**Fabrication of a Micromachined Silicon Structure**

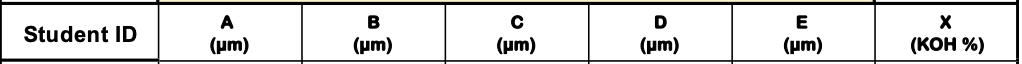
**PART A)**

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.

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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.

**PART B)**

**The etch rate at 70 degrees Celsius and 42% KOH solution can be extrapolated from the graph:**

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**Extrapolating to the y-axis, we can see the etch rate of the silicon is roughly 33 microns per hour.**

**Now, we know that the Boron concentration in the heavily doped regions is 10^20 cm^-3, we can determine the relative etch rate of Boron from the below graph:**

**A graph with different colored lines

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**It can be seen that the relative etch rate is approximately 10^-1. This means the etch rate is 10 times slower in the Boron than it is in the Silicon. This implies then that the etch rate in the Boron layer is the etch rate of silicon, divided by 10:**

**We know that the etch rate in silicon for 42% KOH solution is 33 microns per hour, and thus the etch rate for Boron in 42% KOH solution is 3.3 microns per hour. Dividing this by 60 will give us the etch rate per minute, which means:**

**After 20 minutes of etching in the KOH solution, we can say that 1.1 micro-meters of Boron is etched, while 11 micro-meters of the Silicon is etched. The cross section diagram would look as follows:**

1.1μm

P+

P+

P+

0.1μm

11μm

9.8μm

Lightly Doped Silicon

**PART C)**

**1 – Substrate preparation**

**Before the process is started, it is crucial that the substrate is cleaned such that the subsequent fabrication steps are not effected. This step aims to remove any contaminents from the silicon wafer [1].**

**2- Boron Doping**

**To create heavily boron-doped regions, which are critical for defining the electrical and structural properties of the MEMs device, Boron implantation would be employed. This involves implanting Boron ions into the silicon substrate to achieve the desired doping concentration. After implantation, thermal annealing will be performed to activate the dopants and repair the lattice damage caused by the ion implantation process. [1]**

**3. Silicon Nitride Deposition**

**The silicon Nitride layer acts as a mask during KOH etching process and provides mechanical stability to the structure. Plasma-enhanced chemical vapour deposition (PECVD) is commonly used for depositing silicon nitride films due to its ability to deposit uniform films at relatively low temperatures, which is crucial for maintaining the integrity of the underlying silicon and doped layers.**

**4 – Patterning and etching**

**The next step involes patterning the silicon nitride layer to expose areas of the silicon substrate that will be etched away. This is achieved using photolithography, where a light sensitive chemical (photoresist) is applied to the surface, exposed to light through a mask defining the structure, and then developed to remove either the exposed or unexposed regions, depending on the type of photoresist used. Following patterning, reactive ion etching (RIE) or deep reactive ion etching (DRIE) can be used to etch the silicon where needed, based on the pattern defined by the silicon nitride mask.**

**5- Critical Analysis**

**Factors such as the uniformity of the boron doping and silicon nitride deposition, the resolution and accuracy of the photolithography step, and the etch rate consistency during the KOH etching process.**

**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.

**References**

**[1]** Han, X., Huang, M., Wu, Z. *et al.* Advances in high-performance MEMS pressure sensors: design, fabrication, and packaging. *Microsyst Nanoeng* **9**, 156 (2023). <https://doi.org/10.1038/s41378-023-00620-1>

**Appendix**

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