the signal S_X from the each metal foil. It is evident from the curves shown that the different potential at the segments has impact both on the contrast magnitude and on the pressure of the contrast maximum. It is obvious from the dependences in Figures 1a, 2a and 3 that the contrast maximum is moved to a lower pressure if the detection area increases. No highest signal and contrast were obtained with the largest detection area, as presented in Figure 3. In the given case, contribution of backscattered electrons is supposed to be the major cause. The highest signal and contrast were obtained with the connection shown in Figure 2a, where the outer segment was grounded. It is assumed that the reason could be the influence of the outer grounded segment, which can contribute to the decrease of positive ion concentrations in the space between the specimen and the detector. The positive influence of the grounded outer segment is also evident from the comparison of the dependences in Figures 1a and 1b as well as in Figures 2a and 2b.

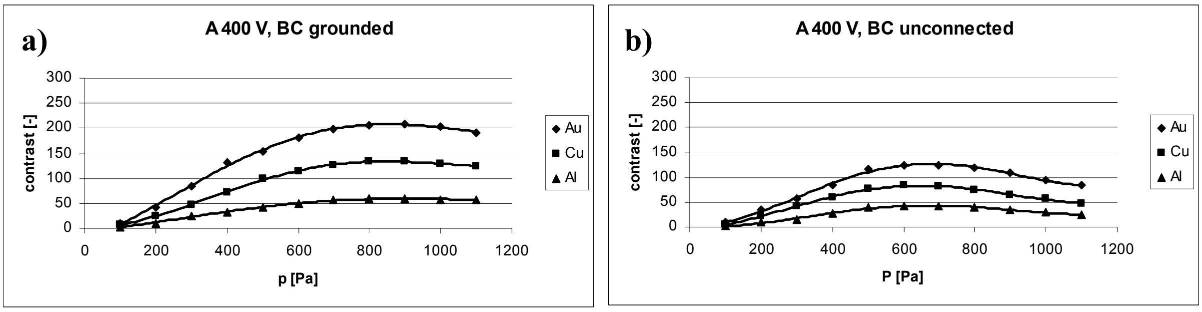

Figure 1. Dependences of the contrast on the pressure of water vapors in the specimen chamber. Segment A is at the potential of 400 V, segments B and C are a) grounded or b) unconnected.

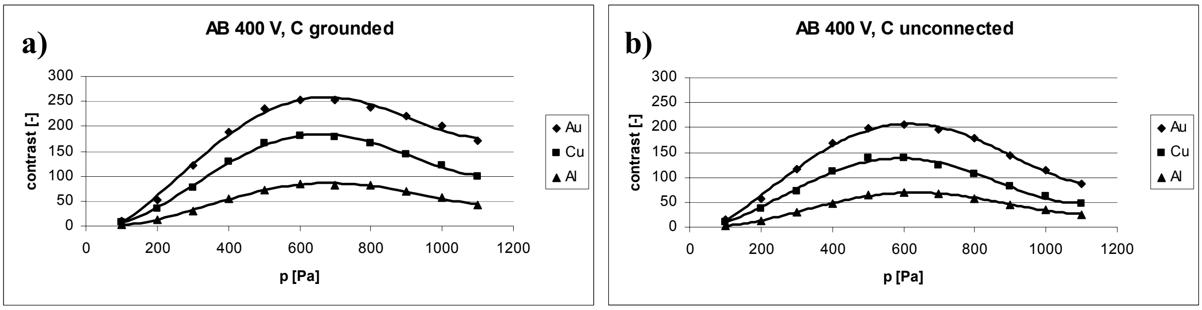

Figure 2. Dependences of the contrast on the pressure of water vapors in the specimen chamber. Segments A and B are at the potential of 400 V, segment C is a) grounded or b) unconnected.

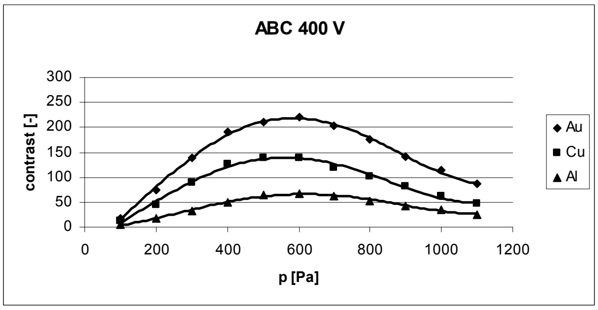

Figure 3. Dependences of the contrast on the pressure of water vapors in the specimen chamber. Segments A, B and C are at the potential of 400 V.

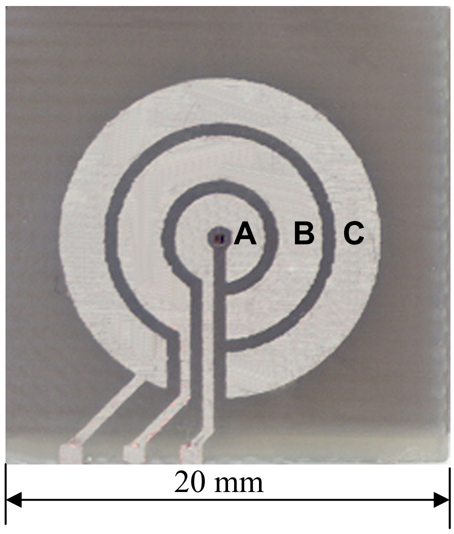

Figure 4. Segmental ionization detector with the concentric segments A, B, C.

1. G. D. Danilatos, "Theory of the Gaseous Detector Device in the ESEM", Advances in Electronics and Electron Physics, Academic Press, Vol. **78** (1990), p. 1-102.
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