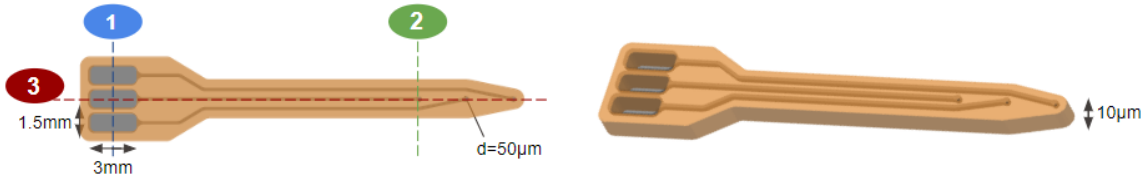
Neural interfaces - Session 2

Exercise 1 – Microfabrication of a neural implant

You want to create a flexible probe with embedded microelectrodes for acute and chronic neural recordings. The microelectrodes are made out of platinum (Pt) and encapsulated in polyimide (PI). The overall probe's geometry is depicted below.

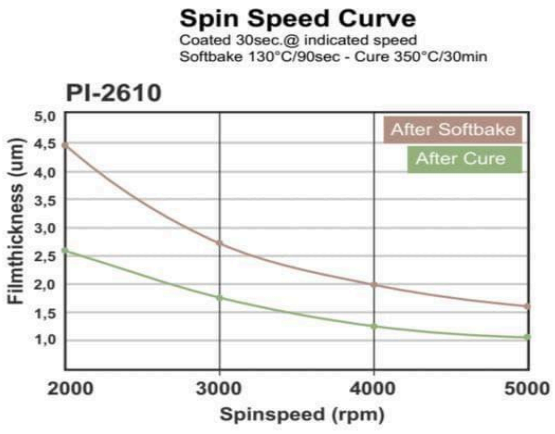


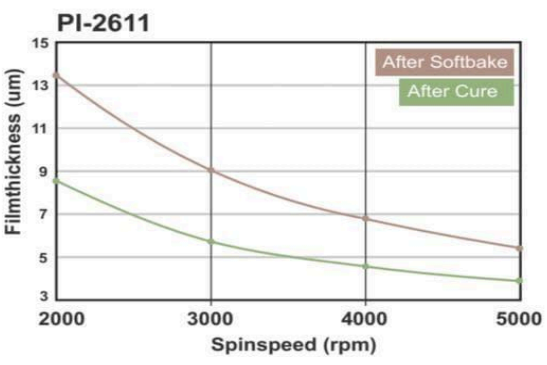
a. Draw the device cross section along lines 1, 2, and 3. Assume the top and bottom encapsulation have the same thickness. What is a typical thickness of the layer containing metal(s)?

b. Outline the steps of the process flow you would use to fabricate the implant in the cleanroom. Provide the thickness of every layer at every step and justify your choices of techniques and materials (for example: etching vs lift-off)

Below you have the different polyimide and photoresists that you can use:

- Photoresists: ECI3027 4µm and AZ10XT 12µm
- Polyimide: PI-2610 and PI-2611





Exercise 2 – Stress strain curves

a. What is the bending strain on the top surface of a polyimide film of 50 µm thickness rolled over a 1 mm diameter tube? If the same polyimide substrate is coated with a 0.5 µm thick multilayer (made of stiff, inorganic electronic materials), how will the resulting strain at the top of the structure be affected?

b. Consider the critical strain of a Cu thin film to be 2%. Calculate what is the minimum bending radius such a film (with a thickness of 100 nm) can sustain when deposited on top of a 25µm parylene C substrate.

c. In a similar device consisting of Cu on a parylene C substrate, how thick should the substrate be if you want it to bend around a small human hair (diameter of 20µm)? Is this feasible?

d. Draw the stress-strain relationship for the following materials: rubber, platinum, parylene and silicon dioxide (SiO_2). Fill in the correct units, and include an order of magnitude estimate of the x-y axis values.

Exercise 3 - Neutral plane

A capacitive pressure sensor is composed of the following multilayer stack:

Ti/Al 5nm/100nm

Ti/Au 5nm/100nm

Young's modulus:
Polyimide 2.5 GPa
Parylene 2.8 GPa
Titanium 110 GPa
Gold 79 GPa
Aluminum 69 GPa

a. Calculate the position of the neutral plane (Assume $\overline{E_i} \approx E_i$).

$$z_n = \frac{\sum_{i=1}^{N} \overline{E_i} h_i \overline{z_i}}{\sum_{i=1}^{N} \overline{E_i} h_i}$$

b. For R=1mm, calculate the bending strain and stress on:

i.) the top surface of the sensor

ii.) the top of the Au layer

iii.) the top of the Al layers

$$\varepsilon_i = \frac{z_i - z_n}{R}$$