

Name: _____

Student ID: _____

Introduction to MEMS

Quiz #1

UCI Fall Quarter 2008

Note to the student: There are several versions of this quiz being used today. Each quiz has the same or similar questions and answers, but in different order. The same answer may be correct on one quiz and incorrect on another. Please BEWARE. If you notice the answer on a neighbor's quiz, it may not be the correct answer for yours.

Please answer questions using the answer sheet at the end of this quiz. For short response questions, you should not use more than one sentence.

Turn in **all** portions of this quiz after finishing. Good luck.

ANSWER KEY

Section 1: Multiple choice

Do not answer in this portion; use the answer sheet at the end of the test. Write your answers clearly. If I can't understand your writing, I have to assume it to be incorrect.

Identify the most correct answer:

- 1 What is the wavelength of the "I-line" of mercury?
(a) 800 nm (b) **[365 nm]** (c) 2 microns (d) 50 nm
- 2 What is the typical thickness of a surface micromachined device?
(a) Between 50-100 microns (b) Less than 1 micron (c) Greater than 100 microns (d) **[Between 5-20 microns]**
- 3 What is a typical resolution for micro metal injection molding?
(a) 1 mm (b) 1 um (c) **[50 um]** (d) 100 nm
- 4 What is the typical thickness of a CVD film?
(a) 10 Angstroms (b) **[0.1 to 2 microns]** (c) 1-2 millimeters (d) 10 nanometers
- 5 Which of the following materials is grown from a single seed into a boule?
(a) Silicon dioxide (b) Silicon nitride (c) **[Single crystal silicon]** (d) Polysilicon
- 6 Which is typically the last step in a silicon MEMS process?
(a) Polishing (b) **[Sacrificial release]** (c) Lithography (d) LPCVD
- 7 Which is NOT a component of photoresist?
(a) Resin (b) **[Polysilicon]** (c) Photoinitiator (d) Solvent
- 8 What does "six nines" mean?
(a) **[Highly pure material]** (b) Crystal orientation of silicon (c) Double sided wafer (d) Reaction time
- 9 Low Pressure Chemical Vapor Deposition (LPCVD) typically requires what?
(a) Spin-on layer (b) **[High temperature]** (c) Aggressive etchants (d) Magnetic fields
- 10 Which gives an anisotropic etch?
(a) Xenon difluoride (b) Nitric acid (c) **[KOH]** (d) HF

- 11 Deep reactive ion etch uses which phenomenon?
(a) Wet chemistry (b) **[Plasma]** (c) Sandblasting (d) Ion milling
- 12 Which semiconductor process is NOT commonly used in MEMS?
(a) CVD (b) **[Ion implantation]** (c) Etch (d) Lithography
- 13 Which represents a high cost barrier to MEMS commercialization?
(a) **[Difficult to package]** (b) Poor characterization (c) Rough silicon wafers (d) Difficult to obtain raw materials
- 14 Which process makes device primarily from thin films?
(a) Bulk micromachining (b) **[Surface micromachining]** (c) Casting (d) Injection molding
- 15 Which of the following processes use plasma?
(a) Electroplating (b) Lithography (c) **[Sputtering]** (d) Vacuum evaporation
- 16 Which is NOT a benefit of lithography?
(a) High resolution (b) Batch fabrication (c) Semiconductor infrastructure (d) **[3-D processing]**
- 17 Which is a serious problem during MEMS release?
(a) **[Stiction]** (b) Planarity (c) Rough surfaces (d) Vibrations
- 18 Which products demonstrates sub-micron precision injection molding?
(a) Game controllers (b) Cell phone cases (c) **[Compact disks]** (d) Satellite antennas
- 19 MEMS micromachining has borrowed techniques primarily from which industry?
(a) Aerospace (b) **[Semiconductor]** (c) Pharmaceuticals (d) Energy
- 20 Which process is commonly used for soft lithography?
(a) Precision machining (b) Electroplating (c) Stereo lithography (d) **[Casting]**
- 21 Which is an example of physical vapor deposition?
(a) Spin-on (b) **[Evaporation]** (c) Electroplating (d) Oxidation
- 22 What does LIGA use sychrotrons for?
(a) Ion beams (b) **[X-rays]** (c) UV light (d) Electrons

- 23 Which of the following produces high aspect ratio structures in polymer?
(a) [LIGA] (b) Reactive ion etch (c) Electroplating (d) KOH etching
- 24 Which force is strongest at the microscale?
(a) [Surface tension] (b) Inertia (c) Sound pressure (d) Gravity
- 25 Which glass can be treated to etch at high aspect ratio?
(a) Borosilicate (b) Soda lime **(c) [Foturan]** (d) Float glass

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Section 2: Multiple choice answers

Please denote your answers by filling in the appropriate diamond below. Make your answer clear; completely erase any unintended marks. Check the question number carefully.

1) A B C D

2) A B C D

3) A B C D

4) A B C D

5) A B C D

6) A B C D

7) A B C D

8) A B C D

9) A B C D

10) A B C D

11) A B C D

12) A B C D

13) A B C D

14) A B C D

15) A B C D

16) A B C D

17) A B C D

18) A B C D

19) A B C D

20) A B C D

21) A B C D

22) A B C D

23) A B C D

24) A B C D

25) A B C D

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Section 3: Short response

Answer each question in one or two sentences. Write your answers clearly and be brief. If I can't understand your writing, I have to assume it to be incorrect.

26 What is "spinning" and why is it used in MEMS processes?

"Spinning" is the process of spreading a thin layer of polymer on the surface of a wafer by spinning the wafer at high speed. It is important because it is an inexpensive way to put photoresist on the surface of a silicon wafer.

27 Why is silicon so commonly used in micromachining applications?

Silicon has a long history of micromachining for semiconductor applications so the manufacturing processes are well known. Also, electronics can be added to silicon MEMS devices because silicon is a semiconductor.

28 What is a "hard mask" and why is it necessary in micromachining?

A "hard mask" is a tough material like silicon nitride or silicon dioxide that can resist an aggressive etch. It is patterned first to allow deep etching of silicon--photoresist cannot survive such aggressive etches.

29 Describe what happens during chemical vapor deposition.

Discussion should describe molecule attachment, nucleation and growth into islands.

30 Give an example of "bottom up" nanofabrication and an example of "top down" nanofabrication.

Bottom up are chemical growth processes such as nanotube growth. Top down examples use assembly or lithography.

31 What is the advantage of wafer level packaging for MEMS?

If MEMS devices could be packaged at wafer level, then release could be performed at wafer level and packaging would be easier.

32 Describe how "soft lithography" works.

PDMS (elastomer) is cast against a high quality mold then cured. The elastomeric part is then used to stamp molecules or resist against a surface.

33 Identify two non-silicon processes for building MEMS devices and indicate how they work.

SU-8, LIGA, EFAB, stereo lithography, Foturan, micro-injection molding, casting, soft lithography

34 What are two drawbacks to using SU-8 photoresist to replace LIGA?

Cannot strip (remove), hard to integrate, difficult to process.

35 How does metal evaporation work? Why does it produce shadows behind tall structures?

Metal is heated to liquid point in a vacuum. Metal vapor atoms fly off from melt in straight lines because there is no air to stop them or diffuse them. Straight paths produce shadows if there are other materials in the way.