**Fabrication of a Micromachined Silicon Structure**

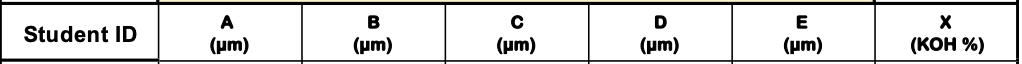
**PART A)**

The aim of the exercise is to predict the etching characteristics of a MEMS structure (shown in Figure 1) and to design a suitable fabrication process.

A diagram of a diagram

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Figure 2 shows the design parameters to be used in this exercise:



features a heavily doped p+ region, indicated in grey, **the depth of this p+ layer is 1.2μm**

The substrate is oriented along the (100) crystal plane with pattern edges aligned in the [110] direction. The MEMS structure is to be etched using a KOH solution at 70 °C temperature.

1. (a)  Refer to Appendix A, which contains various graphs correlating the etch rate of silicon in KOH solutions at different temperatures. Using the graph that matches your assigned KOH concentration, determine the etch rate of silicon at 70 °C.
2. (b)  The heavily boron doped region of the silicon substrate (shown as *p+* in Figure 1) has a boron concentration of 1020 cm-3. Determine the relative etch rate of the heavily boron doped silicon regions in the KOH solution (refer to plot in Figure 6). Hence, find the etch rate per minute of the heavily boron doped silicon. **You may assume the lightly doped silicon has a boron concentration of 1017 cm-3**.
3. (c)  Sketch the cross-section of the structure after 20 minutes of etching, and explain the reasons for any significant features including any angles and dimensions.
4. (d)  Finally, sketch the cross-section of the structure after 3 hours of etching and explain the reasons for any significant features including any angles and dimensions.

ANSWER A)

1. Looking at the graph correlating etch rate of silicon in KOH solution at 70 degrees Celsius. We can extrapolate to determine the etch rate to be roughly **37 microns per hour.**

**PART B)**

In the fabrication of a silicon-based MEMS structure, the etching process plays a crucial role in shaping the microstructure. You have been provided with a cross-sectional diagram (Figure 1) of a silicon substrate that features a heavily doped p+ region, indicated in grey, **the depth of this p+ layer is 1.2μm**; and silicon nitride masking regions depicted in black. The substrate is oriented along the (100) crystal plane with pattern edges aligned in the [110] direction. The MEMS structure is to be etched using a KOH solution at 70 °C temperature.

Each student has been assigned a specific concentration of KOH solution and varying silicon nitride mask opening widths on the surface of the substrate. At a standardised temperature of 70 °C (degrees Celsius), you are to predict the etching profile of the MEMS structure using your designated KOH concentration. There are two tasks for this stage of your coursework:

1. (a)  Refer to Appendix A, which contains various graphs correlating the etch rate of silicon in KOH solutions at different temperatures. Using the graph that matches your assigned KOH concentration, determine the etch rate of silicon at 70 °C.
2. (b)  The heavily boron doped region of the silicon substrate (shown as *p+* in Figure 1) has a boron concentration of 1020 cm-3. Determine the relative etch rate of the heavily boron doped silicon regions in the KOH solution (refer to plot in Figure 6). Hence, find the etch rate per minute of the heavily boron doped silicon. **You may assume the lightly doped silicon has a boron concentration of 1017 cm-3**.
3. (c)  Sketch the cross-section of the structure after 20 minutes of etching, and explain the reasons for any significant features including any angles and dimensions.
4. (d)  Finally, sketch the cross-section of the structure after 3 hours of etching and explain the reasons for any significant features including any angles and dimensions.

**PART C)**

Research, using open sources, and describe a suitable fabrication process to produce the MEMS structure of Figure 1 prior to it being immersed in the prescribed KOH solution, paying particular attention to the fabrication steps to produce the heavily doped boron layer and silicon nitride layer. The fabrication process should use lightly doped silicon as the starting material. There are several possible fabrication sequences which would be capable of producing a functional structure, any viable process sequence will be acceptable for this coursework.

In describing the fabrication, you should include both plan (or surface) views and cross-sectional diagrams of all key steps in the process sequence. Include as much detail on the materials and process steps as you can within the page limitation. The diagrams may be drawn either by hand or using a drawing package but should clearly show the various layers and features of the structure.

A vital part of the exercise will be a critical analysis/review of your process design, identifying any strengths or weaknesses in the process and suggesting any potential improvements.

**PART D)**

Produce a laboratory instruction manual to guide other users in the steps involved in the KOH etching process, addressing the considerations for each step from the preparation of the etching solution to the final post- processing of your MEMS structure. Include aspects such as the steps involved, apparatus required and any other significant factors that should be taken into account.

**Appendix**

**A graph with a line

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**A graph with different colored lines

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