Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2017/2018

COURSE NAME	:	MEMS AND NEMS DESIGN
COURSE CODE	:	BED 40503
PROGRAMME	:	BEJ
EXAMINATION DATE	:	DECEMBER 2017 /JANUARY 2018
DURATION	:	2½ HOUR
INSTRUCTION	:	ANSWER **ALL** QUESTIONS.

THIS QUESTION PAPER CONSISTS OF **FIVE (5)** PAGES

Q1 There are three major groups for Integrated MEMS or microsystem; microstructures, microsensors and microactuators.

(a) List **TWO (2)** examples of MEMS microsensors and microactuators.

(4 marks)

(b) An example of MEMS microstructure is a tip which is the important component in an AFM probe. Describe the simplest fabrication process to obtain the tip microstructure by using an appropiate diagram.

(8 marks)

(c) MEMS design process basically involves of modeling, simulation and experiment. Desribe the importance of these processes.

(8 marks)

(d) Explain why silicon is an ideal subtrate material for MEMS device.

(5 marks)

Q2 Reactive ion etching is used to etch silicon with masking of 30 μm × 30 μm square window under the following three plasma conditions. The etching time is 10 minutes with fixed power level. Draw cross-section view (2D) of the etched silison for each of the conditions and label accordingly.

(a) Plasma is created in the SF_6 gas, without any accelerating ions, therefore dry etching take place due to pure chemical reaction. The etch rate due to this chemical reaction is found to be 0.3 μm per minutes.

(8 marks)

(b) Plasma is created in the mixture of SF_6 and Argon gaseous, therefore the Argon ions can enhance the reaction rate to 1.2 μm per minutes.

(8 marks)

(c) Plasma is created in the mixture of SF_6 with 40% of hydrogen gaseous, therefore the pure chemical reaction is zero, and argon gas is added to produce the Argon ions.

(9 marks)

Q3 There are two principal signal transduction methods widely used in MEMS known as piezoresistive and capacitive.

(a) Compare the advantages and disadvantages of using capacitor and piezoresistor as transduction methods in MEMS.

(8 marks)

(b) Develop the main process flow to fabricate the MEMS capacitive microphone shown in **Figure Q3(b)**.

(10 marks)

(c) A fixed-free cantilever is made of single crystal silicon with Young's modulus of 150 GPa. The piezoresistive element is made by diffusion doping with a gauge factor of 100. The length, width and thickness of the cantilever are 200 μm, 20 μm, and 5 μm, respectively.

(i) If a force F=150 μN is applied in the lognitudinal direction, calculate the magnitude of stress.

(4 marks)

(ii) By the aid of diagram, show the direction of force, F that shows the tranverse piezoresistor configuration.

(3 marks)

Q4 A MEMS system can always be simplified into a classic mass-spring-damping dynamic system. The understanding of MEMS system dynamic is crucial for predicting the performance characteristics of sensors and actuators.

(a) Characterize the damping factor, ξ in the design process consideration of MEMS system dynamics. Define the relation between ξ and Q-factor.

(8 marks)

(b) By the aid of appropiate diagram, list the source of damping, b in MEMS system.

(5 marks)

(c) The mechanical spring constant is the ratio of the applied force and the resultant displacement.

(i) Analyse the 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.

(6 marks)

(ii) The mass, m which is equal to 5 g is attached to the beam as shown in **Figure Q4(c)**. The equivalent beam spring constant k_{eq} in the arrangement is 18240 N/m. Analyse the natural frequency of the system in Hz and in rad/s.

(6 marks)

- END OF QUESTION-

FINAL EXAMINATION

SEMESTER/SESSION	: SEM I / 2017/2018	PROGRAMME	: BEJ
COURSE NAME	: MEMS AND NEMS DESIGN	COURSE CODE	. BED 40503

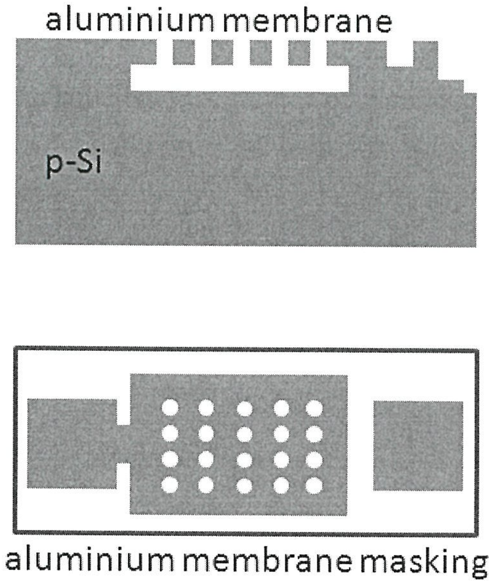

Figure Q3(b)

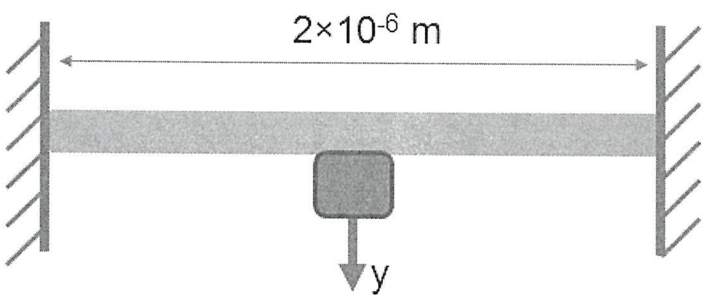

Figure Q4(c)