

Homework #4

2.008 Design and Manufacturing II Spring 2004

Out: March 10th

Due: March 15th

Note: this is due coming Monday.

Problem 1:

The purpose of this problem is to have you understand the effect of heat intensity of various welding heat sources on the interaction time and the feed rate. For a planar heat source on steel, the interaction time, t_m , was given at the lecture as below. H.I. is the heat intensity, in W/cm^2 . You are supposed to weld a straight lap joint with a length of 40 cm.

$$t_m = (5000/\text{H.I.})^2$$

- a) You have manual oxyacetylene welding equipment, which has a weld pool size of 10 mm. How long will it take to finish the job? Assume the H.I of an oxyacetylene welding source is $10^3 \text{ W}/\text{cm}^2$.
- b) If your boss buys you new SMAW (shielded Metal Arc Welding) equipment, which is 3 times more expensive than the oxyacetylene equipment, how long will it take to finish the same job? Will it justify the purchase of the SMAW tool? Assume that SMAW has H.I of $10^4 \text{ W}/\text{cm}^2$ and the weld pool size is 5 mm.
- c) The upgrade in b) has been very successful, and made a huge increase of the productivity in your division. If your boss considers buying you the state-of-the-art laser welding system with a hope to make a big breakthrough one more time, what would be your advice to your boss before he buys one? Assume the laser has the HI of $10^6 \text{ W}/\text{cm}^2$ with a weld pool size of 1 mm. Consider your assessment in the following way:
 - What should be the minimum speed of the welding to avoid over melting (or vaporization)?
 - Can you handle it manually? Or will a robot handle the welding operation with this heat source?

Problem 2

Aligning an optical fiber to the laser light source with less than 1 μm transverse error is a demanding task. V-grooved Silicon substrate has been developed to enable accurate and cost effective interconnection without the use of highly skilled labor and expensive fixtures.

The technology is available through the KOH bulk micromachining of the $\{100\}$ silicon. The mechanical tolerances delivered can be tight with this method at a relatively low processing cost. Assume that the diameter of an optical fiber is $160\ \mu\text{m}$ and that the fiber is aligned along the B-B' direction of the groove. The cross sectional shape of the groove along A-A' is given in Figure 2-1.

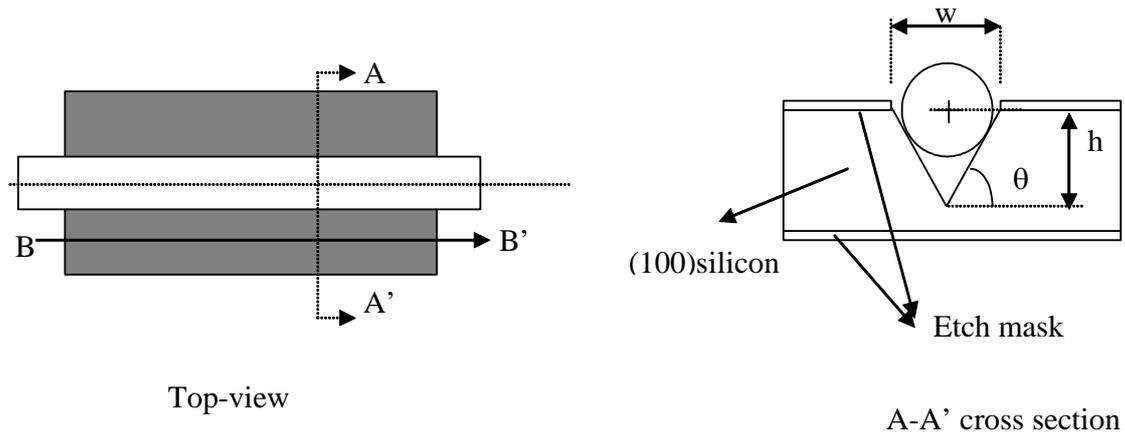


Figure 2-1 A self terminated V-groove is formed on the $\{100\}$ plane.

- As etching proceeds, the exposed $\{100\}$ planes etch rapidly while the $\{111\}$ planes etch slowly, which causes the angle θ with the plane of the wafer. What is the magnitude of the angle θ ?
- The etch mask material is silicon nitride, which is better than silicon oxide in terms of dimensional accuracy of the V-groove. If the center of the fibercore is located exactly on the surface plane of the silicon, what is the depth of the V-groove, h , and width of the groove opening, w ?
- Assume the KOH solution etches the (100) silicon at $2\ \mu\text{m}/\text{min}$ and the thickness of the wafer is $500\ \mu\text{m}$. What will be the etching time needed for the V-groove in Figure 2-1?