# CONSTRUCTION OF DIFFERENTIAL PUMPING CHAMBER WITH DETECTOR BOARD FOR ADAPTATION OF SCANNING ELECTRON MICROSCOPE FOR WORKING IN HIGHER PRESSURE

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**ABSTRACT**

This paper deals with adaptation of the scanning electron microscope (SEM) to the environmental scanning electron microscope (ESEM). ESEM allows work at higher pressure in some parts of the microscope. It focuses especially to the construction and assembly of the differential pumping chamber together with the detector board of the differential pumping chamber and it comments reasons of necessity of the assembly of these parts in the environmental scanning electron microscope.

## 1 INTRODUCTION

Environmental scanning electron microscopy is one of the latest evolutional states of scanning electron microscopy. It is based on the same physical principles as classical scanning electron microscopy, but it exploits the presence of gas or water vapor in the specimen chamber. It is possible to achieve higher pressure of gas or water vapor in the specimen chamber e.g. using a differential pumping chamber, which forms another individually pumped space of the microscope and it changes substantially its constructional configuration. It has been found out (pressure higher than 200 Pa) that, as a consequence of ionization collisions of atoms and molecules of gases with electrons, no negative surface charge originates on an insulation specimen, because this charge is compensated with collision ions. The compensation of the electric charge enables direct observation of electrically non-conductive specimens without their covering with an electrically conductive layer. At higher pressure of gases or water vapour in the specimen chamber (more than 609 Pa) it is possible to observe specimens containing either bigger or smaller amount of water.

## 2 ESEM VACUUM SYSTEM

The problem of vacuum and different pressures in individual parts of the microscope is a key constructional demand, on which not only the functions, but also substantial advantages and possibilities of the ESEM microscope depend. A simplified scheme of the vacuum system of the environmental microscope, working with directly heated tungsten cathode and the specimen chamber with pressures in the order of $10^3$ Pa, is presented in Fig. 1.

The tube, in which high voltage is exploited for generation and acceleration of the electron beam, is a part with the lowest pressure of $10^{-3}$ Pa. Very high vacuum in the whole part of the tube also contributes to an easy propagation of this beam, whose electrons could be dispersed by the air molecules. The tube of the microscope is pre-pumped with the rotational vacuum pump RV1, providing functional environment for second diffusion DV vacuum pump. By this vacuum pump convenient pressure is achieved for the proper function of the directly heated tungsten cathode. It will not be possible to maintain the mentioned pressure of $10^{-3}$ Pa in the tube of the ESEM microscope without use of two pressure-limiting diaphragms. These diaphragms with small holes enable suppression of gases flow between individual spaces of the microscope with different pressures and, together with effective pumping of these individual spaces, they contribute to achievement of the demanded gradient of pressures.

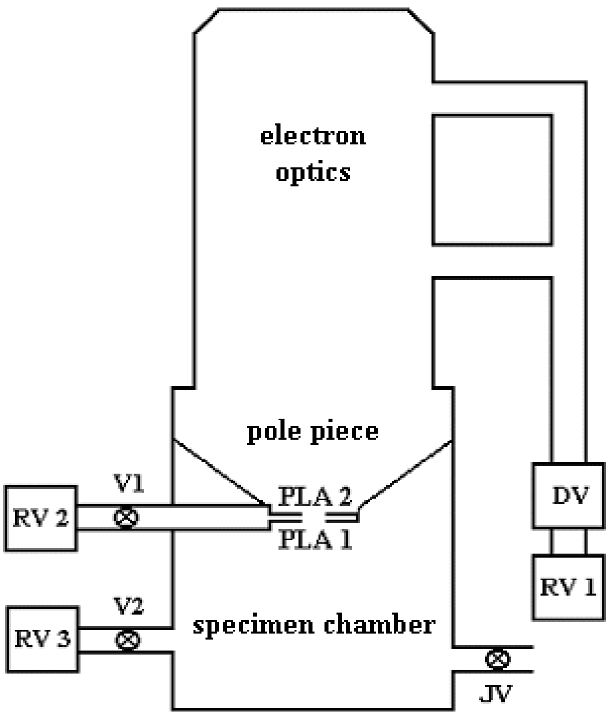


**Fig. 1:** *Schematic layout of two-stage system of differential pumping for ESEM*

The vacuum diaphragm PLA2 functions also as an aperture of the projection lens of the microscope. The space between PLA2 and PLA1 is usually called differential pumping chamber, which is pumped with rotational or turbo-molecular vacuum pump RV2. Because of high difference of pressures of gases, which effect in the vicinity of the PLA1 diaphragm, viscously effusive flow of gases originates in this area, which must be considered at computations of vacuum conductivity of the system. Because of very strict demands to the tightness, minimizing of the diameters of the diaphragms seems to be reasonable. However, it is necessary to consider the demands of electron optics in the case of PLA2 diaphragm and decreasing of the field of view in the case of the PLA1 diaphragm.

The specimen chamber is a part of the microscope with the highest pressure. The working pressure of the gas is reached in this case by achievement of balance between filling the chamber with gas and evacuation of the chamber with the rotational vacuum pump RV3. Filling the chamber with gases is provided by the needle valve JV. In many cases the use of the vacuum pump RV3 is not necessary and evacuation of the chamber through pressure limiting aperture from the space of differential pumping chamber is fully sufficient.

## 3 CONSTRUCTION OF DIFFERENTIAL PUNPING CHAMBER WITH DETECTOR BOARD

As it was already mentioned, the space between pressure-limiting apertures PLA2 and PLA1 is a space of the differential pumping chamber. The construction of this chamber and construction of a detector board of the differential pumping chamber, functioning also as a carrier and position stabilizer of the detector, is the subject of my work. I realize adaptation of SEM to ESEM using these two parts. In this specific case of the microscope, the pressure-limiting aperture PLA1 is formed with single-crystal scintillation detector YAG. The designed differential pumping chamber, which we have recently built into the SEM, is in the high part of Fig. 2. The detector board of differential pumping chamber is in the bottom part.

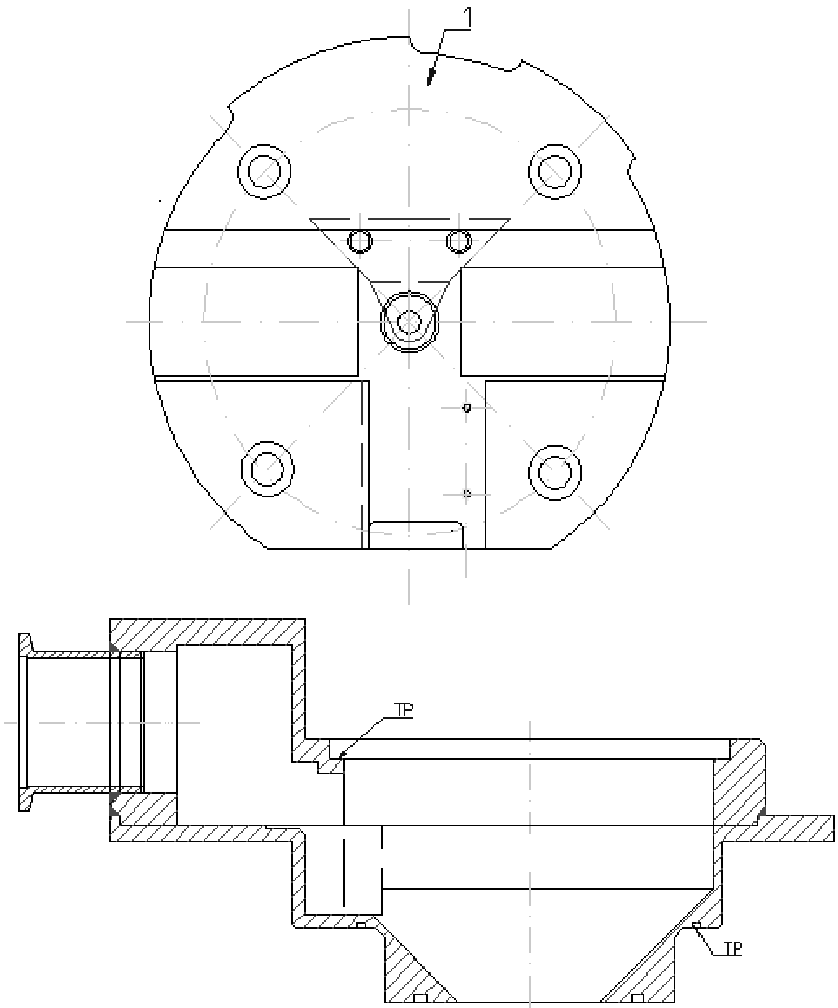


**Fig. 2:** *There is a differential pumping chamber of ESEM microscope in the bottom part of the figure and there is an upper view of detector board of differential pumping chamber in the high part.*

The whole configuration of the adapted environmental scanning electron microscope after in building of the differential pumping chamber and detector board of this chamber is presented in Fig. 3. It is noticeable from Fig. 3 how the separate evacuation of gas by rotational vacuum pump is carried out from the space of differential pumping chamber. Pressure of gas in the differential chamber is approximately 5 Pa. Pressure in the tube of microscope is $10^{-3}$ Pa.

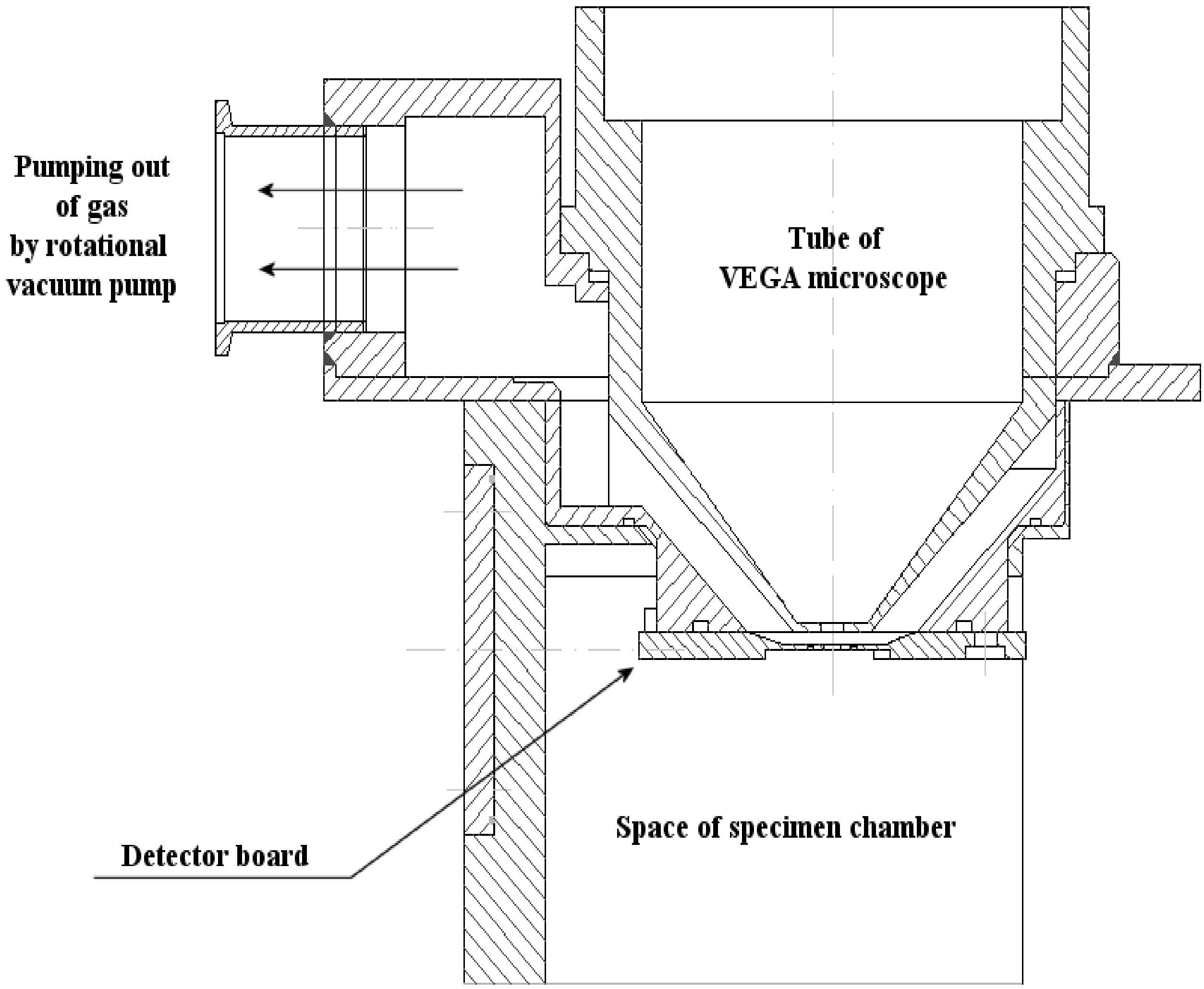


**Fig. 3:** *Complete view of adapted configuration of Environmental microscope with differential pumping chamber, detector board, part of specimen chamber and part of microscope tube.*

## ACKNOWLEDGEMENTS

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