Electron beam induced current measurement on a specimen biased in a cathode lens

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The retarding potential between the specimen and an anode, a cathode lens, is already commonly used for high resolution imaging at very low electron beam energies, even below 10 eV, in a scanning electron microscope (SEM). Standard configuration consists of an electron column (either magnetic or electrostatic), YAG single-crystal scintillator positioned under the objective lens, used as an anode, and an insulated specimen used as a cathode of the cathode lens [1]. The scheme of an electrostatic column, where an outer electrode of the objective lens forms the anode of the cathode lens, is shown in Figure 1 [2]. The microscope with the cathode lens can be used not only to acquire standard signals as secondary electrons (SE) and backscattered electrons (BSE); transmitted electrons (STEM) [3] and electron beam induced current (EBIC) can be used as well. Two problems are addressed. First, we have to bring a high voltage on the insulated specimen in the microscope chamber, and second, we have to solve the induced current measurement on the high voltage level. Two independent high-voltage power supplies are obviously used to supply the electron gun (U_G) and to bias the specimen (U_S). The interference between both supplies consecutively causes a smearing and glitches in the microscope image.

The use of a high voltage module that should guarantee stable energy of the decelerated electrons is necessary for the proper function of the SEM with cathode lens. The high voltage power supply for the specimen offset should be designed as a floating power supply connected to the high voltage of the supply for the electron gun. This floating power supply will define the beam landing energy, its value will be in the range of ($+U_G \div -50$ V) and its centre will be connected to the electron gun supply $-U_G$. The schematic configuration of the proposed high voltage power supply for the specimen bias including current measurement and its joining to the electron gun high voltage power supply is shown in Figure 2. Bipolar design is necessary for approaching the zero energy of electron impact, the mirror image. The full range of the specimen bias power supply is divided into three separate independently regulated and switchable power supplies to achieve better stability and finer regulation near zero energy where it is the most sensitive.

The design of the high voltage power supply for the specimen bias is based on the precision high voltage (HV) modules from Applied Kilovolts [4]. Three HV modules (10kV, 1kV and 100V), current sensing, amplifier and signal conditioning circuits and 50V bias power supply are mounted separately into plastic high voltage air insulated box. The power supplies are controlled by digital control system with 16 bit digital/analog converters and communicate via USB port. The insulation of high voltage against ground potential is solved using a fibre-optics cable between the USB receiver on the ground and a relay module on the HV. The HV-insulated power supply for individual HV modules and current sensing electronics have to be used.

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Thanks to this solution we will eliminate mutual instability of both the electron gun and the specimen offset power supplies. This solution is necessary for successful experimental work using very low energy electrons in the range down to units of eV, as follows from our experiments with separate power supplies for specimen offset and electron gun. In addition to that we make the measurement of the EBIC on a specimen biased in a cathode lens possible. The simultaneous acquisition of the standard video signals as well as STEM and EBIC signals at very low electron primary beam energies is only a question of a sophisticated control system.

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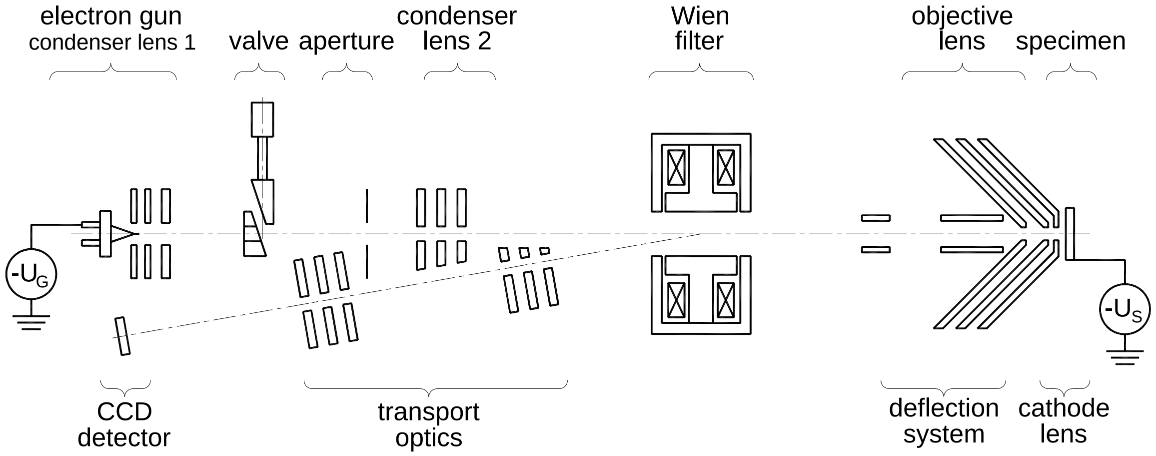

Figure 1. The configuration of electrostatic column and a cathode lens with two independent high voltage power supplies for electron gun and specimen bias.

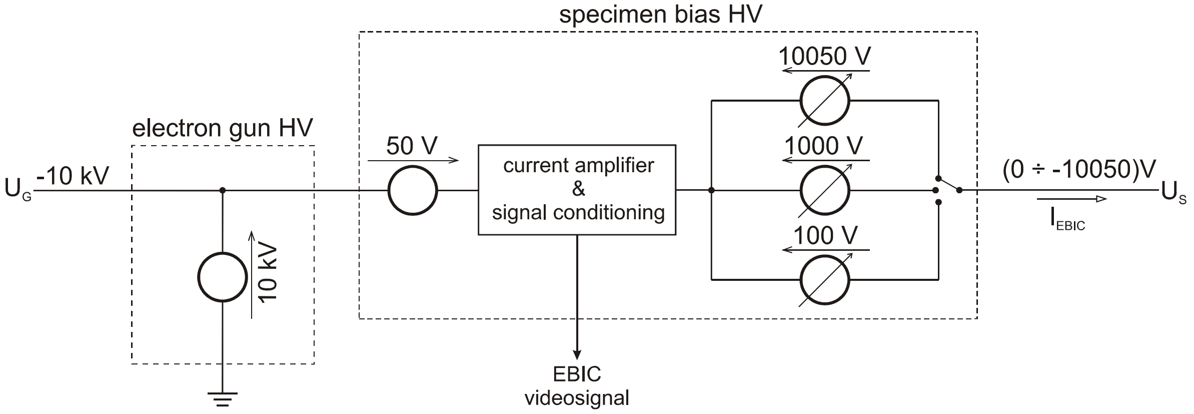

Figure 2. The schematic configuration of combined electron gun and specimen bias supply (presented values are for cathode voltage U_G = -10 kV).