LAB #2:
CLEANING AND OXIDATION

Purpose:

Grow field oxide for electrical isolation between active devices. You will carry out pre-furnace clean; and operate Thermco diffusion furnaces.

Process Steps:

Record all details along with any results, measurements, or other observations on clean room paper provided in the Lab.

1. Pre-furnace clean wafers your device wafer and appropriate monitor wafers using RCA cleaning procedures. (For RCA Clean: read Handout and Campell Ch. 14.1, p. 356-357; Ref. Kern and Poutinen, RCA Review, *31*, 187-206 (1970))

2. Grow field oxide; include wafers device wafer and monitor wafers.
   a. Set the furnace temperature to 1100 °C and 3 slpm (standard liters per minute at 0 °C and 760 Torr) N_2 flow.
   b. Load the wafers in the boat and insert the sled into the elephant. Remove the end cap from the tube and gently place the elephant in place. Push the sled to the center of the tube using the push rod. Remove the elephant and replace the end cap.
   c. When the temperature re-stabilizes at 1100 °C, begin the following oxidation sequence:

Temp.	Time	Ambient	Tube	Gas Flow	Gas Setting
1100 °C	5 min	DRY O_2	R2-15-C	3 slpm	66.5
	60 min	WET O_2			
		O_2	R2-15-B	1.75 slpm	32.6
		H_2	R2-15-B	2.5 slpm	41.6
	5 min	DRY O_2	R2-15-C	3 slpm	66.5

The field oxide thickness is ~650 nm.
Note that oxidation depends on temperature, time, gas ambient, and pressure.

3. At the end of the oxidation, pull the wafers slowly from the furnace and let them cool down to room temperature.

GENERAL INFORMATION ABOUT LAB REPORTS

YOUR CLASS PERFORMANCE IS BASED ON THE LAB REPORTS. PLEASE PROVIDE EXPLANATION OF WHAT YOU HAVE DONE IN THE LAB AND THE RESULTS. IT IS IIMPORTANT TO INCLUDE WHAT YOU EXPECT THE RESULTS SHOULD BE AND COMPARE YOUR RESULTS TO THEORY. ORGANIZE YOUR LAB REPORT IN THE SAME ORDER AS THE REQUIRED INFORMATION LISTED IN LAB EACH HANDOUT.

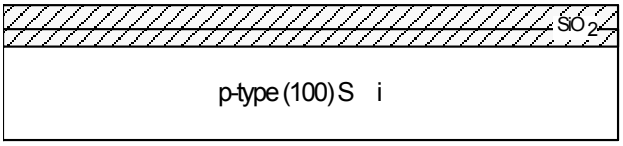
- Prepare the Lab Report as a technical report - easily readable, technically complete, typed, and include references as needed (except you don't have to reference the textbook for this class).
- Use figures, plots, and equations whenever they are useful. (They can be hand written). Label all diagrams or drawings with their dimensions and layers.
- **Make sure all questions listed in the handout are answered. Adjust the details in your answers according to the points assigned.**
- Compare measured results to theory. **Explain the results and the differences between theory and experiment. THIS IS THE MOST IMPORTANT PART OF THE LAB REPORT.** For example, in this Lab, you should estimate the oxide thickness from the oxidation conditions using the oxidation chart and the simulation results. In the next Lab, after the color of the oxide is inspected and the oxide thickness is measured, you need to compare the experimental results with theory. If they don't agree, explain why.
- Provide clear, physical explanations; not just key words. For example, in this Lab, you are asked to explain "reasons for the pre-furnace clean". You need to state how the different steps can affect/benefit the devices. Another example: in this Lab, you are asked to "compare oxidation rate and oxide quality for wet vs. dry oxidation and high vs. low temperature". You need to summarize all the constants under different oxidation conditions (useful to summarize in a table), state what trends are expected, and which oxidation condition provides high quality oxide. **Always relate the process conditions to how they would benefit device performance.**
- Allow enough time for the Lab Report.

INFORMATION TO BE INCLUDED IN THE LAB REPORT #1

1. From Lab #1:
   Convert the measured sheet resistance to resistivity in Ω-cm and doping concentration in cm^{-3}. Analyze the mean and the standard deviation of the doping concentration measured. Determine the doping uniformity across your device wafer and among 4 different wafers. Compare the results to the manufacturer's specifications.

2. From Lab #2:
   Explain the reasons for the pre-furnace clean. Explain the reasons for the dry/wet/dry oxidation sequence.

3. Carry out Tsuprem4 simulation of the field oxidation:
   a. The same condition as used in the Lab.
   b. Reduce the oxidation temperature to 1000 °C, all other conditions the same as a.
   For a and b, include the printouts for the simulation output file and dopant distribution plots. Summarize the following for each step in a table: oxide thickness grown, Si consumed, linear rate constant, parabolic rate constant, boron diffusivity in Si and SiO_2, boron concentration in oxide and in Si close to Si-SiO_2 interface. Compare oxidation rate and oxide quality for wet vs. dry oxidation and high vs. low temperature.
   c. Describe and explain dopant distribution in Si and SiO_2. How would non-uniform doping in Si and doping in SiO_2 affect device performance?



Pre-Furnace Clean
Grow Field Oxide
Dry/Wet/Dry Oxidation

- **Explain Reasons for Wafer Clean and Oxidation Sequence**
- **Simulations for Field Oxidation**
- **Compare Wet vs. Dry Oxidation and High vs. Low Temperature**
- **Effects of Dopant Distribution in Si and SiO_2**