CAE of Sensors and Actuators
Assignment 1

Tutorial: November 3rd and November 4th, 2014
Assignment due: November 10th, 2014, 6 pm

Electrostatic Field Problem: Capacitive Sensor

The following setup consists of a **cylindrical** capacitor with three aluminum electrodes. The space between middle and ground electrode is filled with the dielectric material strontium titanate ($SrTiO_3$). The remaining space is filled with air. Between the top and the ground electrode a constant voltage of V_0 is applied. The potential at the middle electrode is unknown but can be assumed constant (equal value) on the whole electrode. The dimensions of the capacitor can be seen in Figure 1.

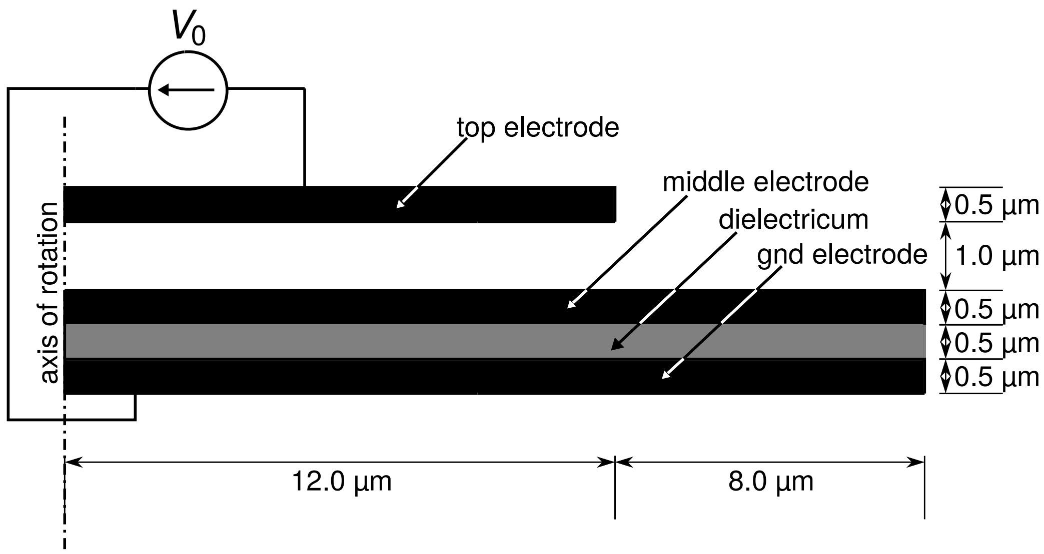

Figure 1: Cylindrical capacitor

Task 1: Field calculation (3.5 points)

Simulation tasks

1. Create a `.nmf`-mesh file using Ansys scripting. As element size choose 0.25e-6.
   Hint: To account for the stray field the capacitor should be enclosed by air. Therefore add **additional air of 5 µm** at bottom, top and right side of the capacitor!
2. Perform a static simulation of the capacitor using a voltage of $V_0 = 50$ V.
3. Postprocess your results with GiD. Create a contour fill of the **electric potential** and show the **electric field** with vector arrows.
   Hint: Do not forget to enable GiD output in NACS.

Questions

1. What boundary conditions have to be used to model the electrodes, especially the middle one?

Files to submit / Grading

- Ansys mesh script **and** mesh file (1 point)
- NACS simulation script (`.py`) (1 point)
- GiD screenshots of potential and electric field (1 point)
- `Results.txt` file answering the question (0.5 points)

Task 2: Calculation of the capacitance (2 points)

Simulation tasks

1. Simulate the capacitance of the setup using NACS. You can reuse the mesh of the previous task.
   Hint: The capacitance is not directly available as a result in NACS. Which quantity do you have to use?

Calculations

1. Calculate the capacitance of the setup using the analytic formula for plate capacitors.
   Hint: Sketch the electrical network.

Questions

1. Compare the simulated and calculated capacitance. What are the differences and why do they occur?

Files to submit / Grading

- `Results.txt` file containing the value of the simulated capacitance (including the intermediate steps you used to calculate it out of NACS results) (0.5 points)
- `Results.txt` file containing the value of the calculated capacitance (including the intermediate steps and the formulas you used) (1 point)
- `Results.txt` file answering the question (0.5 points)

Task 3: Mesh study (1.5 points)

Simulation Tasks

1. Create at least **6 additional** `.nmf`-mesh files with element sizes between 1.5e-6 and 0.1e-6.
2. **For each** created mesh simulate the capacitance C of the setup and determine the maximal value of the electric field E_{max}.
   Hint: Take a look at the maximal value in GiD under `View results`.

Plots

1. Create two **semi-logarithmic** (x-axis logarithmic, y-axis linear) plots showing the maximal value of E_{max} and C over the number of nodes (get displayed by NACS under `Global`).
   Hint: You can use any program you like for plotting (e.g. gnuplot, matlab, octave, ...). However, label your graph correctly, i.e. with units and in a readable font size!

Questions

1. How do the values of E_{max} and C change if you decrease the meshsize? Give reasons for the observed behavior.

Files to submit / Grading

- `Results.txt` file answering the question (0.5 points)
- Plot file showing E_{max} **over the number of nodes** (0.5 points)
- Plot file showing C **over the number of nodes** (0.5 points)

General hints and remarks

- as reference for the `Results.txt` file take a look at the sample file `Results_sample.txt`
- take a look at the electrostatic tutorial
- submit all your files until the due date by copying your results (`Results.txt`, scripts, screenshots, ...) to
  `/home/userHome/stud/CAESAR/group<Group#>/assignment<Assign#>/`
- Points are only given if submitted data contain correct results, answers are comprehensible and plots are labeled correctly!