Applied Physics Laboratory
IV.: Scanning Electron Microscopy

Pál Balázs*
Somogyfoki Réka*,m, Tuhári Richárd*,m

October 31, 2019

Abstract

On the fourth occasion of the *Applied Physics Laboratory* we've learned the basic of the usage of a scanning electron microscope (SEM). The nature of this lecture was purely informative, where we didn't have any complex calculation or measurement task, besides a very short one. Our objective was to learn, how to set up the SEM, to take somewhat higher-quality pictures, which could be further analysed if needed.

I. INTRODUCTION

During the lab, we used a SEM, to make observations of three different samples, each for everyone in our lab group. We used an approximately 30 years old equipment, which could be operated and set up only fully manually. This meant, that we have to set all the settings and adjustments for every picture, without the aid of any kind of automatic corrections.

II. OBSERVATIONS

The first sample, a microscopic copper lattice was studied by me. I made my observations only with the detector which is capable of the detection of the secondary electrons. Due to the short duration of the lab, I didn't have enough time to study my sample also with the detection of backscattered electrons.

The secondary electrons are created, when the electron beam of the SEM knocks out electrons from the higher atomic levels of the sample, into the direction of the detector. These electrons always have low energy, and originate from the uppermost layers of the sample. The SEM uses a so-called Everhard–Thornley-detector, which is technically a photomultiplier tube with an outer electric field, which collects the scattered secondary electrons.

During my measurement I had to take numerous pictures of my sample with different magnitudes, and had to calibrate the images' brightness, contrast, focus, position and the corrections for edge distortions. The 95% of my work was consisted of by setting up the first two of them. The image could be displayed by either the SEM's own oscilloscope-like display, or by an external monitor. The contrast and brightness could be efficiently set using the monitor, while the other parameters using the SEM's own monitor.

The rendering of the image on the external monitor was painfully slow, the whole picture was gradually displayed on the monitor line by line over the span of a minute. During this rendering the brightness and contrast could be changed in real time, but the changes only took effect on the currently rendered lines, while the already rendered parts were unchanged. This created an image with horizontal segments of gradually changing contrast and brightness. After the rendering was complete, the rendering program returned the histogram of the images.

After slowly setting the right brightness and contrast on a picture, we could save it finally. My pictures could be seen on the figures (1) - (8), along with their corresponding histograms. In these pictures the On the copper lattice, there are numerous bright spots and artifacts, which are simply contamination, found on the surface of the sample. Thorough the holes of the lattice, the sample holding plate could be seen, which is clearly also contaminated by dust and other pollution.

The second sample - which wasn't calibrated by me - was a human hair. The calibration process was the same, but my lab partner had some problems with the correct setting of brightness and contrast, and not even any of us could help her. Here, only two images with secondary electrons, and one with backscattered electrons were taken. One of them which was taken using secondary electrons, and the backscattered one could be seen along with their corresponding histogram on figures (9) - (12). The first thing which could be seen on these pictures is the damage of the hair, also the smooth surface along which the hair was cut (probably with a razor). In the pictures of the secondary electrons, this surface is very bright, indicating the presence of some other material, than other parts of the hair.

The last sample was calibrated by our third lab partner, which sample was some kind of microchip. Setting the correct brightness and contrast was pretty much smoother in this case. Some numbers, which size was approximately 100 μm could be also seen and clearly read from the surface of the chip. These pictures could be seen on figures (13) - (18).

*Eötvös Loránd Tudományegyetem
mLab partners

III. DISCUSSION

We've seen the hard part of the calibration and taking images with a scanning electron microscope, but still managed to make our very first pictures with it, which I think is the main objective of this lab measurement. Hence, we can conclude, that our lab work was successful.

APPENDIX A. – FIGURES

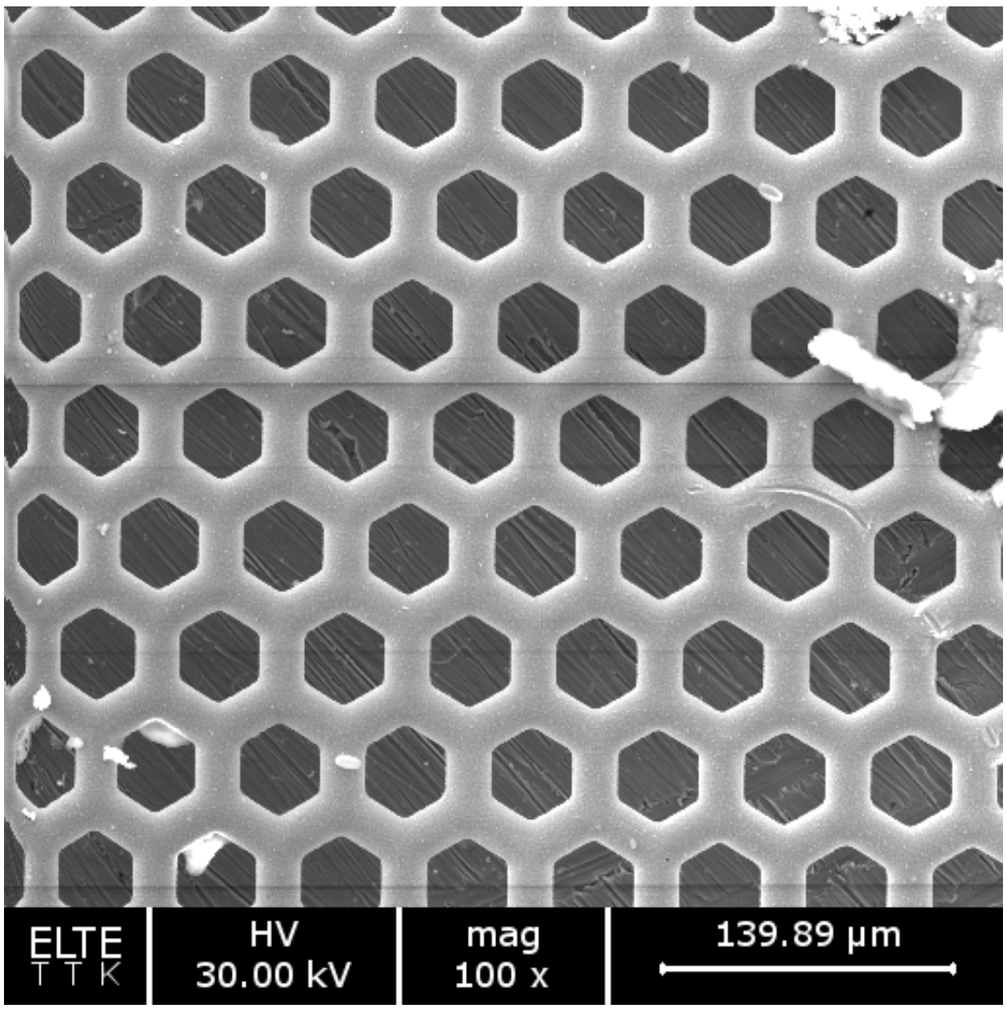

Figure 1: Surface of a microscopic copper lattice with 100x magnitude by detecting secondary electrons.

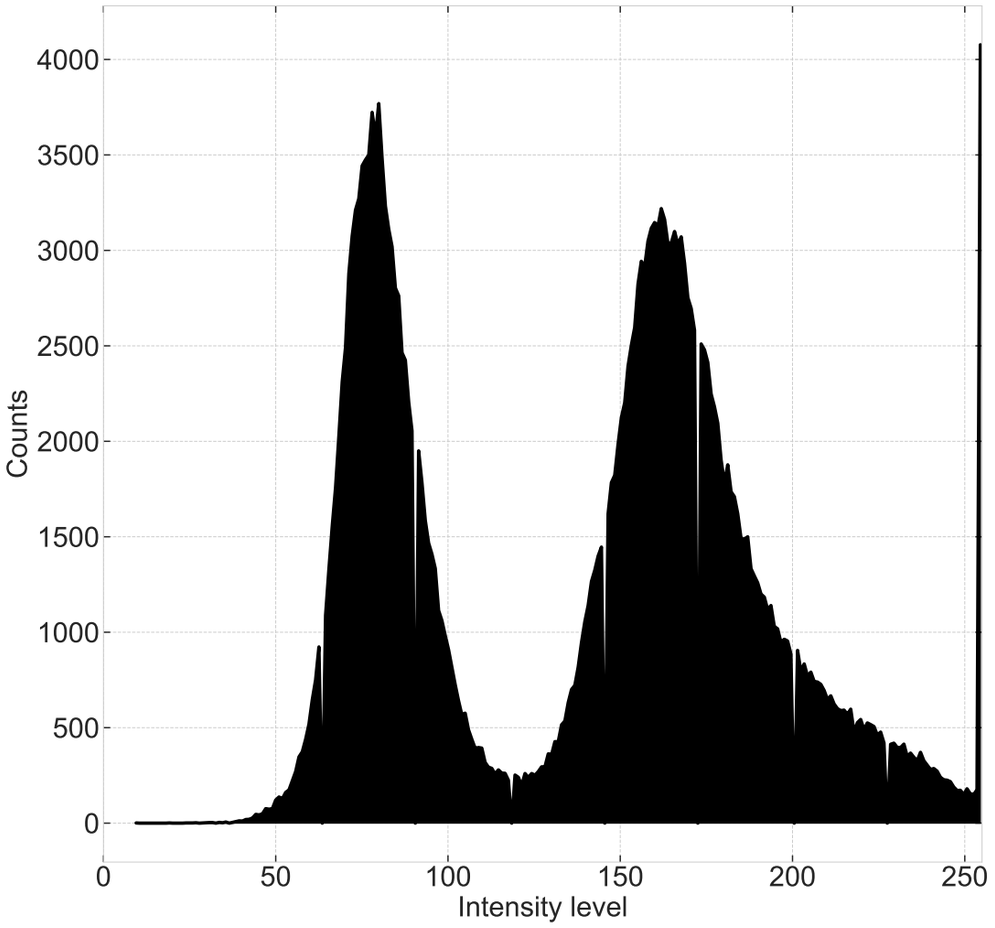

Figure 2: Histogram of the image of the microscopic copper lattice with 100x magnitude by detecting secondary electrons.

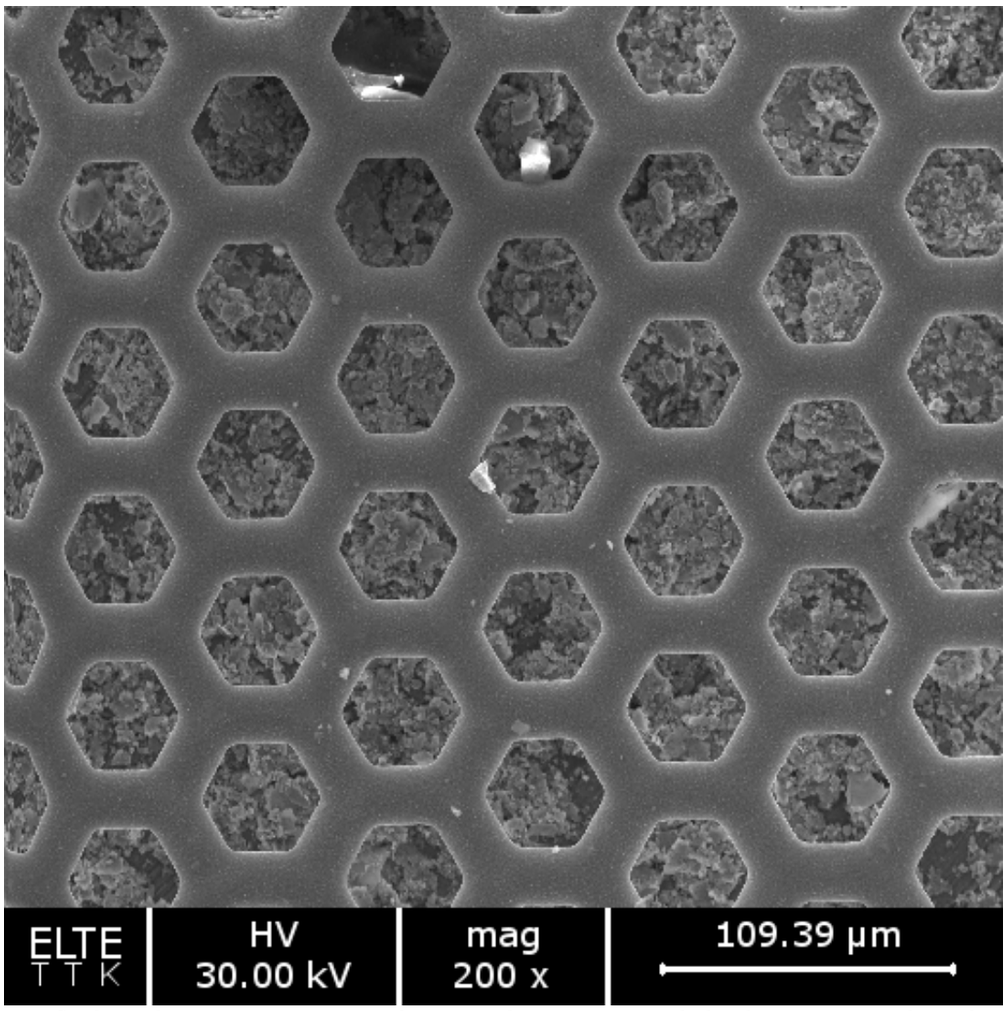

Figure 3: Surface of a microscopic copper lattice with 200x magnitude by detecting secondary electrons.

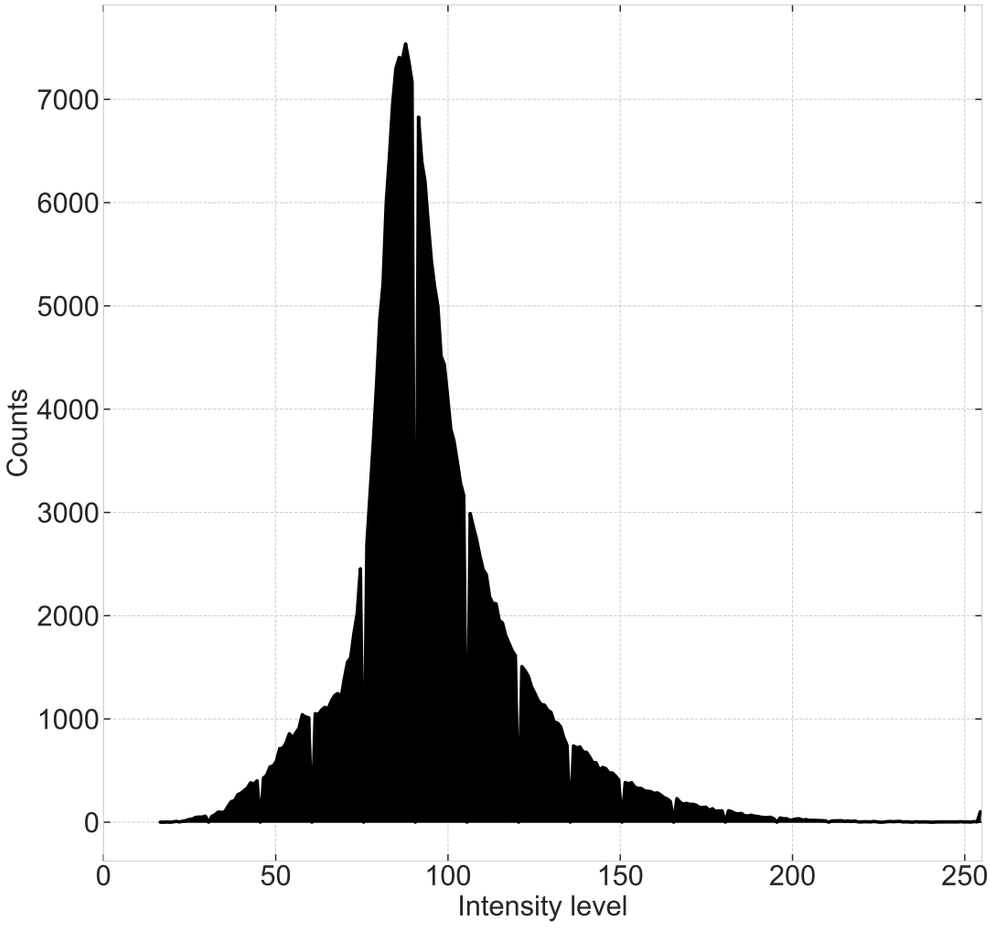

Figure 4: Histogram of the image of the microscopic copper lattice with 200x magnitude by detecting secondary electrons.

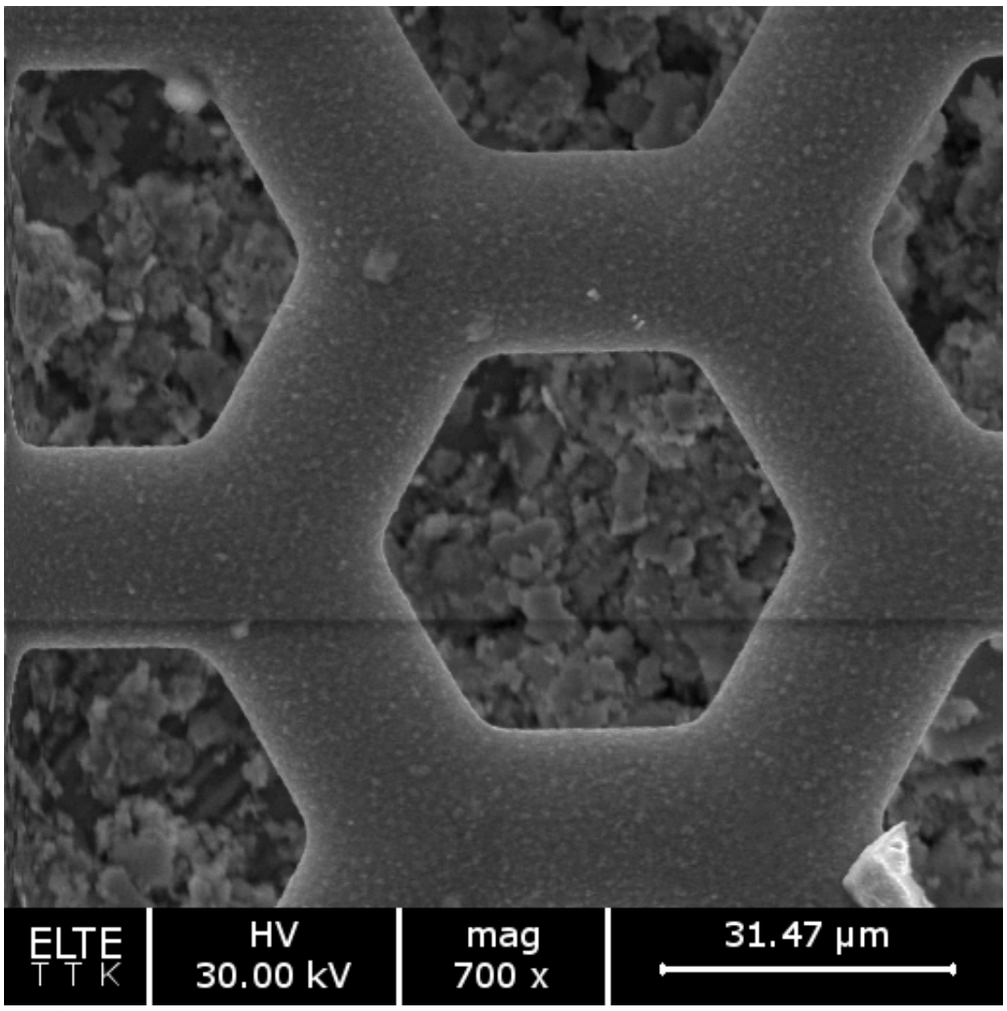

Figure 5: Surface of a microscopic copper lattice with 700x magnitude by detecting secondary electrons.

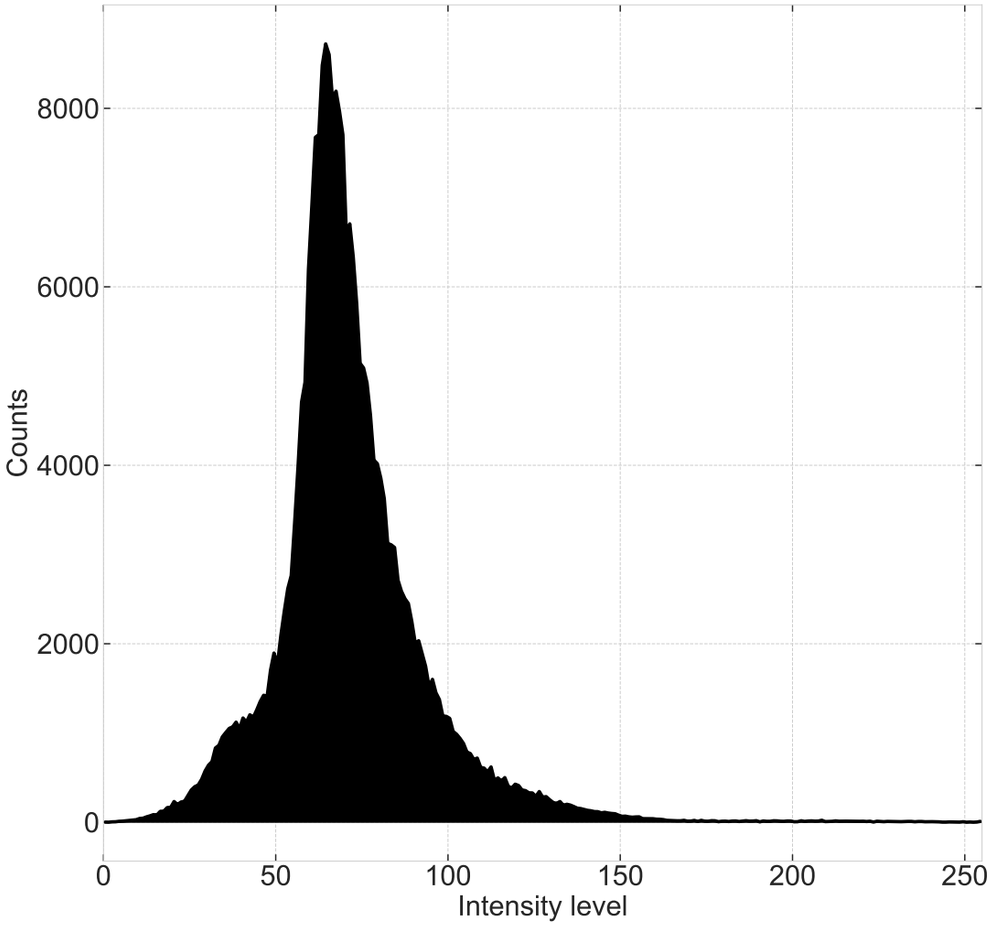

Figure 6: Histogram of the image of the microscopic copper lattice with 700x magnitude by detecting secondary electrons.

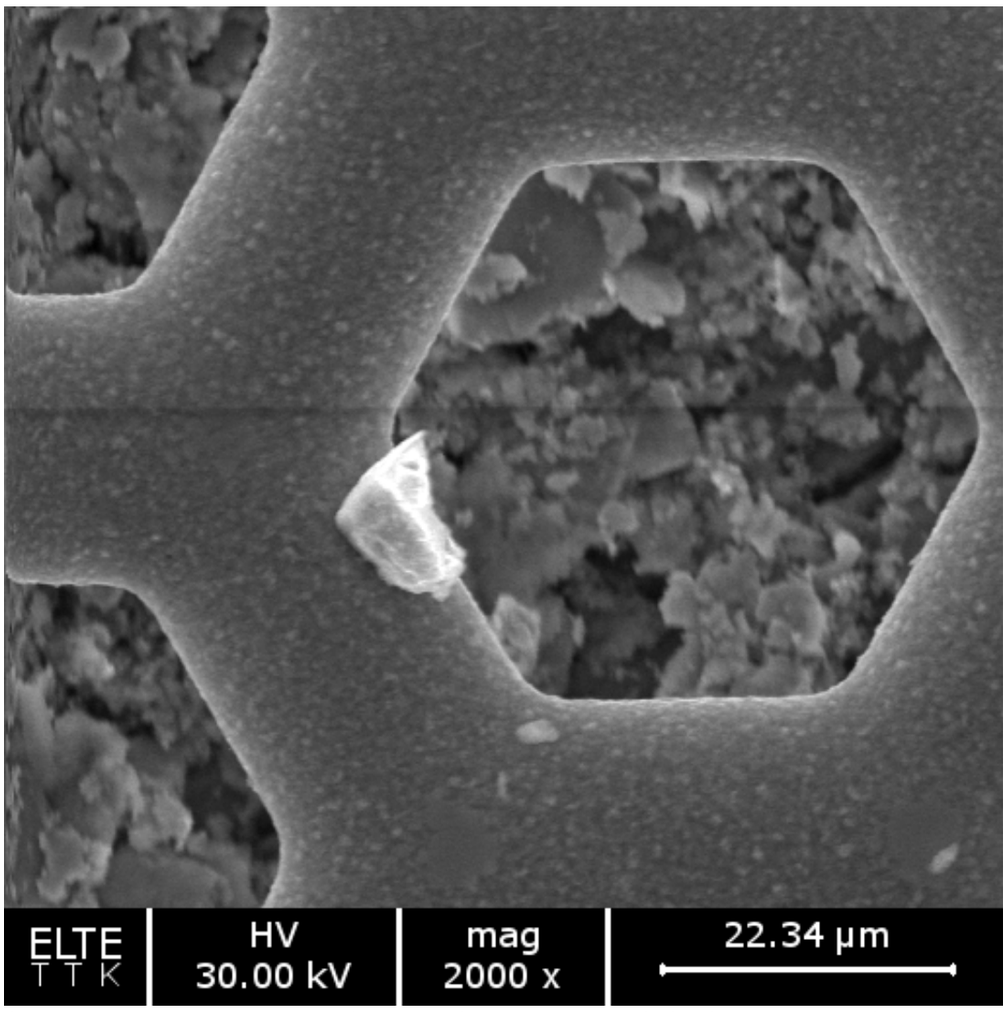

Figure 7: Surface of a microscopic copper lattice with 2000x magnitude by detecting secondary electrons. On the copper grid also some contamination could be seen.

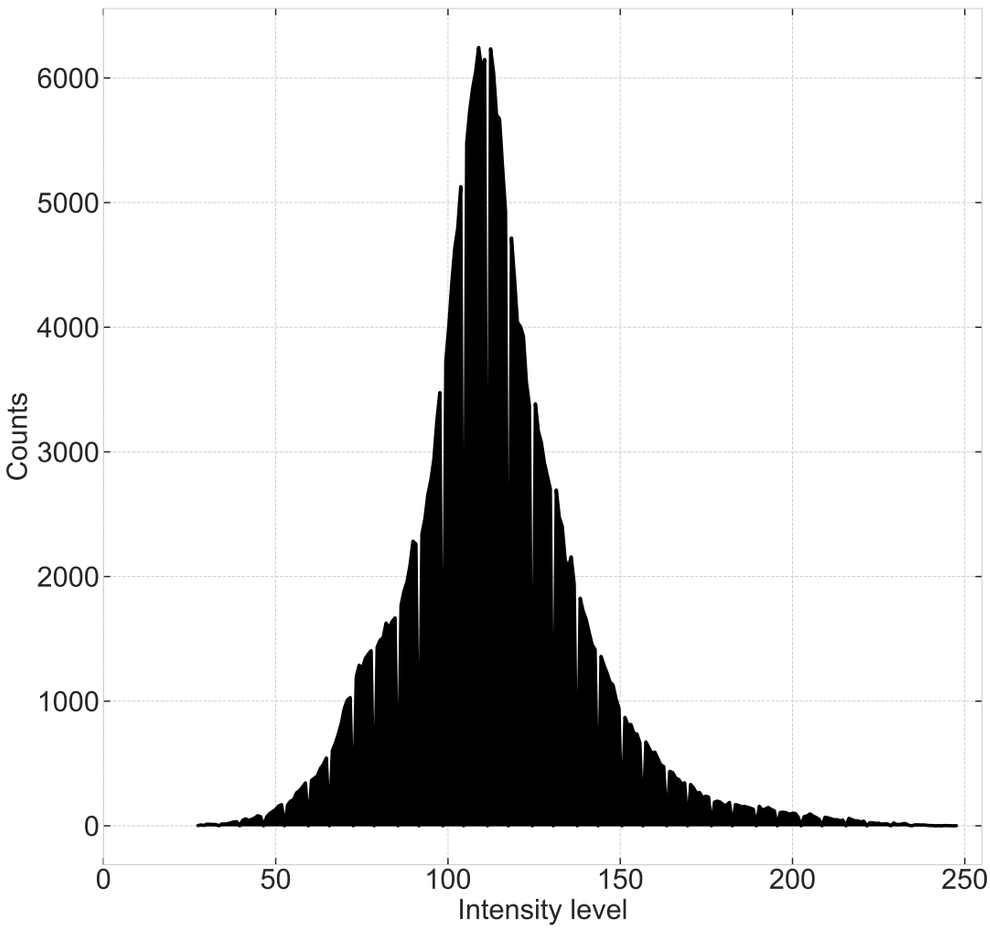

Figure 8: Histogram of the image of the microscopic copper lattice with 2000x magnitude by detecting secondary electrons. On the copper grid also some contamination could be seen.

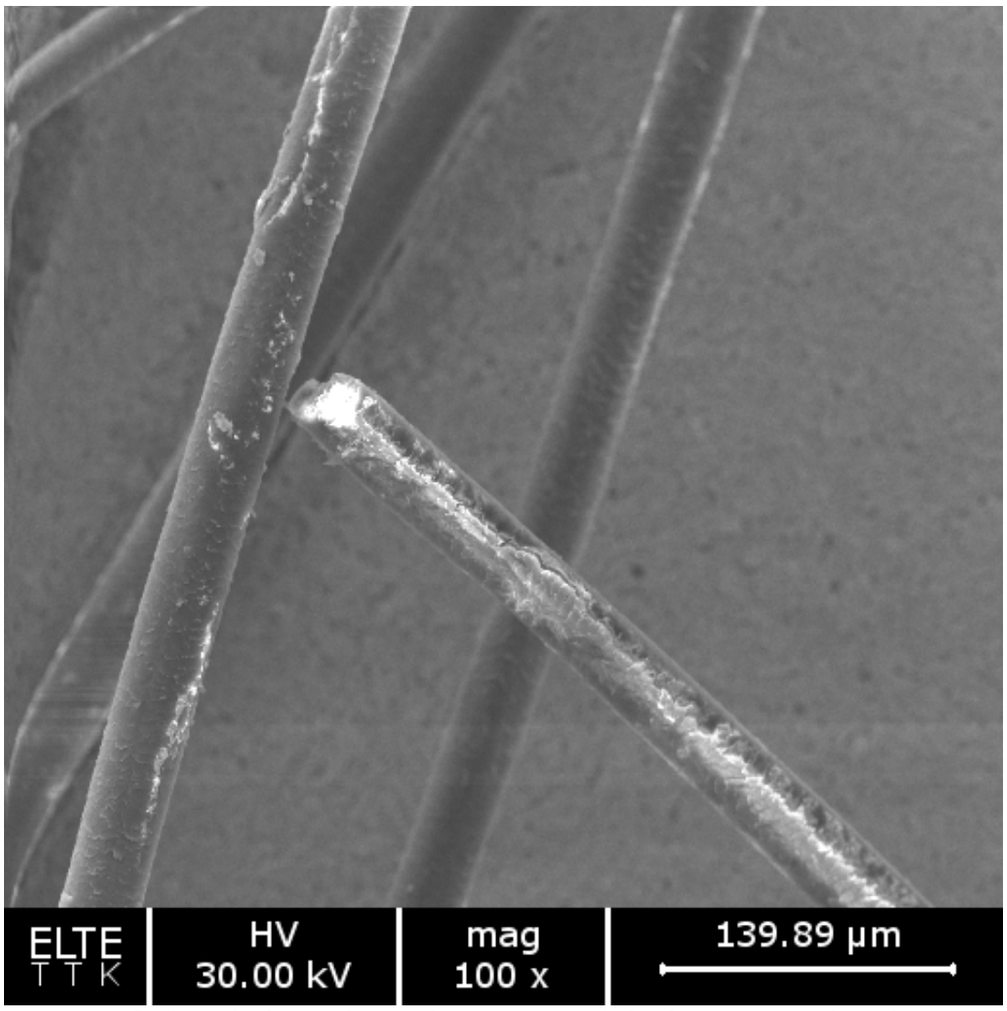

Figure 9: Surface of a human hair with 100x magnitude by detecting secondary electrons.

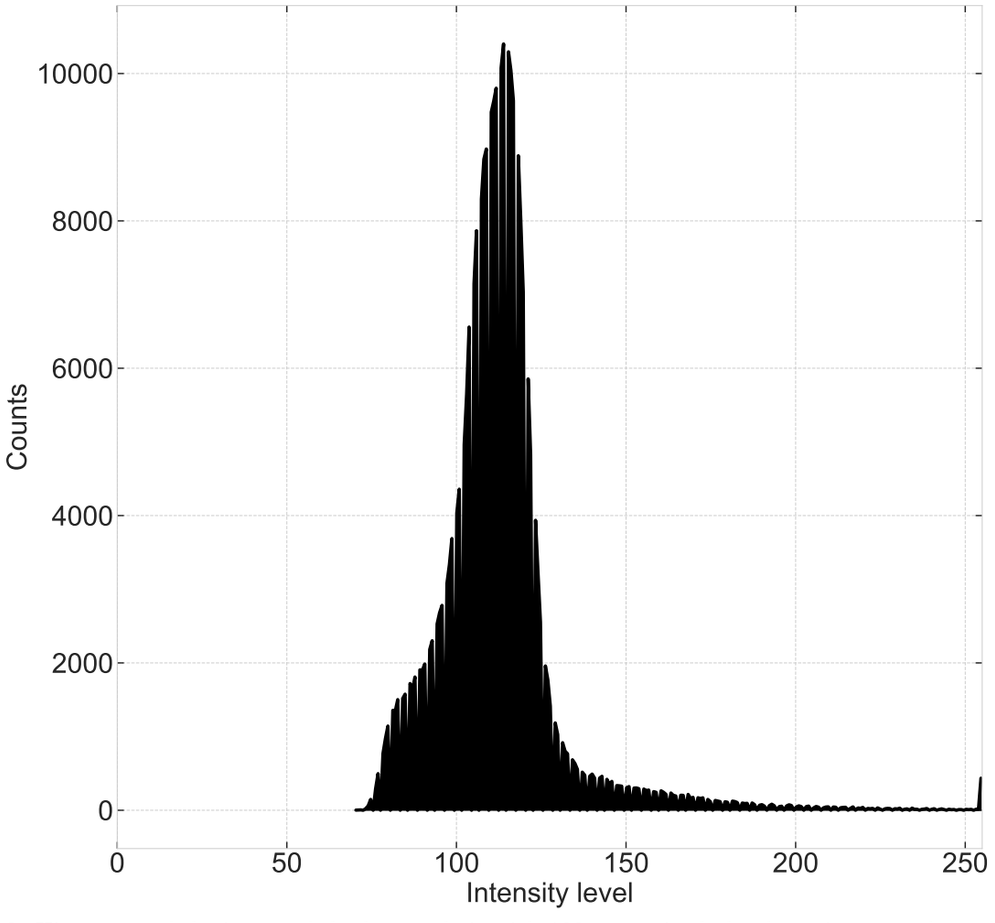

Figure 10: Histogram of the image of the human hair with 100x magnitude by detecting secondary electrons.

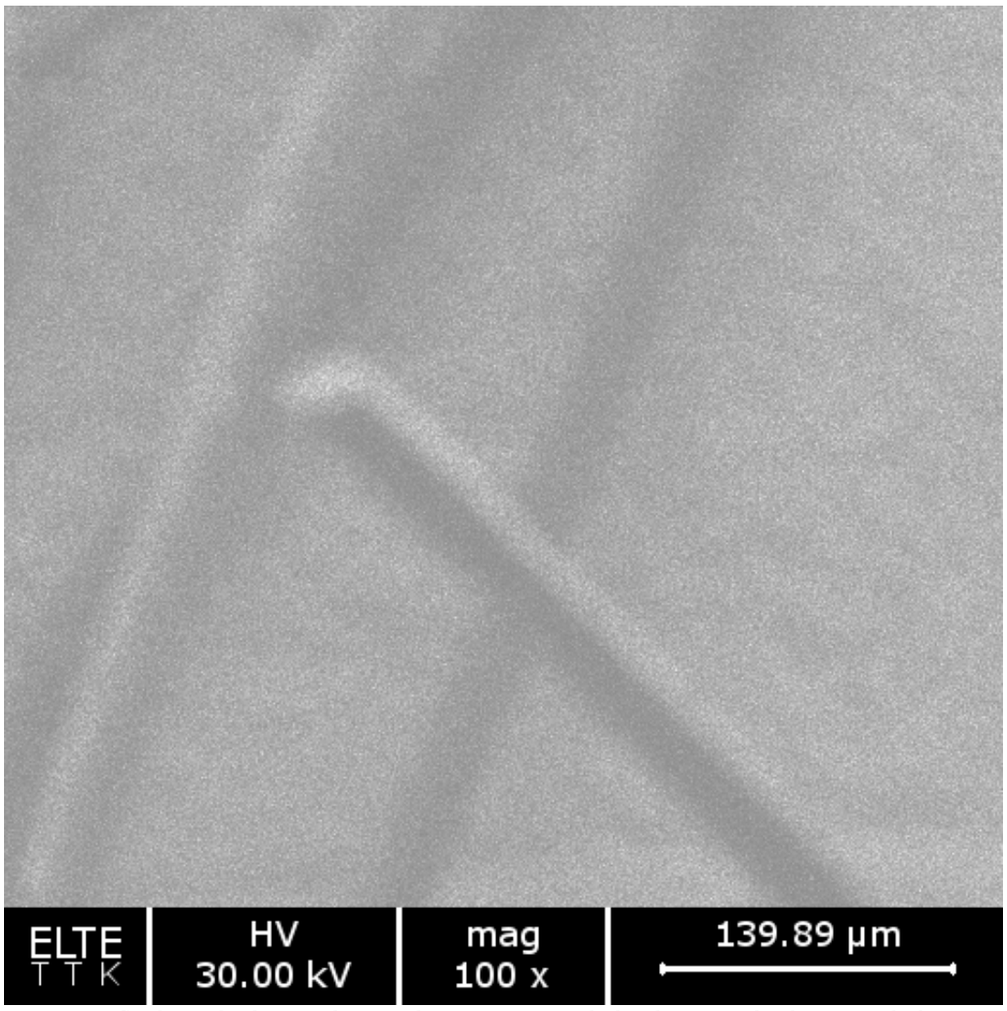

Figure 11: Surface of a human hair with 100x magnitude by detecting backscattered electrons.

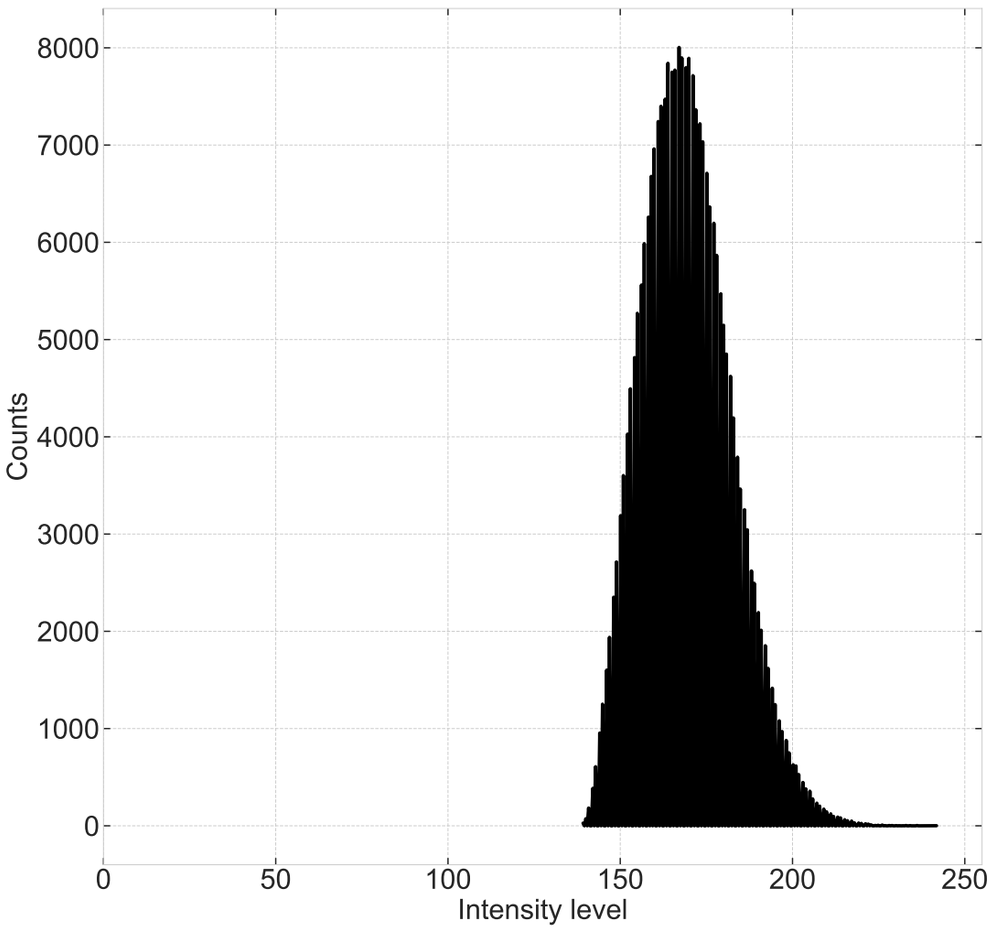

Figure 12: Histogram of the image of the human hair with 100x magnitude by detecting backscattered electrons.

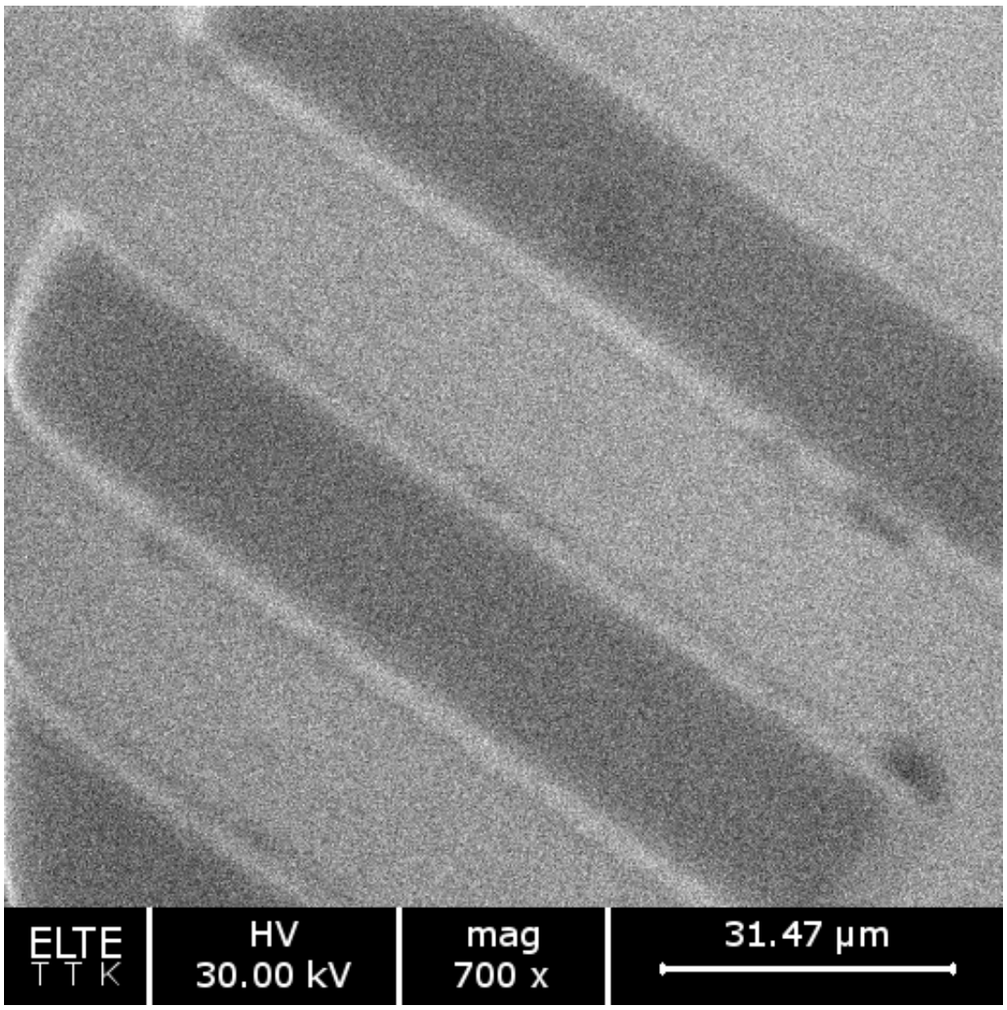

Figure 13: Surface of a microchip with 700x magnitude by detecting secondary electrons.

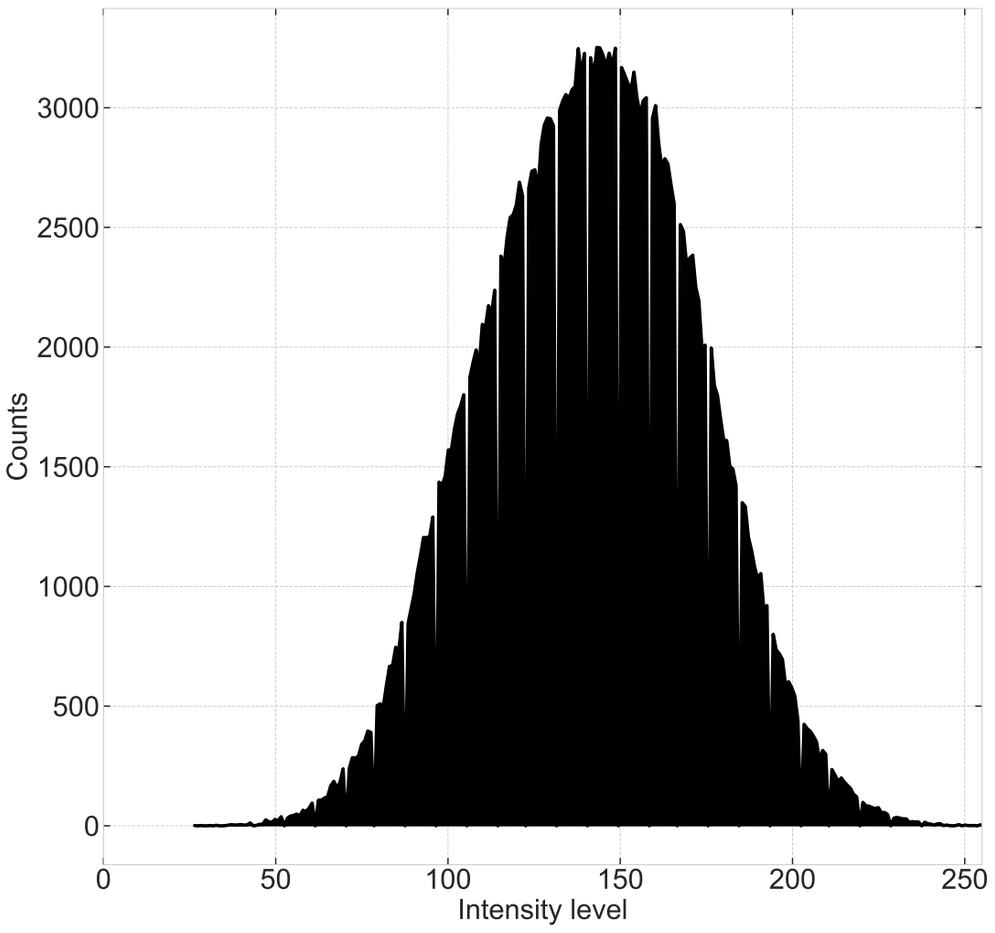

Figure 14: Histogram of the image of the microchip with 700x magnitude by detecting secondary electrons.

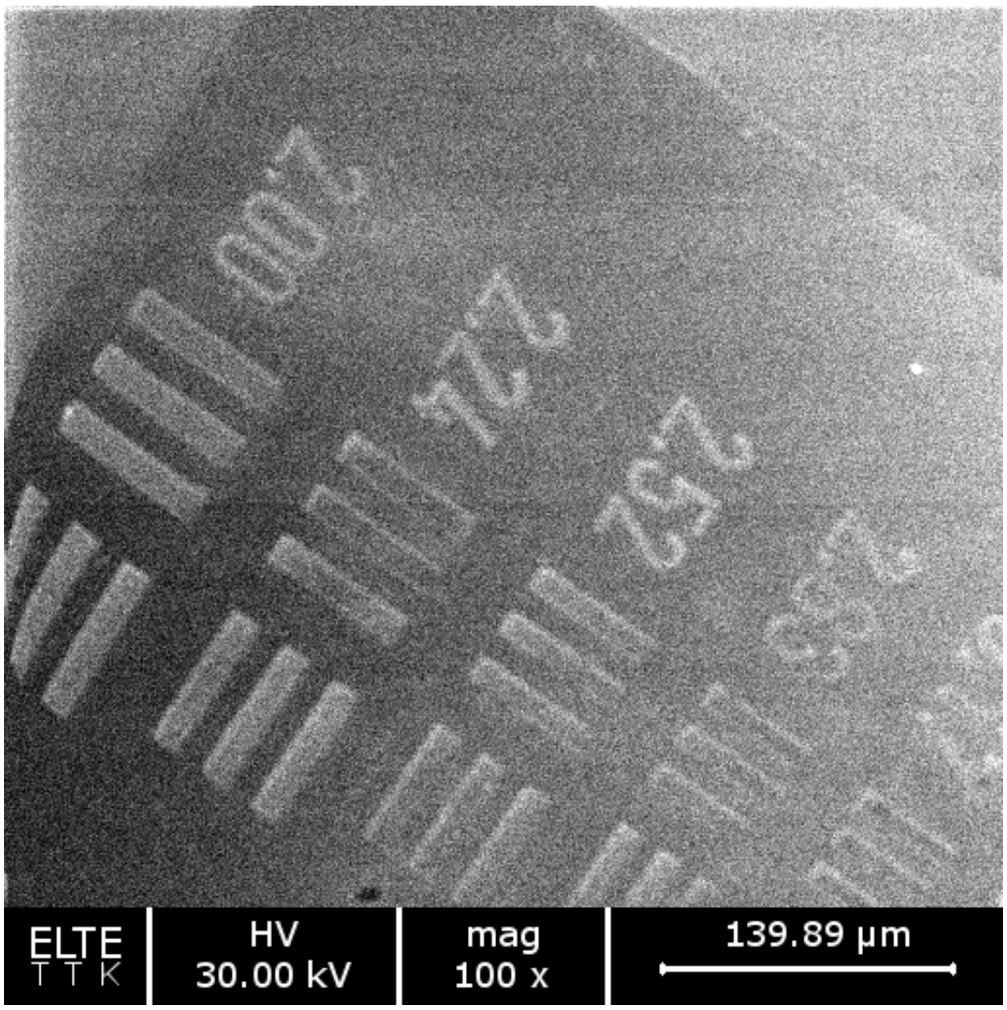

Figure 15: Surface of a microchip with 100x magnitude by detecting secondary electrons.

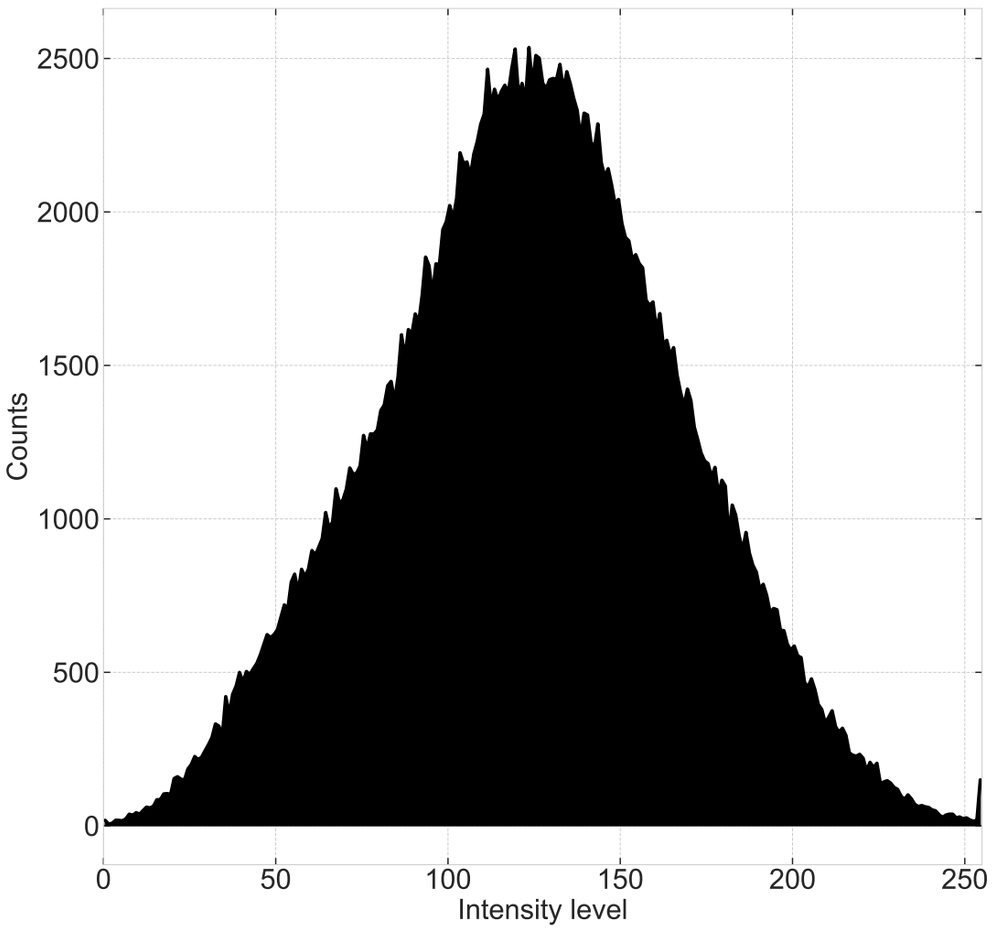

Figure 16: Histogram of the image of the microchip hair with 100x magnitude by detecting secondary electrons.

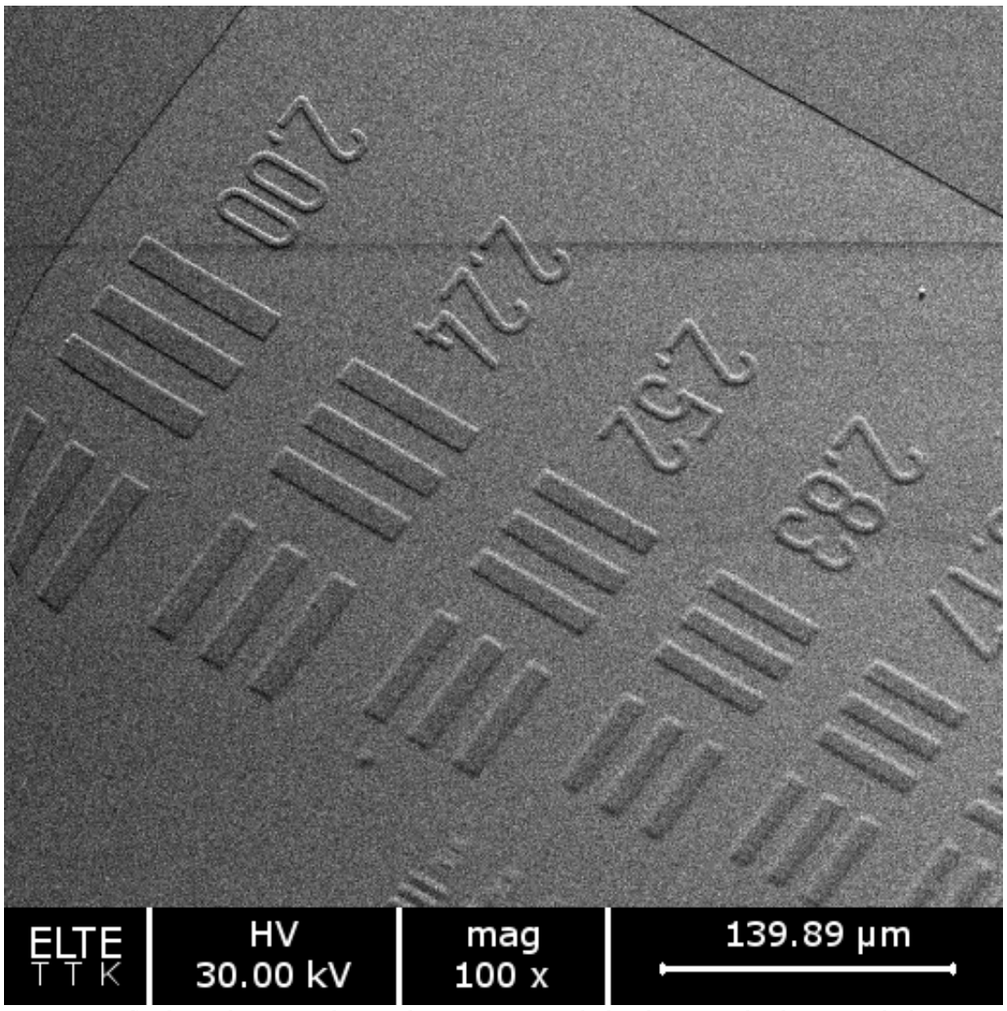

Figure 17: Surface of a microchip with 100x magnitude by detecting backscattered electrons.

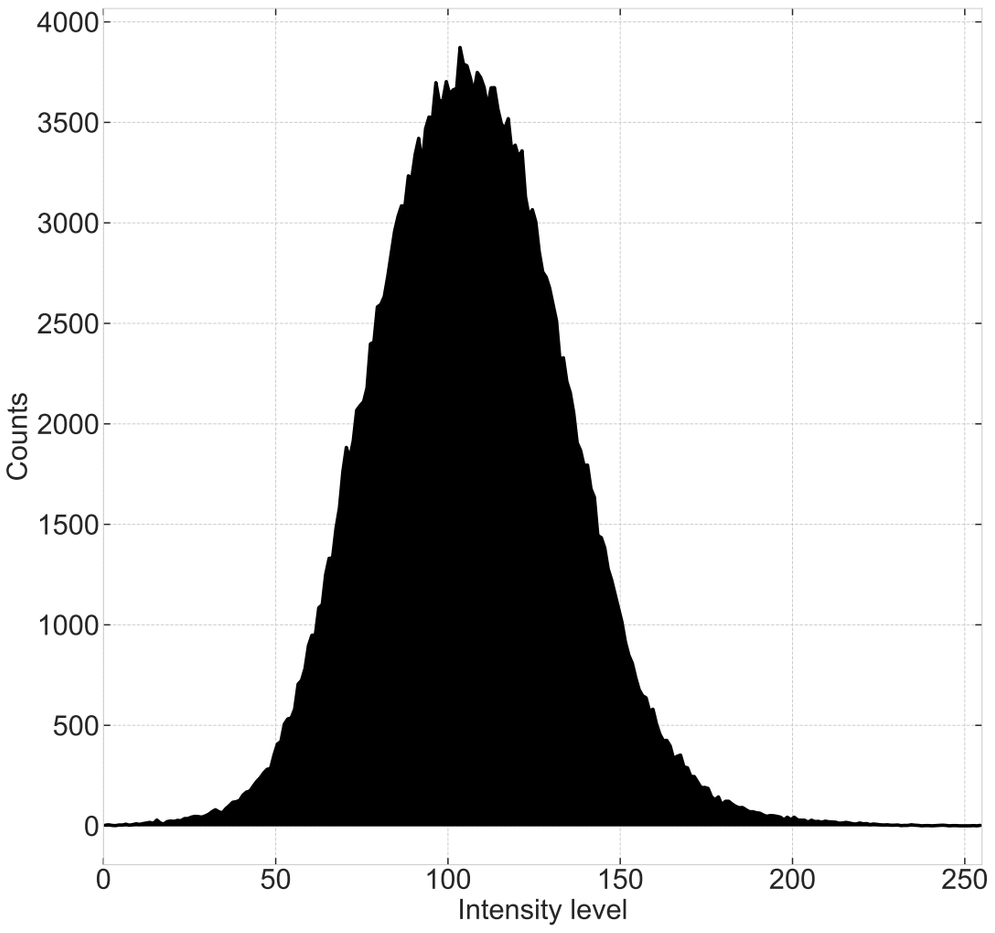

Figure 18: Histogram of the image of the microchip with 100x magnitude by detecting backscattered electrons.