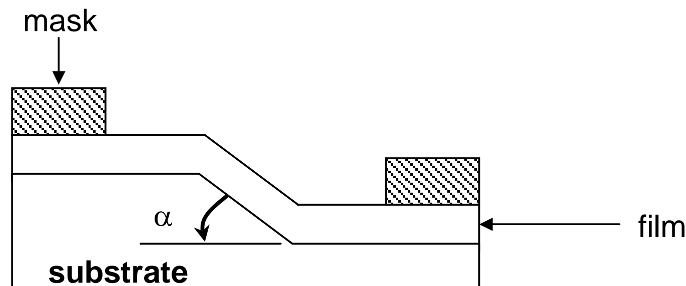
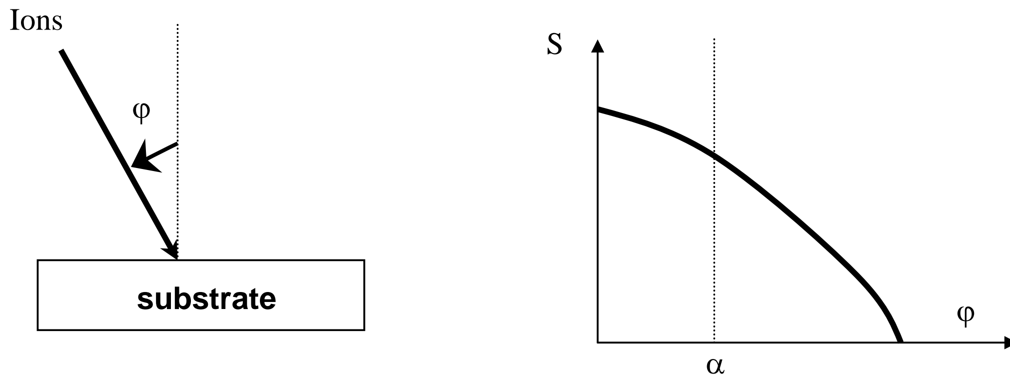
MECH597 Homework #3

Due: 6 Oct 2005

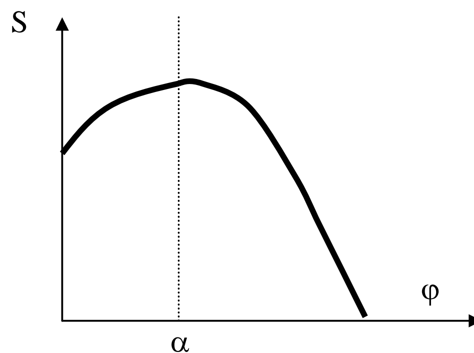
Problem 1:
Sputtering can be also used for etching if the polarity in the system is reversed. In this new configuration, it is sometimes called *ion milling*.We want to use it to etch the step structure shown below with the ion beam perpendicular (or tilted) to the substrate. The mask material has a very low etch rate compared to the film and the substrate which have high etch rates.



Sketch the structure when the flat (horizontal) part of the film has just been consumed. The sputtering yield of the film (S) is a function of angle of impingement, as shown in the plot below:



Repeat if the sputtering yield is given by the new curve shown below:



Problem 2:

Assume that all of the material are initially stress free and flat. The density (ρ)and Young's modulus (*E*) of polysilicon are 2.32 g/cm^3, 170 GPa respectively.

a) Hydrofluoic acid (HF) etches phosphosilicate glass (PSG), a phosphorus-doped silicon oxide, very rapidly (up to 3.6 μm/min depending on phosphorus content and HF concentration) compared to single-crystal and polysilicon (few Å/min). This very high selectivity allows us to make many complex microstructure out of polysilicon when we use PSG as the sacrificial layer. Once the PSG is removed, the free standing cantilever beam is free to move or vibrate.

Starting with a plain single-crystal silicon (SCS) substrate and using a series of poly and PSG depositions, it is possible to make very complicated MEMS devices (cf MUMPs MEMS foundry service, www.memsrus.com). Draw a top view and cross section at etch major step for the fabrication of a free standing micro cantilever beam. Indicate how many photolithography steps are needed and at which step they are used. The poly and PSG are deposited by LPCVD which deposits films conformally (i.e., the deposited thin films follow the topography and coat everything with a uniform thickness – even underneath overhanging microstructure and on the back of the wafer.

b) If you make a polysilicon cantilever beam 2 μm thick and 2 μm wide on top of sacrificial PSG layer that is 2 μm thick, how much would the tip of a released cantilever beam deflect downwards due to its own weight? Please find the displacement of the tip for the two cases: length of the beam =100μm and 1mm. Assume the anchor for the fixed end of the cantilever is 100% rigid.

c) How long would you have to make the cantilever for the end to just touch the substrate due to its own weight.

Problem 3: Design of piezoresistors for a pressure sensor

A boron diffusion is used to form the piezoresistors of a pressure sensor in a 0.18-Ohm-cm n-type silicon wafer. A solid-solubility-limited boron predeposition is performed at 900 °C for 15 min followed by 5-hr drive-in at 1100 °C. Find the surface concentration and junction depth (a) following the predeposition step and (b) following the drive-in step, (c) find the sheet resistance in Ohm/square after boron diffusion using Irvin's curve, (d) How many squares are required to form a 5 kilo-Ohm piezoresistor?