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Mechanical Engineering Department

ME119, Fall 2007 **Liwei Lin**

Quiz II (80 minutes)

Close book, close notes, open two pages of formula sheet

Please answer questions as concise as possible

Problem 1, Concepts (30 points, 15 points each)

Please answer the questions as concise as possible (less than 100 words), use illustrations as much as possible if it will help your answers

a. Explain the LIGA process by drawing the cross sectional view of the process flow on making a microstructure of 400μm in thickness made of (i) nickel and (ii) polymer.

b. We would like to make (i) a micro hemispherical shell shape structure and (ii) a solid full spherical ball. Please design process flows for each of the structures.

Problem 2 Research Papers (50%)

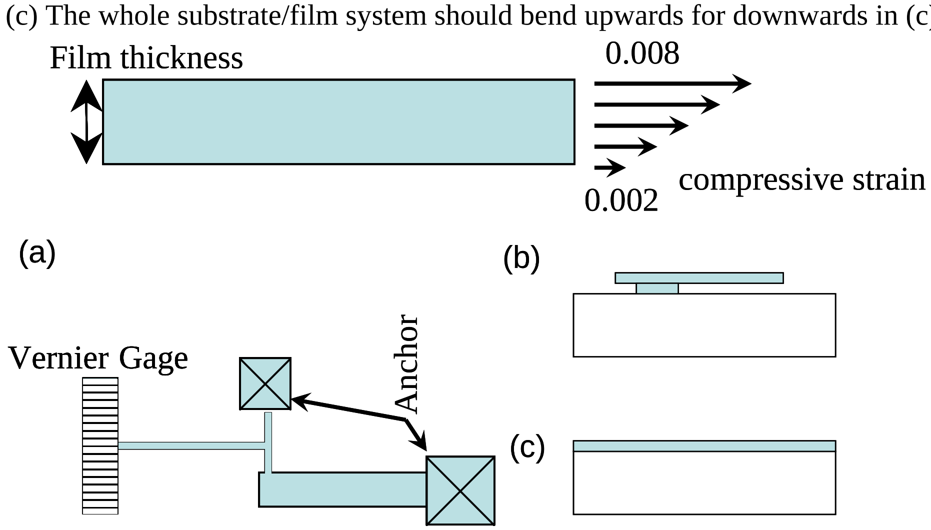
a. Residual Stress (15%)

A thin film is deposited on top of the silicon and the thin film has the stress state as drawn on the top portion of the figure. (a) The film is either used for in surface micromachining process with a sacrificial layer as shown in – top view; (b) – cross sectional view; or (c) it is attached to the substrate. Explain briefly your answer for -

(a) The vernier gauge shown in the figure should move up or down in (a)?

(b) The film should curl up or down in (b)?

(c) The whole substrate/film system should bend upwards for downwards in (c)?



b. Surface-Micromachining (15%)

Explain the <u>supercritical drying process</u> and the <u>sublimation process</u> by drawing the 3-phase diagram and please illustrate and explain the process with short description of each step including the typical process flow used in the polysilicon surface-micromachining process.

c. Bulk-Micromachining (20%)

Anisotropic silicon wet etching is conducted on a (100) silicon substrate of 500μm in thickness and the masking layer is designed as a square of X-μm in width as shown. We would like to have an opening of 20-μm wide at the bottom of the wafer. (hint: the angle between (100) and (111) direction is 54.74^o)

a. What should be the size of X assuming the etching rate of <100> to <111> is infinity? (5%)
b. If the etching rate of <100> to <111> is 10:1, what should be the correct angle (not 54.74^o) at the end of the process? (7%)
c. A square shape mask is drawn as shown in the figure. Please illustrate the schematic view (prefer 3-D drawings instead of simple top or side view) of the etching results if this is a "dark" mask and "bright" mask, respectively, in the manufacturing process. The etching process is only etching through half thickness of the wafer (8%)

Problem 3 IC process (20%)

The following schematic shows the process to from a flat silicon dioxide trench with a deep implant to from the channel stop at the bottom of the trench and junction isolation at the bottom of an n-well. We will assume that the silicon dioxide has identical ion stopping properties as Silicon. The bottom implantation (dose = $10^{13}/cm^2$) was performed such that the profile peaks exactly at the bottom of the silicon dioxide trench.

(a) Use the attached table to find out the boron implantation energy (closest level from the table is good for your answer, no extrapolation is needed) (5%)
(b) Calculate the junction depth between the implant p layer and the substrate n-Silicon ($N_B = 10^{15}/cm^3$) – (5%)
(c) Following the implantation, a thermal annealing cycle was carried out at 1100^oC (D of boron at 1100^oC is 2.21×10^{-13} cm^2/sec for 30 minutes, what is the new junction depth? (10%)