Tutorial 3

1. **Figure 1 shows the isoetch curve for silicon using the HF:HNO_3:diluent system. If HF: HNO_3: H_2O = 50:30:20, (a) determine the etch rate of silicon.**

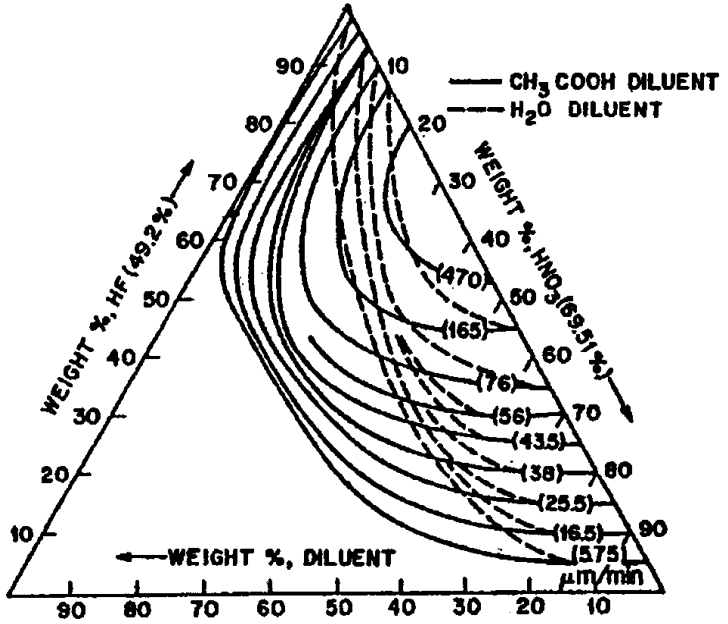

Figure 1 : Isoetch Curves for Silicon

(b) If the diluent is changed to $HC_2H_3O_2$, what will be the new etching rate? Explain why the etch rate is usually higher when the diluent is changed to acetic acid.

(c) Assuming an etch rate of 56 μm/min and the ratio of HNO_3: $HC_2H_3O_2$ is maintained at 3:1, what is the %wt of HF used in the etchant.

(d) Define etch selectivity. Explain whether physical etching has high etch selectivity. What are the problems associated with physical etching?

(e) Suggest ways to increase the etch rate of an RIE system.

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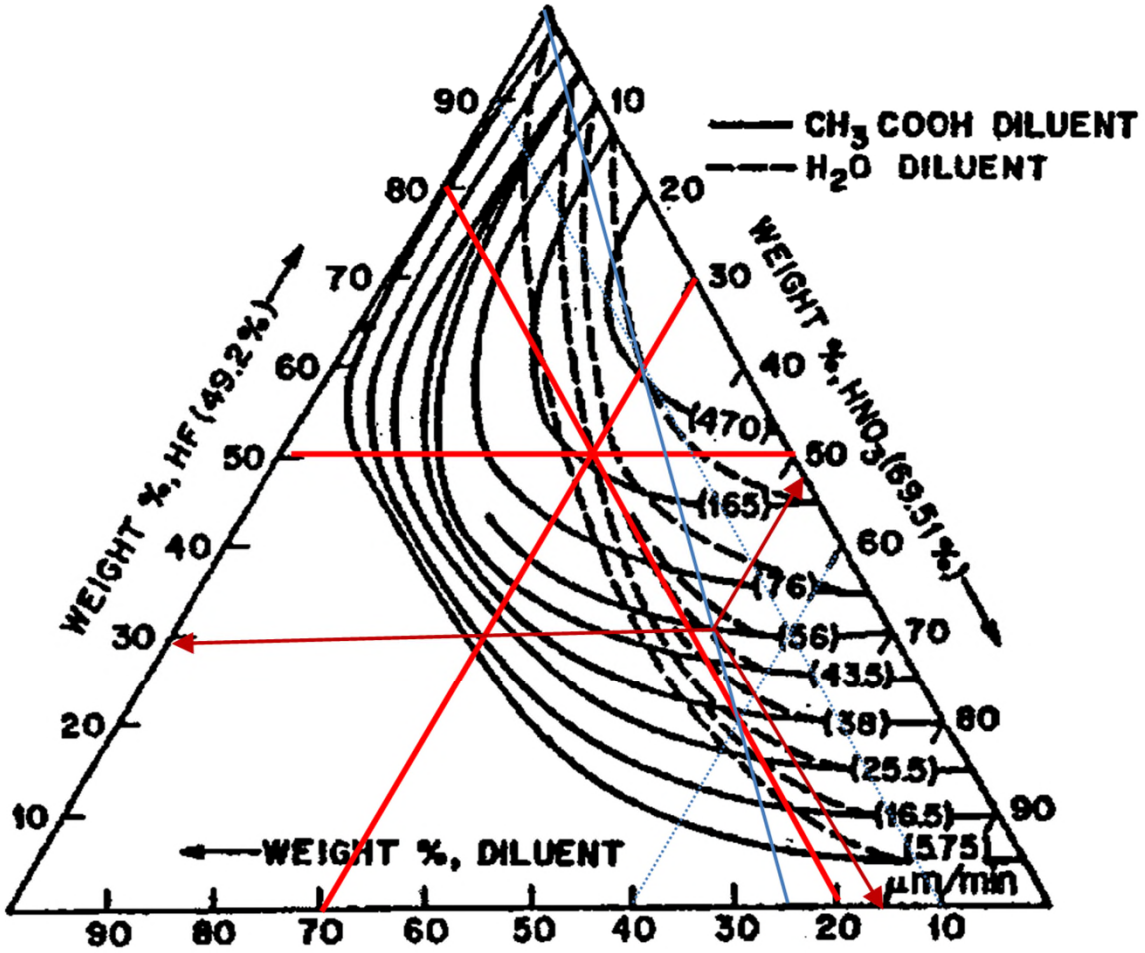
(a) HF: HNO_3: H_2O = 50:30:20,



Etching rate is 25.5 um/min

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(b)
New etching rate will be 175 um/min. This is because with HC2H3O2 as the diluent, there is less dissociation of the concentrated HNO3.

(c)
HNO_3: $HC_2H_3O_2$ is maintained at 3:1, Respective percentage of the etchant constituents as follows

HNO_3-CH_3COOH: HF
52%:17%:31%

(d)
Selectivity is the ratio of the etch rates between the different materials, especially the material that needs to be etched compared with the material that we do not want to remove. (*Ef*: high etch rate; *Er*: low etch rate)

Physical etching is very directional because ions arrive perpendicularly to the wafer surface, collide with the surface and cause surface to become loose and subsequently removed. Reactive plasma etching is very selective because free radicals etch by chemical reactions.

Faceting, trenching, redeposition and radiation backscattering are problems associated with physical etching.

(e) Any 3 of the possibilities: Increase the Anode Area , Decrease Cathode Area, Increase Power Density, Introduce higher temperature, Introduce inert gas with heavier atomic weight

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2. **Figure 2 shows the isoetch curve for the etching of Si wafers.**

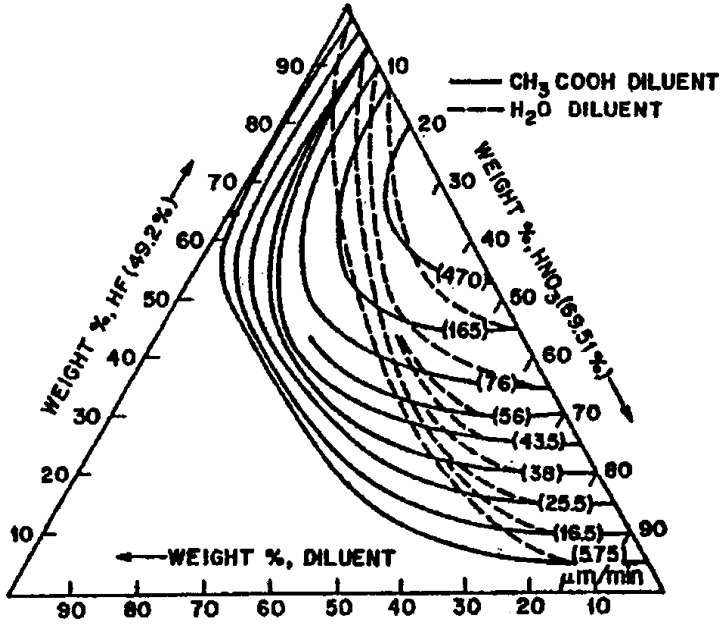

Figure 2 : Isoetch Curves for Silicon

a) Draw the 7:3 HNO_3-CH_3COOH load line on the isoetch curve.

b) If the etching rate of the silicon is 56 μm/min, derive the respective percentage of the etchant constituents.

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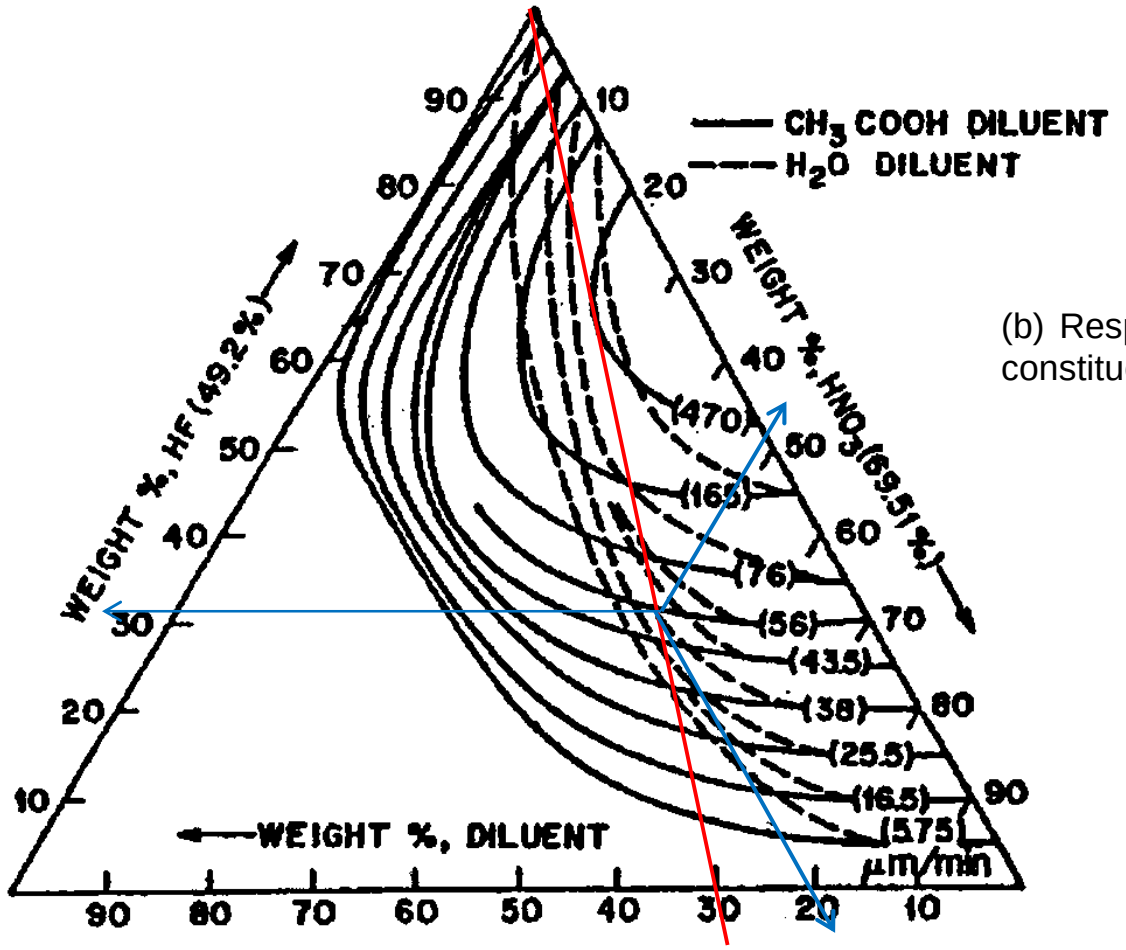
2. a) Draw the 7:3 HNO3-CH3COOH load line on the isoetch curve.



(b) Respective percentage of the etchant constituents.

HNO3-CH3COOH: HF
47%:21%:32%

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3. **Figure 3 shows thin film A (thickness t_a) with a patterned photo-resist of feature L >> t_a on substrate S. Explain why condition L >> t_a is imposed. Complete the table below under the etching condition listed in the table for two etching recipes: (i) no over-etch and (ii) 50% over-etch. The etch selectivity is of A:S is 10:1. State two assumptions about the photoresist.**

Profile	Substrate etch depth , t_s	Undercut in A, U_a
Degree of Anisotropy = 0.70	(i)	(i)
	(ii)	(ii)

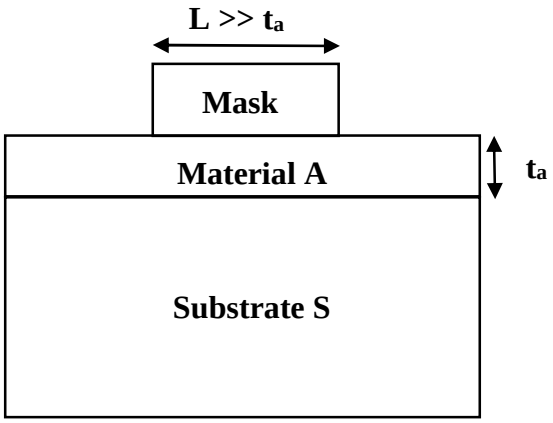

Figure 3

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Profile	Substrate etch depth , t_s	Undercut in A, U_a
Degree of Anisotropy = 0.70	(i) 0	(i) 0.3 x t_a
	(ii) 0.1 x 0.5 x t_a = 0.05 t_a	(ii) (0.3t_a)+ (0.5 x 0.3t_a) = 0.45 t_a

L >> ta to ensure that under-cutting does not consume the feature size completely.

Assumptions : (i) photo-resist is not fully corroded (ii) photo-resist has vertical profile