Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2017/2018

COURSE NAME	:	MEMS DESIGN
COURSE CODE	:	BED 40503
PROGRAMME	:	BEJ
EXAMINATION DATE	:	JUNE / JULY 2018
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **FOUR (4)** PAGES

Q1 (a) MEMS design process basically involves of modelling, simulation and experiment. Describe **TWO (2)** importance of these processes in system development.

(4 marks)

(b) Compute effective spring constant for an elastic microbeam of length 1500 μm, width 5 μm, height 10 μm and Young's modulus of 150 GPa. The loading force, F gives out-of-plane movement to the microbeam.

(5 marks)

(c) Both bulk and surface micromachining have become a common techniques in MEMS fabrication process. Analyse **ONE (1)** advanced method over both bulk and surface micromachining that could improve MEMS device quality.

(5 marks)

(d) Fluid-structure interaction (FSI) is one of key criteria performed in MEMS design simulation. Analyse how this component of simulation is critical in MEMS design process.

(5 marks)

Q2 (a) Explain the main purpose of transduction unit in a general MEMS system.

(4 marks)

(b) A parallel plate capacitor is suspended by four cantilever beams shown in **Figure Q2(b)**. The lower electrode is connected to a voltage supply of value V = 2V, while the suspended plate is grounded. The gap between the lower electrode and the plate is g_0 = 1.0 μm. Find the area of the lower electrode.

(6 marks)

(c) Referring to **Figure Q2(b)**, If the bias voltage is doubled and the gap is increased to 10 μm, determine the new area to maintain the same capacitance in the cantilever.

(6 marks)

(d) Hysteresis is one of main characteristic in transduction principle for MEMS-based transducer. Analyse how this principle helps to improve the system performance.

(5 marks)

(e) Repeatability is another characteristic in transduction principle for transducer. Analyse the essential criteria that need to be fulfilled to establish repeatibility.

(5 marks)

Q3 (a) Explain the main purpose of microactuators in MEMS system.

(4 marks)

(b) The behaviour of fluids at the microscale differ from "macrofluidic" behaviour due to factors such as surface tension, energy dissipation, and fluidic resistance. Analyse in the perspective of microfluidics how these behaviours change.

(5 marks)

(c) Recent development is to use droplet-based microfluidics rather than continuous microfluidics. Analyse the improvement of device performance when droplet-based microfluidics is employed in MEMS system.

(5 marks)

Q4 (a) Explain the reasons piezoresistive sensors are preferred in MEMS system.

(4 marks)

(b) **Figure Q4(b)** shows a lateral driven thermal actuator based on asymmetrical thermal expansion of a microstructure with two arms made of the same conductive material. These two arms have different heating power and thermal expansion, resulting in difference of longitudinal expansion when a current, i passes through. The actuator has the long beam of 500 μm and the short one 300 μm. The width and thickness of the beams are 2.8 μm and 2 μm, respectively. The resistivity of the arms is equal to $5 \times 10^{-6}\ \Omega cm$.

(6 marks)

(c) Calculate the total power, P_{total}, applied to the arm at 14 V bias voltage in **Figure Q4(b)**.

(6 marks)

(d) The current trend in electronic industry is to use MEMS-based accelerometer in consumer products. Analyse how the MEMS-based accelerometer becomes more superior to the conventional accelerometer.

(5 marks)

(e) Accelerometer measures the acceleration by denoting in g-force rather than standard gravity. Analyse the reason why this practice is used in the accelerometer either in MEMS-based or conventional accelerometers.

(5 marks)

Q5 (a) Explain **TWO (2)** importance of nanoindention technique in microstructure characterisation.

(4 marks)

(b) One of the reason of microstructure failure is due to weakness in initial design process such as material process. Analyse methods of material process that could improve the performance of microstructure.

(5 marks)

(c) There are some imperfections occur during fabrication process that affect microstructure such as pores. Analyse the vulnerability in microstructures due to presence of pores during the design process.

(5 marks)

- END OF QUESTIONS -

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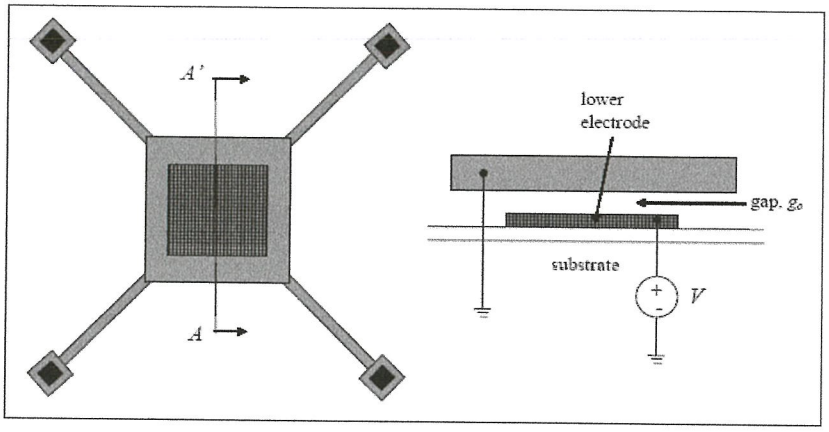

Figure Q2(b)

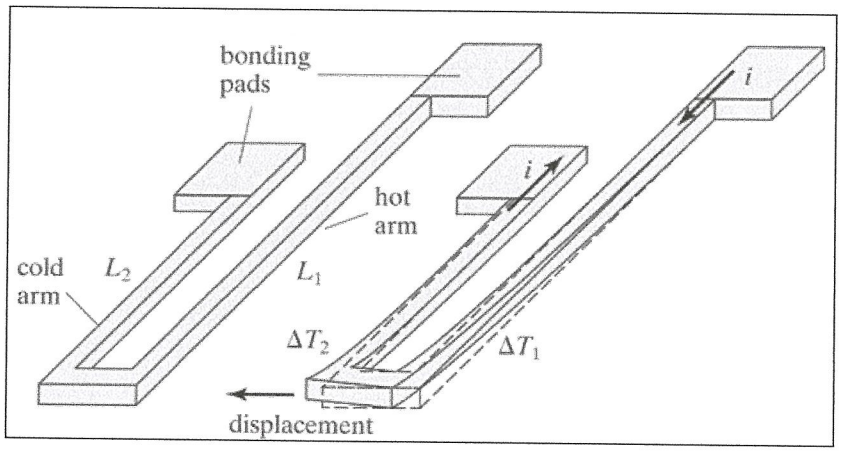

Figure Q4(b)