1. You are given a wafer with the cross-section shown in Figure PS2.1-1 and intend to release etch the structure, i.e., to leave only the polysilicon structure atop the blanket nitride/oxide layer. To perform the release, you need to do the following steps:

   i. Etch polysilicon via RIE and stop on the sacrificial oxide layer (The etch rate and selectivity of the polysilicon etch are given in Table PS2.1-1).

   ii. Remove photoresist (PR).

   iii. Dip the wafer in HF to etch the sacrificial oxide until polysilicon structures are fully released. (Assume this wet etch is completely isotropic with characteristics given in Table PS2.1-2.)

Due to topography across the wafer, a given layer thickness might not be the same over the entire wafer. So when you etch a given layer, you must etch a bit longer than what you calculate from knowledge of thickness and etch rate to make sure all material is removed from unmasked areas. It is common practice to etch for at least 20% longer than the calculated time (i.e., to do a 20% overetch). Include this overetch in your calculations for this problem.

Fig. PS2.1-1

Fig. PS2.1-2
Polysilicon etch rate 0.5 μm/min
Selectivity over Oxide 5:1
Selectivity over Nitride 10:1
Selectivity over Photoresist 2:1

Table PS2.1-2
Oxide wet etch rate 0.3 μm/min
Selectivity over polysilicon 100:1
Selectivity over Nitride 20:1
Selectivity over Photoresist 5:1

Table PS2.1-3
Oxide dry etch rate 0.3 μm/min
Selectivity over polysilicon 14:1
Selectivity over Photoresist 4:1

Table PS2.1-4
Polysilicon DRIE etch rate 1.5 μm/min
Selectivity over oxide 100:1
Selectivity over Photoresist 50:1

(a) How long should you etch (including the 20% overetch) to remove all the unprotected polysilicon? Draw the wafer cross-section immediately after the polysilicon etch step. You can assume the RIE etch is completely anisotropic.
(b) Suppose a 1\(\mu\)m oxide hard mask layer is deposited atop the polysilicon film before photoresist deposition and patterning, as shown in Fig. PS2.1-2. You first dry etch the oxide in an RIE system with etch rate and selectivity given in Table PS2.1-3. You follow with an RIE etch as in Table PS2.1-1 to define the polysilicon structure using the patterned oxide layer as a hard mask. How long should you dry etch the oxide layer (including a 20% overetch)? Draw the wafer cross-sections immediately after the oxide etch step and after the polysilicon etch step. (To make sure you are not affected by the results you calculated in part (a), assume an 8 min polysilicon etch after etching the oxide.)

(c) After the polysilicon etch step in part (b), you release the structure in HF, as indicated in step iii of the process flow. How long does it take to completely release the structure? Draw the wafer cross-section immediately after the release step. Assume the wet etch is completely isotropic.

(d) Assume now the sacrificial oxide layer thickness is reduced to only 50nm, as shown in Fig. PS2.1-3. To avoid etching through the sacrificial oxide to the polysilicon underneath, you now choose the high-selectivity BOSCH DRIE process with etch rate and selectivity given in Table PS2.1-4. How long should you etch the polysilicon layer now (including the 20% overetch)? Is 50nm oxide thick enough to protect the polysilicon below? How long does it take to completely release the structure with 50nm thick sacrificial oxide?

(e) What are the drawbacks of the BOSCH DRIE process?