

Exercise on Oxidation (Jupyter notebook)

In many microsystems it is necessary, useful or practical to have a thin film of silicon dioxide on top of silicon. This SiO_2 can be grown directly from the Si atoms of the surface of the wafer, by a chemical oxidation reaction. We are going to focus here on two possible processes at high temperature: dry and wet oxidation, where the adjective refers to the absence or presence of H_2O in the reactor, respectively.

We want to achieve thin films of 50 and 2000 nm of SiO_2 on Si, with a maximum of 2 nm and 10 nm of accuracy, respectively. You have to suggest a choice of chemistry (dry/wet), temperature of reaction and duration of process, for each thickness. To inform your decisions you can use the Jupyter Notebook “oxidation” (see Moodle for notebook cloning).

- a. Using the plots of thickness vs. process time, and the buttons to choose the recipe determine the required time (in hours and minutes HH:MM) for each recipe to achieve exactly the desired thickness and fill it in the table below. Hint: you can write a short code to find numerically the intersection of the curve data with the desired thickness.

Temperature	Dry		Wet	
	50 nm	2000 nm	50 nm	2000 nm
880 C (dry) / 850 C (wet)				
900 C				
950 C				
1000 C				
1050 C				

- b. What is the thickness variability of each of these points if, due to operational characteristics of the furnace, the effective time of reaction can be controlled to ± 5 minutes of accuracy? Hint: you can estimate time derivatives of thickness by using the target thickness slider and some fast math.

Temperature	Dry		Wet	
	(50 +/- 2) nm	(2000+/-10) nm	(50 +/- 2) nm	(2000+/-10) nm
880 C (dry) / 850 C (wet)				
900 C				
950 C				
1000 C				
1050 C				
1100 C				

c. Which processes fulfill the accuracy requirements? Which one would be your first choice for each case? Why? Complete the first 4 columns of the table below with your choice.

d. Using the animation of thin film growth, tell us how much thickness of silicon was consumed and how much the new surface has moved “upwards” w.r.t. the initial surface, for the two chosen processes. Data: for calculating the coefficients of the animation (see code comments), consider:

- atomic weight of Si: 28.09, density: 2.33 g/cm³
- atomic weight of SiO₂: 60.08. Density of Si: 2.2 g/cm³

Finally complete the last two columns for the two chosen processes in the table below.

Thickness	Dry/wet?	Temp.	Duration	Accuracy	Th. Si cons.	SiO ₂ upwards
50 nm						
2000 nm						