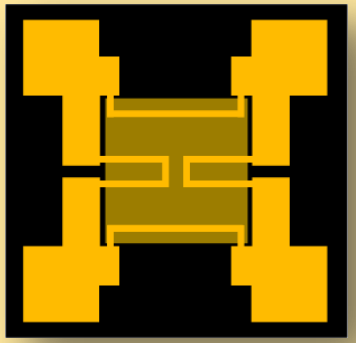
MTTC PRESSURE SENSOR PROCESS



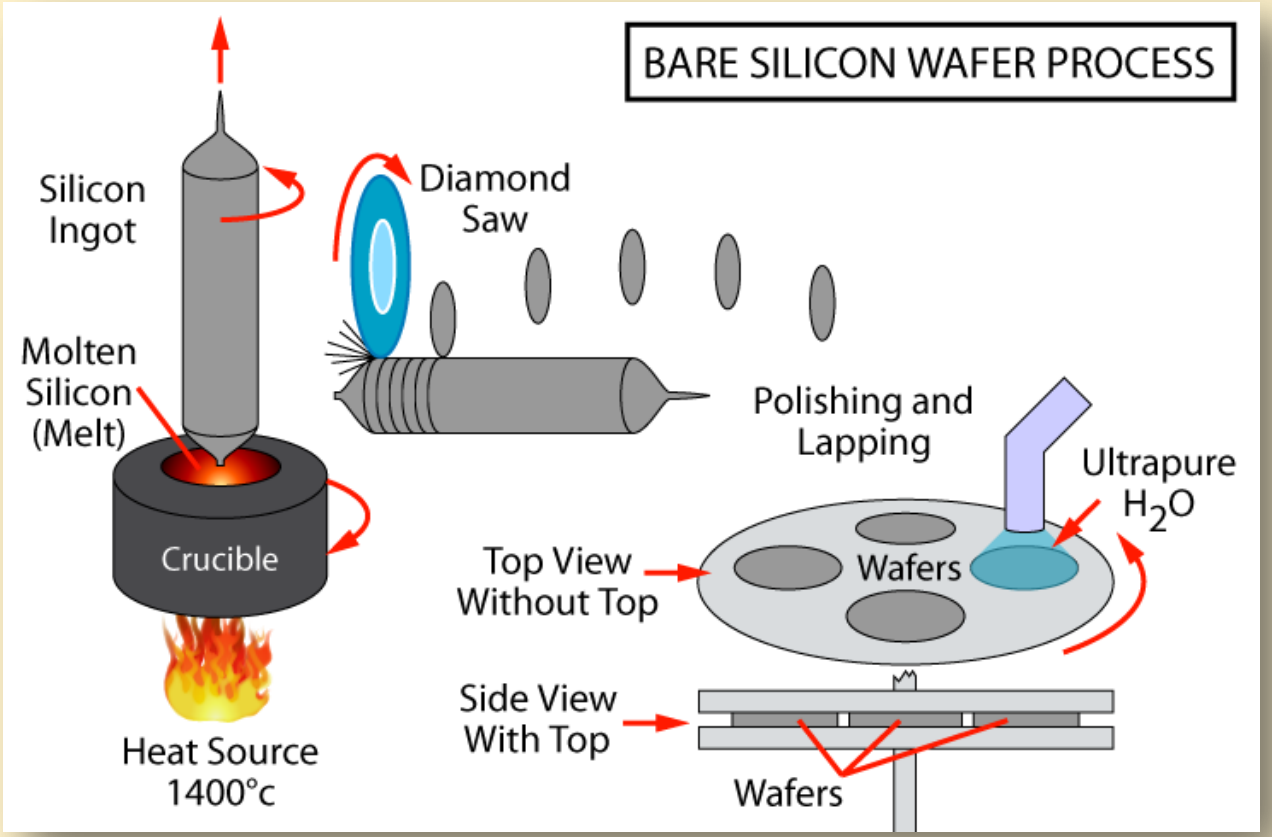
Process Storyboard

(Process parameters may change due to process improvements.)

Bare Silicon

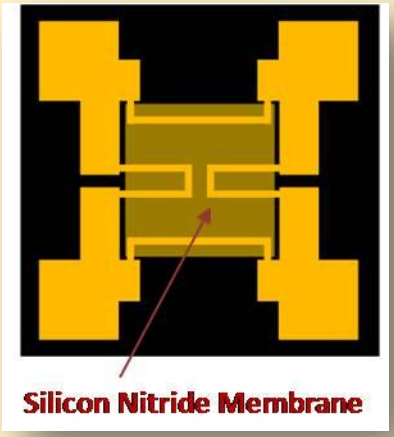
Description and Parameters:
Standard 150mm monocrystalline silicon wafer having <100> crystal orientation

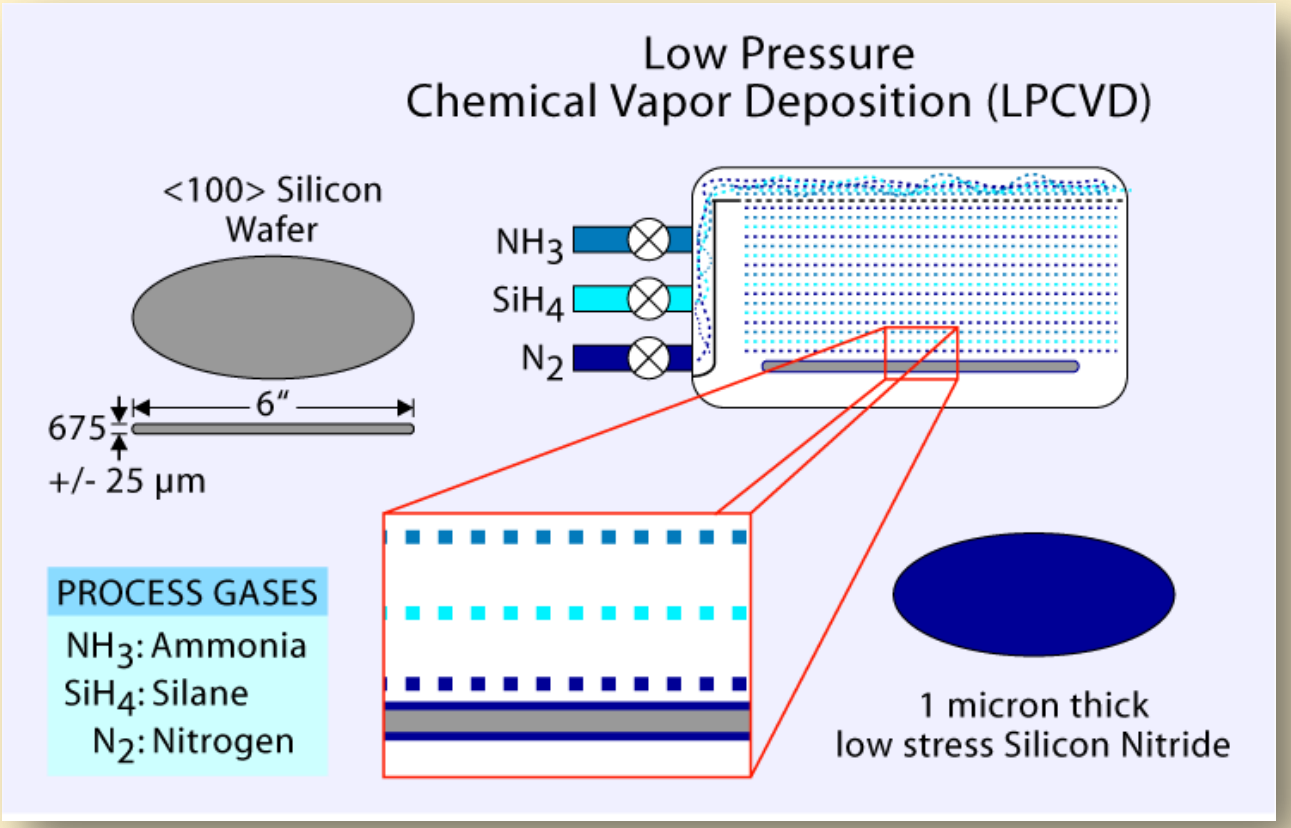
***Thickness**: 675+/- 25 μm*
***Dopant** (An intentional impurity to alter the resistivity): Boron*
***Resistivity** (The resistance to current flow and movement of electrons in the silicon): 20 Ω-cm*



Silicon Nitride Deposition

Description and Parameters:
LPCVD deposited
1 µm low stress silicon nitride on both sides of wafer





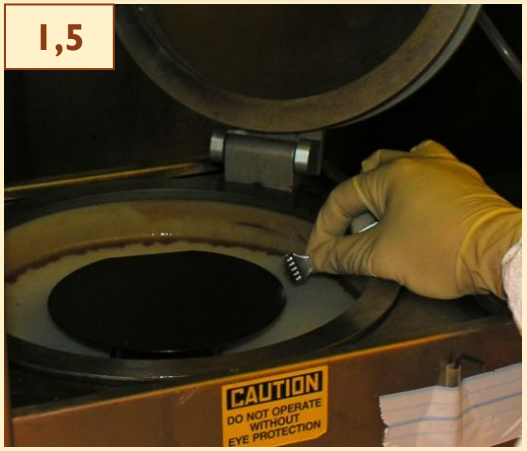
Photolithography - Coat

Process Description:
Pattern the backside of the wafer with a photoresist window to expose the silicon.
This step will coat the frontside of the wafer first for protection against scratches, then the backside of the wafer.

Coat Parameters:

1. *Frontside coat - Carefully center wafer on vacuum chuck*
2. *Bake wafer for 2 minutes at 110°C / Cool wafer on metal table to bring wafer back to room temp*
3. *Dispense HMDS w/pipette/Spin (HMDS is a primer to allow photoresist to stick to the wafer)*
4. *Dispense photoresist (AZ9260) w/pipette/Spin*
5. *Backside coat - Carefully align and center wafer on vacuum chuck*
6. *Dispense HMDS w/pipette/Spin*
7. *Dispense photoresist (AZ9260) w/pipette/Spin*
8. *Bake wafer for **2 minutes at 110°C** to cure and remove solvents / Cool wafer on metal table to bring wafer back to room temp*

1,5



2,8

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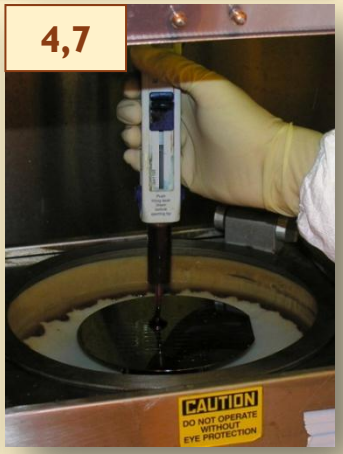
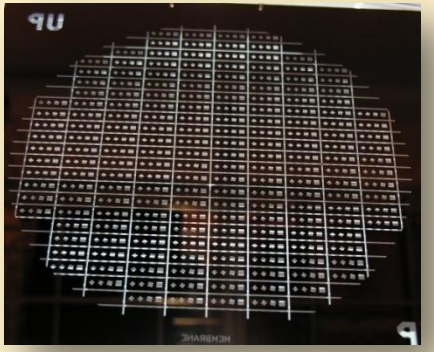


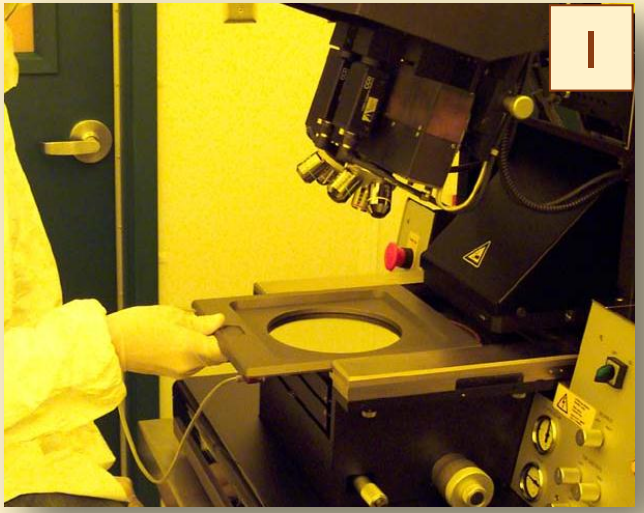
Backside Photolithography - Expose

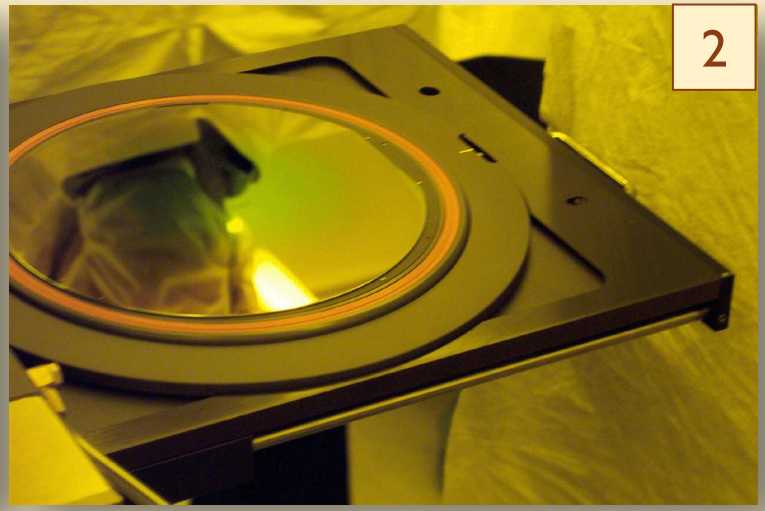
Process Description:
Pattern the backside of the wafer with a window to expose the silicon.
The photoresist will become soluble when exposed to the ultraviolet light. The mask contains the window pattern.

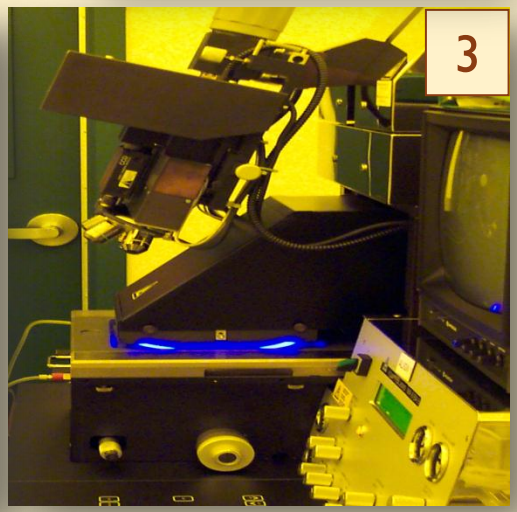
Expose Parameters:
1. *Load Mask Into Holding Tray and slide the tray into the Karl Suss alignment system*
2. *Load Wafer Into Karl Suss Contact Aligner*
3. *Expose wafer to UV light for approximately **300 seconds***

Mask Pattern







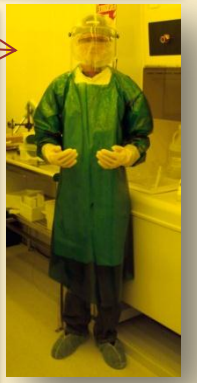


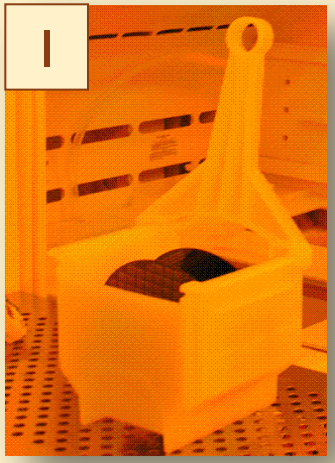
Backside Photolithography - Develop

Process Description:
Develops the exposed photoresist to open the windows and expose the silicon for a subsequent etch.
The developer is AZ400K 1:4 potassium based solution

Develop Parameters: Performed at Caustic Wet Bench, USE ACID GEAR

1. *Place exposed wafer in last slot of white Teflon boat (closest to H bar)*
2. *Pour develop solution into container and insert boat so entire wafer is submerged*
3. *Allow wafers to develop for **10 minutes***
4. *Remove boat from develop solution*
5. *Place in QDR (Quick Dump Rinse) and Rinse 5X*
6. *Place entire boat into SRD (Spin Rinse Dryer) (H-bar in first) until unit reaches **15MΩ***
7. *Do a microscopic inspection to check for defects*





Backside Etch – RIE

Process Description:

This step uses a plasma etcher to etch the backside silicon nitride layer through the open resist windows, exposing the underlying monocrystalline silicon wafer. The March Reactive Ion Etcher (RIE) is used for a very highly selective etch. The RIE uses13.56 MHz (RF) to energize the plasma. The positive ions bombard the wafer's surface to create openings in the silicon nitride layer using this dry etching technique.

RIE Parameters:

- *Place wafer in the RIE for **300 seconds***
- *Turn wafer 180° and etch for another **300 seconds***, this insures a uniform etch
- *Remove wafer*

Backside Photoresist Strip

Process Description:
The wafers are placed in a Piranha bath. Piranha is a mixture of H_2SO_4/ H_2O_2. This chemical solution aggressively removes photoresist. Extreme care should be taken when using a Piranha solution. The acid will interact with skin very quickly. Be sure to use the appropriate personal protective equipment (PPE) when performing the photoresist strip.

Photoresist Strip Parameters: **USE ACID GEAR**

Piranha Clean Mixture (**Heated to 100°C**)

- 4.5 gallons of Sulfuric Acid
- 200 mL Hydrogen Peroxide

Always add Peroxide to the Acid!!!!!

Chemicals Used: H_2SO_4/ H_2O_2

Process Time: ***15 minutes***

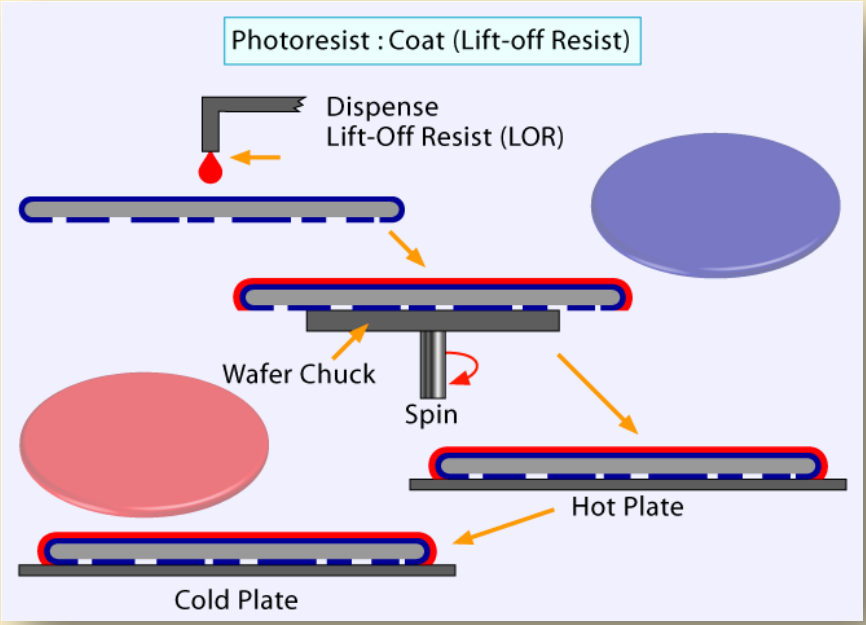
Frontside Photolithography - Coat

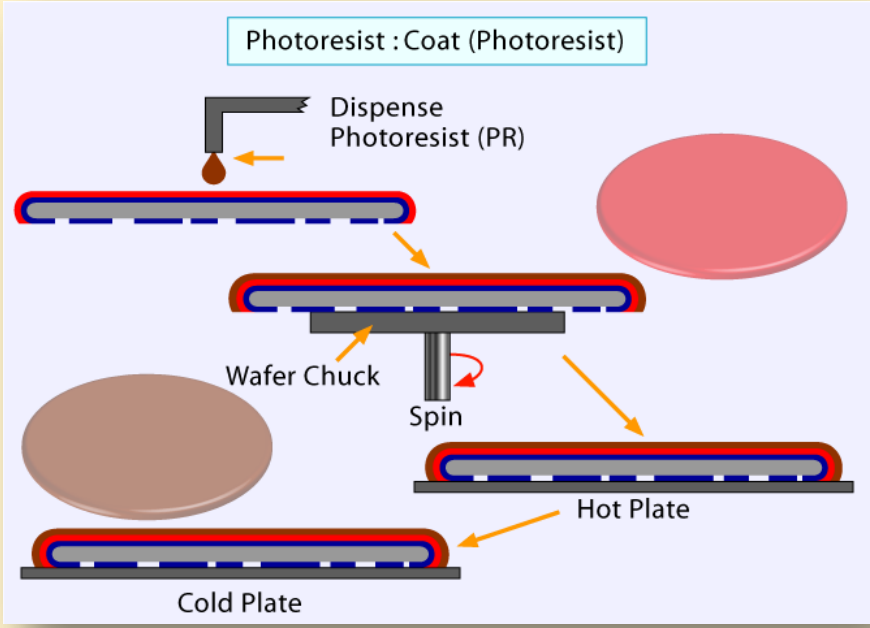
Process Description:
The next step in the process is to pattern the frontside of the wafer with the Wheatstone Bridge pattern. In this step, a lift-off resist is applied to create a desired undercutting during the develop process.

Frontside Coat Parameters:

1. *Carefully align and center wafer on vacuum chuck*
2. *Dispense Lift off Resist (LOR) w/ pipette and spin*
3. *Bake wafer for **2 minutes at 190°C.***
4. *Cool wafer on metal table to bring wafer back to room temp*
5. *Align and center wafer on vacuum chuck*
6. *Dispense photoresist w/pipette and spin*
7. *Bake wafer for **5 minutes @ 100° C***
8. *Cool wafer on metal table*

Chemicals Used: LOR, Photoresist





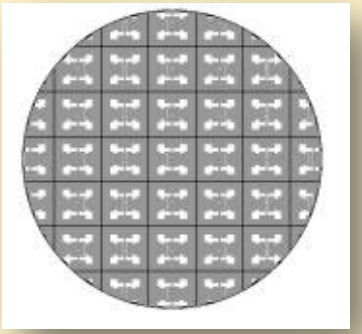
Frontside Photolithography - Expose

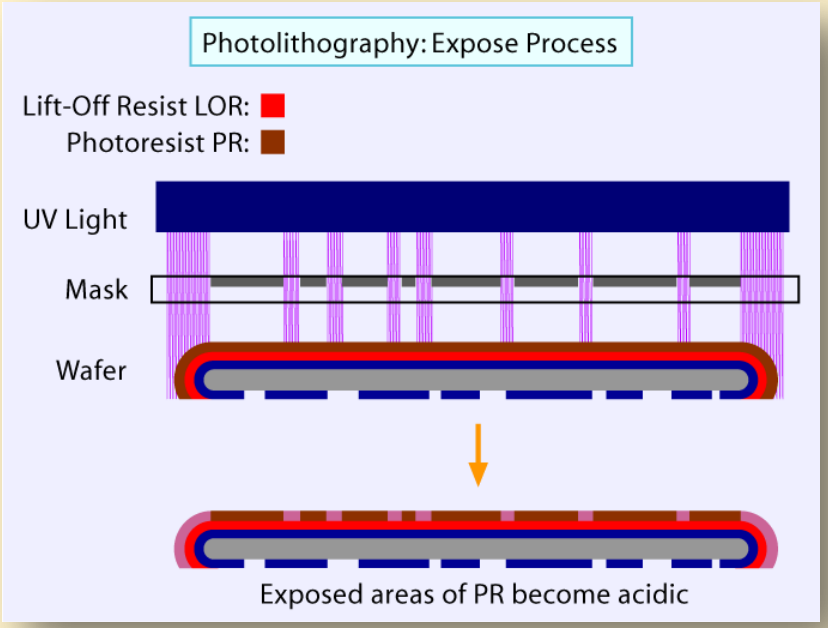
Process Description:
Exposes the Wheatstone Bridge circuit pattern.

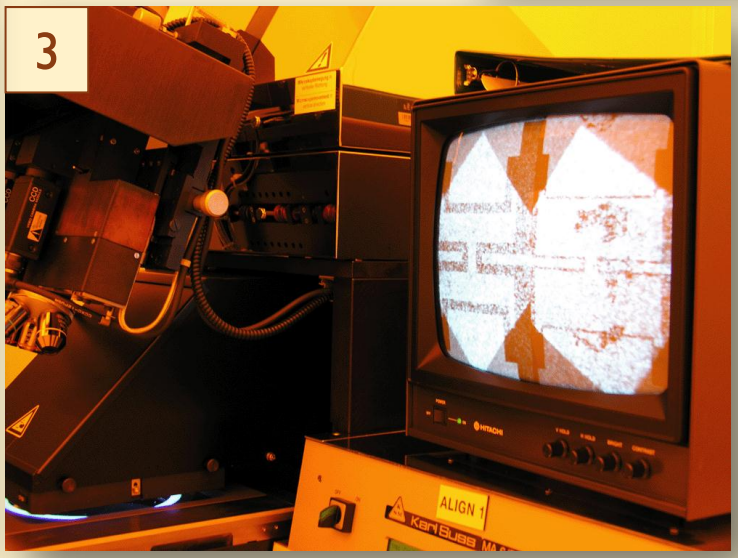
Frontside Expose Description & Parameters:

1. *Load Mask Into Holding Tray and slide the tray into the Karl Suss alignment system*
2. *Load Wafer Into Karl Suss Contact Aligner*
3. *Align wafer using alignment system*
4. *Expose wafer to UV light for **40 seconds***

Mask Pattern





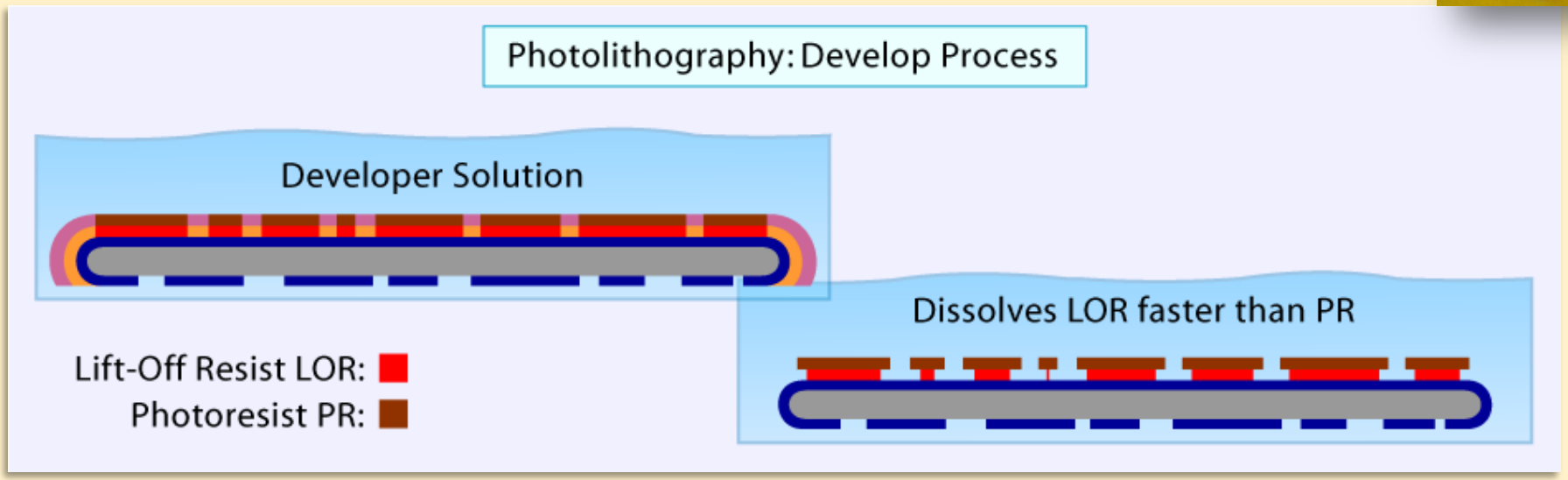


Frontside Photolithography - Develop

Process Description: Develops the photoresist & creates the resist undercut.

Frontside Develop Parameters: Performed at Caustic Wet Bench, USE ACID GEAR PPE

1. *Place exposed wafer Teflon boat*
2. *Pour develop solution. Insert boat so entire wafer is submerged*
3. *Allow wafers to develop for **60 seconds***
4. *Remove boat from develop solution and place in QDR (Quick Dump Rinse) and Rinse, repeat this 5 times*
5. *Remove and place entire boat into SRD (Spin Rinse Dryer) until unit indicates **15MΩ** rinse water resistivity*
6. *Perform a microscopic inspection to check for defects*



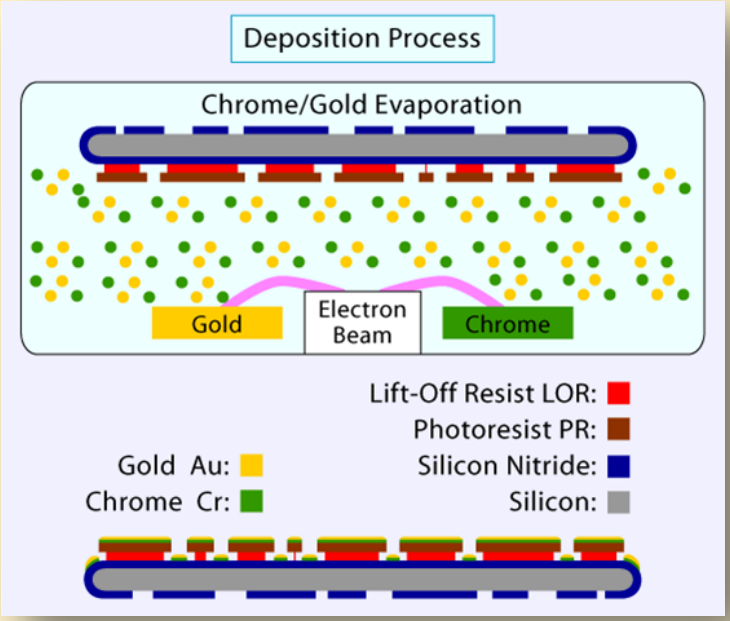
Metal Deposition

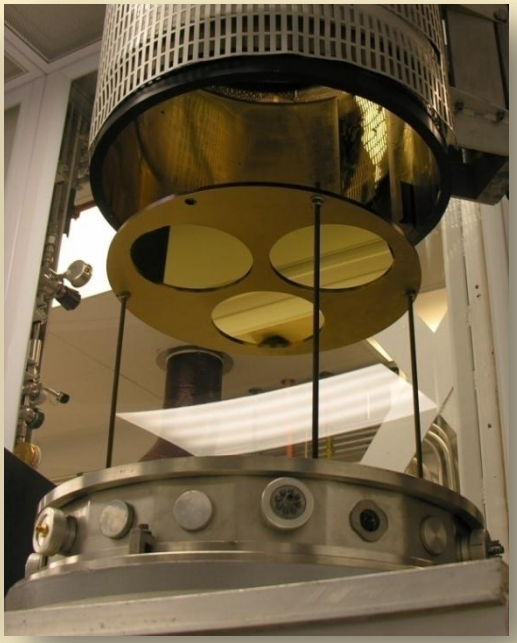
Process Description:

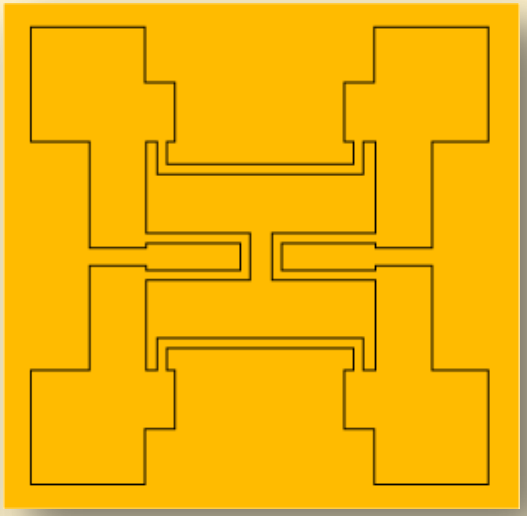
A vacuum evaporator deposits chrome and then gold onto the wafer. Chrome is used because it adheres well to the silicon nitride and the gold adheres well to the chrome. The gold acts as the conductive layer and strain gauge for the resistor bridges in the Wheatstone Bridge.

Deposition Parameters:

1. *Mount wafers in the vacuum evaporator*
2. *Deposit 100 Angstroms of chrome onto the wafer –* ***Process Time: 90 seconds***
3. *Deposit 4000 Angstroms of gold over the chrome –* ***Process Time: 5 minutes***





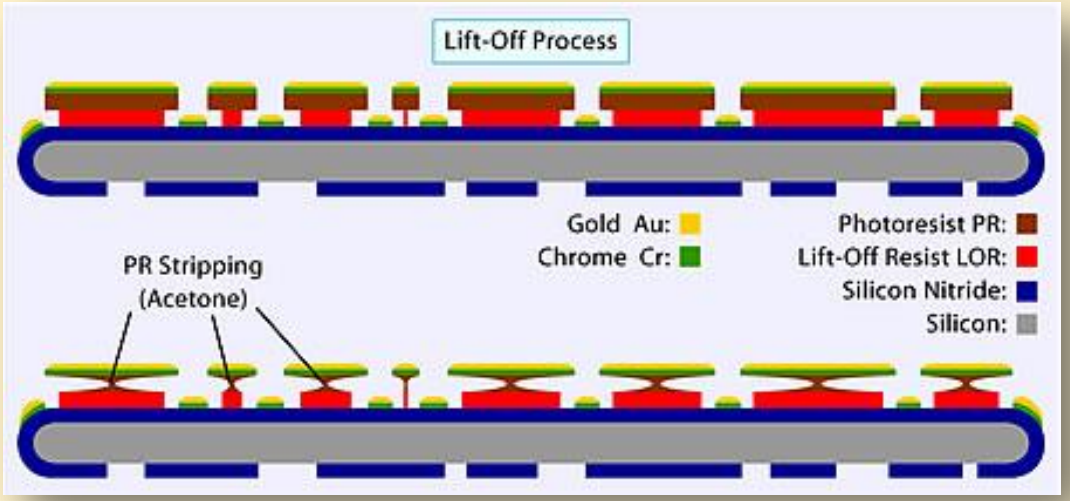


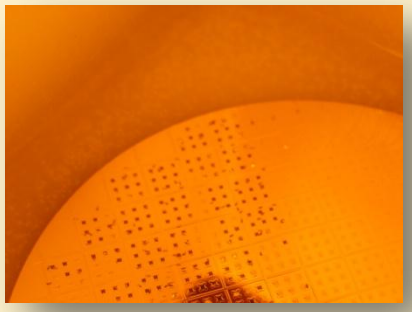
Wheatstone Bridge pattern after metal deposition

Metal Liftoff

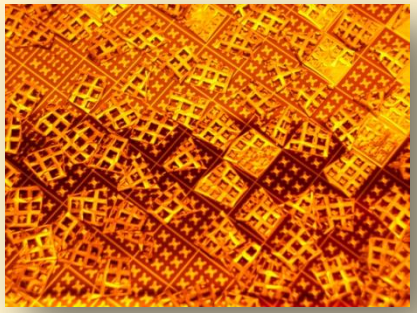
Process Description:
The wafer is soaked in acetone to dissolve the photoresist causing chrome/gold leads to lift off. The wafer must stay wet or the metal may stick randomly to the wafer surface. LOR will remain.

Liftoff Parameters:
Chemicals Used: Acetone
Process Time: *Approximately 30 minutes*

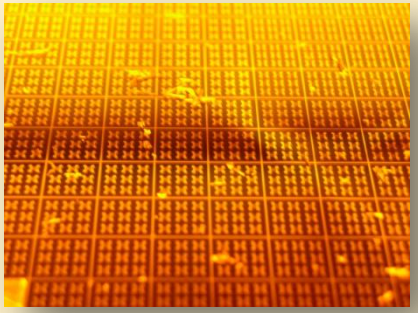




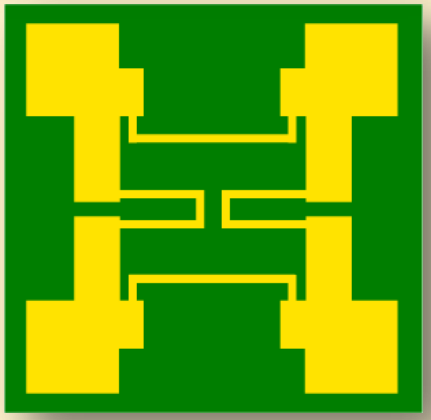
Stage 1: Chrome/Gold beginning to liftoff



Stage 2: Wheatstone bridge structures beginning to be revealed



Stage 3: Chrome/Gold liftoff complete



Microscope photo of Wheatstone bridge after liftoff

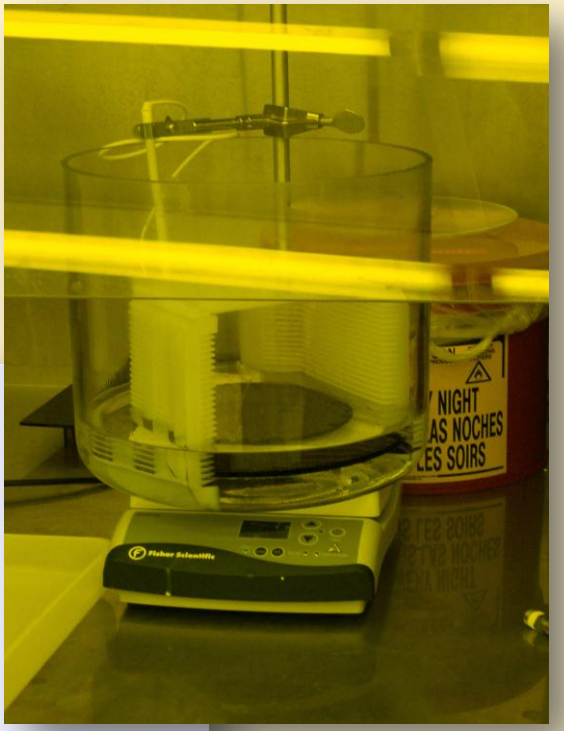
LOR Strip

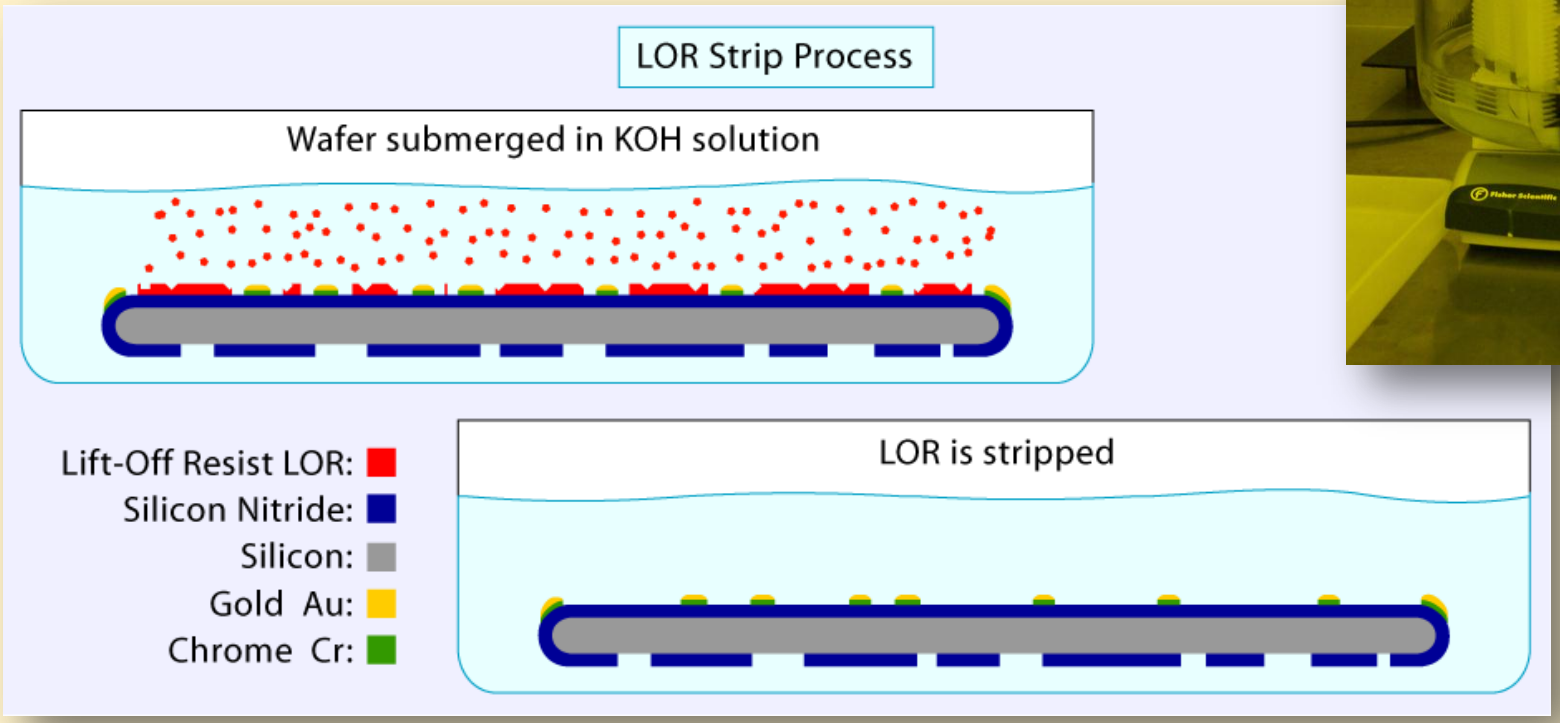
Process Description and Parameters

Wafers are now submerged in develop solution to strip the LOR.

Chemicals Used: Develop solution at room temperature

Process Time: Approximately ***2 minutes***





KOH Etch

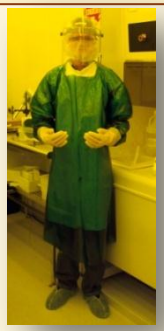
Process Description and Parameters : Performed at a Wet Bench, USE ACID GEAR PPE

Wafers are now submerged in a heated Potassium Hydroxide (KOH) bath. The silicon nitride acts as a hard mask and the exposed silicon etches anisotropically following the crystal planes. At the end of the etch, the wafers will be fragile since the bulk of the Si is removed.

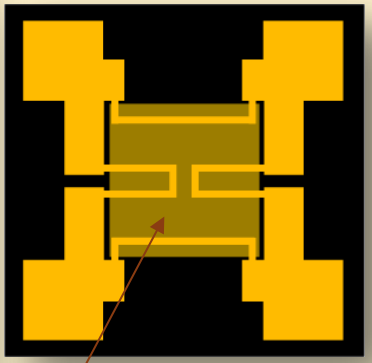
KOH Etch Parameters :

1. *Place wafers in a Teflon boat and place very gently into a **105°C** KOH bath, **process for 2 hours***
2. *Reduce the temperature to **95°C and leave for 90 minutes***
3. *Reduce the temperature to **80°C for approximately 45 minutes**, or until etch is complete*
4. *Place wafers in QDR then blow dry with nitrogen*

Chemicals Used: KOH, IPA, nitrogen

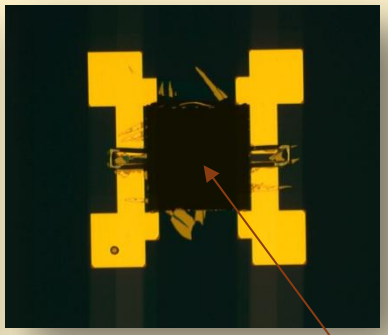


Good KOH Etch

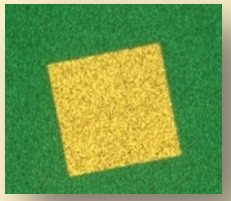


Silicon Nitride Membrane

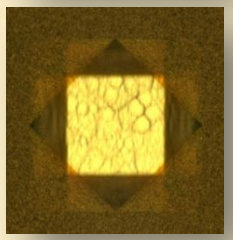
Bad KOH Etch



Blown Silicon Nitride Membrane due to over etch



cavity pattern before KOH



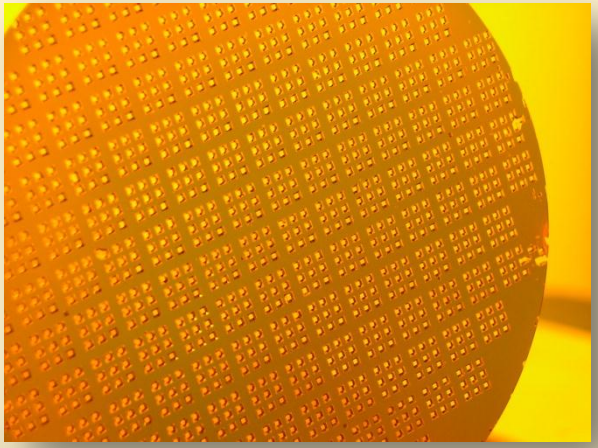
cavity during KOH shows silicon nitride pattern

Testing and Probing

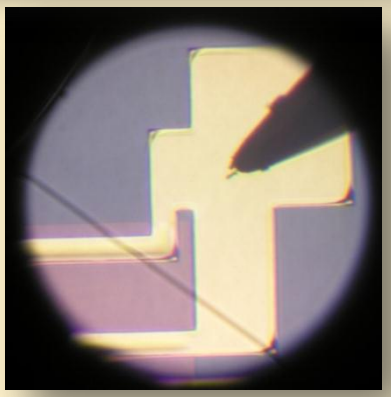
Process Description and Parameters

Wafers are now placed on a probing station. A power supply is used to apply a voltage, causing the membrane to deflect.

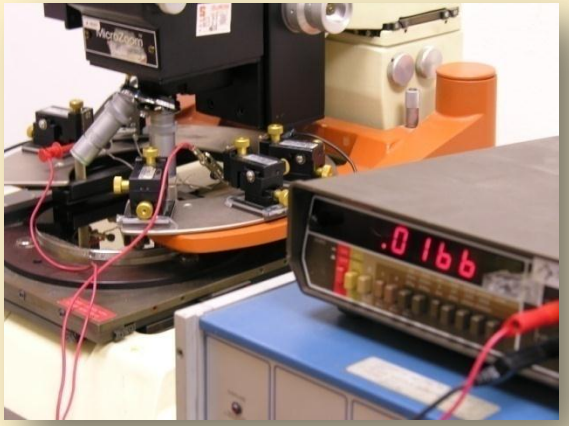
Final Product



Pressure Sensor wafer on probing station



Probe on the Wheatstone Bridge



Probing station and power supply

Acknowledgements

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Albuquerque, NM 87106-4346

Phone: 505-272-7150

Website: www.scme-nm.org

The work presented was funded in part by the National Science Foundation Advanced Technology Education program, Department of Undergraduate Education grants: 0830384, 0402651, 1205138.

Revised 06/20/14