Student's Project

Design and optimize a simple electron detector setup. The setup shall consist of the following:

- **A target**, where electrons are emitted (e.g. in an ion impact event)
- **A transparent electrode** (grid) at positive potential which collects the emitted electrons
- **A detector** at positive high potential, where the electrons are detected.

Build an Ion Optic Workbench to simulate this setup. Optimize the electrode voltages so that the **collection efficiency** (i.e. the fraction of electrons splatting on the detector surface vs. the number of emitted electrons) becomes maximal. For this purpose use the supplied .lua file, which writes the collection efficiency to the log output of SIMION.

The geometry

Build two potential arrays, one containing the detector setup the other representing the target.

The Target PA

The target is 3 mm thick and has a quadratic base area with an edge length of 10 mm.

The Detector Setup PA

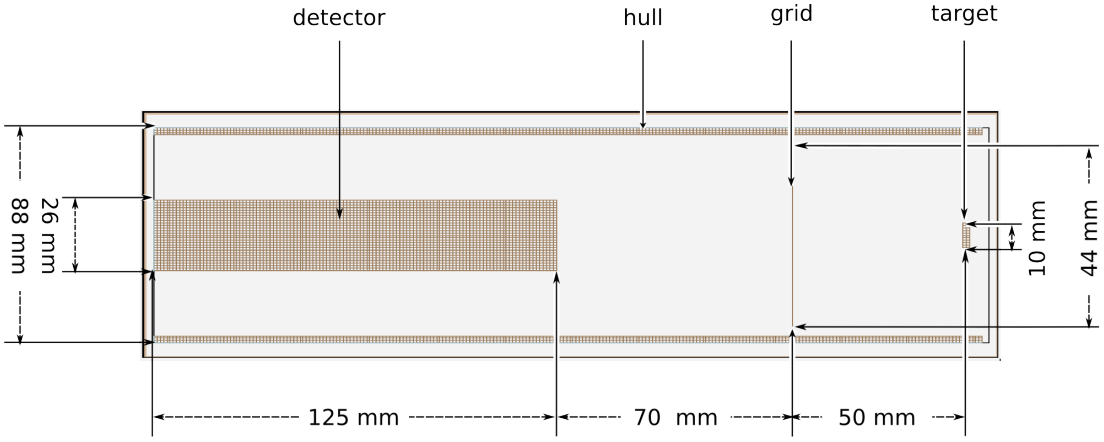

fig. 1: The detector setup

This potential array includes the detector and a transparent grid electrode, which, biased at a positive voltage, collects the electrons that are emitted at the target surface. A sketch of the

setup including all dimensions necessary to build it can be found in figure 1. The grid as well the detector will have to be biased positively for collecting electrons on the detector surface. They should be designed as two distinct electrodes in order to be able to set the voltages independently. The hull enclosing the setup will be kept at ground potential.

Assemble the two potential arrays in an ion optic workbench. Position the target facing the detector at a distance of 50 mm in front of the grid (i.e. at a distance of 120 mm from the detector surface).

Emitted electrons

Simulate 1000 electrons (for good statistics). The electrons are emitted at the target surface with a kinetic energy of 370 eV (for a start). Suppose that they are emitted within a circle of 7 mm in diameter around the center of the target. They leave the target in a cone distribution with an opening angle of 30° in direction normal to the surface.

The user program file

There is a user program file, which is provided in order to determine the collection efficiency of the detector. It is called 'project.lua'. Make sure it is located in the same directory as your IOB and is named identically! This is necessary for the simulation to work properly! The user program simply determines the collection efficiency (in percent) as the fraction of electros collected on the detector surface out of all simulated electrons. The collection efficiency is recorded to the log output of SIMION and will be used to optimize the electrode voltages.
There are 3 variables in the variables-tag that need to be set correctly for the user program to work properly. These are:

- `detector_M_z`, `detector_M_y:` the center (x and y) coordinates of the detector
- `detector_x` the x position of the detector surface

Adjust these variables according to the coordinates of the detector in your IOB. Only electron trajectories ending up on the detector surface (which is determined by these variables) will be interpreted as being detected by your detector. Have a look at the lua-file – it contains detailed comments on what it does!

Answer the following questions in your final presentation

1. Describe the problem briefly and explain how you built your IOB! Also give a short description on how the collection efficiency is determined with the user program.

2. Determine the **optimal voltages** for the grid and the detector with respect to collection efficiency. Keep the target at ground potential. Assume that for experimental reasons the detector voltage is restricted to values below 30 000 V and that the grid voltage cannot exceed 500 V. What is the optimum collection efficiency that can be obtained?

3. A soon as you have found optimal electrode settings, vary the **electron energy** between 50 eV and 500 eV. How does this affect the collection efficiency? Plot the collection efficiency as a function of the electron energy (at fixed electrode voltages)! Do you have to re-adjust the voltages for different electron energies to retain maximum collection efficiency? If so: how?

4. Investigate and present how the collection efficiency changes if you **tilt the target** by 30°, 45° and 60° with respect to the target surface normal along the azimuthal direction! Make sure that after tilting the target the electrons are still emitted at the target center in a cone distribution oriented normal to the surface area!