2006.

PME 4352 微機電系統導論 期中考

28.5×1

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一 (15%)	二 (35%)	三 (60%)	總分
14	~~8~~ 29	49	~~91~~ 92

一、單選題 (15%)

C 1. 一般而言，何者有較佳之蝕刻選擇比 (etching selectivity): (A) reactive ion etching, (B) sputter etching, (C) plasma etching, (D) 以上皆同

A 2. 一般而言，何者有較佳之蝕刻速率 (etching rate): (A) plasma etching, (B) sputter etching, (C) ion etching, (D) 以上皆同.

A 3. Thermal SiO_2 會產生何種殘餘應力 (A) compression, (B) tension, (C) 以上皆是, (D) 以上皆非

C 4. 何者可被 anisotropic etching (A) thin film, (B) silicon substrate, (C) 以上皆是, (D) 以上皆非

B 5. 在 CVD 時，何者具有較均勻之膜厚 (A) APCVD, (B) LPCVD, (C) PECVD, (D) 以上皆同

A 6. 在鍍膜前，基材已存在另一低熔點金屬膜，何者為較佳之選擇 (A) APCVD, (B) LPCVD, (C) PECVD, (D) Thermal growth

B 7. 何者可進行 Si 和 Si 直接接合，而毋須其他薄膜或物質作為介面(A) Anodic bonding, (B) Fusion bonding, (C) Eutectic bonding, (D) Epoxy bonding

B 8. 何者具有較高的 bonding temperature (A) Anodic bonding, (B) Fusion bonding, (C) Eutectic bonding, (D) Epoxy bonding

C 9. PECVD SiO_2 較適合作為 (A) micro structure, (B) etching mask, (C) sacrificial layer, (D) 以上皆同

A 10. 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

A 11. 一般而言，蝕刻薄膜時，何者可得到較佳之截面 (A) ion etching, (B) wet etching, (C) plasma etching, (D) 以上皆同

C 12. 何種殘餘應力會造成懸臂樑彎曲 (A) compression, (B) tension, (C) gradient stress, (D)以上皆可

C 13 下列何種技術，可以在 Si substrate 進行 KOH anisotropic etching 時，產生顯著的 etching selectivity/stop (A) amorphous Si, (B) poly-Si, (C) p^{++} Si, (D) n^{++} Si

C 14. 除了龐大的設備外，X-ray LIGA 還受限於: (A) photoresist, (B) hot embossing, (C) mask, (D) electroplating.

A 15. 於 wet etching 時，經由 CVD 或 PVD 的 Thin film materials: (A) 僅能 isotropic etching, (B) 僅能 anisotropic etching, (C) 以上皆可, (D) 以上皆非.

二、簡答題 (35%)

1. Show two different kinds of **SLIGA** process **(5%)**

2. Explain **step coverage**. Which one has better step coverage, (1) sputtering, (2) evaporation, (3) LPCVD (answer in the following form: e.g. (1) > (2) >(3)) **(5%)**

3. What is **convex corner**? Show its (1) drawback (缺點), and (2) contribution for MEMS **(5%)**

4. Explain **anisotropic etching**, show two different anisotropic etching technologies for Si wafer **(5%)**

5. **Hinge** is an important component for MEMS. Show its (1) major drawback during applications, and (2) major contribution for MEMS **(5%)**.

6. In MEMS processes: show three different approaches to **increase the stiffness** of MEMS structures **(5%)**.

7. What happen to the cantilever shown in the photo? List three approaches to prevent this **(5%)**.

三、問答題 (50%+10%)

1. You fabricate a bulk micromachined cantilever with its stiffness different from the design value. Show five possible reasons (also give a short explanation) to cause this difference. **(10%)**

(1) Film deposition: 不同方法、機台所沉積之膜品質不同。Wet thermal oxide 較鬆散,E小;而 Dry thermal oxide 較緻密 E大。

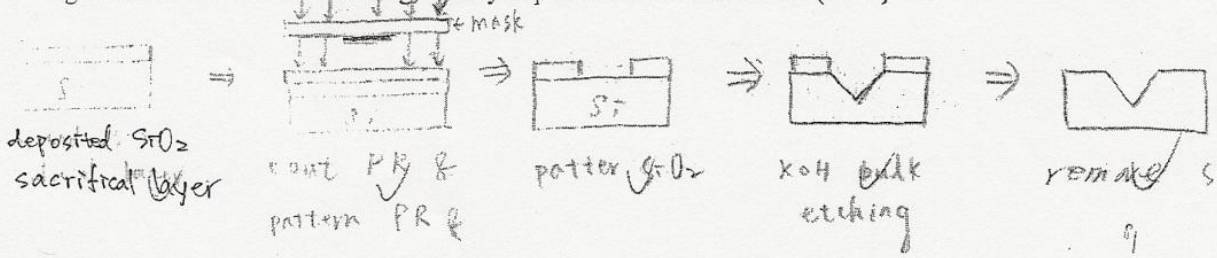
(2) Lithography: 對準誤差,導致結構線寬改變,影響後續蝕刻製程改變斜面形狀

(3) Film etching: convex corner 和 undercut 的現象,改變結構形貌

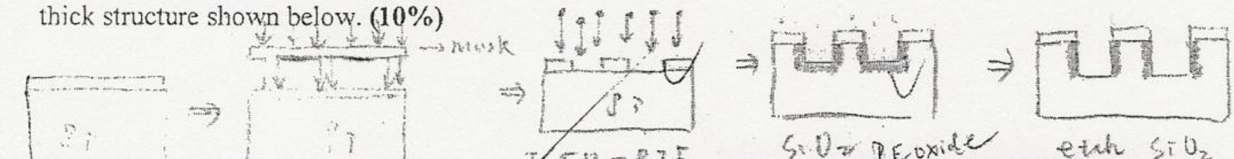
(4) Si etching: etch selective 的因素,導致在 Si etching 中使 structure 受到 etching,改變 structure 形貌

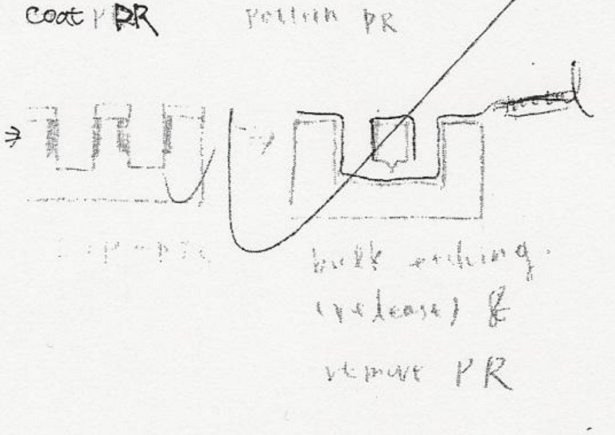
(5) Si etching: 因為晶格面的因素,在 cantilever 之邊界形成突端。

2. Bulk Micromachining: Show five different cross-sections of micro-channel fabricated using the single-mask bulk micromachining, briefly explain how to make them. **(10%)**



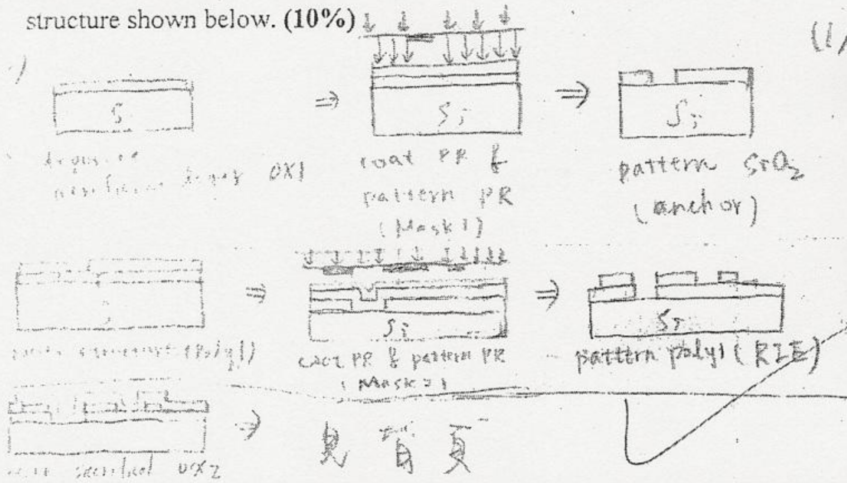
3. Thick Micromachining (SCREAM process): (1) design the fabrication processes (**1 masks**) for the thick structure shown below. **(10%)**



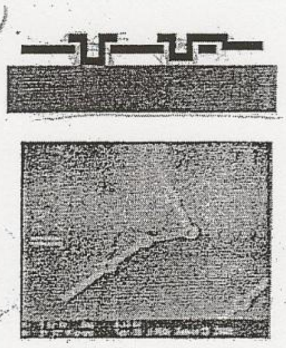


Tay et.al., 2000

4. Surface Micromachining: (1) Draw the cross section view of the device (a spring connected to a rotor and its spindle) shown in figure below, and (2) design the fabrication processes (**4 masks**) for the structure shown below. **(10%)**



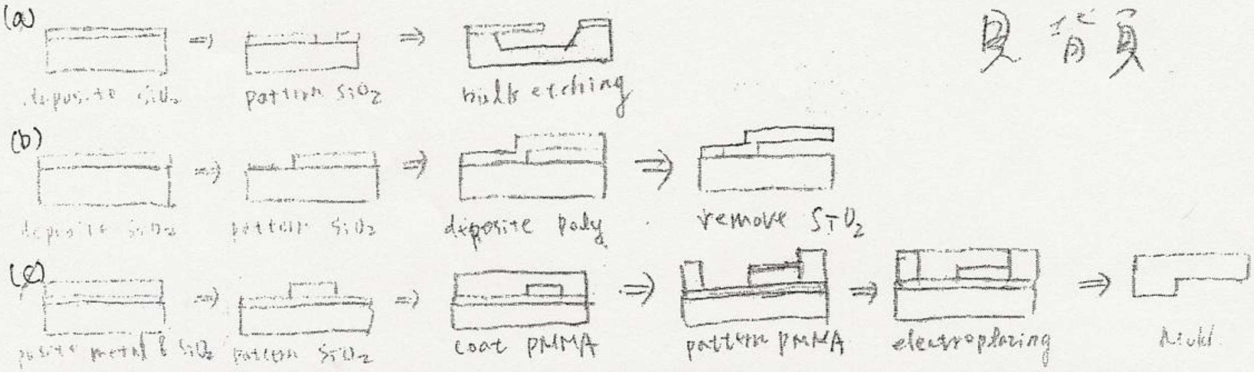
(1)



Fan, Tai, and Muller, 1988

5. Show the processes to fabricate (a) 1 μm thick bulk micromachining, (b) 1 μm thick surface micromachining, and (c) 100 μm thick LIGA micromachined cantilever beam.

Show two possible approaches to fabricate **bulk micromachined cantilever** beams with thickness in the range of (d) 4 to 5 μm, and (e) 30 μm or above, by wet etching **(no bonding)**. Please draw their fabrication processes. **(10%)**



見背頁

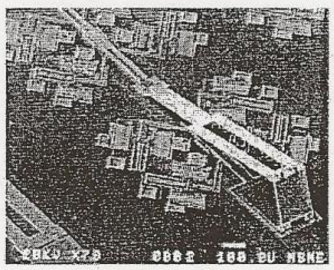
6. **(Extra credits)** In this class, I mentioned about an optical scanner driven by the comb-drive actuator.

(1) Describe three characteristics of the motion of comb-drive **I mentioned in the class**

(2) Describe three characteristics of the motion of scanner **I mentioned in the class**

(3) Explain the mechanism to lead to the different motion characteristics of driver and scanner

(1) ① 靜電驅動，無摩擦損耗。
② 可視為一 spring-mass 系統。
③ 可串聯而產生大出力

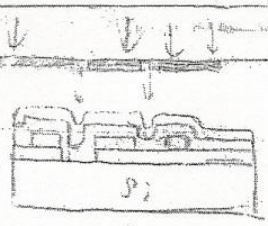


BSAC, Berkeley

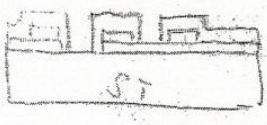
(2) ① 可做 3-D scanning
② 藉由槓桿放大，使掃描範圍大。
③ 易與其它光學元件整合，應用於"微光學桌"。

(3) 藉由comb-drive及hinge的組合，將一 in-plane 的往復運動，轉換成 out-of-plane 的翻轉運動。(含有槓桿放大的效果使翻轉運動更大)

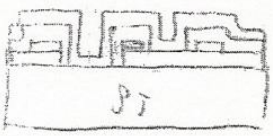
(f)



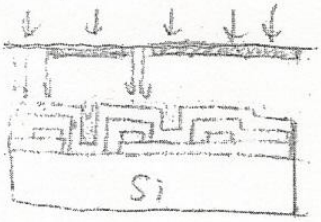
coat PR & pattern PR
(mask 3)



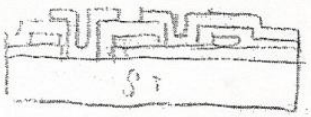
pattern OX_2



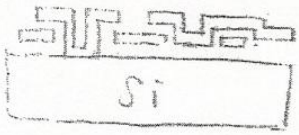
deposite structure (Poly2)



coat PR & pattern PR
(mask 4)



pattern poly 2.



remove OX_1 & OX_2

→ release structure!

(g)

(d)

pattern PR B^+ diffusion back side pa

back etching remove SiO_2

(e)

deposite PR pattern PR

remove PR back side pattern

remove SiO_2