

The exam paper consists of six groups of questions (each having maximum of 6 points) but only five of them are to be answered. If you answer more than five questions and you do not specify the questions to be evaluated, five questions with the lowest points will be included in the evaluation. Use a separate sheet of paper to answer.

Suomeksi: Tenttipaperissa on kuusi ryhmää kysymyksiä (kukin 6 pistettä), joista ainoastaan viiteen vastataan. Mikäli useampaan kuin viiteen kysymykseen on vastattu, eikä vastauspaperissa ole määritelty, mitkä vastaukset arvostellaan, otetaan viisi heikointa vastausta huomioon. Vastaa erilliselle paperille. Voit vastata **joko suomeksi tai englanniksi**.

**1. Microfabrication**

Explain the principle of the photolithographic process in silicon microfabrication. (6 p.)

**2. Microscopy**

- a) How does an AFM work? (3p)
- b) How does the Constant Force Mode differ from the Constant Height Mode of operation? (3p)

**3. Characterization of Microstructures**

If you should measure thickness of a Si<sub>3</sub>N<sub>4</sub> film on silicon wafer, which method would you choose and why? The assumed film thickness is 500 nm and the film covers the entire wafer surface. Describe also the operation principle of the chosen method. (6 p.)

**4. Microsensors**

Piezoresistive pressure sensor. (6 p.)

## 5. Scaling Effect and Micromanipulation

a) Give a short description of the scaling effect and one example of its influences. (1 p.)

b) Choose the correct option to continue the following sentence. (1 p.)  
Handling of microparts

- 1) is different from handling of macroparts, since gravitational forces dominate in the micro world
- 2) is different from handling of macroparts, since adhesive forces dominate in the micro world
- 3) is different from handling of macroparts, since surface forces become less important in the micro world
- 4) is not significantly different from handling of macroparts

c) Name and briefly describe three adhesion forces dominant in microscale (4 p.)

## 6. Microactuators

a) Linear electrostatic microactuators: describe the operation principle, actuator implementations and applications (4 p.)

b) You can find below four illustrations of actuation principles used in microscale applications. Name the principles and list one strength and one weakness for each principle. (2 p.)

