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PME 4352 微機電系統導論 期中考

姓名　　　　　　學號

一 (20%)	二 (30%)	三 (60%)	總分
19	30	42.5	91.5

44.5　96

一、單選題 (20%)

1. 無塵室潔淨度等級為 class N，N 越大表示潔淨度越 (A) 低, (B) 高, (C) 相同, (D) 無法辨識
2. 和傳統機械相較，何者為 MEMS 的特色 (A) standard parts, (B) parts assembly, (C) process integration, (D) 以上皆是
3. 以下何者不屬於平面加工 (planar fabrication) 技術 (A) IC, (B) MEMS, (C) TFT-LCD, (D) Optical pickup head
4. 薄膜沉積的過程如存在孔隙(void)缺陷會造成何種殘餘應力 (A) compression, (B) tension, (C) gradient stress, (D)以上皆可
5. 何種殘餘應力會造成微懸臂結構彎曲 (A) compression, (B) tension, (C) gradient stress, (D)以上皆可
6. 如欲鍍合金薄膜如 *AlCu* 那一種技術佳 (A) Sputtering, (B) Evaporation, (C) Thermal Growth, (D) Electroplating
7. 那一種曝光技術光罩較易污染 (A) Contact, (B) Proximity, (C) Projection, (D) 以上皆同
8. 曝光時何種光源可定義較細之線寬，(A) g-line (436nm), (B) i-line (365nm), (C) KrF (248nm), (D) ArF (193nm)
9. 一般而言，何者有較佳之蝕刻速率 (etching rate): (A) ion etching, (B) sputter etching, (C) wet etching, (D) 以上皆同
10. 一般而言，何者有較佳之選擇比 (selectivity): (A) ion etching, (B) sputter etching, (C) wet etching, (D) 以上皆同
11. Si wet anisotropic etching 無法製造 (A) cavity, (B) plate, (C) mesa, (D) circular channel
12. 對於 KOH 蝕刻液而言，蝕刻速率最慢的矽晶格面是 (A) (100), (B) (110), (C) (212), (D) (111)
13. 有些 bulk micromachining 的懸浮結構如 clamped-clamed beam 和傳統機械結構不同，主要是受限於何種製程 (A) deposition, (B) photolithography, (C) etching, (D) bonding
14. 一般而言，經由 PVD 的 thin film materials 的成份為多晶和非晶，因此其蝕刻的方式為 (A) isotropic etching, (B) anisotropic etching, (C) 以上皆有可能, (D) 以上皆非
15. 何者具有較高的 bonding temperature (A) Anodic bonding, (B) Fusion bonding, (C) Eutectic bonding, (D) Epoxy bonding
16. Anodic bonding 常選用 Pyrex 7740 玻璃，主因是那一項材料特性? (A) stiffness, (B) thermal expansion coefficient, (C) density, (D) dielectric constant
17. 何者在進行接合時，接合面需介質輔助 (A) Si-Glass anodic bonding, (B) Si-Si fusion bonding, (C) Si-Si eutectic bonding, (D) 以上皆有可能
18. LIGA 製程不包括 (A) Lithography, (B) Bonding, (C) Electroplating, (D) Molding
19. 同步輻射光所提供的是何種製程 (A) Laser LIGA, (B) X-ray LIGA, (C) SOI MEMS, (D) CMOS.
20. 何種元件沒有磨耗的問題 (A) Comb drive, (B) Micro motor, (C) Spindle, (D) Hinge

二、簡答題 (30%)

1. **Deposition:** (1) What's **step coverage**? (2) Why **sputter** could give a better step coverage, as compare with **evaporation**? (3) Why **LPCVD** could give a better step coverage, as compare with **APCVD**. (6%)

2. **Photolithography:** What is **alignment mark**? Show two approaches for double-side alignment (6%)

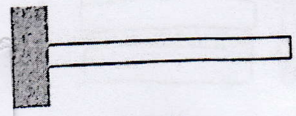
3. **Etching:** we could use the "time-control" etching to define the thickness of MEMS structures (e.g. the plate thickness of pressure sensor), (1) what's the problem the "time-control" etching may cause for mass production? (2) how to solve this problem, and give an example (6%)

4. **Etching:** (1) Show the etching mechanism of RIE, (2) why anisotropic etching can be achieved using RIE

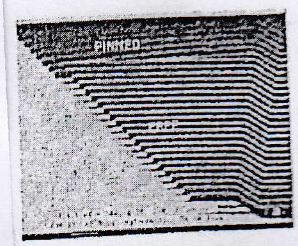
for anodic bonding? (2) Show a design to combine the advantages of the above two electrodes. (6%)

三、問答題 (50%+10%)

1. **MEMS design:** The bending stiffness of **surface micromachined cantilever** could be different with that of the design value. Show the fabrication process of surface micromachined poly-Si cantilever, and indicate **five possible reasons** (give a short explanation) to cause the difference of **bending stiffness** (as compare with that predicted from the ideal cantilever beam model). **(10%)**



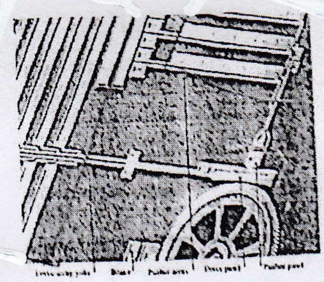
Ideal cantilever



Fabricated cantilever
(Mastrangelo, 1993)

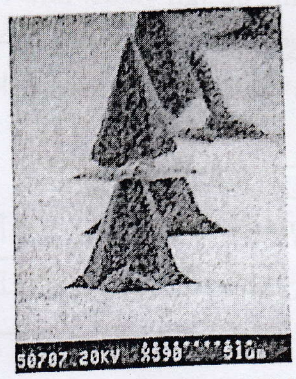
2. **MEMS design:** Show the processes to fabricate (a) **1μm thick** bulk micromachining cantilever, (b) **5μm thick** bulk micromachining cantilever, (c) **10μm thick** cantilever on SOI wafer, (d) **30μm thick** cantilever on (111) substrate, (e) **100μm thick** LIGA micromachined cantilever beam. **(10%)**

3. **MEMS design:** (1) Indicating the thermal actuators on photo and also showing its operation principle, and (2) explaining the operation mechanism of the device to enable the angular motion of rotor **(10%)**



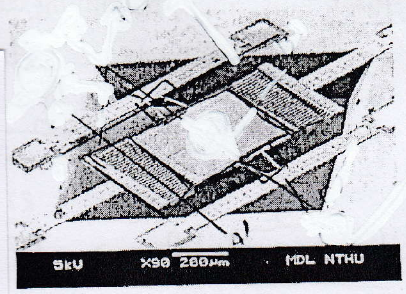
Comtois and Bright 1997

4. **Bulk Micromachining:** Show the fabrication processes to fabricate the micro Velcro below. Note that this one has a sharp tip to enable the easy intrusion. **(10%)**



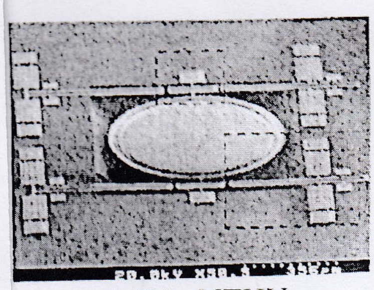
R. Dizon, et. al., 1992

5. **Hybrid Micromachining:** Figure shows the **1-axis scanning mirror** fabricated using the hybrid micromachining processes. **(10%)**
   (1) Indicate key components (vertical comb, spring, and rigid support/mirror) and their cross sections
   (2) Show the fabrication processes for these components
   (3) Illustrate the main mask to define the feature of scanner



MDL, NTHU

6. **Microsystem:** Figure shows the **1-axis scanning mirror** fabricated using the hybrid micromachining processes. The **actuator** and **coupler** are marked with dash lines in figure. **(10%)**
   (1) Show the merits of the **actuator** in terms of the driving voltage and output displacement
   (2) What's the purpose of the **coupler**
   (3) How to enable the mirror to scan at a **large angle** and **high frequency**



MDL, NTHU