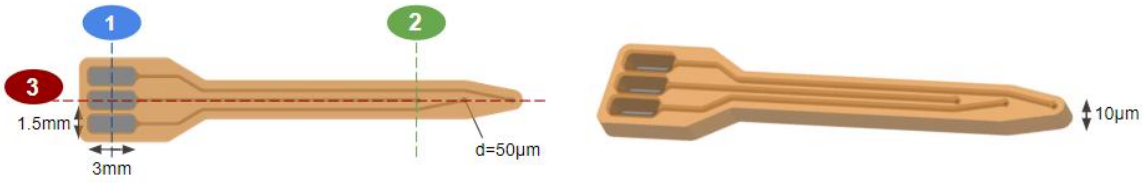
Exercise set 2 - Microfabrication and mechanics

Exercise 1 – Microfabrication of a neural implant

You want to create a flexible probe with embedded microelectrodes (50µm diameter) 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.

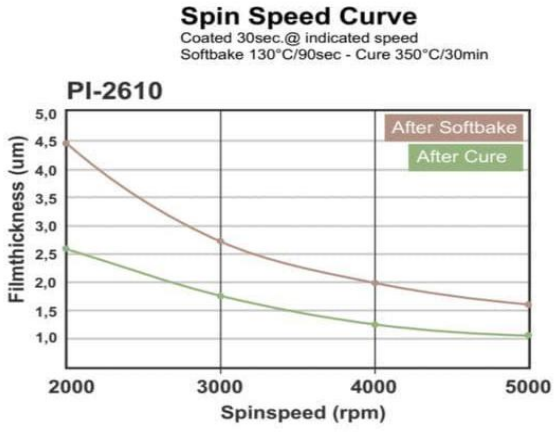


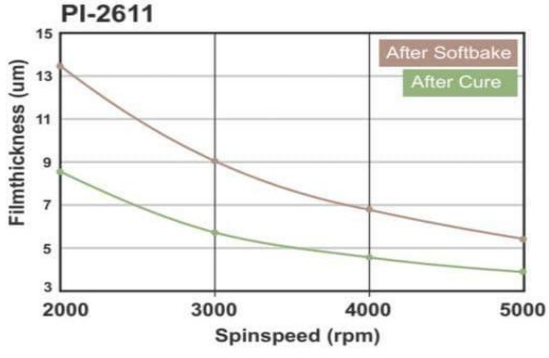
a. Draw the device cross section along lines 1, 2, and 3. Assume the top and bottom encapsulation have the same thickness. What is a typical thickness of the metal layer(s)?

b. We start with a Ti-Al-coated Si wafer, where Ti-Al is a sacrificial layer that will be dissolved at the end of the process to release the finished flexible probe from the Si carrier. Outline the steps of the process flow you would use to fabricate the implant in a cleanroom. Provide the thickness of every layer (PI, Pt, photoresist).

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

- Photoresists: ECI3027 (4 µm) and AZ10XT (12 µm)
- Polyimide: PI-2610 and PI-2611 (see curves below and choose the spin speed to attain your chosen thickness)





Exercise 2 – Bending strain and the neutral plane

Relevant Young's moduli (E):

E(polyimide) = 2.5 GPa

E(platinum) = 170 GPa

a. A 10 µm thick polyimide foil is rolled on a 1-mm-diameter tube. What is the bending strain on the top surface of the foil (farthest away from the tube)?

b. A 150-nm-thick layer of platinum is patterned on the top of that same polyimide film, forming electrodes, tracks, and pads. What is the bending strain on the top surface of the platinum layer if the whole stack (polyimide+platinum) is bent around the same 1-mm-diameter tube conforming to the bottom surface of the stack? (Assume the blanket layer formulas hold)

c. When the stack is bent in this way, does the top surface or bottom surface of the platinum experience more stress? (top Pt surface = away from the polyimide, exposed to air; bottom Pt surface = buried in the stack, in contact with the polyimide)

d. Assume the critical strain of platinum is 1%. What is the smallest diameter tube around which you could bend the polyimide+platinum stack without fracturing the platinum? (Assume the blanket layer formulas hold)

Exercise 3 - Stress and strain

Draw the stress-strain relationship for the following materials: rubber, platinum, parylene and silicon dioxide (SiO_2). Provide the units of the x-y axes and order-of-magnitude estimates for Young's moduli in the elastic regimes.