DEDAN KIMATHI UNIVERSITY OF TECHNOLOGY

University Examinations 2021

EXAMINATION FOR THE DEGREE OF THE:

- **MSc. ADVANCED MANUFACTURING AND AUTOMATION ENGINEERING**
- **MSc. MACHINE TOOLS DESIGN & MANUFACTURING**
- **PHD MECHANICAL ENGINEERING**

EME 6301: Micro-fabrication Techniques and Nanotechnology/ EME 7205: Advanced MEMS and Sensor Systems/ EMG 6217: Precision Engineering and Nanotechnology

DATE:

INSTRUCTIONS **TIME: 3 HOURS**

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1. This paper contains **FIVE (5)** questions.
2. Answer **FOUR (4)** Questions
3. Question **ONE (1)** is Compulsory.
4. Answer Question one and any other **THREE (3)**
5. Each question carries **25 Marks**

QUESTION 1 **[25 MARKS]**

A. Traditional MEMS manufacturing approaches using "build and test" to design lack of standard process and adequate design tools. With aid of well labeled diagrams, discuss concurrent design for manufacturability of MEMS devices. **[6 Marks]**

B. Many techniques and materials used in IC fabrication are reused in MEMS fabrication for the advantages of low cost, high reliability and performance. With aid of examples differentiate between MEMS and integrated circuit (IC) fabrication. **[6 Marks]**

C. With the aid of the well labelled sketches discuss the laser beam machining process phenomenon for material removal. **[7 Marks]**

D. With aid of schematics diagrams show closed-loop feedback control system of the adaptive optics and discuss the strategies of correcting atmospheric blurring [**6 Marks]**

QUESTION 2 **[25 MARKS]**

A. By considering the experimental set-up in **Fig.Q2A**, discuss the electro-discharge milling process phenomenon of SiC ceramic and why it is advisable to use steel for the tool electrode instead of copper or graphite electrode. **[6 Marks]**

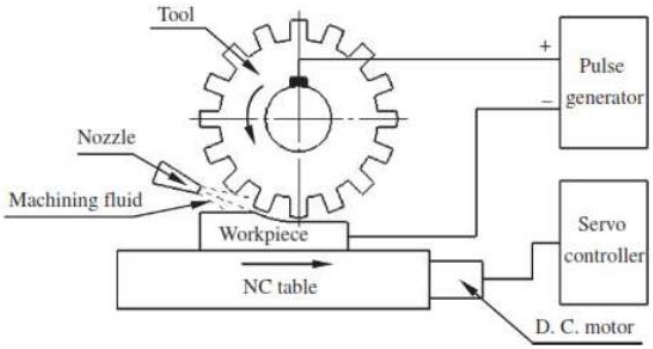

Fig.Q2A

B. Most micro/nanofabrication techniques have their roots in the standard fabrication methods developed for the semiconductor industry. With aid of well labelled diagram, discuss the lithography fabrication process. **[6 Marks]**

C. With aid of well labelled sketches, differentiate between oxidation and doping as two microfabrication methods used most frequently in the manufacturing of micro/nanostructures. **[7 Marks]**

D. With aid of well labelled sketches discuss, the development trends and perspectives of the future sensors and MEMS/NEMS **[6 Marks]**

QUESTION 3 **[25 MARKS]**

A. With aid of well labelled sketches, differentiate between chemical vapor deposition (CVD) and physical vapor deposition (PVD). **[6 Marks]**

B. Thin-film deposition and doping are extensively used in micro/nanofabrication technologies. Discuss the following deposition techniques: **[6 Marks]**

(i) Electroplating

(ii) Pulsed Laser and Atomic Layer Deposition

C. Thin-film and bulk substrate etching is another fabrication step that is of fundamental importance to both VLSI processes and micro/nanofabrication. With aid of well labelled sketches, differentiate between isotropic and anisotropic etching through a photoresist mask. **[7 Marks]**

D. With aid of well labelled sketches discuss application of MEMS in the energy harvesting **[6Marks]**

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QUESTION 4 **[25 MARKS]**

A. Use of laser based and other applied optics tools for inspection and diagnostics of MEMS is predetermined by their noninvasive and contactless nature. With aid of well labelled sketches, differentiate between Michelson and Tolansky interferometers. **[6 Marks**]

B. Nanometer-scale local oxidation of various materials can be achieved using scanning probes operating in air and biased at a sufficiently high voltage. With aid of well labelled sketch, discuss the working principle of Dip-Pen Nanolithography. **[6 Marks]**

C. The nanotemplates used to fabricate nanostructures are usually prepared using self-assembly techniques. Based the assembly principle, differentiate between Physical and chemical self-assembly **[7 Marks]**

D. With aid of well labelled sketches discuss MEMS/NEMS applications in Flexible and Interface **[6 Marks]**

QUESTION 5 **[25 MARKS]**

A. The invention of scanning probe microscopy revolutionized atomic-scale imaging and spectroscopy. With aid of well labelled sketches, differentiate between scanning tunneling and atomic force microscopes. **[6 Marks]**

B. Electrons emitted from a biased SPM tip can be used to expose a resist in the same way e-beam lithography that does. Discuss probe resist exposure process. **[6 Marks]**

C. Referring to the **Fig.Q5C** below, discus the ideal suites of CAD tools required for MEMS development **[7 Marks]**

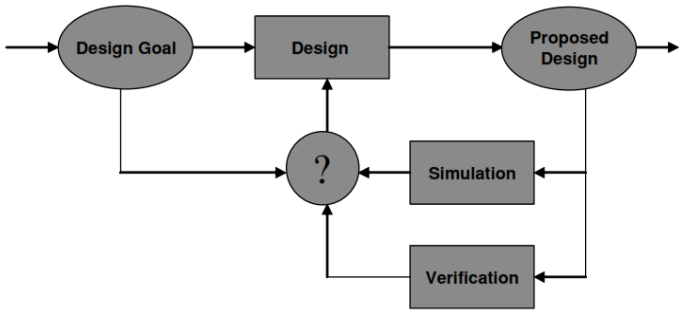

Fig.Q5C

D. Discuss the possibilities of MEMS/NEMS to find its integration in the artificial intelligence, virtual reality, and augmented reality **[6 Marks]**

Good luck!!