Chapter 2: Dry Etching Techniques - Problem Set

2.1 How is a DC plasma created and how does an RF plasma differ? Why is a plasma always positive with respect to the reactor vessel walls? In which etching setup would you prefer to etch an insulator?

2.2 Detail the different dry etching profiles available and how you obtain them.

2.3 Consider a single electron in an electric field between two parallel plates located 10 centimeters apart. Assume the potential varies sinusoidally between 1000 V and ?1000 V at a frequency of 13.5 MHz. Calculate the maximum kinetic energy of the electron.

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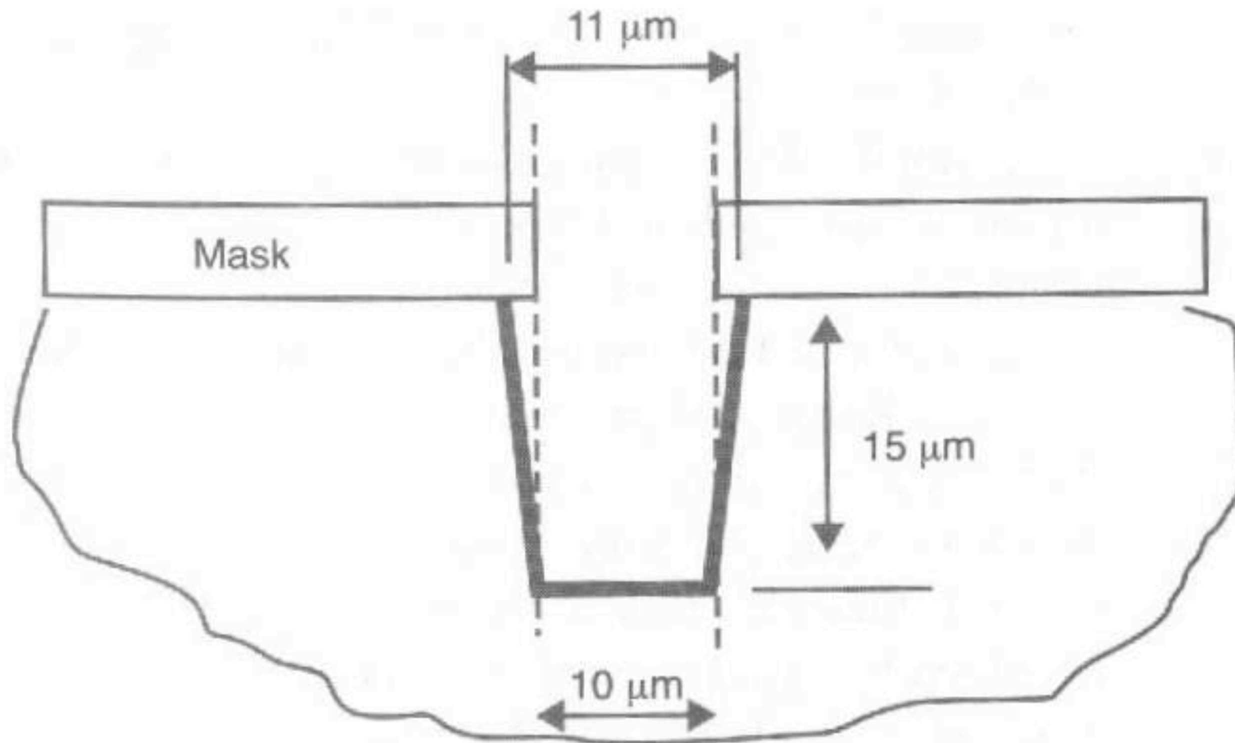
2.4 Using the figure below as a model, assume that the silicon wafer has a bias of ?150 volts. A reactive ion etch is used to etch 10μm wide grooves. After 1 hour, the shape of the grooves is measured and found to have the following topology:



Problem Figure 2.4

(i) **If the bias were increased to ?00 volts and the depth of the groove was maintained at 15 mm, would the width at the top of the groove be less than or greater than 11 mm. Explain.**

(ii) **If the same etch procedure was used to etch SiO_2, qualitatively describe the shape of the grooves in the SiO_2 if a ?50 volt bias is applied**

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2.5 Explain the DC breakdown voltage versus electrode distance curve (Paschen?s law) and how it is relevant to dry etching. How is miniaturization of an electrode set equivalent to creating a local vacuum?

2.6 Use SCREAM to fabricate a capacitive accelerometer. You may rely on the newest deep dry etching technology.

2.7 Why is RIE somewhat of a misleading name? In physical-chemical etching there are four types of ion-surface interactions which may promote dry etching. Detail each of them and show typical etch profiles.

2.8 Make a comparison table of dry versus wet etching. Develop a process sequence to fabricate a capacitive pressure sensor using both wet and dry etching techniques.

2.9 Explain loading effects in wet and dry etching. How do you avoid the loading effect? What is the bull?s-eye-effect? What is the difference between loading and microloading?

2.10 Discuss the etch profiles in physical etching. Also draw profiles exhibiting faceting, ditching, and redeposition.

2.11 Design a process to fabricate a polyimide post 100 ??m high and 10 ??m in diameter on a Si cantilever. The Si cantilever must be able to move up and down over a couple of microns.

2.12 Explain the F/C ratio effect in dry etching and present a couple of means to influence it. How can cryogenic cooling lead to similar etching behavior as inhibitor-driven chemistry?

2.13 Explain the ion energy versus pressure curve for a plasma and how different etching mechanisms are enabled by it. Describe the differences between high pressure plasmas and reactive ion etching systems. Explain when each is the preferred process.

2.14 You have only a high pressure plasma etch and an ion mill at your disposal. Select which one to use in the following applications. Justify your answer.

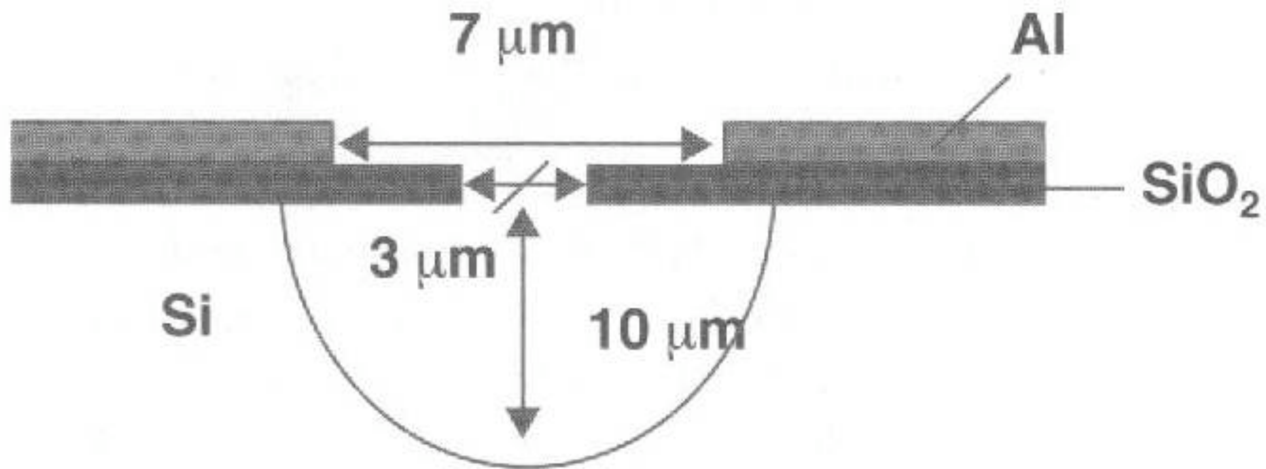
(i) **Etching a 5000 ?(polysilicon layer that serves as the upper electrode of a large square capacitor. The capacitor dielectric is 50 ?(of SiO_2.**

(ii) **Anisotropic patterning of a thin layer of $Yba_2Cu_3O_7$ on a thick insulating film.**

***(iii)* Recessing the channel of a GaAs FET. For this application the residual etch damage must be minimized.**

2.15 Sketch the plasma distribution for a DC diode discharge in equilibrium and contrast it with the voltage distribution in an RF plasma.

2.16 How would you make the structure below with the least expensive equipment, the highest selectivity, and the fastest process?



Problem Figure 2.16

2.17 How could you monitor a dry etching process? Why does endpoint detection of a reactant species require a loading effect?

2.18 Why is the grounded electrode (anode) in an AC sputtering station made as large as possible? What would happen if both anode and cathode were blocked capacitively. Use equations to explain.

2.19 Explain how high ion density plasmas are achieved. Use equations to explain.

Proceed to the Solutions