SCINTILLATION SECONDARY ELECTRON DETECTOR FOR VARIABLE PRESSURE SCANNING ELECTRON MICROSCOPE

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ABSTRACT

This article deals with a scintillation detector of secondary electrons for variable pressure scanning electron microscope. The influence of the change of voltages on electrode system of the detector and on scintillator on secondary electrons detection is proved.

1. INTRODUCTION

Variable pressure scanning electron microscope (VPSEM) which works with pressure up to thousands of Pa in the specimen chamber allows to study wet samples including biological ones, insulating materials without charging artefacts as well as effects on phase interfaces.

For secondary electrons detection in VPSEM ionization detectors are mostly used. These detectors work on the principle of impact ionization of electrons in a gaseous environment of the specimen chamber of the microscope [1]. Another way for detection of secondary electrons is a usage of detectors that work on scintillation principle. To scintillation detectors located in the specimen chamber of the classical scanning electron microscope at a pressure of 10^{-2} Pa a voltage of several kV can be connected without problems with electric discharges. This voltages is necessary to give to secondary electrons sufficient energy for scintillation in scintillators.

In VPSEM which works with higher pressure in the specimen chamber a direct connection of the voltage of several kV to the scintillator is impossible because of problems with electric discharges. Solution of this problem in our experimental detector is based on the placement of the scintillator of the detector in the special room with low pressure up to several Pa. Special electrode system of the detector has to allow to secondary electrons to pass from the specimen to the scintillator [2, 3, 4].

2. SCINTILLATION DETECTOR FOR VPSEM

Construction of scintillation detector for VPSEM which properties are discussed in this paper is showed on Fig. 1. The room with scintillator of the detector is separately pumped by a turbomolecular pump. This room is separated from the specimen chamber by two apertures C1 and C2, the room between these apertures is evacuated by a rotary pump. This system of differential pumping allows achieving of the pressure up to 5 Pa in the scintillator room at the pressure up to 1 kPa in the specimen chamber.

Apertures C1 and C2 with voltages of several hundred volts create an electrostatic lens, voltages on electrodes E1, E2 are several tens of volts. Trajectories of secondary electrons in the electrode system of the detector were simulated by a computer programme Simion 8. These simulations proved that the electrode system of the detector allows to secondary electrons emitted from the specimen to pass to the scintillator.

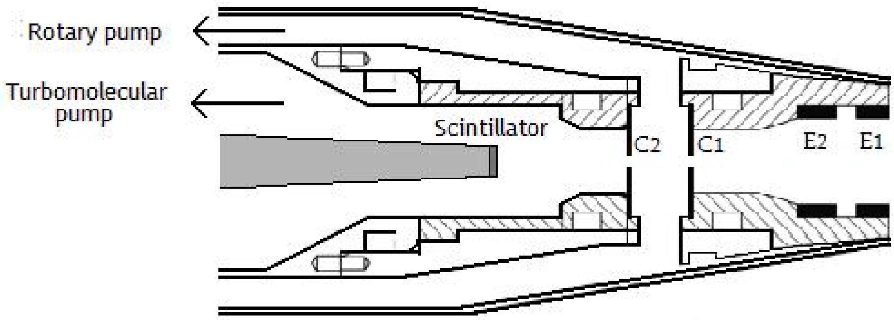

Fig. 1: Scintillation secondary electrons detector for VPSEM

Construction of the electrode system of the detector and voltages on electrodes were optimized by computer programme Simion 8. First experiments determined standard conditions for observation of specimen by this detector:

- primary beam current: I_{PE} = 100 pA at 30 Pa
- working distance from the sample microscope tube: 4 mm
- pressure of saturated water vapour in the sample chamber: 500 Pa
- voltage on electrodes E1, E2, apertures C1, C2 and scintillator of scintillation detector for VPSEM: U_{E1} = 9 V, U_{E2} = 30 V, U_{C1} = 430V, U_{C2} = 570 V, $U_{SCINTILÁTOR}$ = 7 kV

3. EXPERIMENT

The aim of the experiment was to verify the effect of the size of voltage on electrodes E1, E2, aperture C1, C2 and scintillator on the value of the detected signal from the standard specimen.

The specimen was prepared from carbon cylinder with a diameter of 6 mm and height 13 mm with borehole in the middle of the cylinder. The hole was used for measure and adjustment of the primary beam current at pressure of 30 Pa. A foil of Pt was attached near to the hole for the measurement of the signal level.

The signal level from the specimen was evaluated from the images which showed the boundary-line between carbon and platinum, obtained at magnification 670x. The evaluation was carried out using a graphic editor Corel Photo-Paint X3, the signal level was identified as a mean value of grey scale in the selected parts of the image of platinum. In all measurements the constant value of the photomultiplier gain was set to 50% and brightness value to 38.6. This ensures that the size of DC components in the pictures was the same in all measurements.

Experimentally determined dependences of the signal level on voltages on the electrodes E1, E2, apertures C1, C2 and scintillator are pictured for standard conditions of observation on Fig. 2 up to Fig. 6. At all experiments the dependences were measured at changing voltages on selected electrode, voltages on all other electrodes were kept constant.

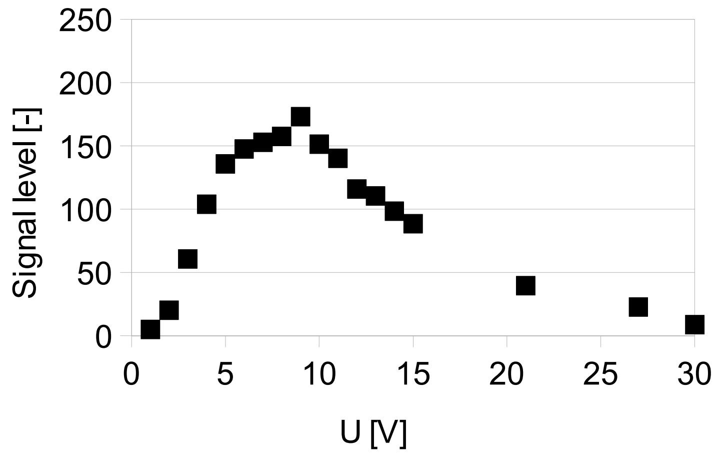

Fig. 2: Dependence of signal level from Pt on voltage on E1 at standard voltages on E2, C1, C2 and scintillator; pressure in specimen chamber 500 Pa

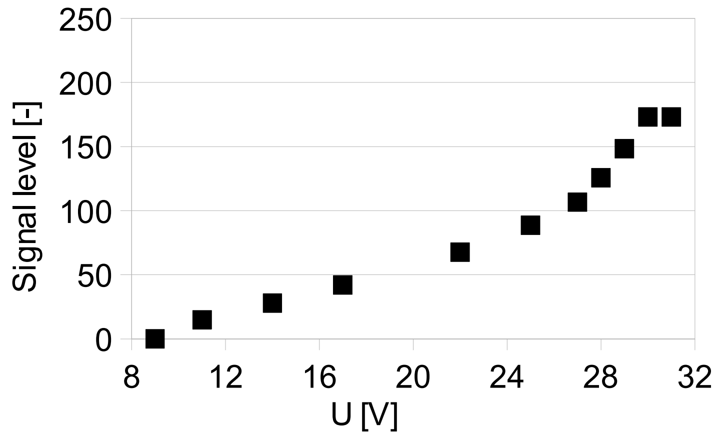

Fig. 3: Dependence of signal level from Pt on voltage on E2 at standard voltages on E1, C1, C2 and scintillator; pressure in specimen chamber 500 Pa

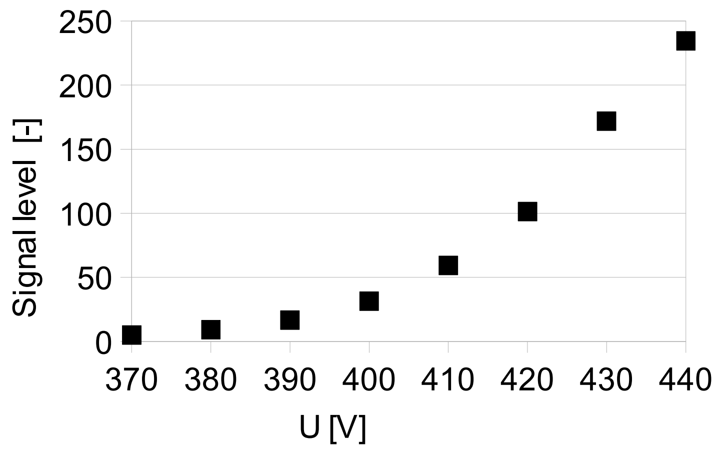

Fig. 4: Dependence of signal level from Pt on voltage on C1 at standard voltages on E1, E2, C2 and scintillator; pressure in specimen chamber 500 Pa

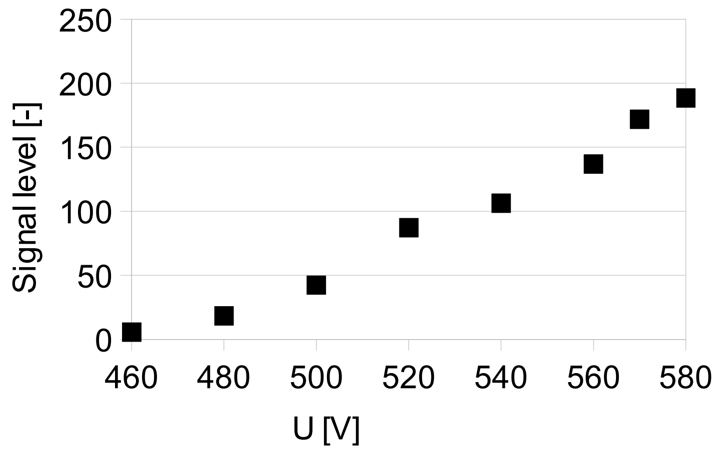

Fig. 5: Dependence of signal level from Pt on voltage on C2 at standard voltages on E1, E2, C1 and scintillator; pressure in specimen chamber 500 Pa

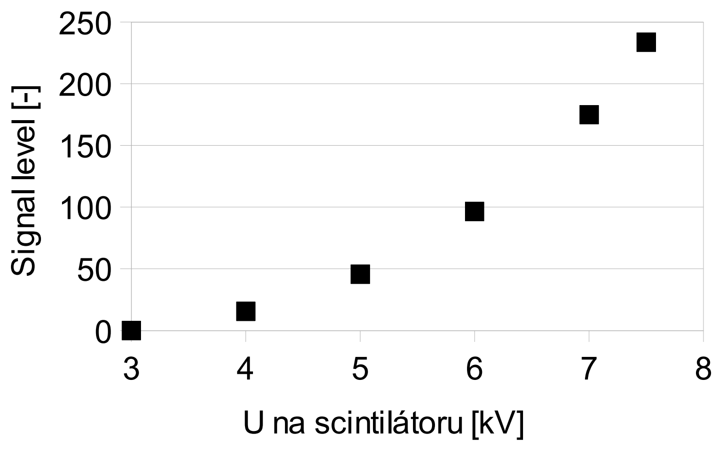

Fig. 6: Dependence of signal level from Pt on voltage on scintillator at standard voltages on E1, E2, C1 and C2; pressure in specimen chamber 500 Pa

4. RESULTS

Experiments proved that the values of voltages on electrodes E1, E2 and apertures C1 and C2 which were set as experimental values were near to optimal values for ensuring of the maximum signal level of secondary electrons from the specimen.

The increase of the voltage on aperture C1 is accompanied by the increase of the signal level, but too high voltages on this aperture bring the risk of electric discharges in the gas in the space in front of the aperture C1. Analogical problem is connected with the increase of the voltage on the aperture C2.

The next work on the scintillation secondary electron detector for VPSEM trends to the ensuring of the higher number of detected secondary electrons from the total number of secondary electrons emitted from the specimen.

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