

**EE 245 / NEEM 6441: Introduction to MEMS Design**  
Homework 1

**Introduction and Fabrication**

1. To pursue your growing interest in MEMS, you decide to attend a conference to learn more about it. For the following conferences, find out
  - a. Five of the major topics covered
  - b. How often the conferences are held
  - c. Where the most recent one was held
  - d. Which you would most like to attend and why

International Conference on Solid State Sensors and Actuators (Transducers 05)

Solid State Sensor and Actuator Workshop (Hilton Head 06)

International Conference on Micro Electro Mechanical Systems (MEMS 06)

2. Use the SIMPL-er website to view cross-sections of an NMOS transistor  
<http://www.ocf.berkeley.edu/~hhile/SIMPLer/>
  - a. Choose the NMOS transistor process and press start
  - b. Move the horizontal slider back until you are on step 1 and press “calculate cross-section” (you’ll have to press this after each step)
  - c. Move the slider forward one step at a time and press “calculate cross-section” after each step
  - d. Choose different mask cross sections by clicking on the border of the layout area

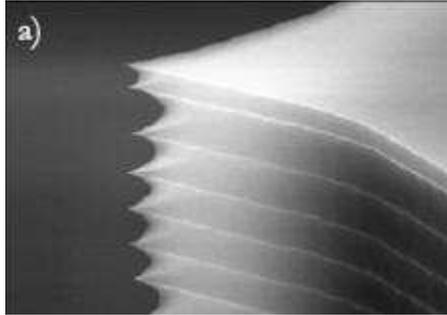
Why doesn’t the area under the polysilicon turn green?

How many holes are punched through the oxide in Step 7?

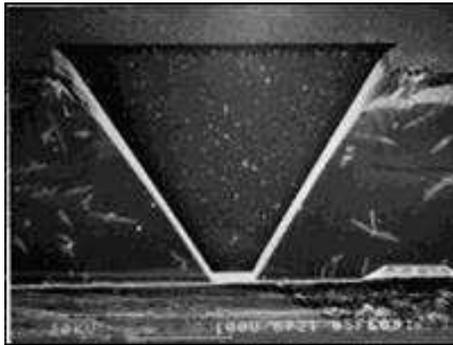
3. For the following structural-sacrificial layer combinations, find the etch rates of the layers using the listed release etchants by consulting the etch tables in Kirt Williams’ article, “Etch Rates for Micromachining Processing.” (Pick the highest etch rate reported for the material and etchant.) For each case calculate
  - a. The selectivity of the etchant
  - b. The etch rate of the sacrificial material with respect to that of the structural material
  - c. If the etch selectivity is low (less than 5), suggest a different etchant

<b><u>Structural</u></b>	<b><u>Sacrificial</u></b>	<b><u>Release Etchant</u></b>
PolySi (n+)	Annealed PSG	5:1 buffered HF (BHF)
LTO (undoped)	Si (100)	XeF <sub>2</sub> (2.6 torr)
PolySi (undoped)	Nitride (stoichiometric)	SF <sub>6</sub> plasma (25 sccm)

4. DRIE is a very common method for dry etching bulk silicon anisotropically. What is going on in this picture?



5. KOH provides a method for an anisotropic wet etch of bulk silicon. Why are these sidewalls sloped and what angle are they at relative to the surface of the wafer?



6. Understanding cross-sections and masks are very important for MEMS fabrication. Draw the cross section obtained from the following masks after each step in the process listed below. What is this structure?
- Deposit  $1\ \mu\text{m}$  PSG on flat silicon wafer
  - Deposit  $2\ \mu\text{m}$  polysilicon
  - Pattern with mask POLY1
  - Deposit  $1\ \mu\text{m}$  PSG
  - Pattern with mask ANCHOR
  - Deposit  $2\ \mu\text{m}$  polysilicon
  - Pattern with mask POLY2
  - Release with HF

