Furnace – Annealing

Process Summary
Annealing: A high temperature process that uses nitrogen to keep wafers in an inert atmosphere. Major applications include dopant diffusion and activation, film stress release, and etc.

Boron Doping: A high temperature process that diffuses boron atoms into the silicon wafer. Boron atoms provide extra electron hole to the silicon substrate, which will make it more conductive.

Equipment Description
The Annealing system is a three-zone APCVD furnace tube. It operates as stand-alone unit that comprises of three modules: wafers load/unload module, furnace/process tube module, and gas control module. Annealing furnace tube has its own computer, FCS10, whose display panel and keypad are located on the front side of the wafer load/unload module. The furnace operation is controlled by using the special function buttons and a series of menu commands. The furnace temperature is controlled by the TCU computer board that runs a proprietary PIC algorithm. The process gases are controlled by the MFS460 controller that has five hardware interlocks to insure the safety of the operation. The maximum allowable process temperature for Annealing tube is 110°C.

Available Gases
Nitrogen (N2) and Oxygen (O2)

Safety
Follow general safety guidelines in the lab as well as the specific safety rules as per follows:

- Electric Shock Hazard: Tystar furnaces utilize high electric power (high amperages) to generate heat. Do not open the side panels or touch the high power electrical parts in the furnace cabinet.

- Chemical Hazard: Boron dust are hazardous, avoid inhalation of the dust or direct contact to the skin or eye. Please refer to the MSDS for first aid information.

- Burn Hazard: Cantilevers, boats, and wafers coming out of the furnace are very hot. Avoid touching of any furnace quartz ware to prevent burning of your hands and contamination of the furnace. No flammable chemical are allowed at the load station when the tube is open.

- All new recipes must be checked by the process staff, before they can be used on the furnaces. Do not alter any of the control setting except those referred in the SOP. Always wear a mask when loading and unloading your wafers into the furnace tube.
Available Process

- Annealing
- Boron Diffusion
- Diffusion Drive In

Operation Procedure

Start up:
- All system components should be on and running 24 hours, 7 days a week. If the system is not on or is not operating in a normal condition, contact the lab staff and do not attempt to start the system without assistance.
- The FCS-10 CRT will either display the system status or will be set to the main menu.
- From the main menu, you can load recipes, display status, display recipe, and load a recipe.

Wafer Preparation:
- Wafers to be placed into the furnace system must be clean by piranha and dry by the spin rinse dryer.
- No metal or PECVD film are allowed on wafer.

Load and Run a Process Recipe:
- Press [Menu] to display the menu. Then type “DS[Enter]” for a display of status. The control computer will display the status of the furnace and indicate whether the furnace is in use, or whether it is free for you to use. You are only allowed to use the Annealing/Diffusion tube provided the program status is IDLE.
- After confirming that there is no program currently running, press [Menu], followed by “RL[Enter]” for recipe load. A list of programs is now displayed with one highlighted. Use the arrow keys to move to the desired recipe. Hit [Enter] twice. After selecting a program, the controller will prompt you for several input parameters. Use the keypad to enter numbers, followed by [Enter]. Use clear to erase mistakes. Make sure to fill all available digits. Once you have finished entering all of your required values, press [Menu], then “DS[Enter]” to check that the recipe is loaded properly.
- Press [RUN] to start the process. The tube door will open and boats come out from the furnace to allow you to access the quartz boat on which your samples will be placed. Cantilevers, boats, and wafers coming out of the furnace are very hot. Avoid touching of any furnace quartz ware to prevent burning of your hands.
- Wait until the loading arm has finished moving before loading your samples. The door and cantilever arms will remain in the fully withdrawn position until you press the [Event] key to skip to the next process step.
- Do not remove the boat cassettes from the cantilever as the boat position is critical. Load one wafer at a time; ensure each wafer is sitting in its own slot, flats up and perpendicular to the boat for a better wafer support and consistent run-to-run results.

- For Boron+ doping process, wafers should be placed between two adjacent solid sources two at a time, and back-to-back facing the solid sources (front side of the wafers faces the solid sources). This means each solid source will have two process wafers on both its sides facing towards it.

- Do not leave the door open for long period of time as it will create a large temperature gradient. Press [Event] after finished loading your wafers, and the boats will start moving into the tube. When the door closes completely, the tube will be process start.

- Now the program will run through its Anneal/Diffusion steps. Monitor its progress using the display process status command (“DS[Enter]”).

- After the process has been completed, the alarm will sound and the FCS-10 will display a HLD1 condition. This is an operator wait mode. The wafers will stay in the furnace under N2 ambient conditions until the operator presses [Event] to skip to the unload wafer step.

- The wafer boat will slowly come out, and will stop after it reaches the outer limit switch. Do not remove wafers when the boat loader is moving. Wafers and boats coming out of the furnace tube are extremely hot. Do not set them on clean wipes, vinyl gloves or anything else which will melt. Set hot items on clean stainless steel bench or on dedicated quartz carrier.

- Once you have finished unloading your wafers, press [Event] to begin the boat-in step. When the door closes completely, the recipe ends and goes to idle step.

Note: After the Boron+ diffusion process, a layer of boron rich film will be formed on the wafers, which need to be removed by a wet oxidation step followed by a BOE wet etch process.