

MEMS Micromachining Overview

Final Assessment Instructor Guide

Notes to Instructor

This Final Assessment (FA) contains 18 multiple choice questions. This MEMS Micromachining Overview Assessment can be used to determine the participant's basic knowledge of micromachining processes and applications.

This assessment is part of the *MEMS Micromachining Overview Learning Module*.

The *MEMS Micromachining Overview Learning Module* consists of the following:

- Knowledge Probe (KP)
- MEMS Micromachining Overview PK
- Terminology Activity
- Research Activity
- LIGA Activities (4) – These activities can be found in the LIGA Micromachining Activities Module. A SCME kit is required for 2 of these activities*.
- **Final Assessment**

*The LIGA Micromachining kit can be ordered through the SCME website (<http://scme-nm.org>) while supply lasts and center is funded.

This Instructor Guide (IG) contains both the questions and answers for 18 assessment questions. The Instructor Guide booklet contains this IG followed by the Participant Guide (PG) assessments which contain only the questions.

Description

This assessment is to determine your knowledge and understanding of the three most common MEMS micromachining processes: surface, bulk, and LIGA.

1. Which of the following are the three most widely used micromachining processes?
 - a. Bulk, surface, PMMA
 - b. Surface, bulk, LIGA
 - c. PMMA, LIGA, surface
 - d. LIGA, CMP, surface

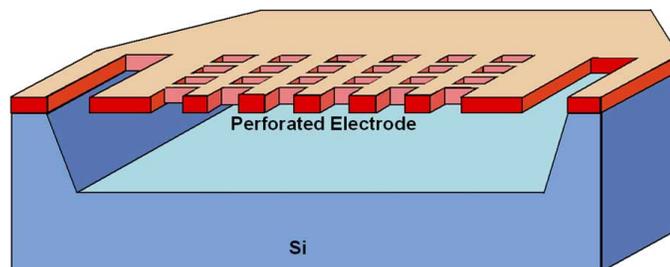
2. Which micromachining process would be most likely used to construct high aspect ratio microchannels and chambers within a silicon or glass substrate?
 - a. Bulk
 - b. Surface
 - c. PMMA
 - d. LIGA

3. The etch rate of silicon in a wet etch process is partially determined by the crystal orientation of the substrate and the planes being etched. Two common crystal planes etched in MEMS micromachining are the (100) plane and the (111) plane. Which of the following statements is true? The etch rate of the ...
 - a. (111) plane is hundreds of times faster than the etch rate of the (100) plane.
 - b. (100) plane is hundreds of times faster than the etch rate of the (111) plane.
 - c. (100) plane is thousands of times faster than the etch rate of the (111) plane.
 - d. (100) plane and the (111) plane is the same regardless of the etchant used.

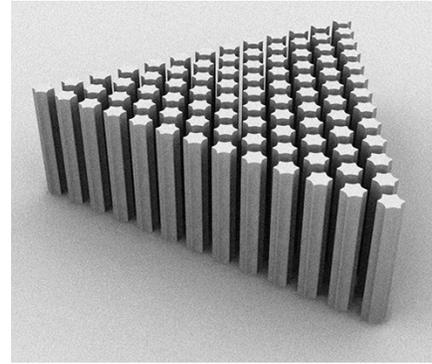
4. Bulk micromachining builds structures _____ the substrate, while surface micromachining builds structures _____ the substrate.
 - a. out of ...into
 - b. on top of ... into
 - c. into...on top of
 - d. into...as part of

5. Which of the following MEMS components would LEAST likely be fabricated using bulk micromachining processes?
 - a. Cantilevers
 - b. Microfluidic channels
 - c. Probes
 - d. Gear trains

6. The device shown in the picture was fabricated using which of the following process(es)?
 - a. Bulk only
 - b. Surface only
 - c. LIGA only
 - d. Bulk and Surface
 - e. Bulk and LIGA



7. The high aspect ratio single posts illustrated in this graphic were made from a mold that was fabricated using which of the following process(es)?
- Bulk
 - Surface
 - LIGA**
 - Bulk and Surface
 - Bulk and LIGA



8. The components fabricated using surface micromachining are _____ aspect ratio components relative to other micromachining processes.
- Low**
 - Medium
 - High
 - Ultra-high
9. Which of the following BEST describes a unique output of a LIGA process compared to other micromachining processes? High aspect ratio...
- microchannels within the substrate
 - probes and needles formed from a substrate
 - holes that go through the entire substrate
 - molds or stamps for mass production of micro-components**
10. Which of the following statements is NOT true?
- Isotropic etching is a chemical process; anisotropic etching can be either a chemical or physical process.
 - Anisotropic etching is used to fabricate V-shaped grooves, nozzles, and straight wall structures such as holes and channels.
 - Isotropic profiles require wet etch processes and anisotropic profiles require dry etch processing.**
 - Wet isotropic etching is used to remove sacrificial layers
11. One major advantages of surface micromachining over other micromachining processes is that the
- electronic circuitry can be fabricated on the same chip simultaneously to the fabrication of the micro-components.**
 - final product can be used as a stamp or mold for the mass production of other micro-components.
 - same chemicals used to build integrated circuits can also be used to fabricate surface micro-components.
 - shape and size of the components can be more easily controlled by exploiting the crystal planes of the silicon.

12. In surface micromachining, the last step of the process might be to remove the sacrificial layers in order to release any microcomponents on the surface. Which of the following processes is used to remove sacrificial layers?
- Chemical mechanical polishing
 - Chemical wet etch**
 - Reactive ion etching
 - Synchrotron radiation expose
13. Surface microcomponents such as gears, cantilevers, hinged mirrors and linkages all need to be released from the substrate and allowed to move freely and smoothly above the surface below it. The process used to flatten or smooth the topography of a surface for subsequent structural components is called
- Chemical mechanical polishing**
 - Chemical wet etch
 - Reactive ion etch
 - Synchrotron radiation expose
14. Photoresist is to surface micromachining as _____ is to LIGA.
- Beryllium
 - Gold
 - KOH
 - Plexiglas or PMMA**
15. Synchrotron radiation is to LIGA as _____ is to bulk and surface micromachining.
- Electromagnetic radiation
 - Microwave
 - Ultraviolet light**
 - Infrared light
16. In the LIGA process, the purpose of “develop” is to
- Strip the photoresist from the substrate surface after expose
 - Remove the PMMA that has been exposed to radiation**
 - Remove the PMMA that has NOT been exposed to radiation
 - Harden the PMMA that has been exposed to radiation.
17. In LIGA the electroforming process requires a(n) _____ solution to allow _____ to travel from the anode to the cathode. (Select the BEST answer.)
- chemical, charged metal particles
 - electrolyte, negative metal ions
 - electrolyte, metallic particles
 - electrolyte, positive metal ions**

18. Which of the following statements is true of LIGA but not true of other micromachining processes?
- a. Uses the same process equipment and chemical as those used in computer chip manufacturing.
 - b. **Able to construct microcomponents with aspect ratios of 100:1 or higher.**
 - c. The substrate can be used as a base for components or can be used as a mold or stamp for microcomponents.
 - d. Able to use a lithography process that is more cost effective and accessible than other processes.
19. Scaffolding is to a bridge as a sacrificial layer is to a MEMS _____ layer.
- a. substrate
 - b. photoresist
 - c. **structural**
 - d. mask
20. Which of the following thin films is used to reduce friction between two dynamic layers or a dynamic and static layer?
- a. Silicon dioxide
 - b. Polycrystalline
 - c. Silicon nitride
 - d. **Self-assembled monolayer**

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