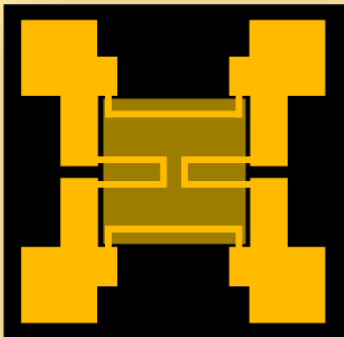


MTTC PRESSURE SENSOR PROCESS



Process Storyboard
(Process parameters may change due to process improvements.)

MTTC PRESSURE SENSOR PROCESS



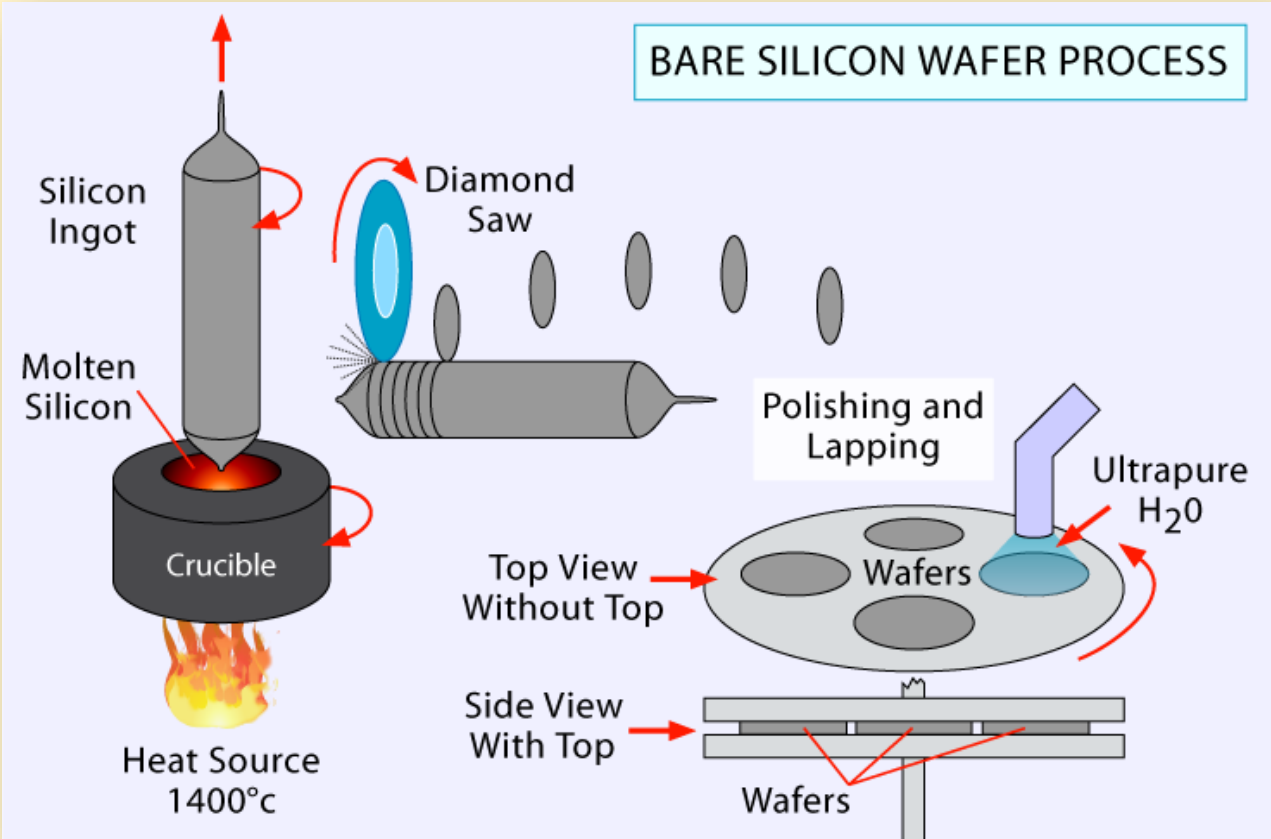
Process Storyboard
(Process parameters may change due to process improvements.)

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 $\Omega\text{-cm}$



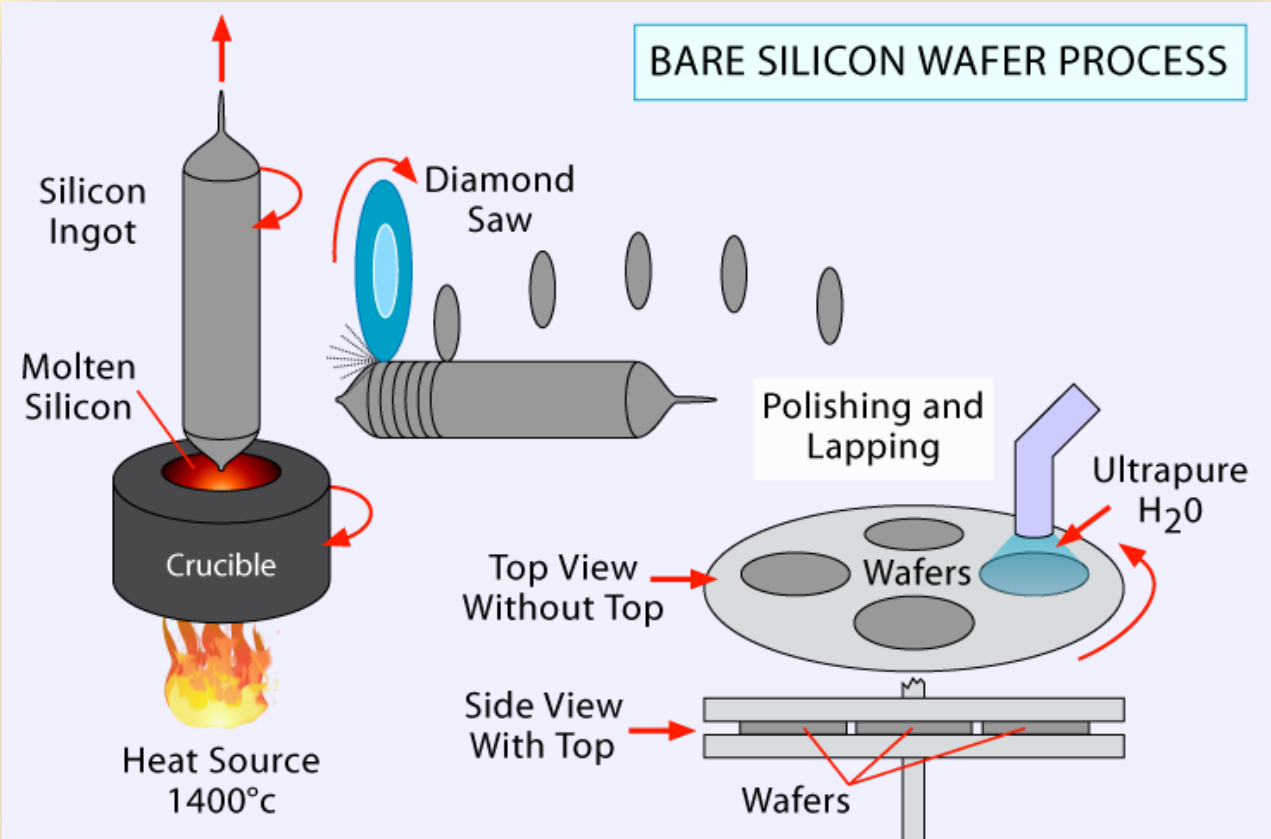
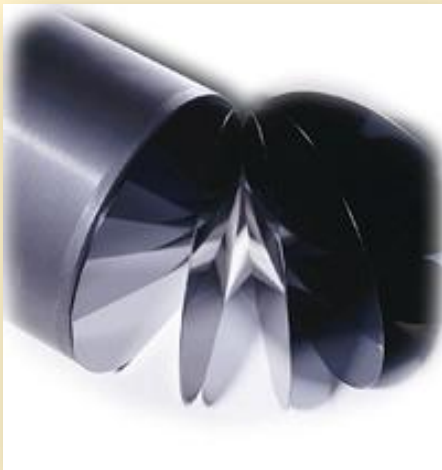
Revised 6/30/10

Bare Silicon

Description and Parameters:

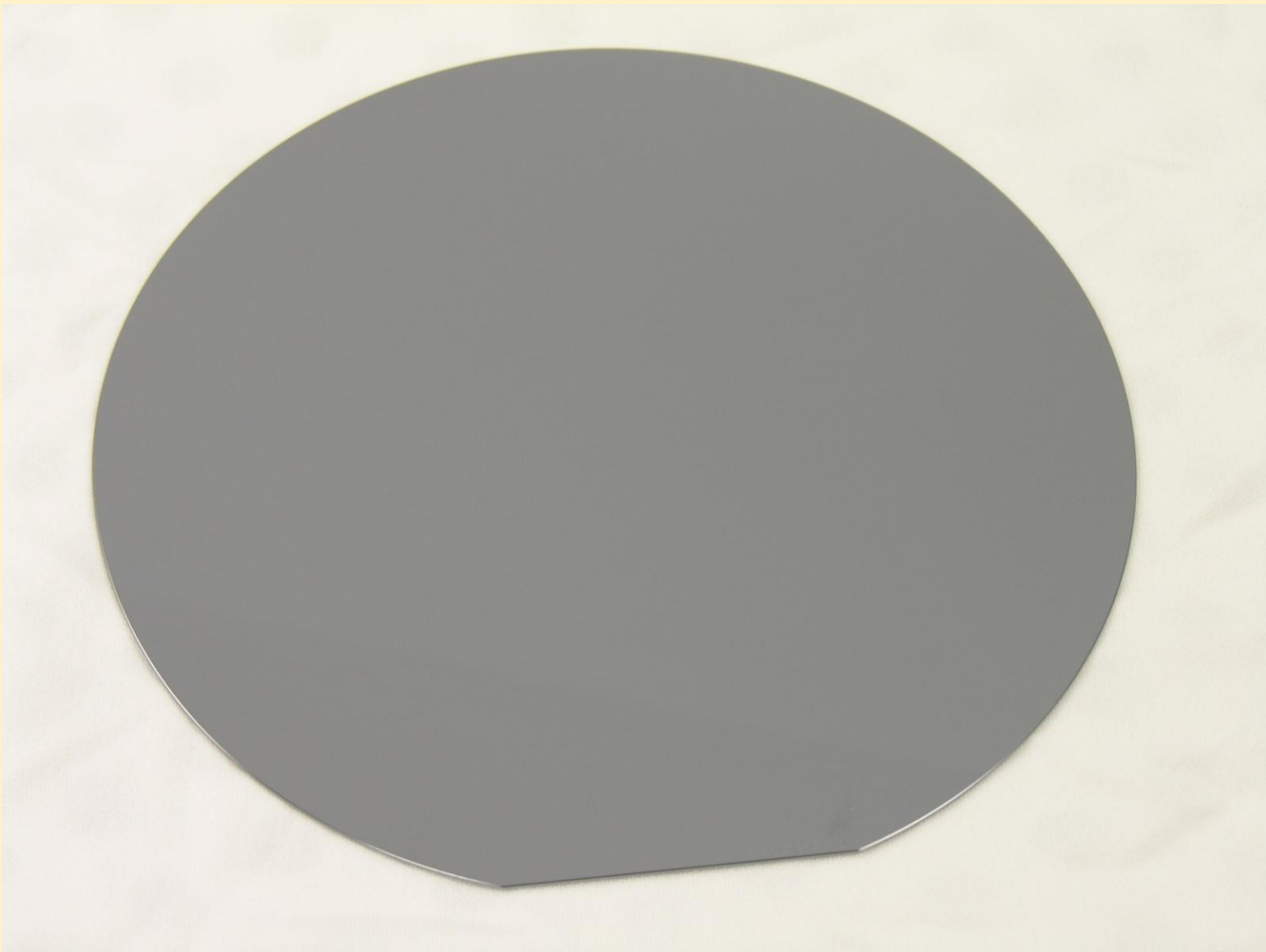
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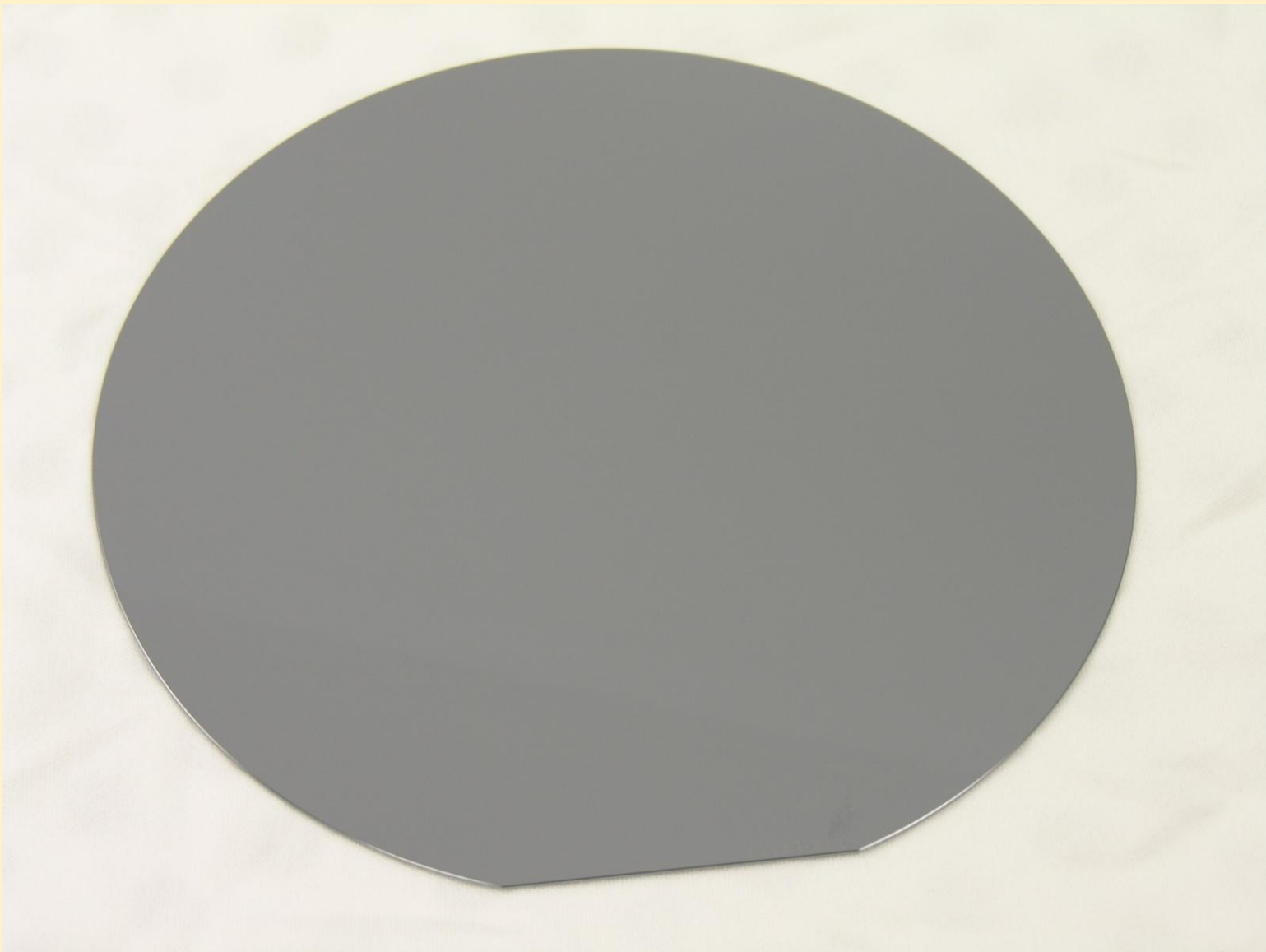
Revised 6/30/10

Bare Silicon



Step I

Bare Silicon

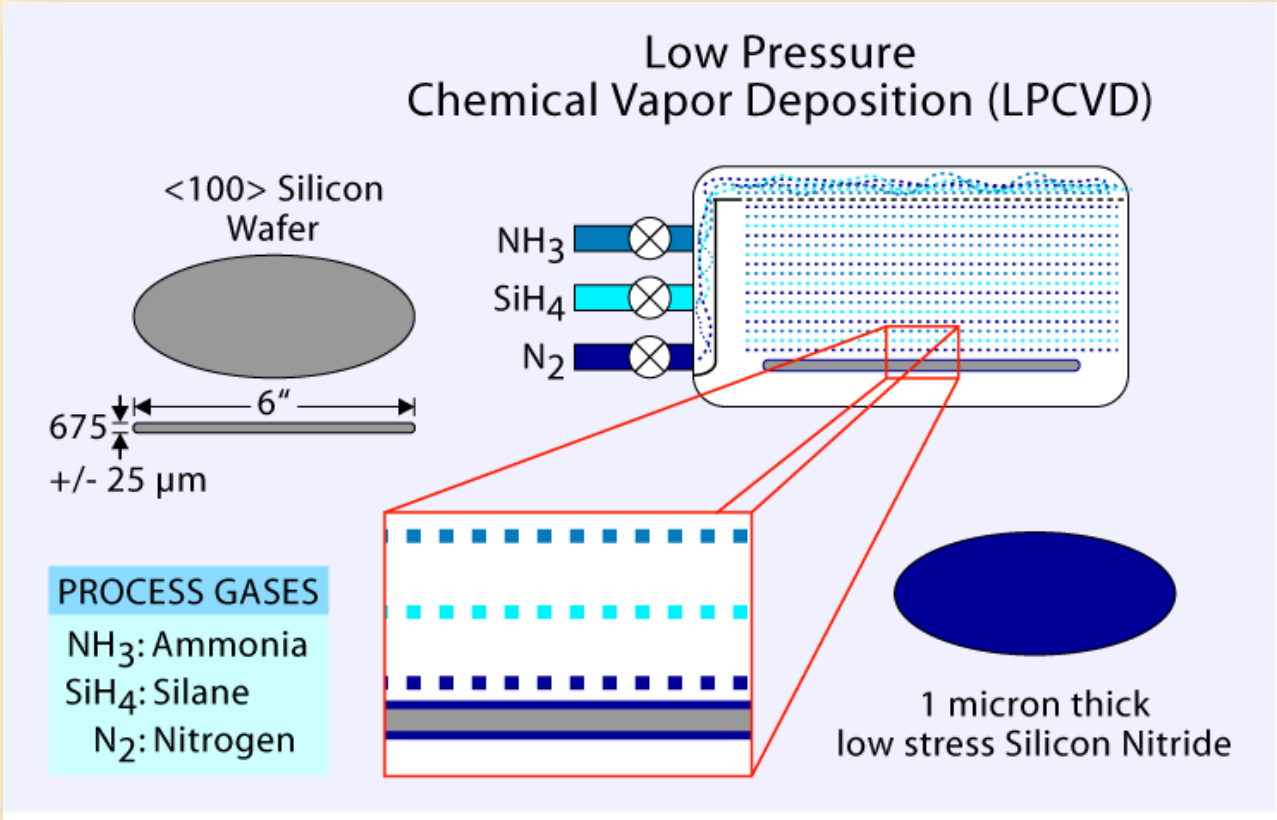
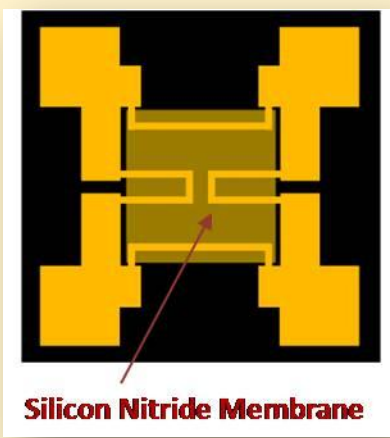


Step I

Silicon Nitride Deposition

Description and Parameters:

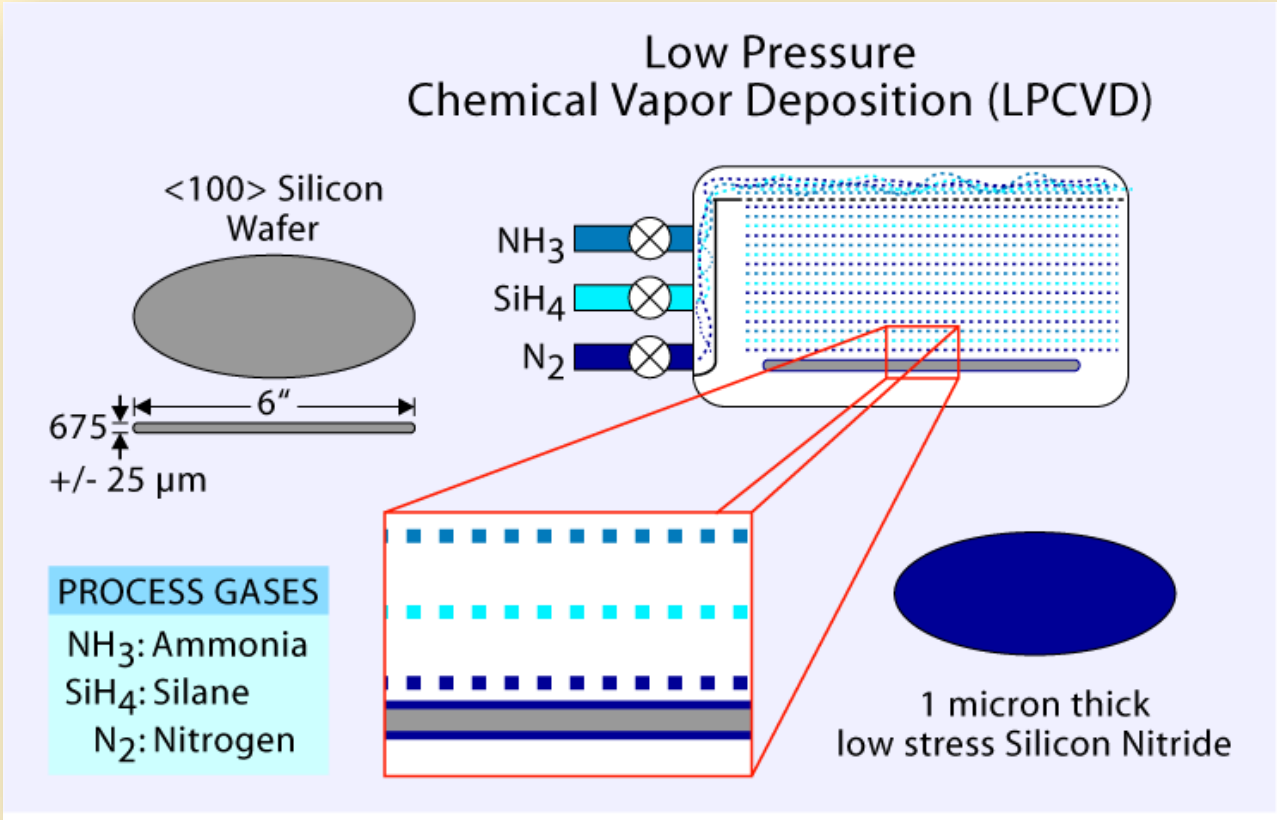
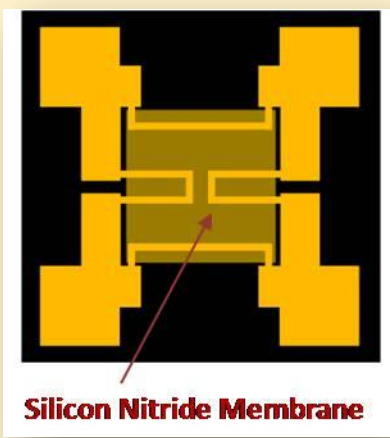
LPCVD deposited
1 μm low stress silicon nitride on both sides of wafer



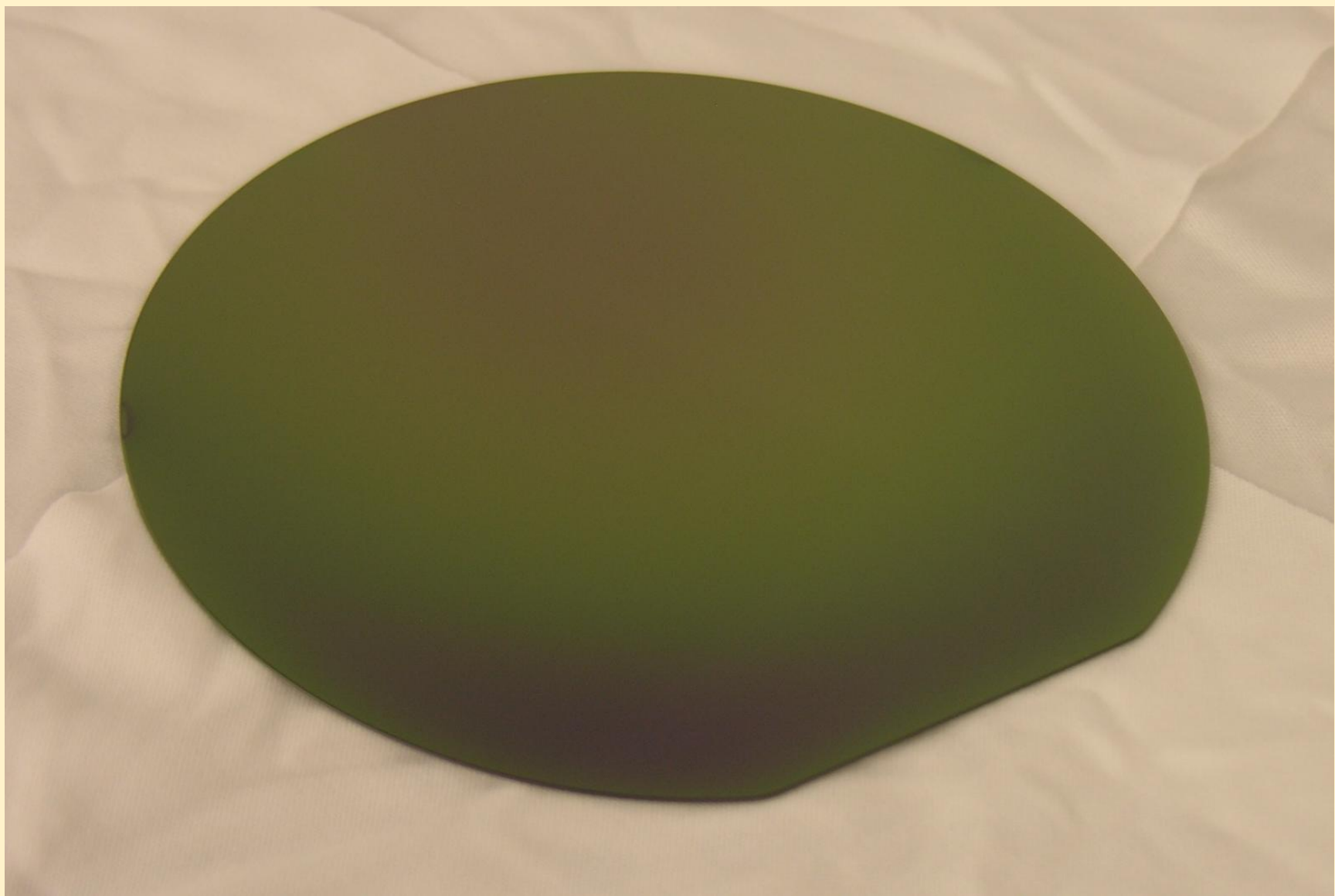
Silicon Nitride Deposition

Description and Parameters:

LPCVD deposited
1 μm low stress silicon nitride on both sides of wafer

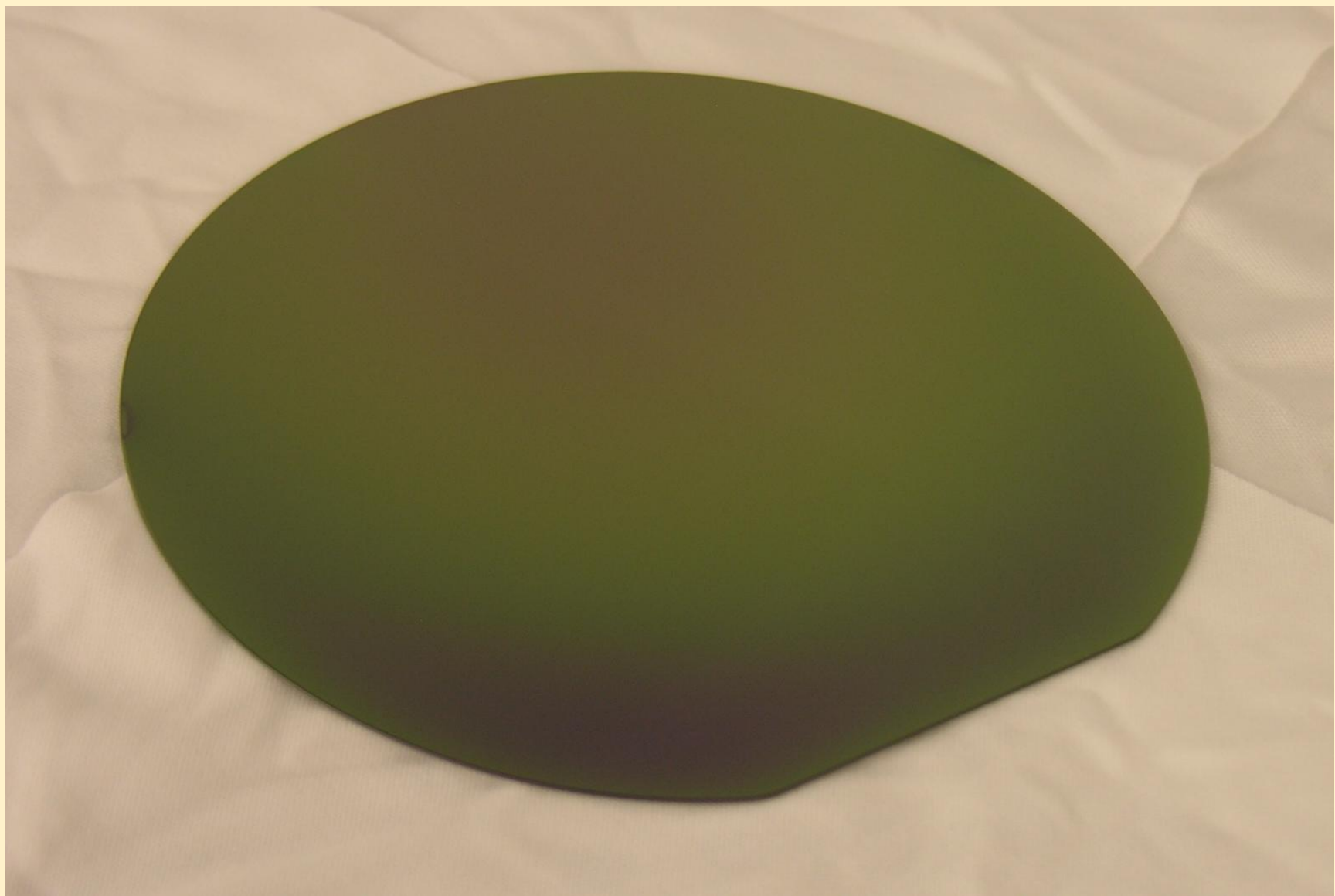


Silicon Nitride Deposition



Step 2

Silicon Nitride Deposition



Step 2

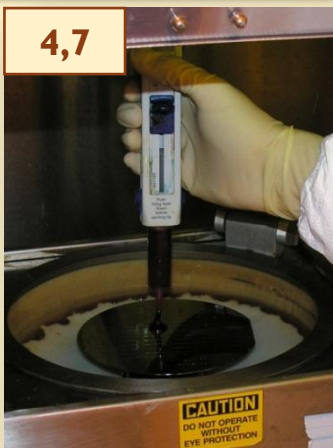
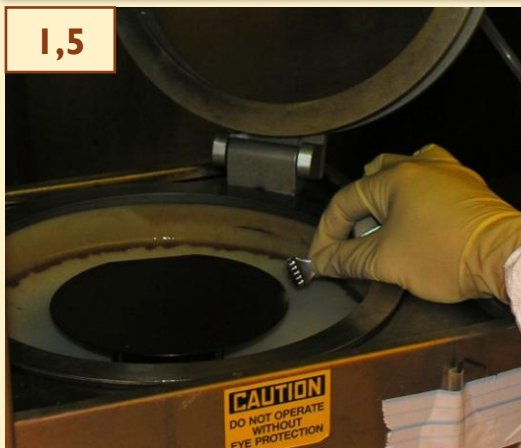
Backside Photolithography - Coat

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 align and center wafer on vacuum chuck –Visually check for misalignment
- 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 –Visually check for misalignment
- 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



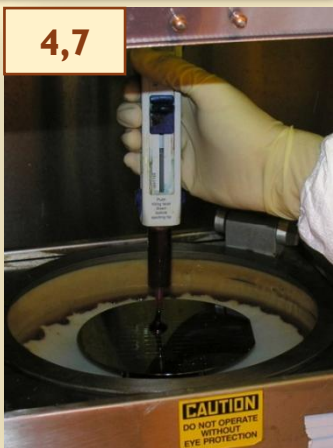
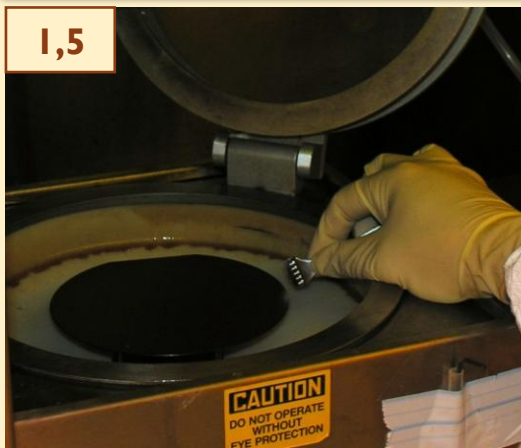
Backside Photolithography - Coat

Process Description:

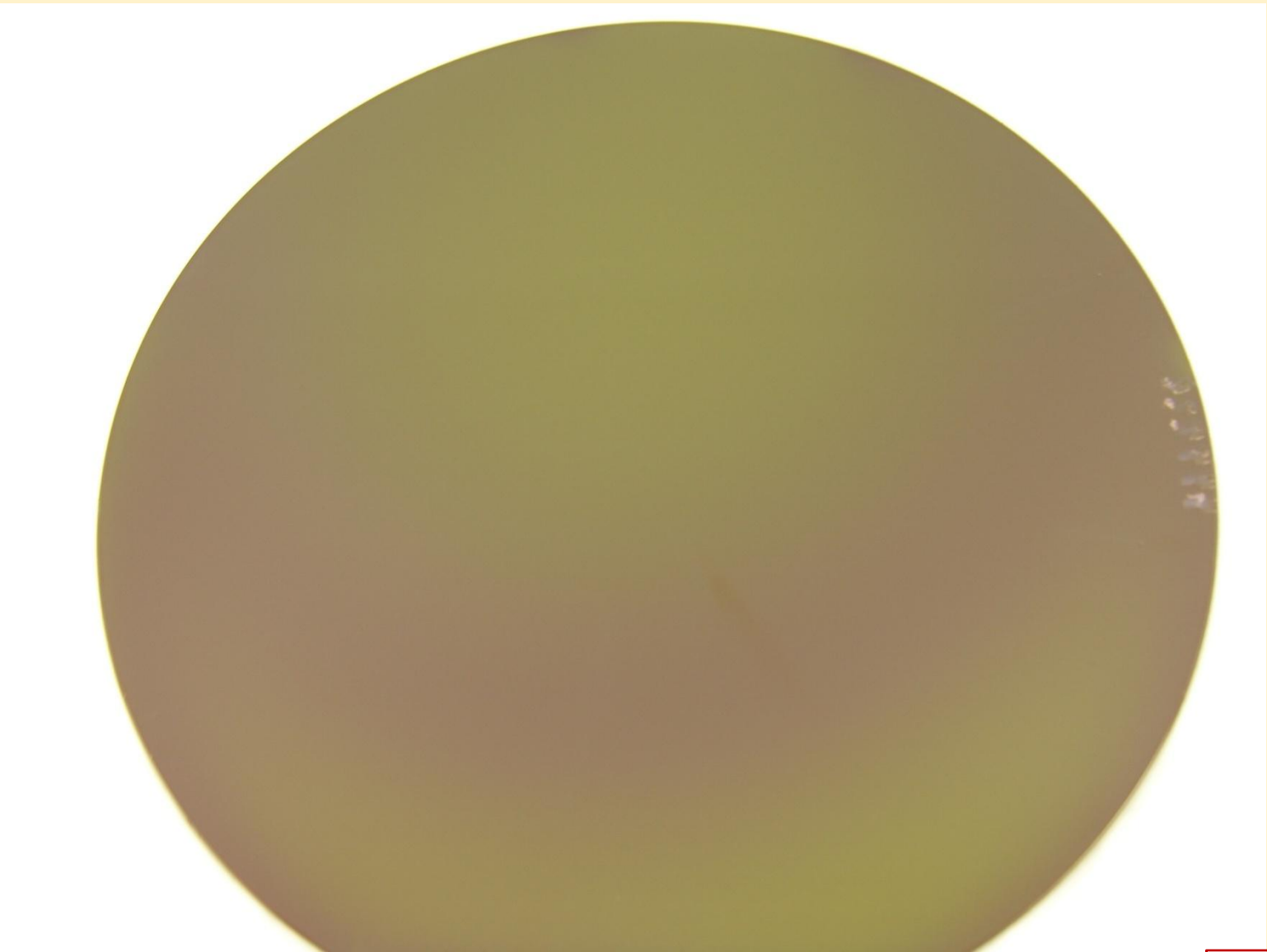
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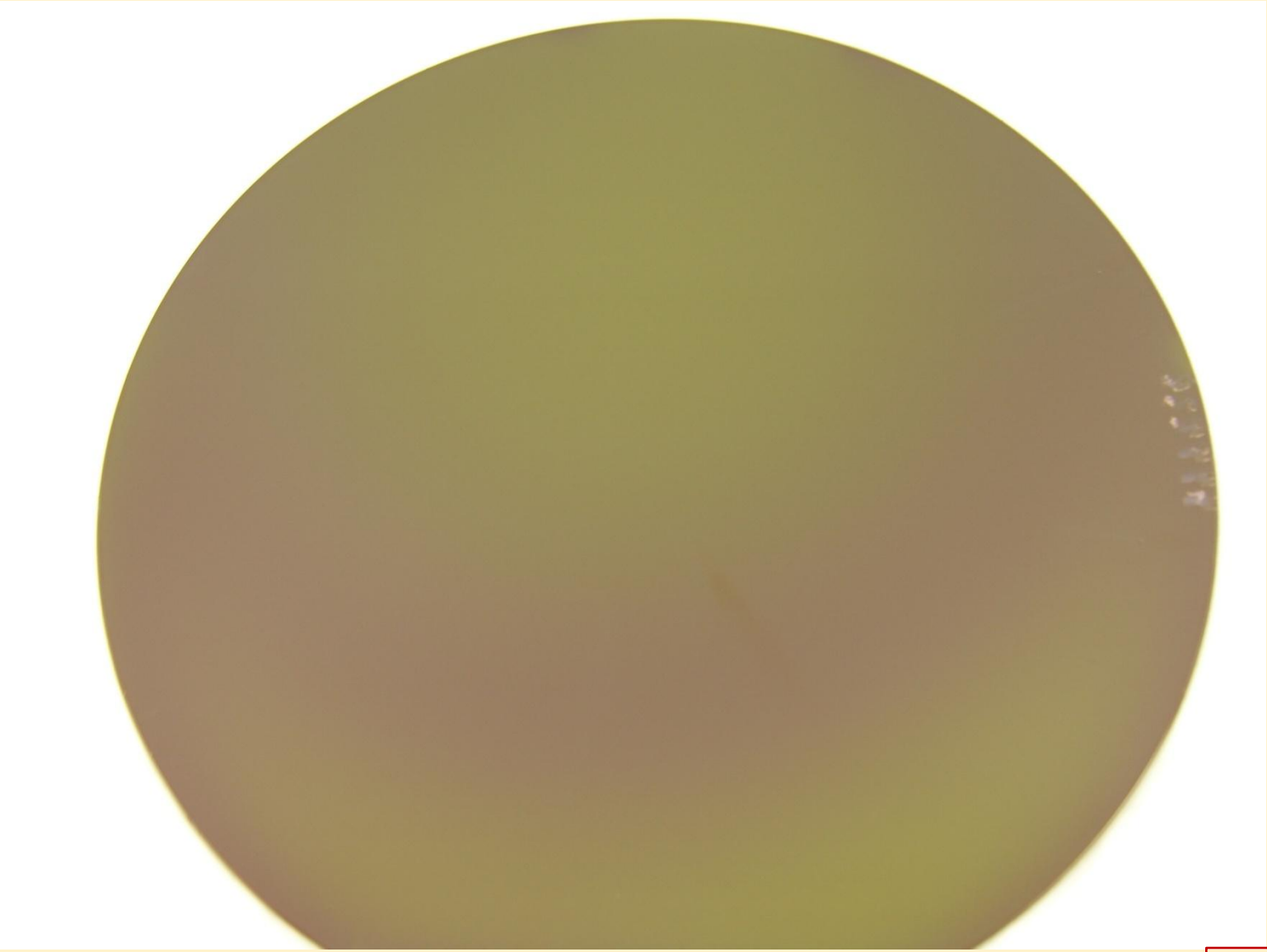


Backside Photolithography - Coat



Step 3a

Backside Photolithography - Coat



Step 3a

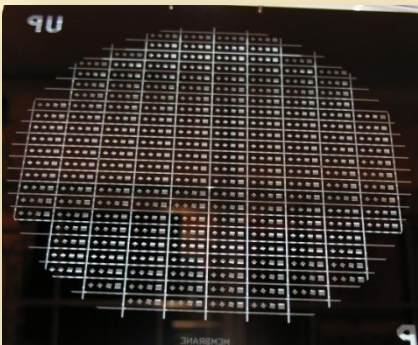
Backside Photolithography - Expose

Process Description:

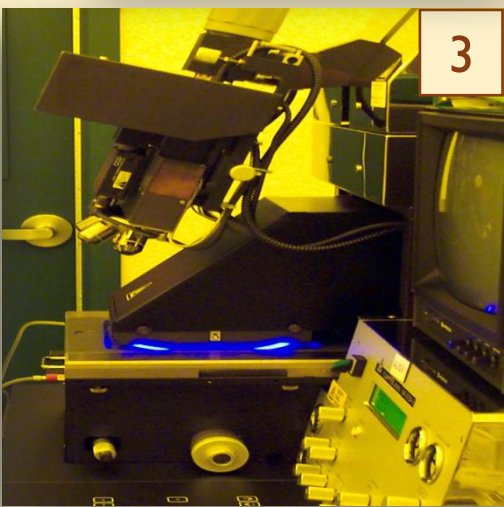
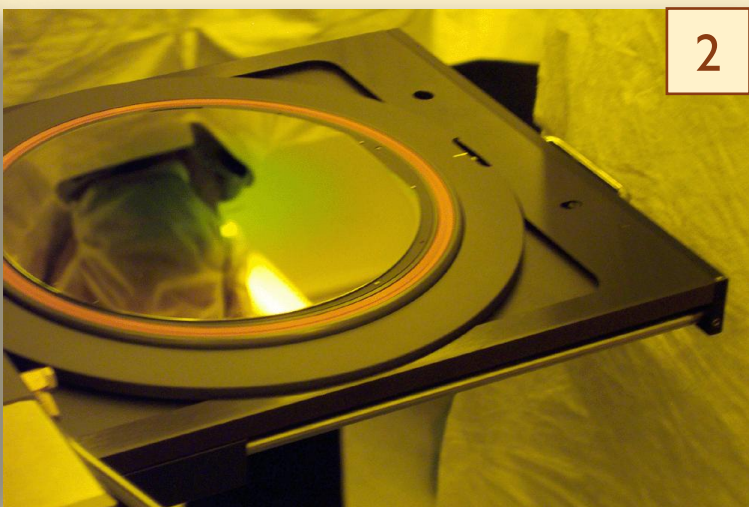
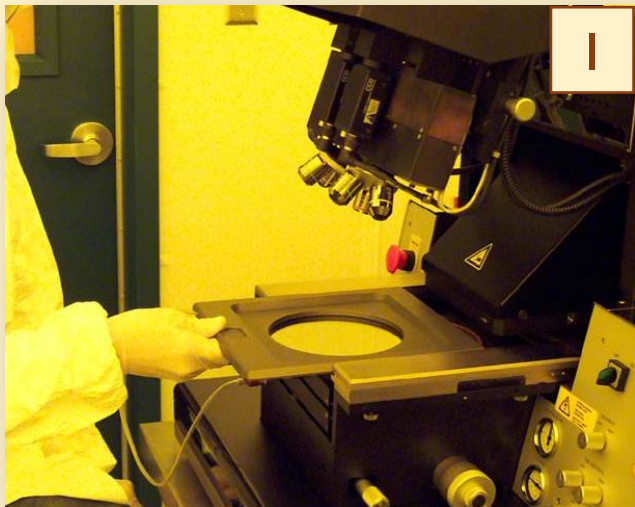
Pattern the backside of the wafer with a window to expose the silicon.
The photoresist will become soluble when exposed to the ultraviolet light. The mask contains the window pattern.

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



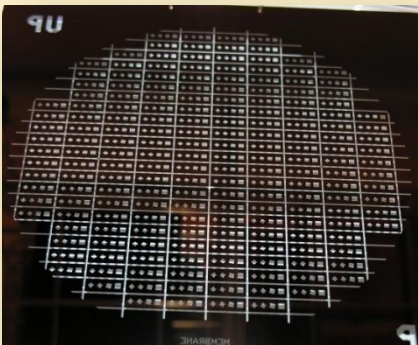
Backside Photolithography - Expose

Process Description:

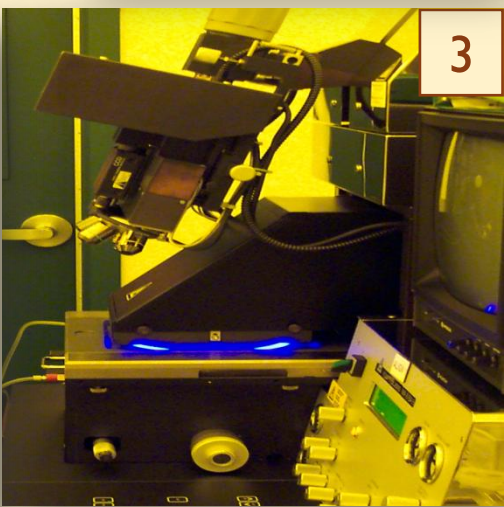
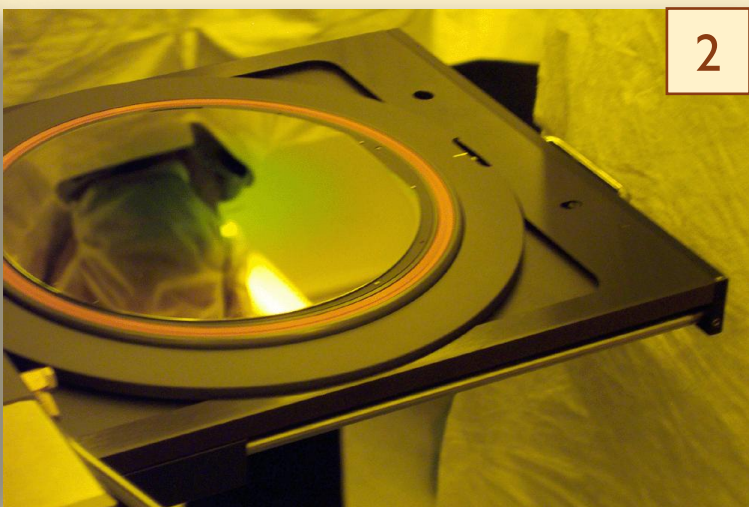
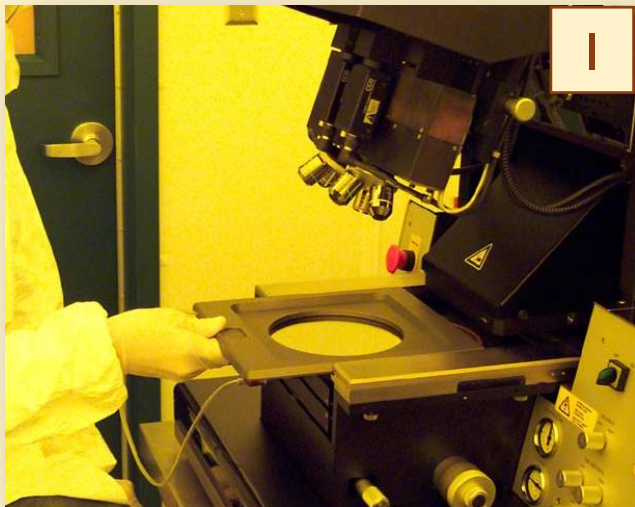
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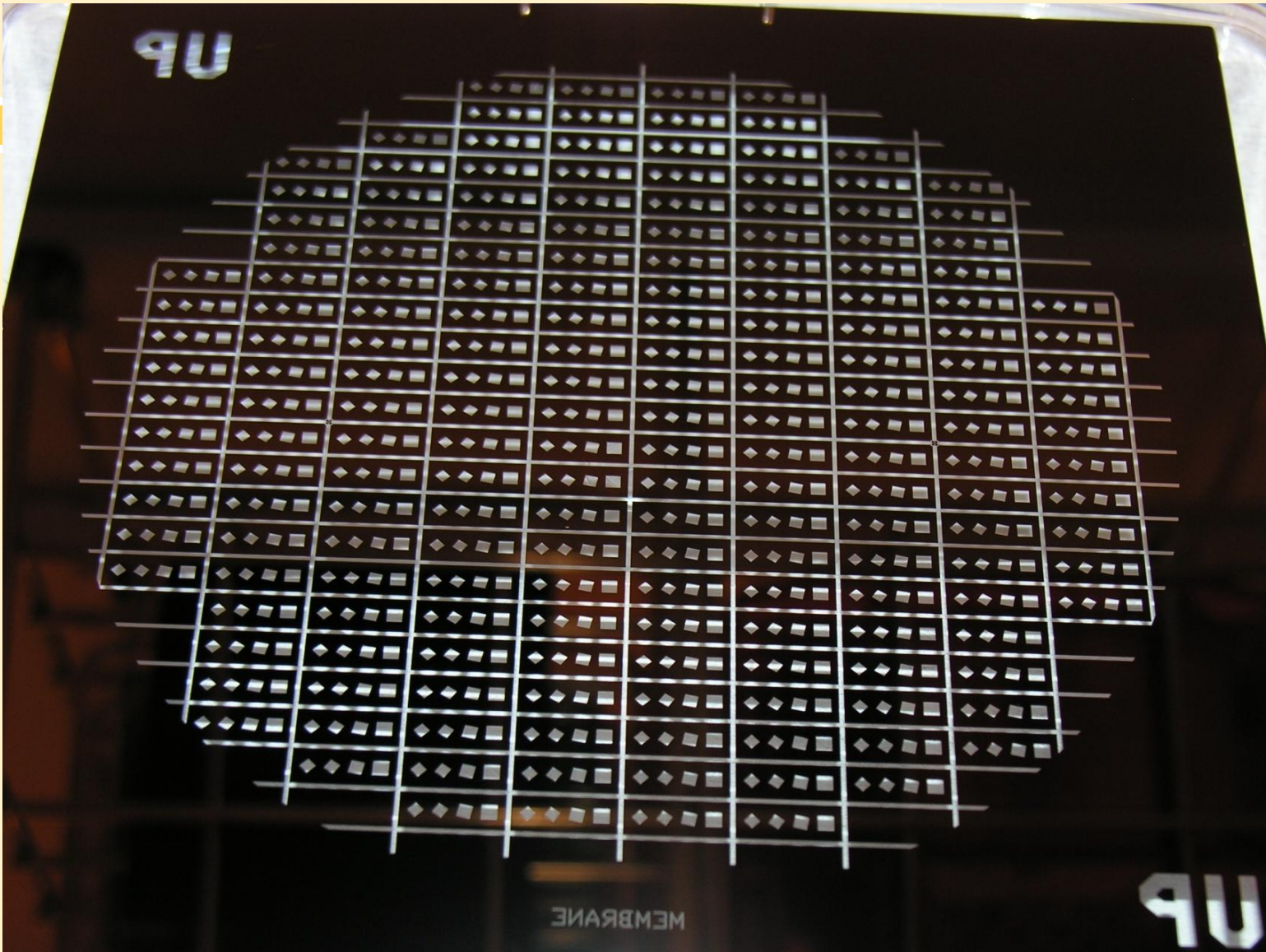
Expose Parameters:

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- 2. Load Wafer Into Karl Suss Contact Aligner
- 3. Expose wafer to UV light for approximately **300 seconds**



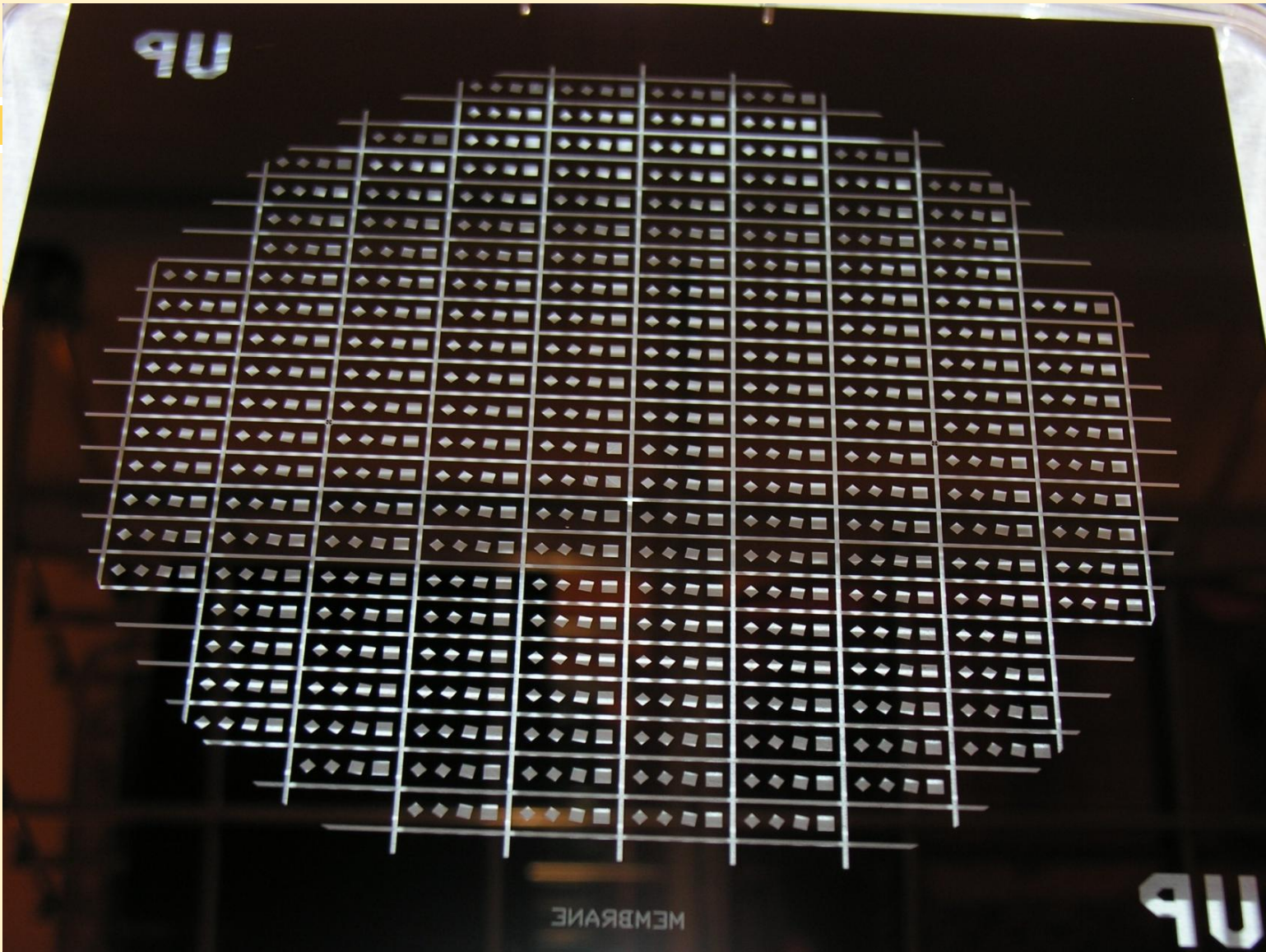
Mask Pattern





Dark Field Membrane Mask

Step 3b



Dark Field Membrane Mask

Step 3b

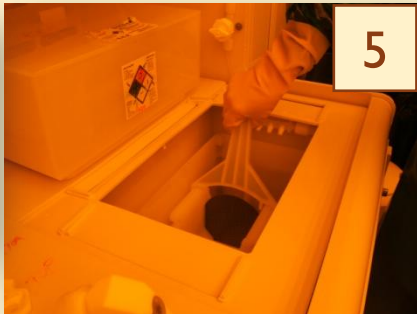
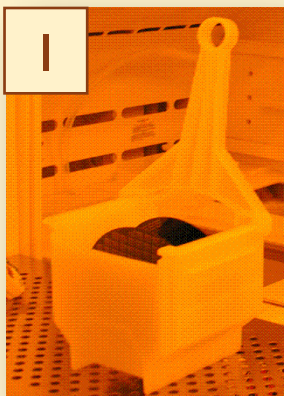
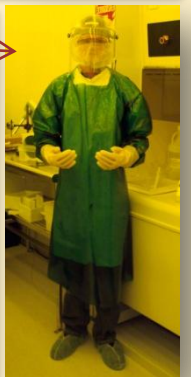
Backside Photolithography - Develop

Process Description:

Develops the exposed photoresist to open the windows and expose the silicon for a subsequent etch. The develop solution uses a small amount of Potassium Hydroxide (KOH).

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 (1:3 concentration of KOH/deionized water) into container and insert boat so entire wafer is submerged
3. Allow wafers to develop for **15 minutes**
4. Remove boat from develop solution at a 45° angle to allow excess mixture to drip off
5. Place in QDR (Quick Dump Rinse) and Rinse 5X
6. Remove at 45° angle to allow for run-off
7. Place entire boat into SRD (Spin Rinse Dryer) (H-bar in first) until unit reaches **15MΩ**
8. Do a microscopic inspection to check for defects



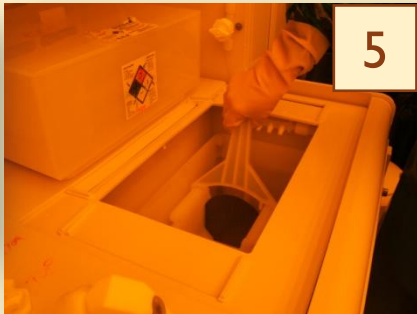
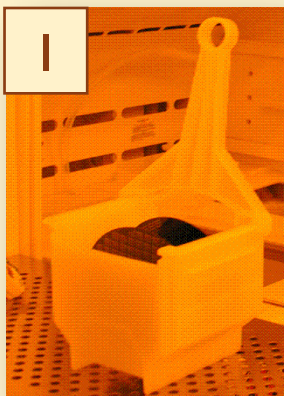
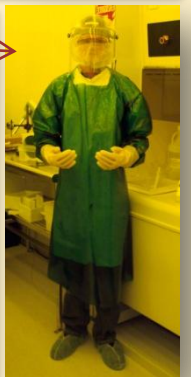
Backside Photolithography - Develop

Process Description:

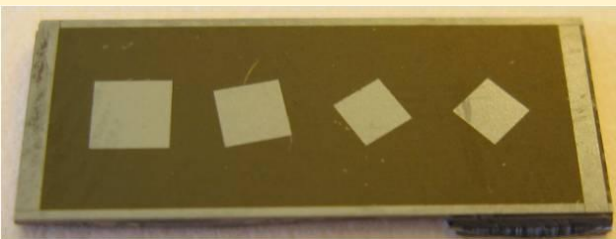
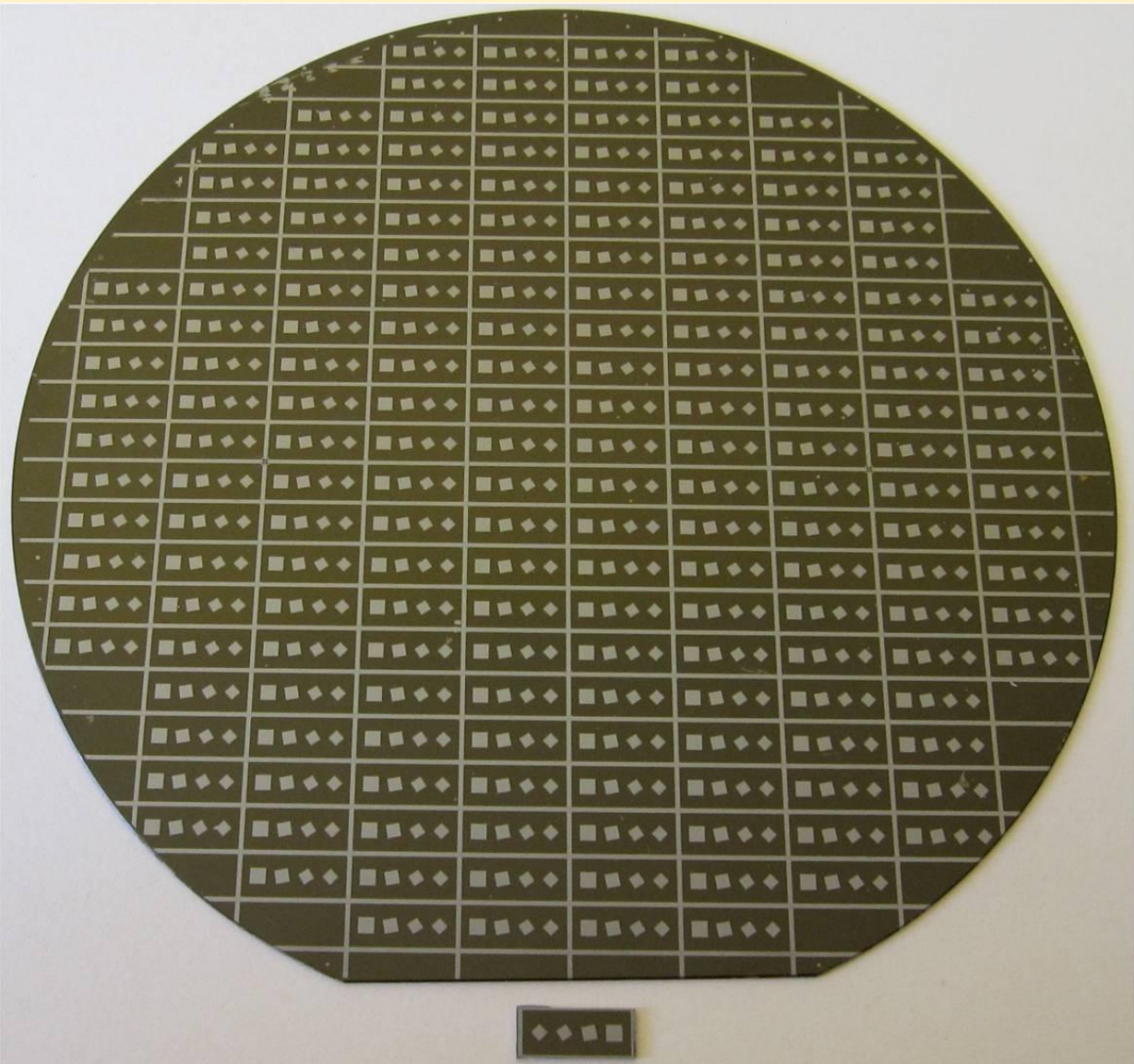
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Develop Parameters: Performed at Caustic Wet Bench, USE ACID GEAR

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6. Remove at 45° angle to allow for run-off
7. Place entire boat into SRD (Spin Rinse Dryer) (H-bar in first) until unit reaches **15MΩ**
8. Do a microscopic inspection to check for defects

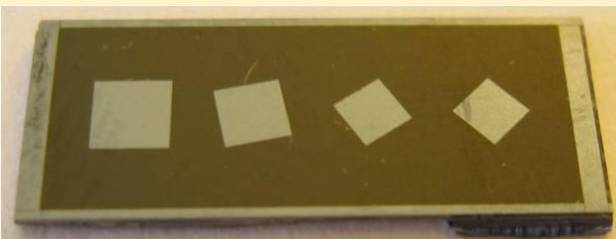
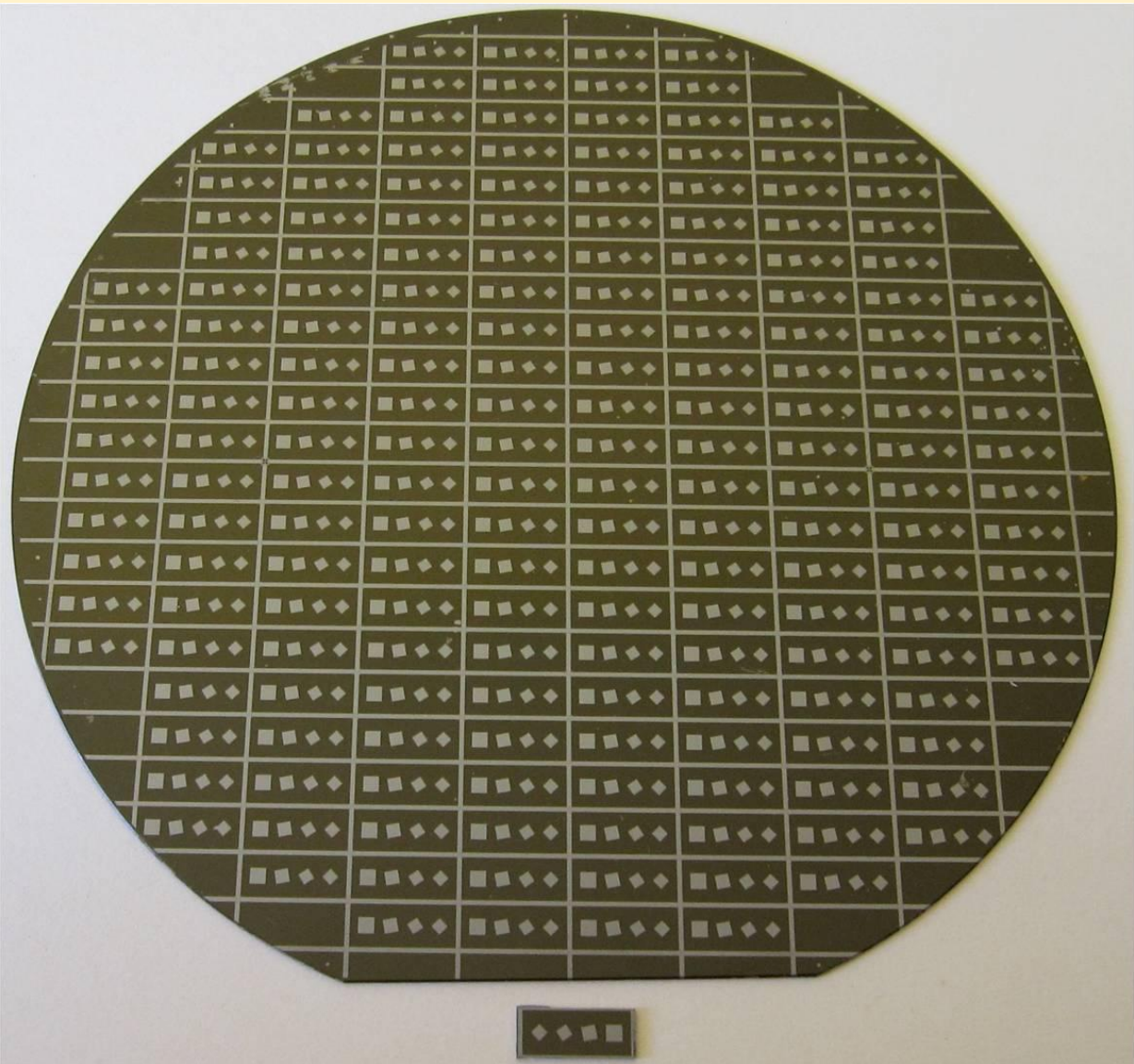


Backside Photolithography - Develop



Step 3c

Backside Photolithography - Develop



Step 3c

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 uses 13.56 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 Etch – RIE

Process Description:

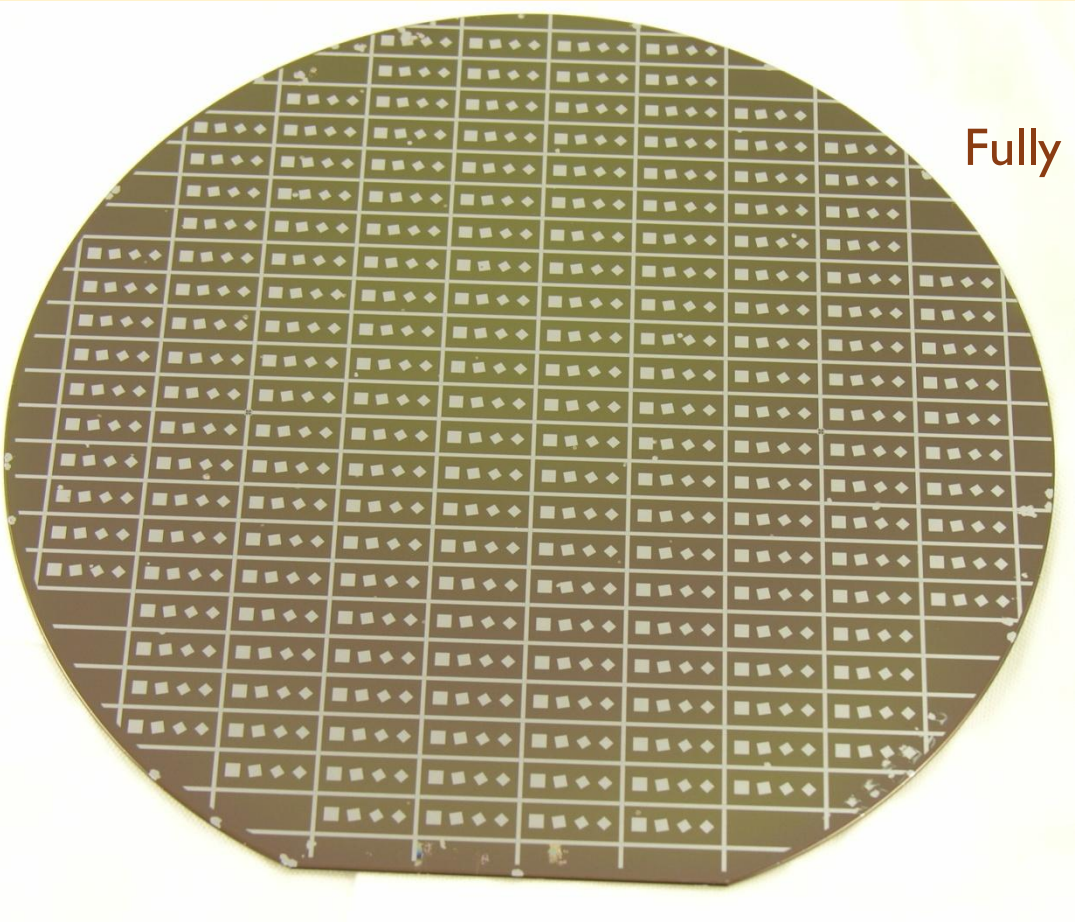
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RIE Parameters:

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



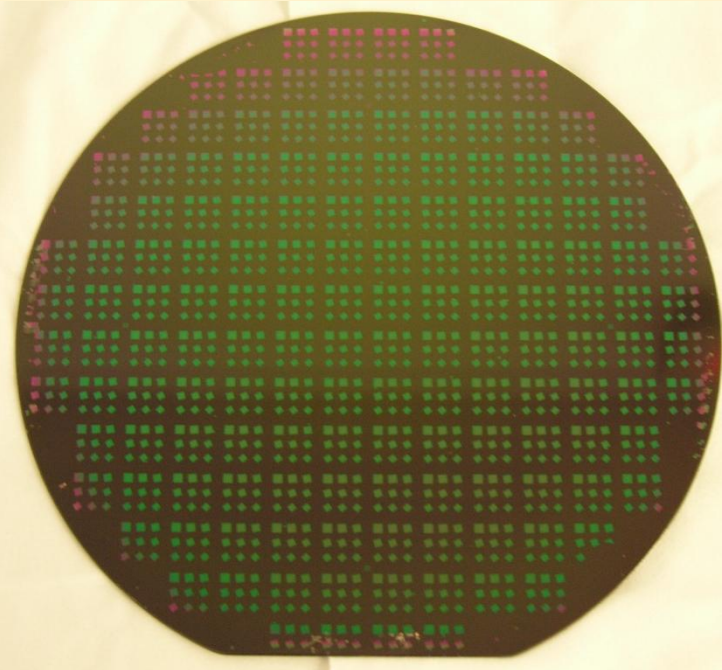
Backside Etch – RIE



Fully Etched

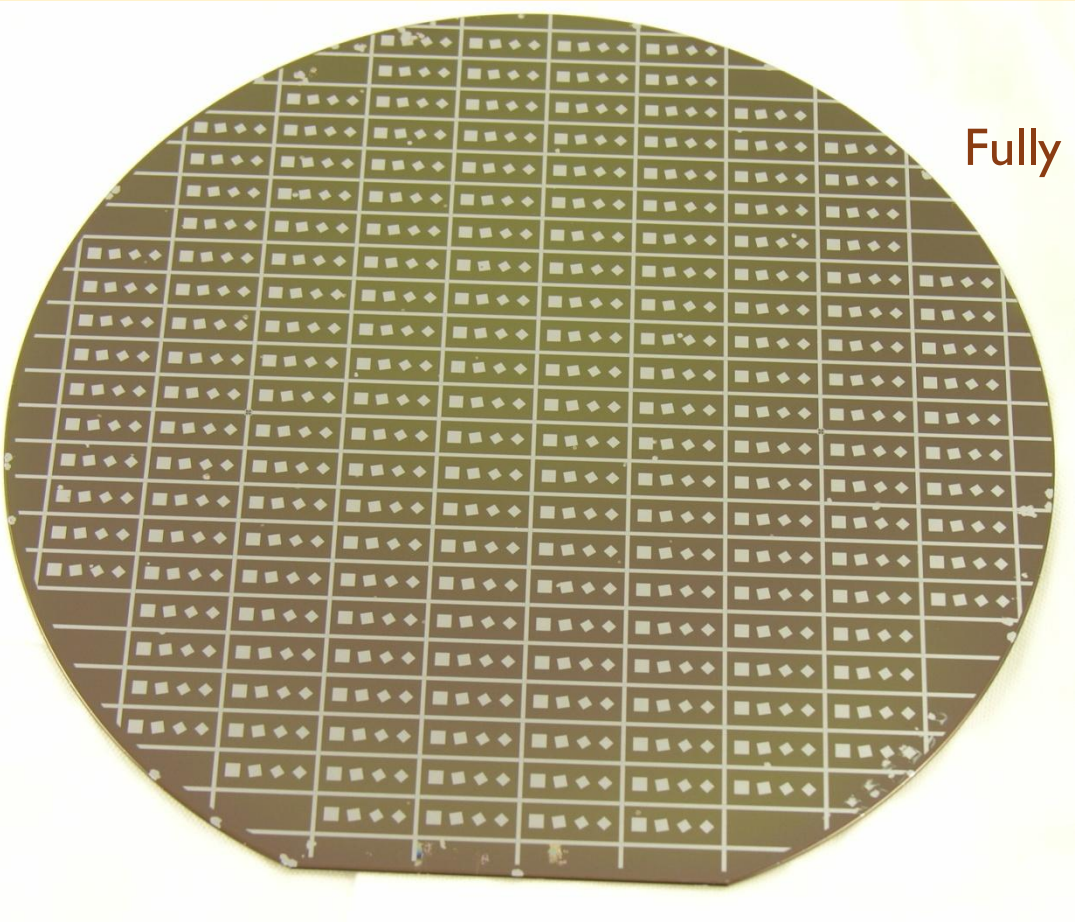


Partially Etched



Step 4

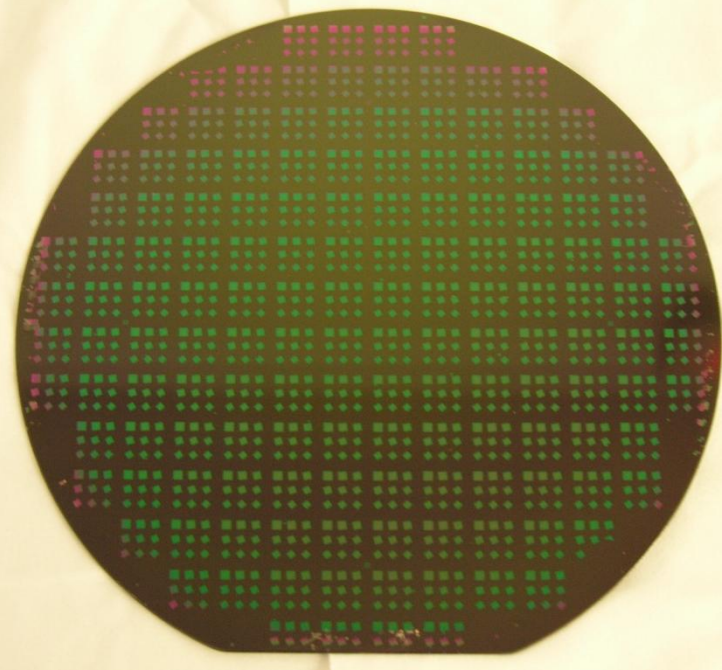
Backside Etch – RIE



Fully Etched



Partially Etched



Step 4

Backside Photoresist Strip

Process Description:

The wafers are now placed in a Piranha bath. Piranha refers to the 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**



Backside Photoresist Strip

Process Description:

The wafers are now placed in a Piranha bath. Piranha refers to the 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

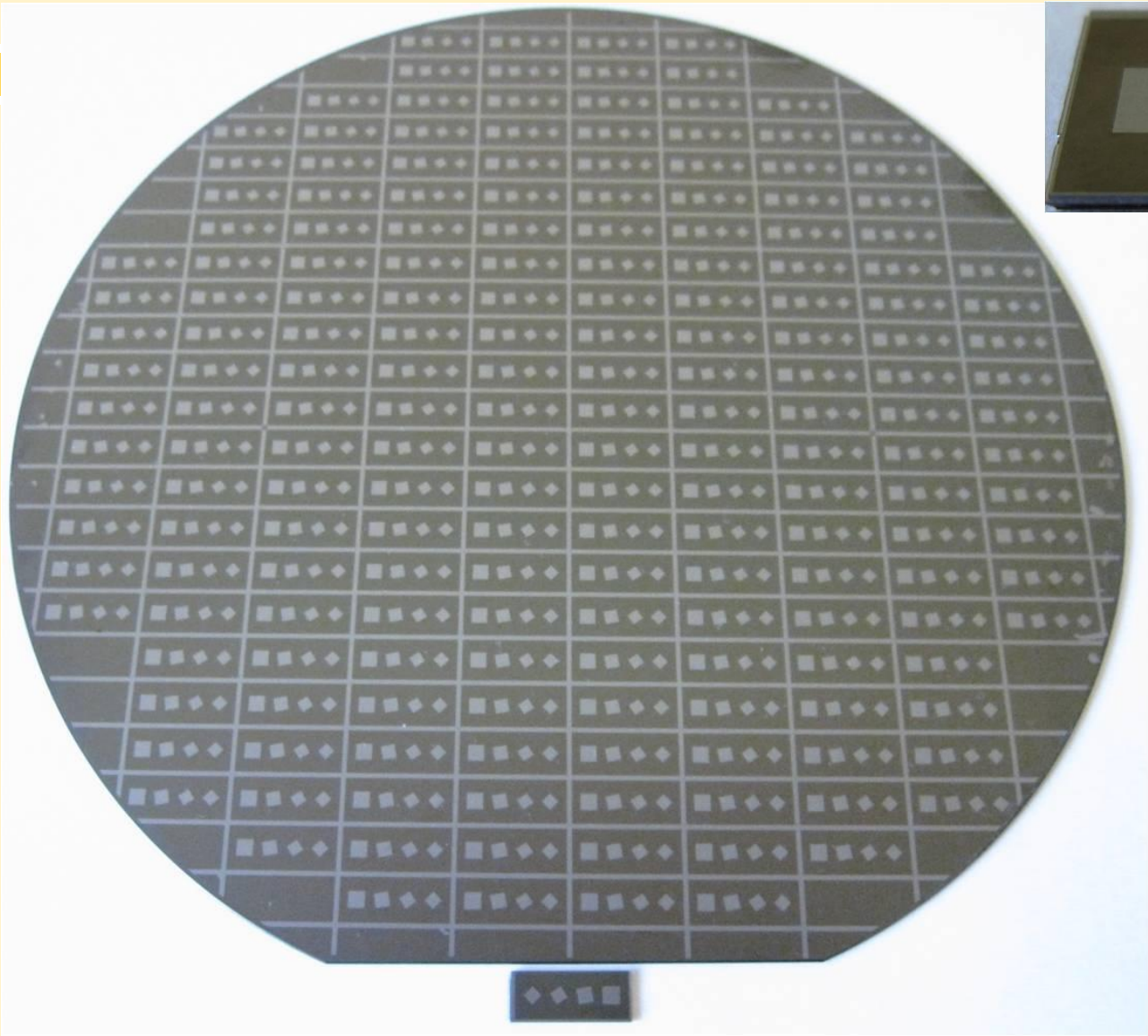
Always add Peroxide to the Acid!!!!

Chemicals Used: H_2SO_4 / H_2O_2

Process Time: **15 minutes**

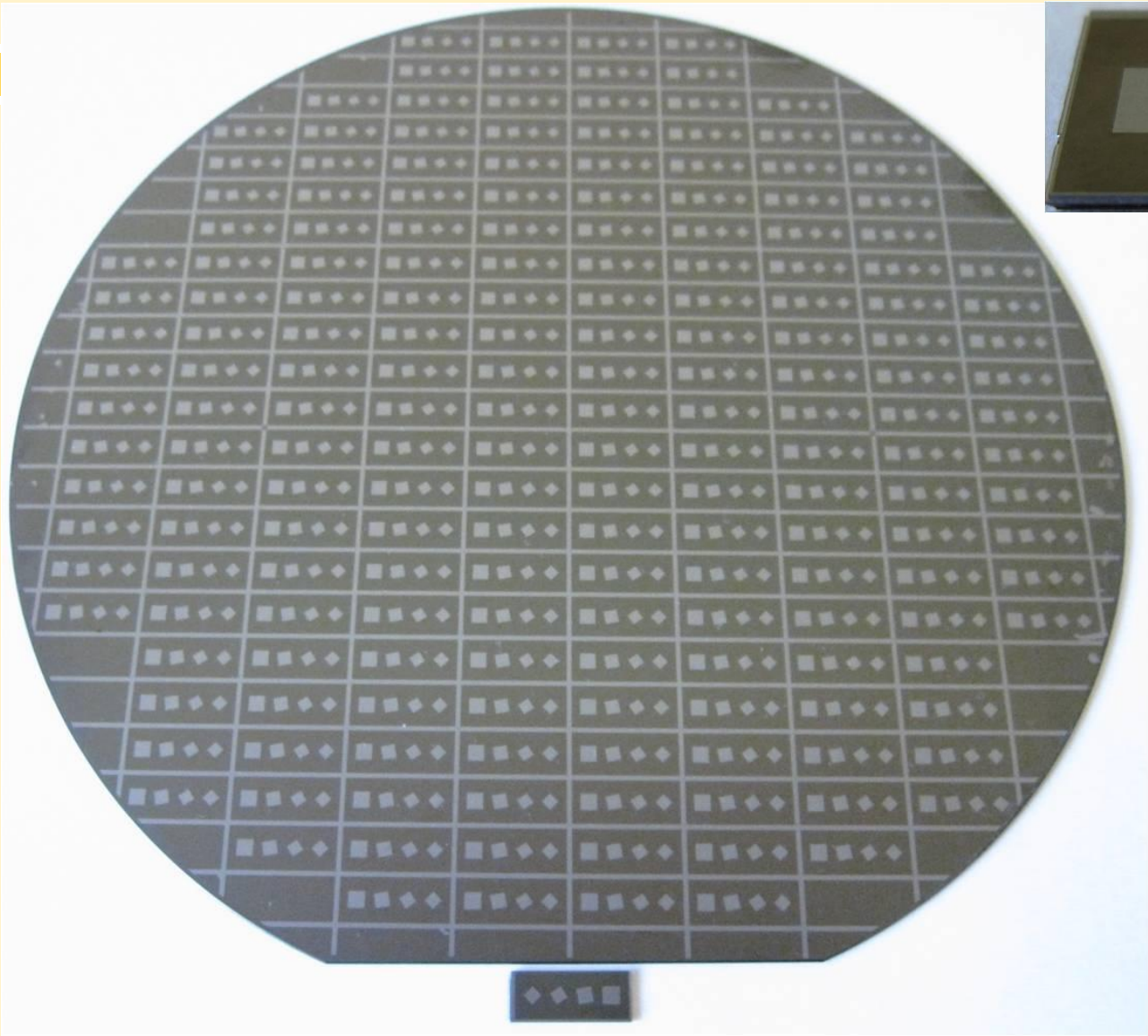


Backside Photoresist Strip



Step 5

Backside Photoresist Strip



Step 5

Frontside Photolithography - Coat

Process Description:

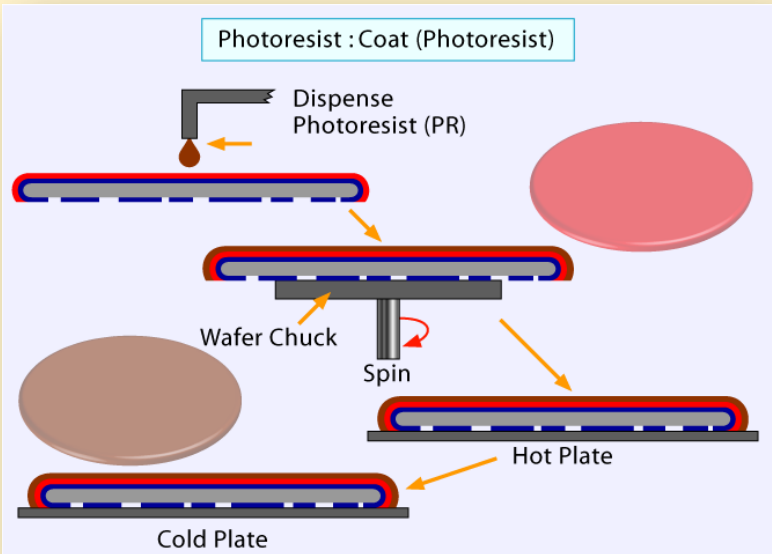
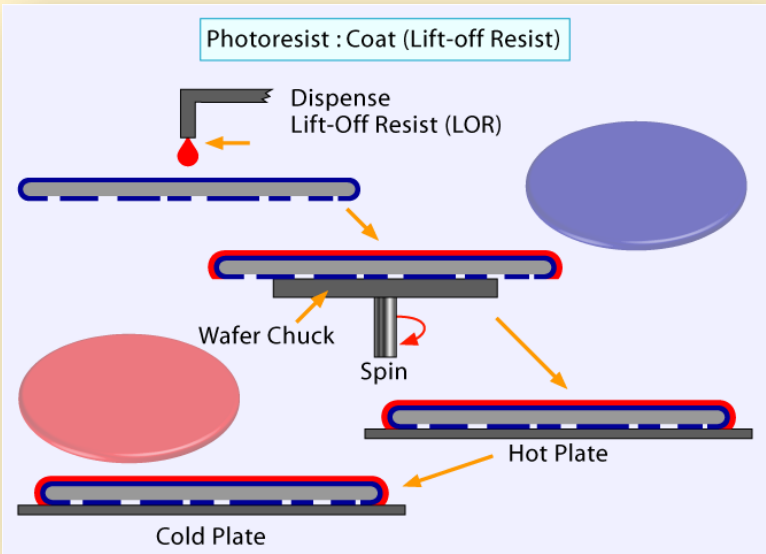
The next step in the process is to pattern the frontside of the wafer with the Wheatstone Bridge pattern. In this step, a lift-off resist is applied to create a desired undercutting during the develop process.

Frontside Coat Parameters:

- 1. Carefully align and center wafer on vacuum chuck –Visually check for misalignment
- 2. Dispense Lift off Resist (LOR) w/pipette and spin
- 3. Bake wafer for **2 minutes at 190°C** to cure and remove solvents
- 4. Cool wafer on metal table to bring wafer back to room temp

- 5. Carefully align and center wafer on vacuum chuck – Visually check for misalignment
- 6. Dispense photoresist (AZ5214) w/pipette and spin
- 7. Bake wafer for **2 minutes at 100°C** to cure and remove solvents
- 8. Cool wafer on metal table

Chemicals Used: LOR, HMDS, Photoresist



Frontside Photolithography - Coat

Process Description:

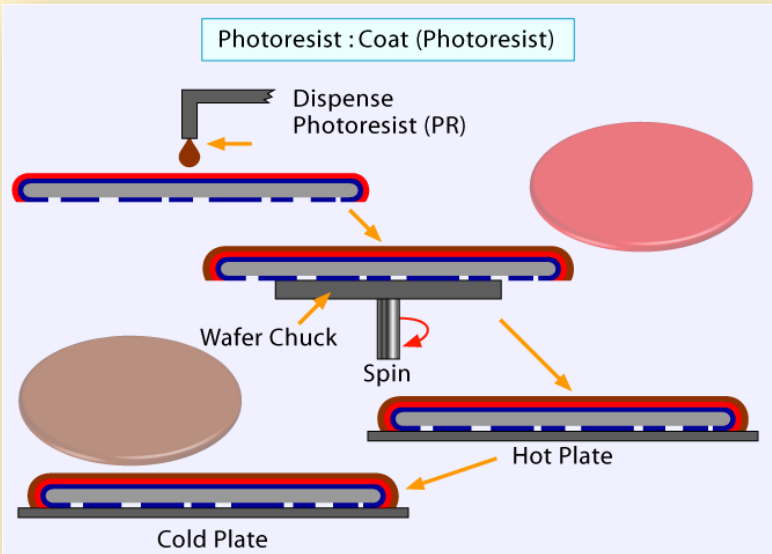
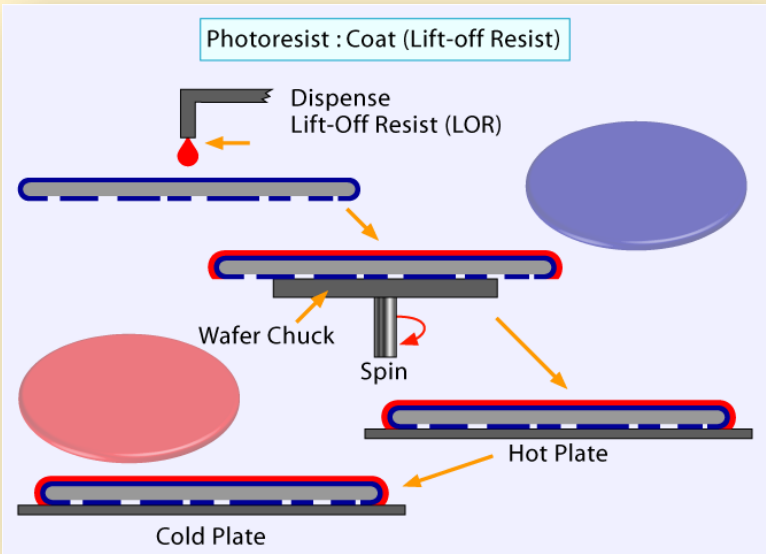
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Frontside Coat Parameters:

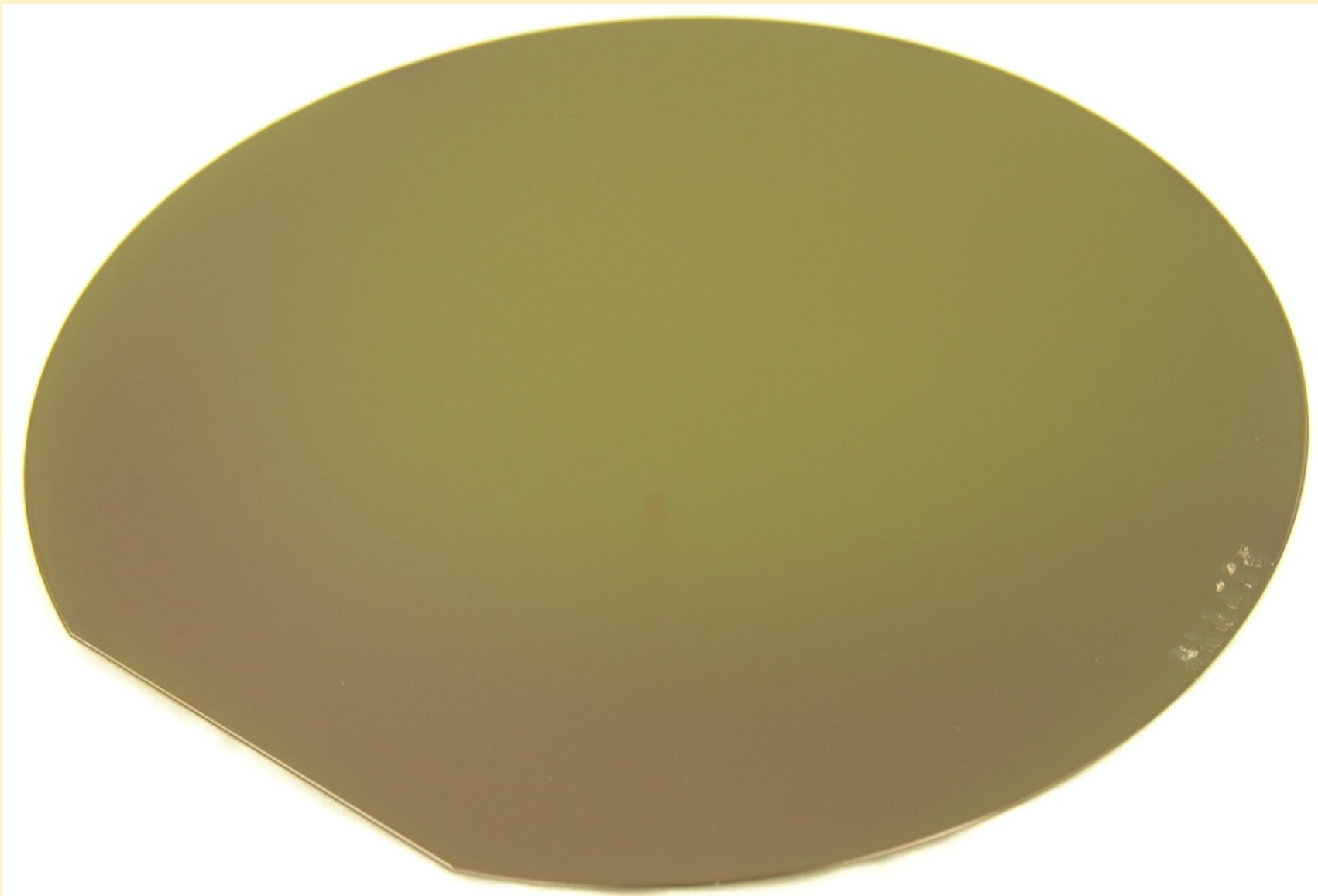
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- 3. Bake wafer for **2 minutes at 190°C** to cure and remove solvents
- 4. Cool wafer on metal table to bring wafer back to room temp

- 5. Carefully align and center wafer on vacuum chuck – Visually check for misalignment
- 6. Dispense photoresist (AZ5214) w/pipette and spin
- 7. Bake wafer for **2 minutes at 100°C** to cure and remove solvents
- 8. Cool wafer on metal table

Chemicals Used: LOR, HMDS, Photoresist



Frontside Photolithography - Coat



Step 6a

Frontside Photolithography - Coat



Step 6a

Frontside Photolithography - Expose

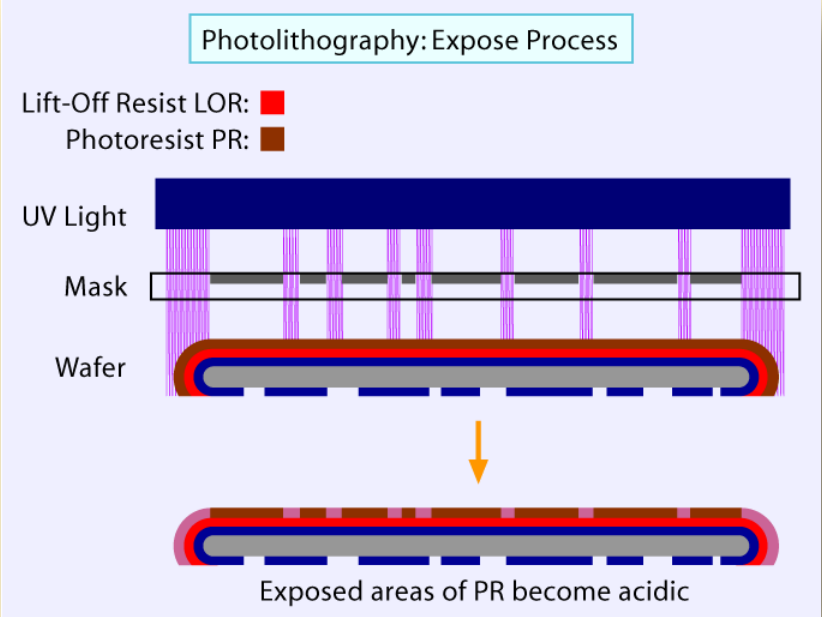
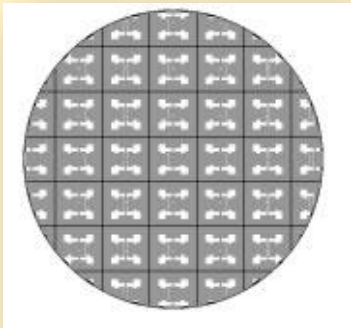
Process Description:

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 - Expose

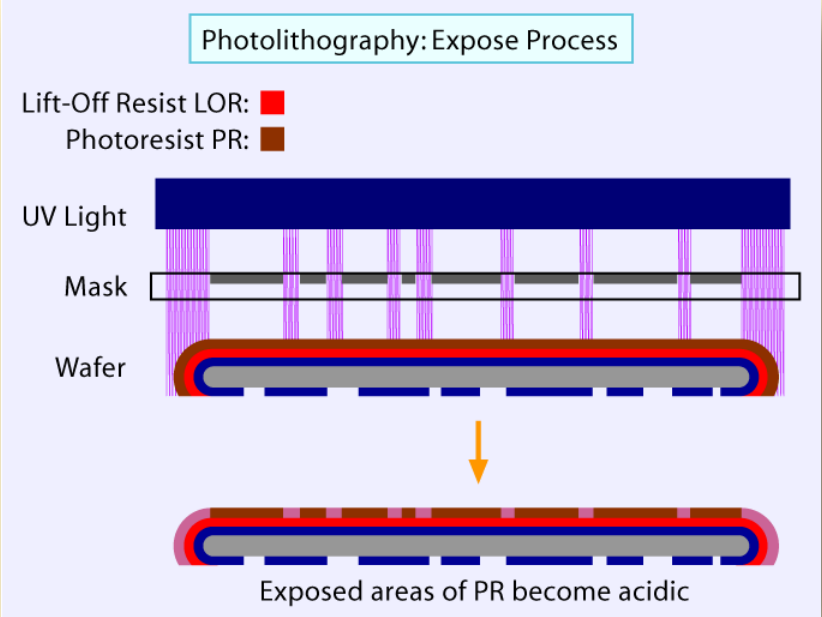
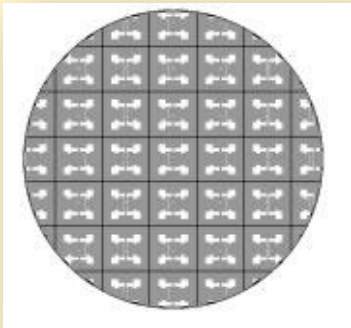
Process Description:

Exposes the Wheatstone Bridge circuit pattern.

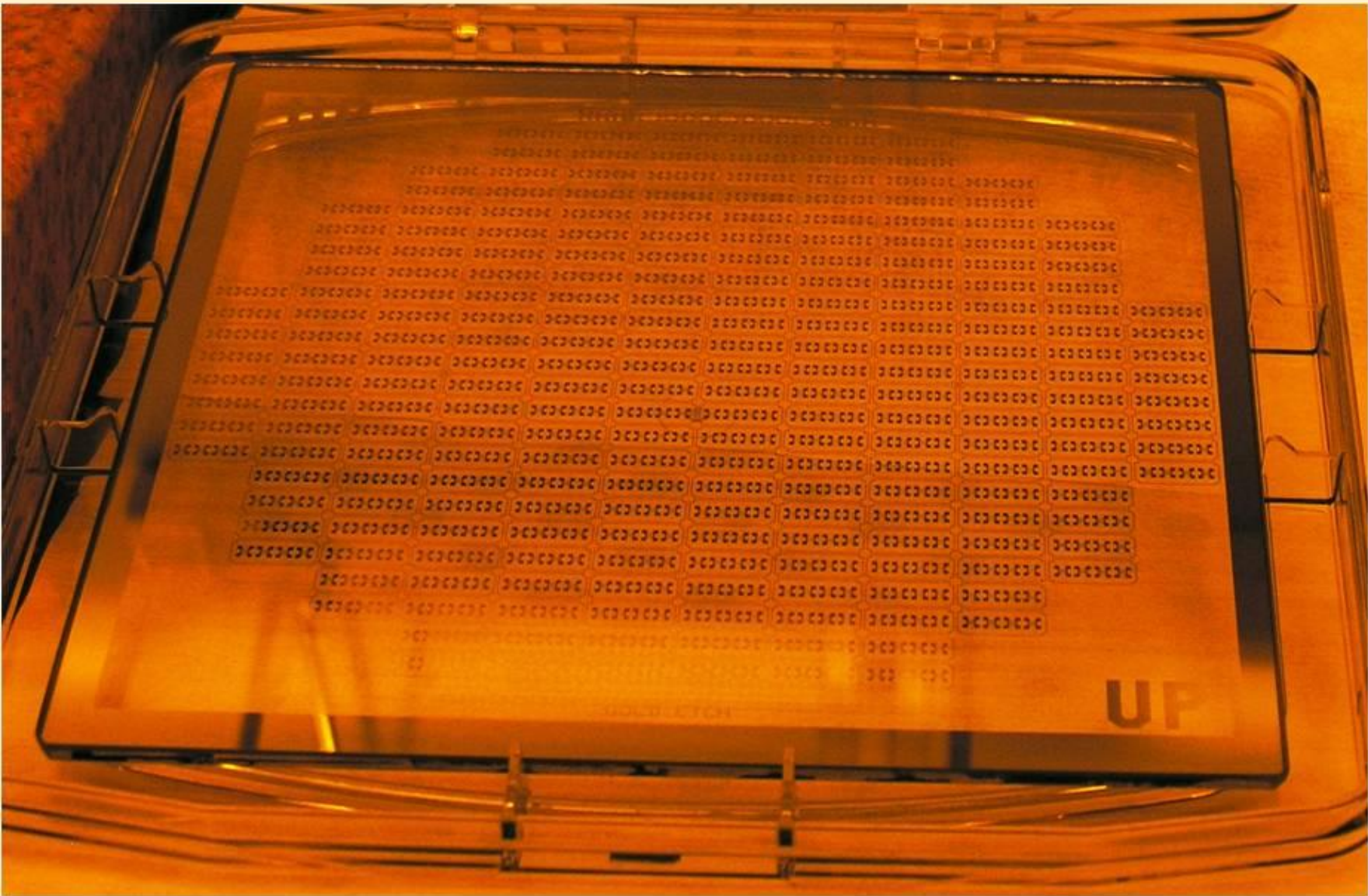
Frontside Expose Description & Parameters:

- 1. Load Mask Into Holding Tray and slide the tray into the Karl Suss alignment system
- 2. Load Wafer Into Karl Suss Contact Aligner
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Mask Pattern

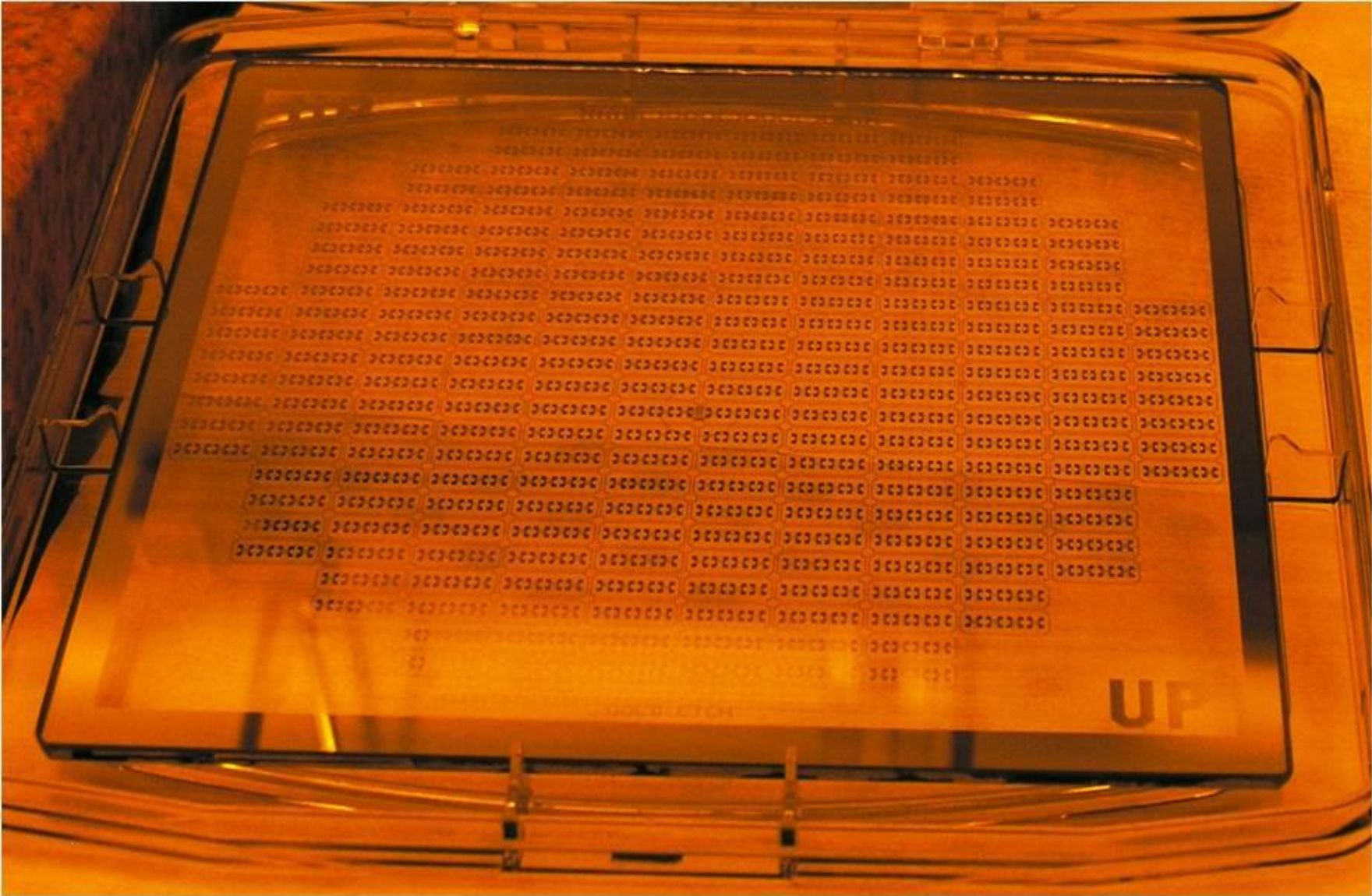


Frontside Photolithography - Expose



Step 6b

Frontside Photolithography - Expose



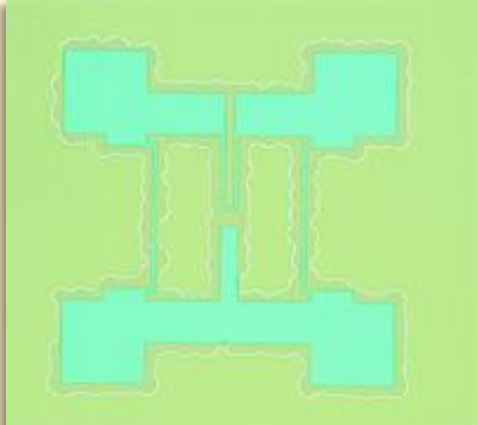
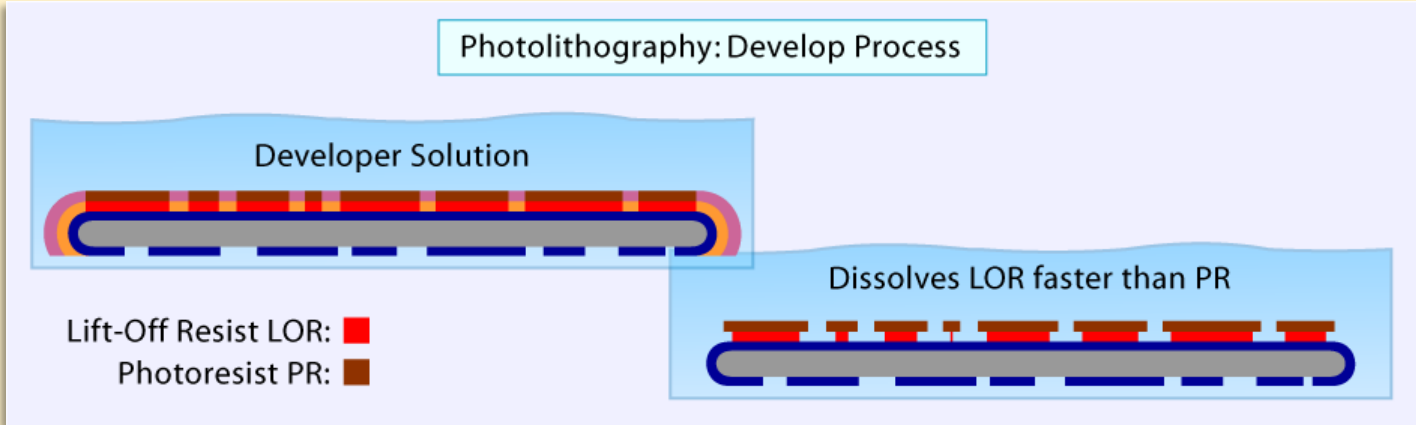
Step 6b

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 in last slot of white Teflon boat (closest to H bar)
- 2. Pour develop solution (1:5 concentration of KOH/DI Water) into container. Insert boat so entire wafer is submerged
- 3. Allow wafers to develop for **60 seconds**
- 4. Remove boat from develop solution at a 45° angle to allow the solution to drain off without splashing
- 5. Place in QDR (Quick Dump Rinse) and Rinse, repeat this 5 times
- 6. Remove at 45° angle to allow for smooth run off
- 7. Place entire boat into SRD (Spin Rinse Dryer) until unit indicates **15MΩ** rinse water resistivity
- 8. Perform a microscopic inspection to check for defects



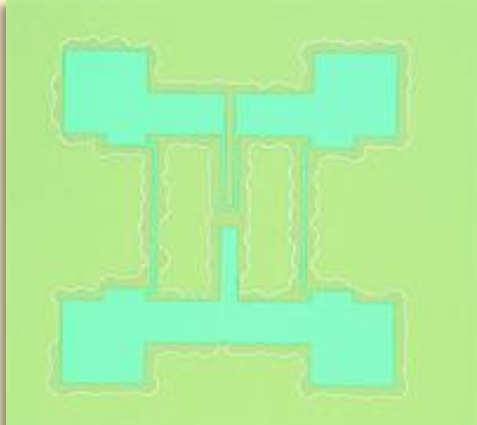
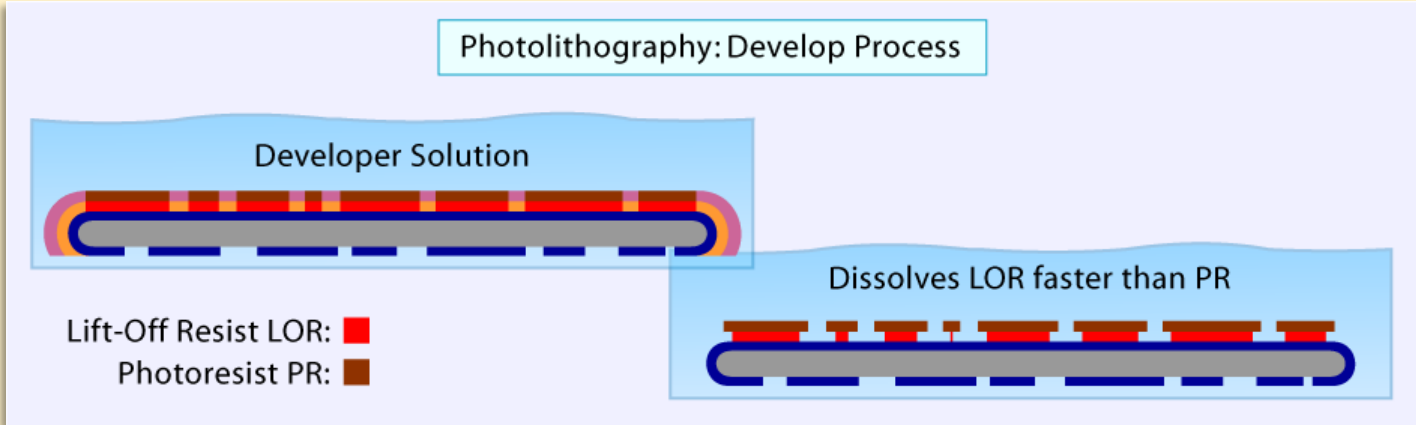
Bad LOR Develop

Frontside Photolithography - Develop

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

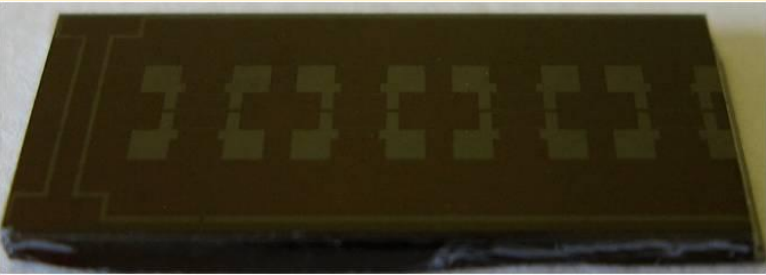
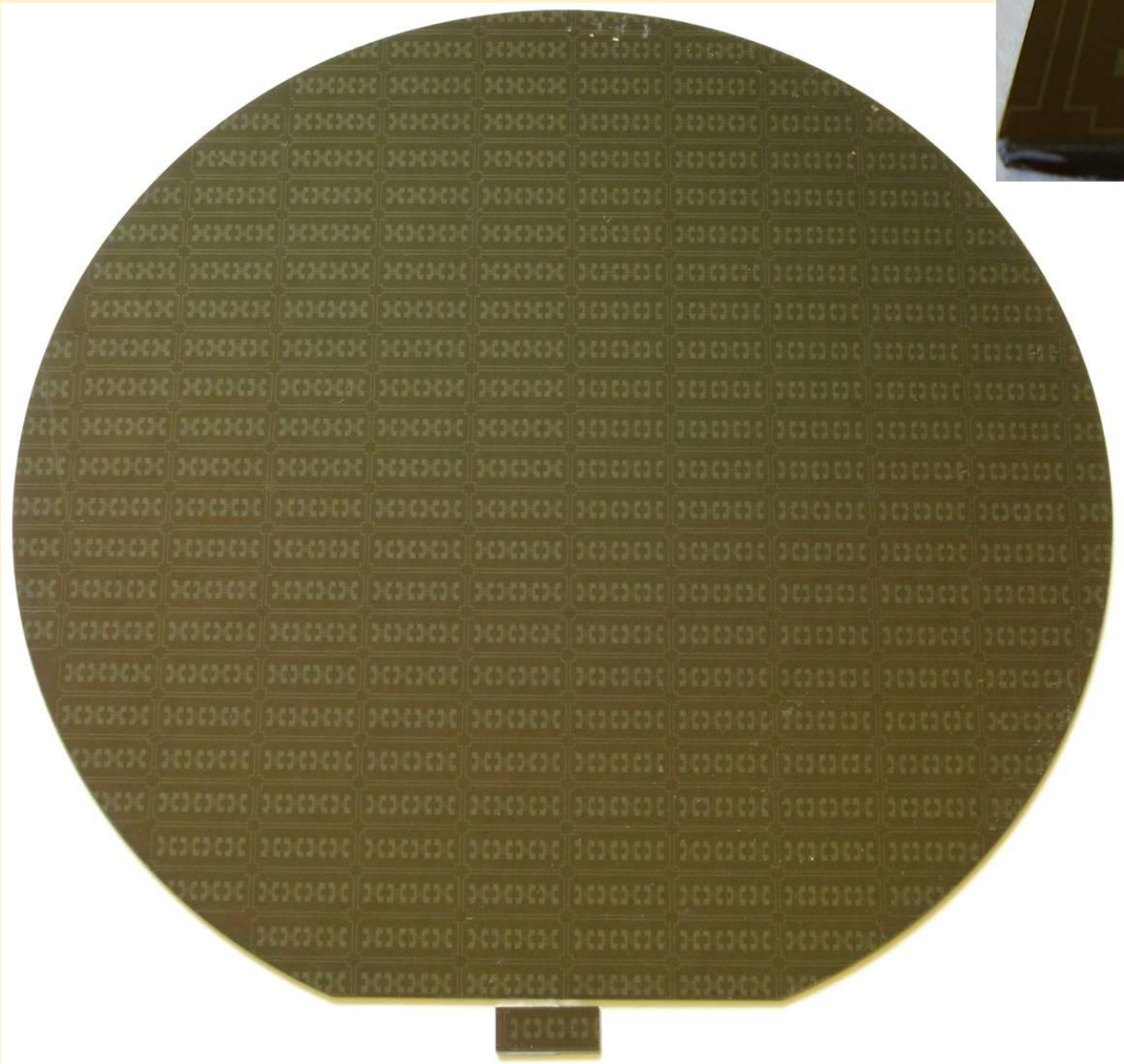
Frontside Develop Parameters: Performed at Caustic Wet Bench, USE ACID GEAR PPE

- 1. Place exposed wafer in last slot of white Teflon boat (closest to H bar)
- 2. Pour develop solution (1:5 concentration of KOH/DI Water) into container. Insert boat so entire wafer is submerged
- 3. Allow wafers to develop for **60 seconds**
- 4. Remove boat from develop solution at a 45° angle to allow the solution to drain off without splashing
- 5. Place in QDR (Quick Dump Rinse) and Rinse, repeat this 5 times
- 6. Remove at 45° angle to allow for smooth run off
- 7. Place entire boat into SRD (Spin Rinse Dryer) until unit indicates **15MΩ** rinse water resistivity
- 8. Perform a microscopic inspection to check for defects



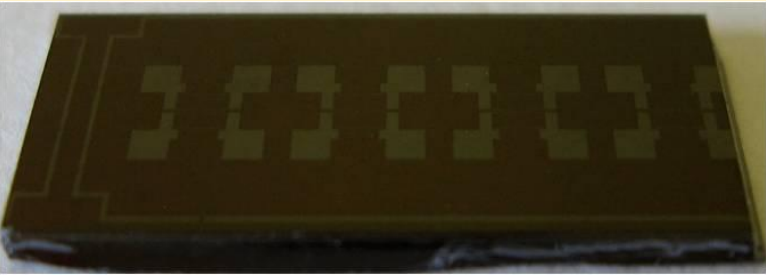
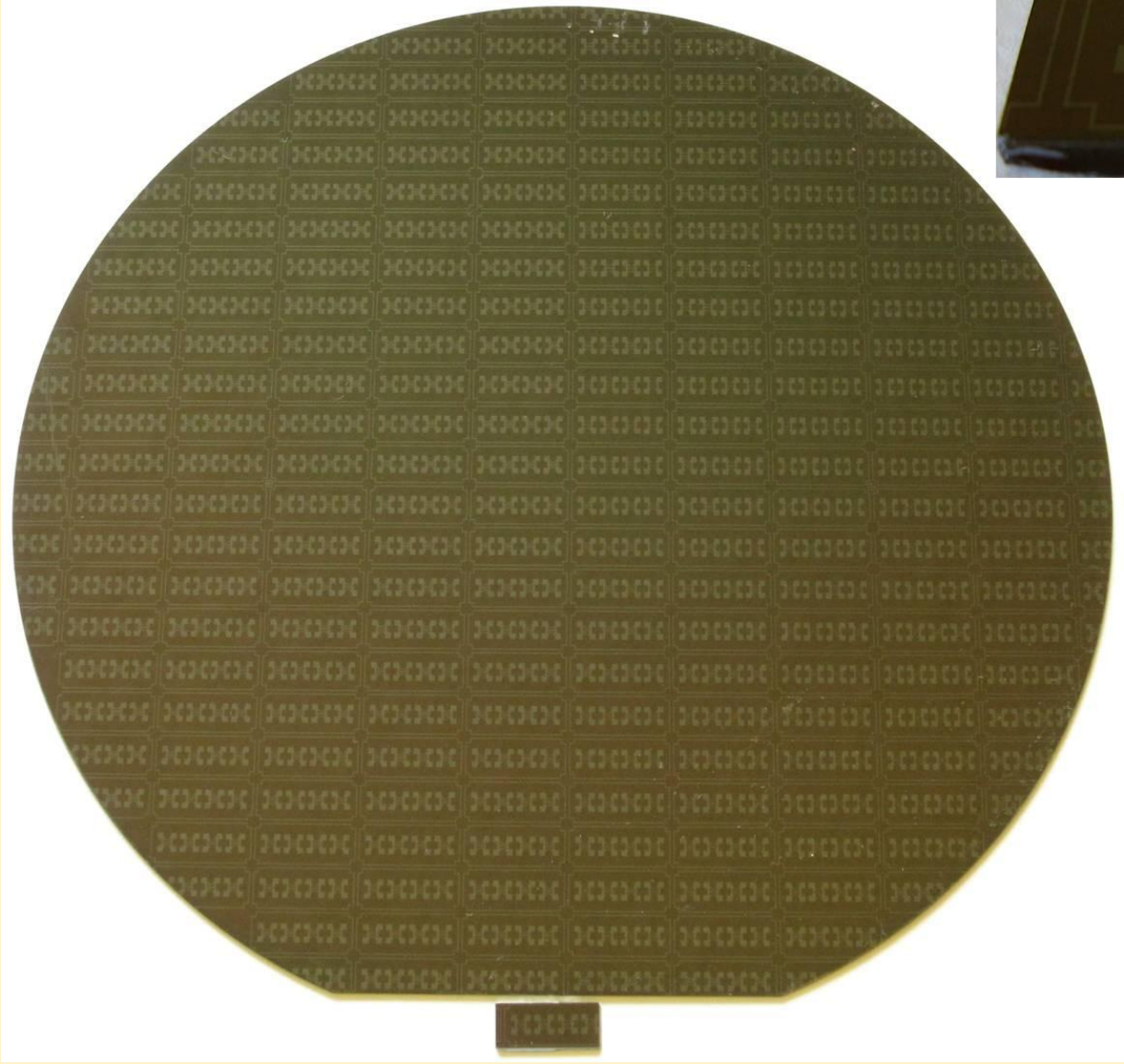
Bad LOR Develop

Frontside Photolithography - Develop



Step 6c

Frontside Photolithography - Develop



Step 6c

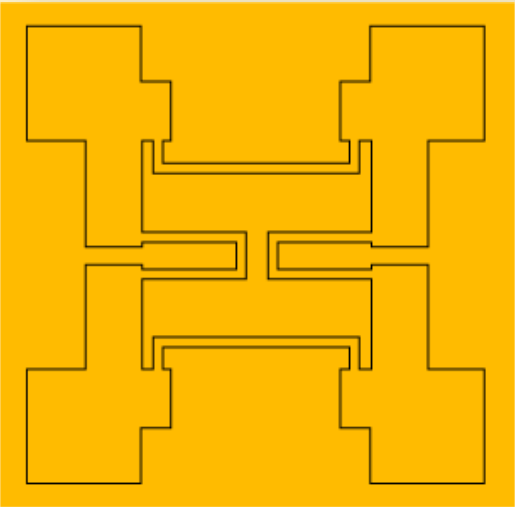
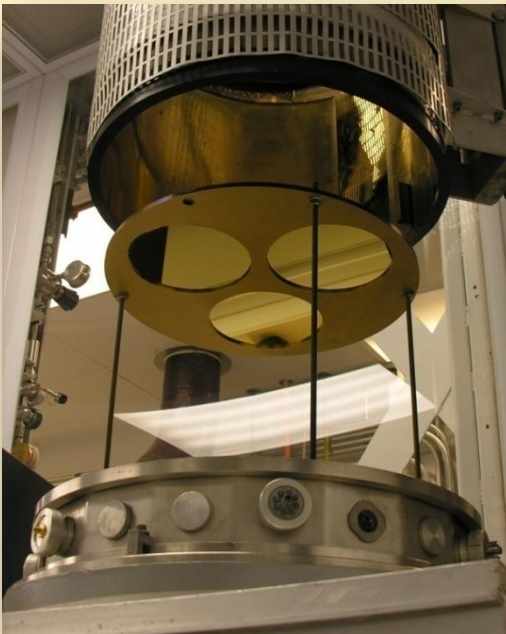
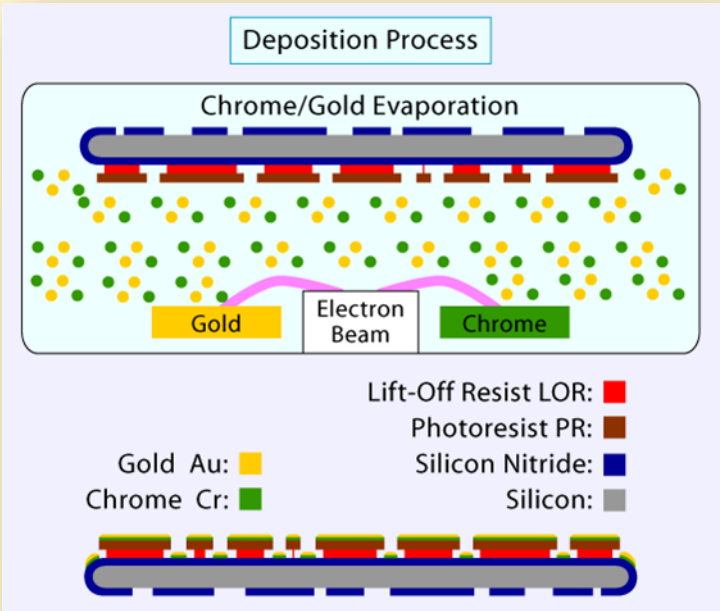
Metal Deposition

Process Description:

A vacuum evaporator is used to deposit 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

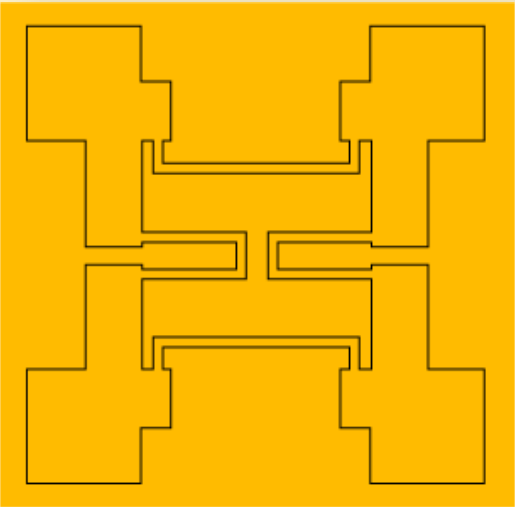
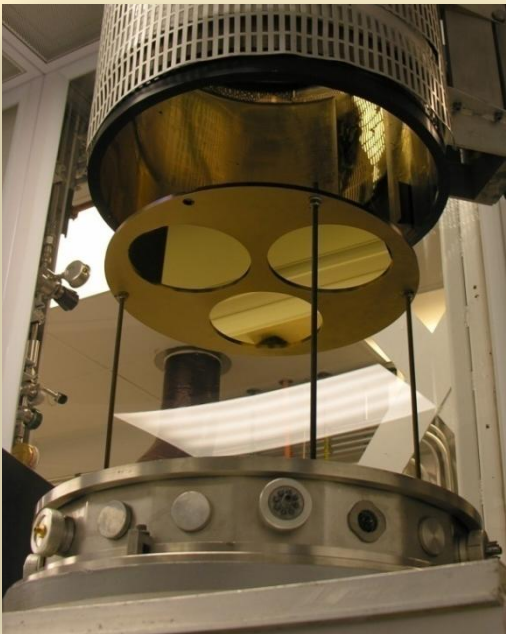
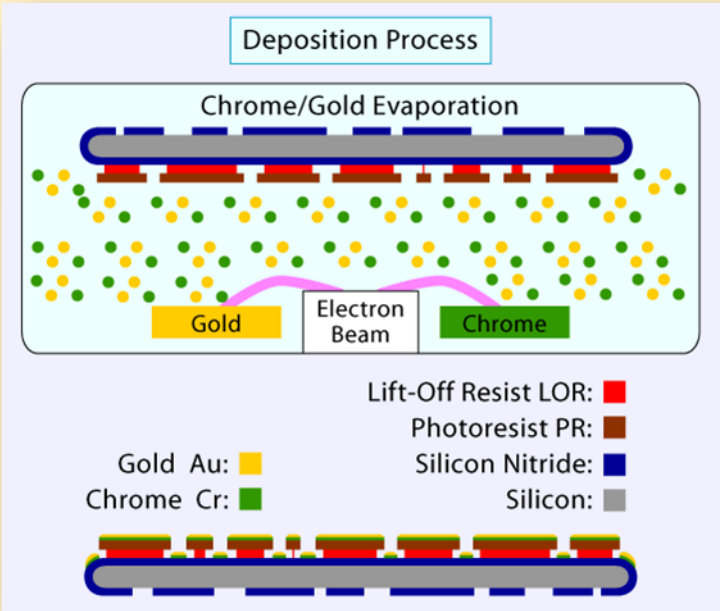
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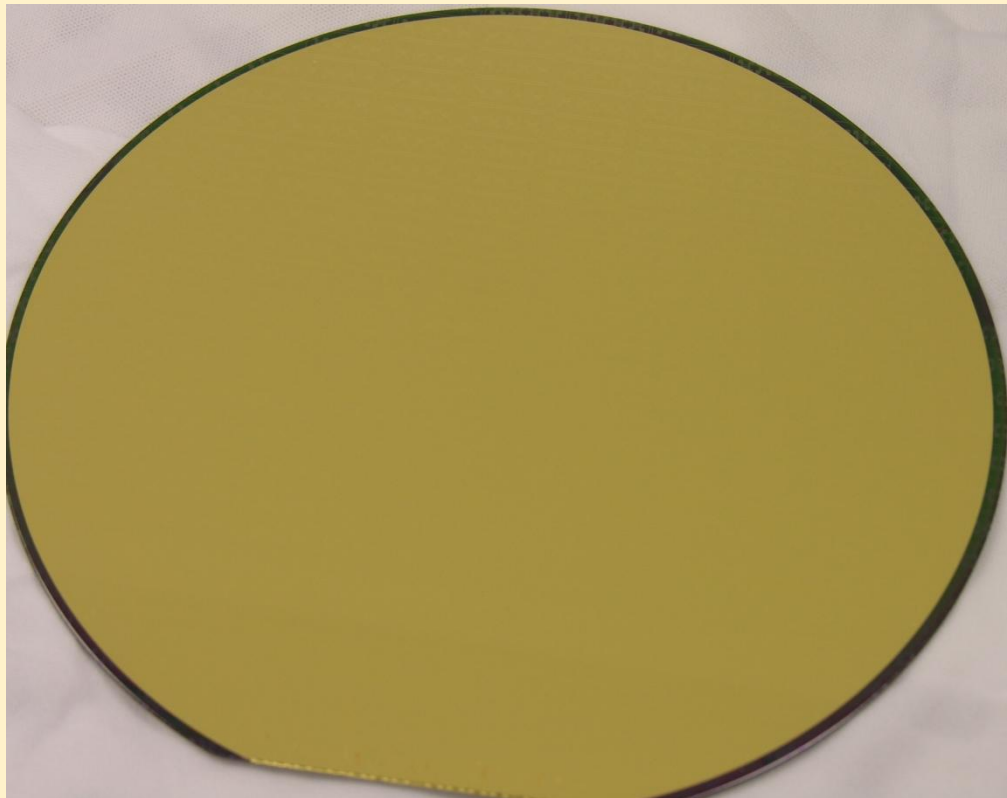
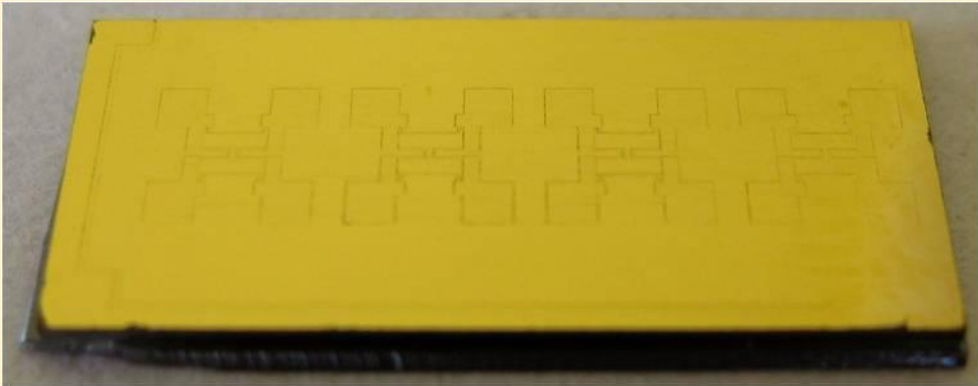
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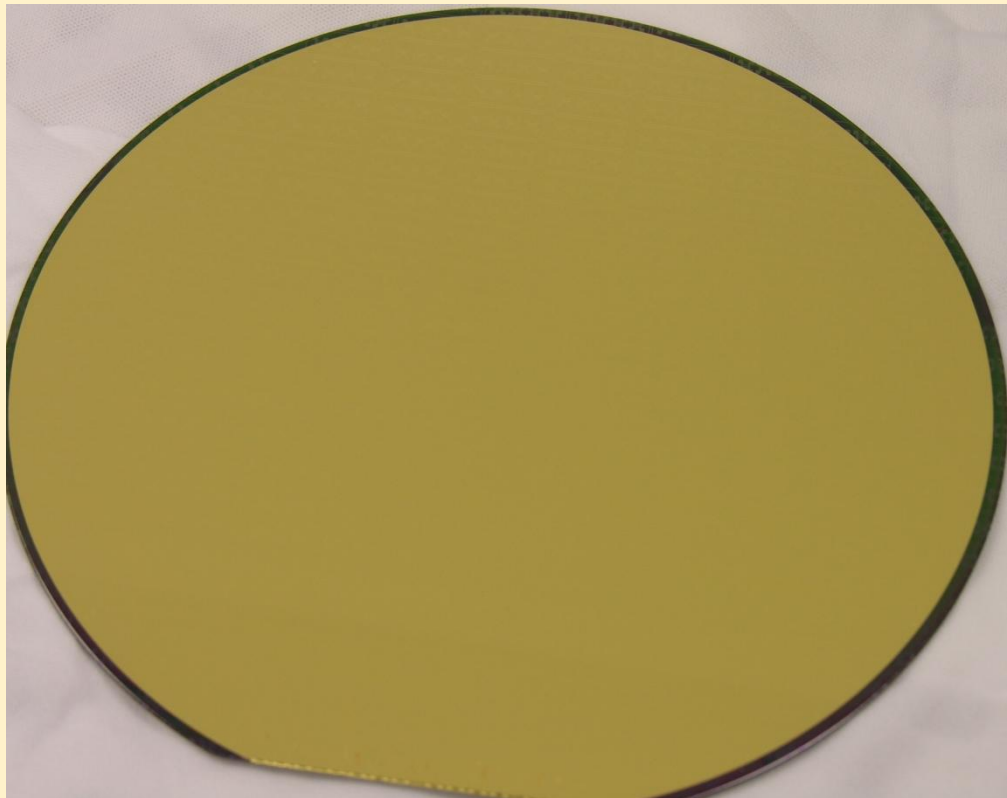
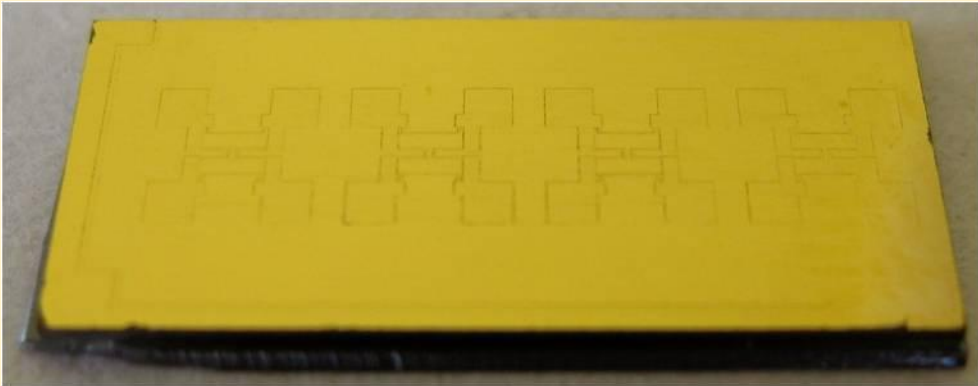
Wheatstone Bridge pattern after metal deposition

Metal Deposition



Step 7

Metal Deposition



Step 7

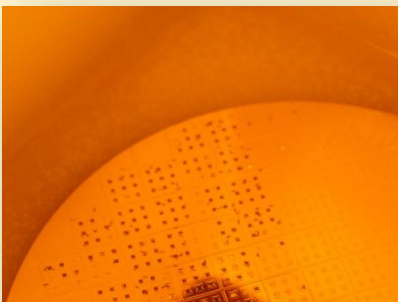
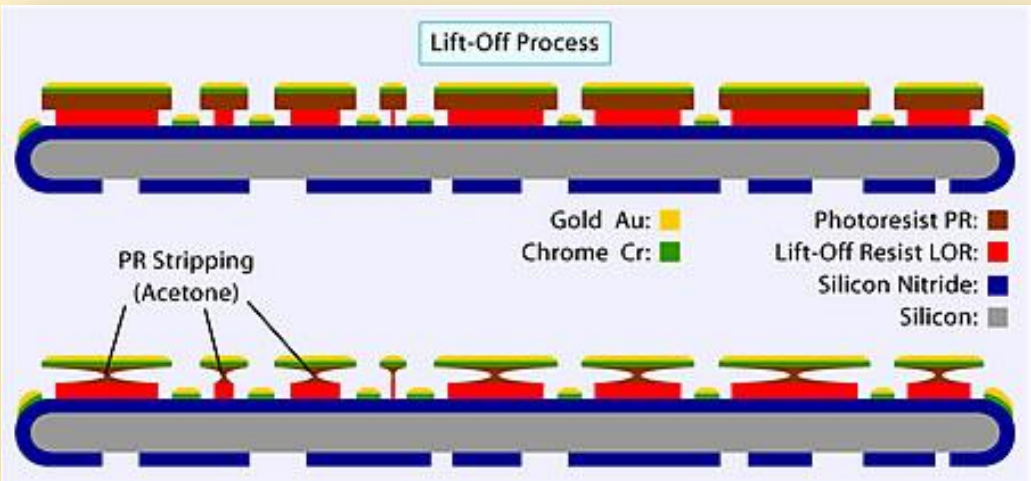
Metal Liftoff

Process Description:

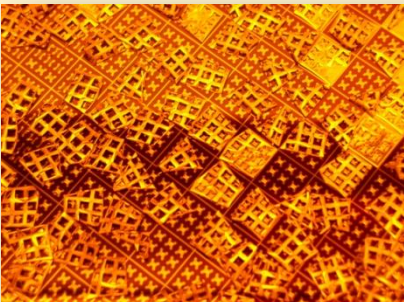
The wafer is soaked in acetone to dissolve the photoresist causing chrome/gold leads to lift off. The wafer must stay wet or the metal may stick randomly to the wafer surface. LOR will remain.

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

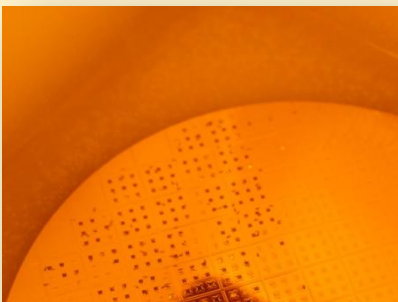
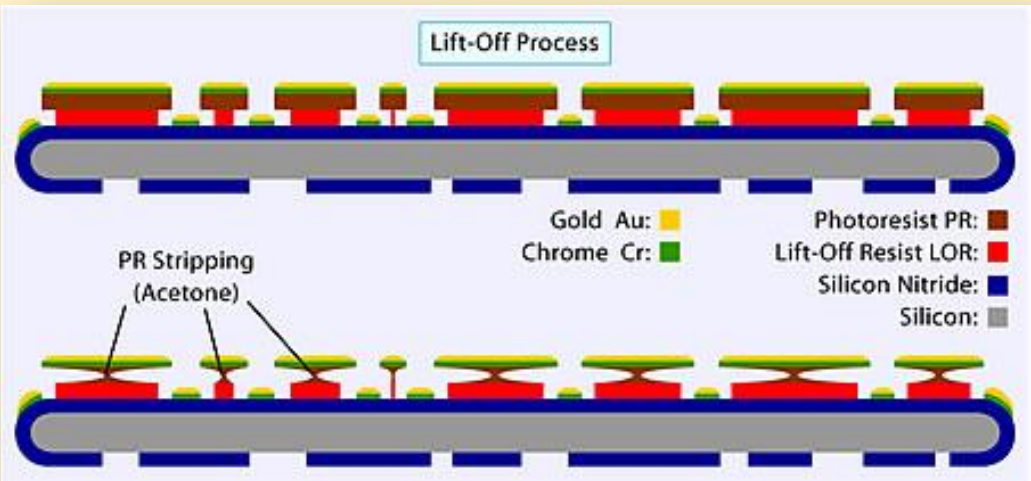
Metal Liftoff

Process Description:

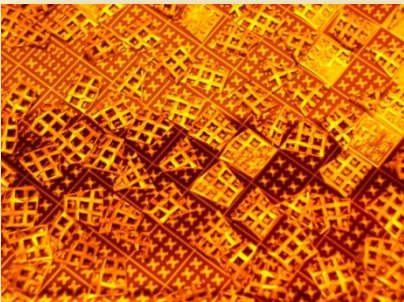
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Process Time: Approximately 30 minutes



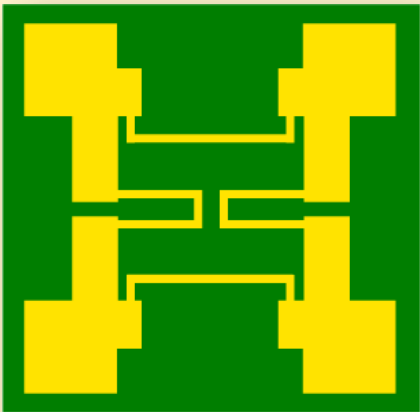
Stage 1: Chrome/Gold beginning to liftoff



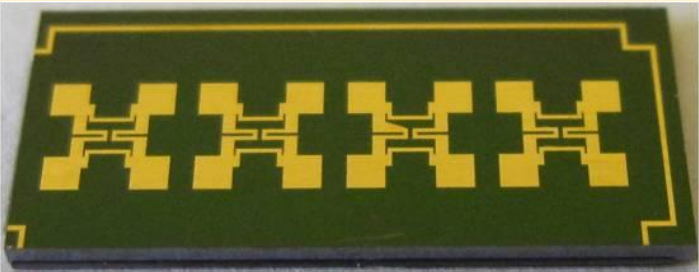
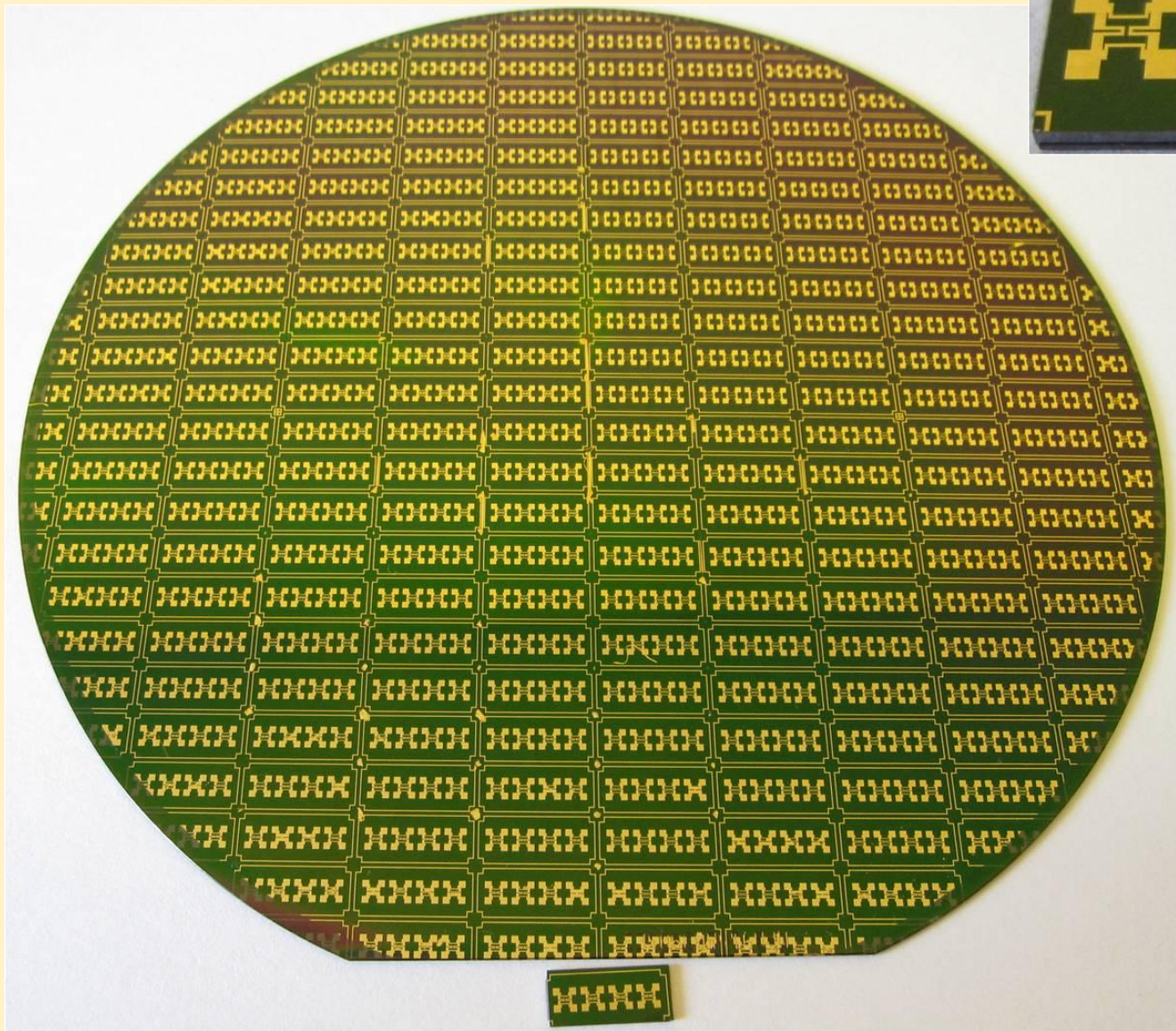
Stage 2: Wheatstone bridge structures beginning to be revealed



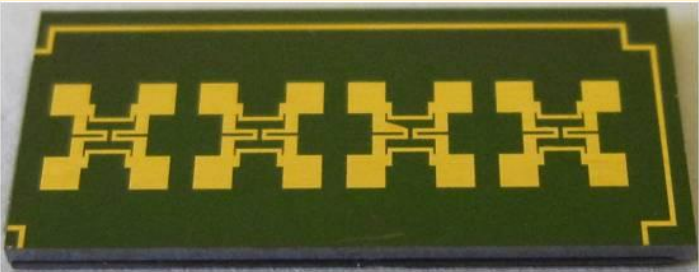
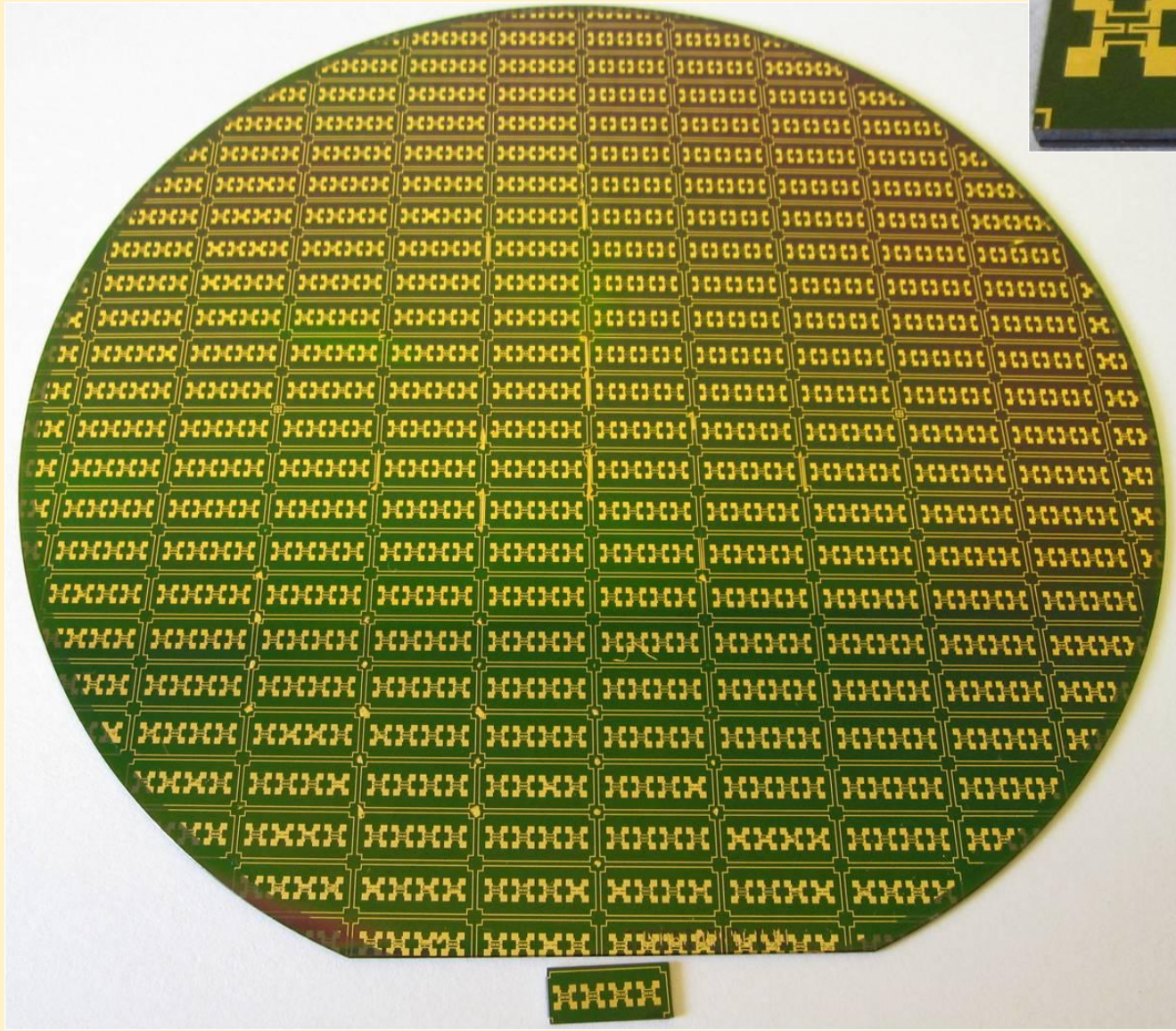
Stage 3: Chrome/Gold liftoff complete



Microscope photo of Wheatstone bridge after liftoff



Step 8

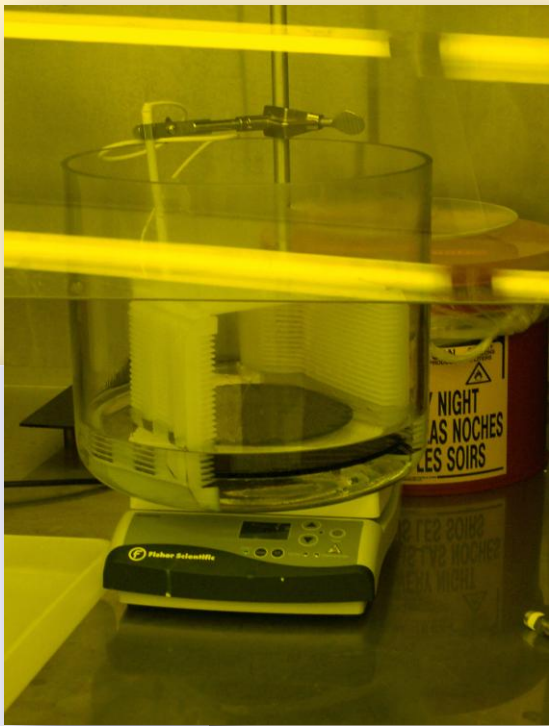


Step 8

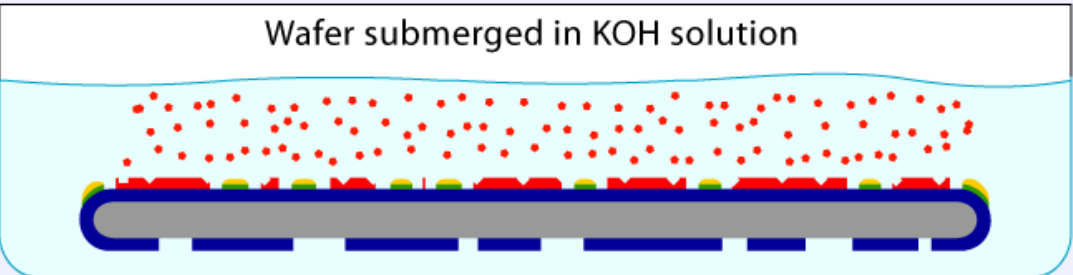
LOR Strip

Process Description and Parameters

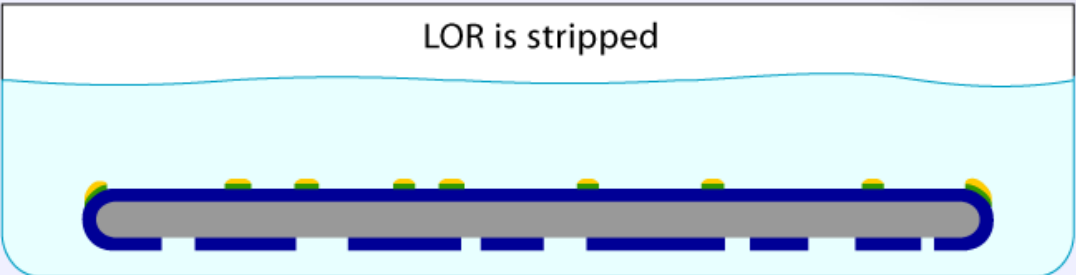
Wafers are now submerged in develop solution to strip the LOR.
Chemicals Used: Develop solution at room temperature
*Process Time: Approximately **2 minutes***



LOR Strip Process



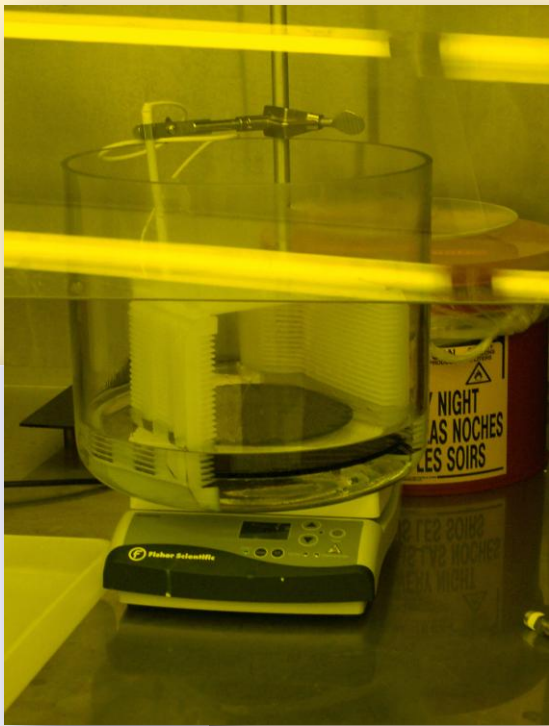
- Lift-Off Resist LOR: ■
- Silicon Nitride: ■
- Silicon: ■
- Gold Au: ■
- Chrome Cr: ■



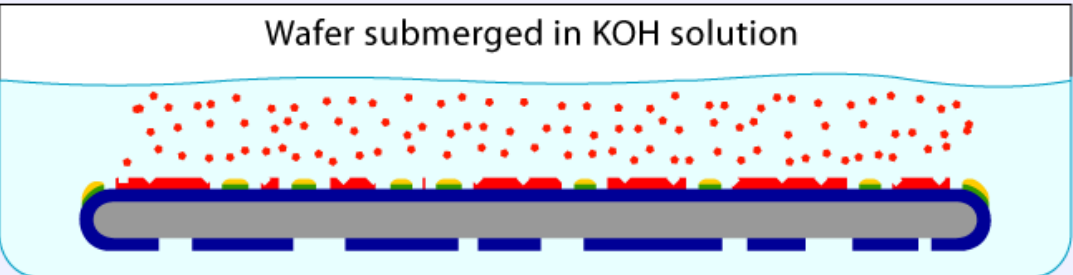
LOR Strip

Process Description and Parameters

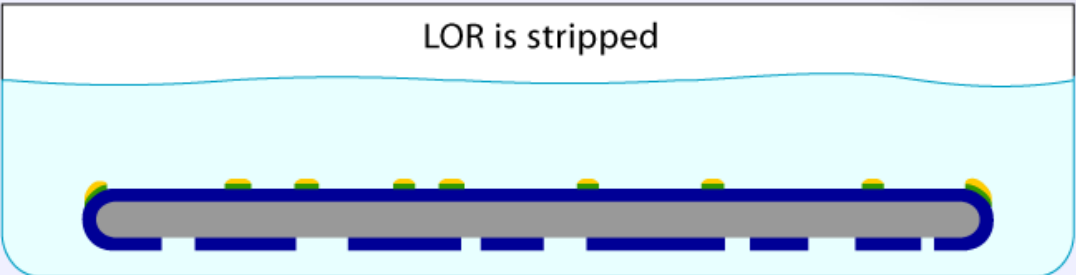
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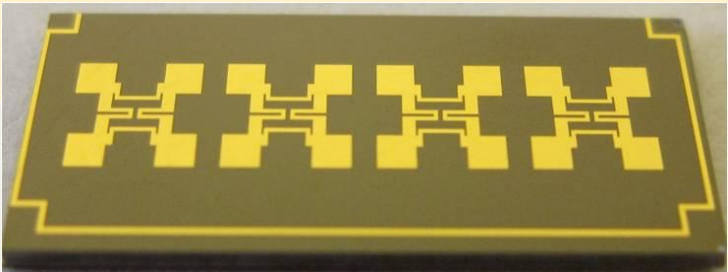
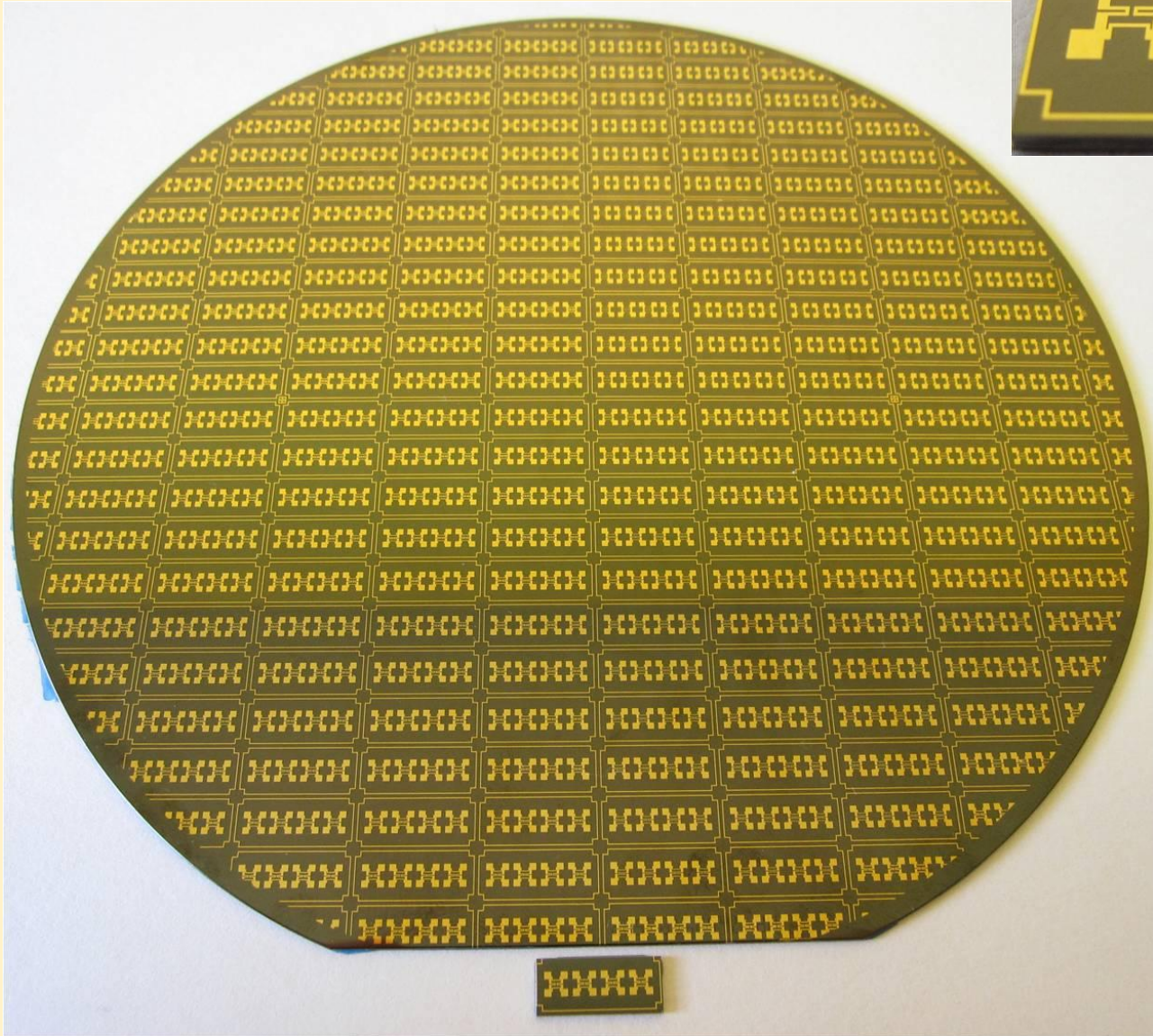
LOR Strip Process



- Lift-Off Resist LOR: ■
- Silicon Nitride: ■
- Silicon: ■
- Gold Au: ■
- Chrome Cr: ■

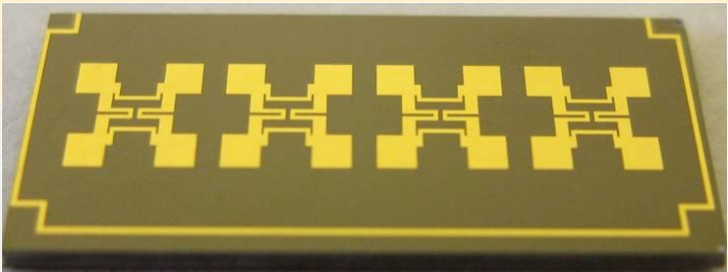
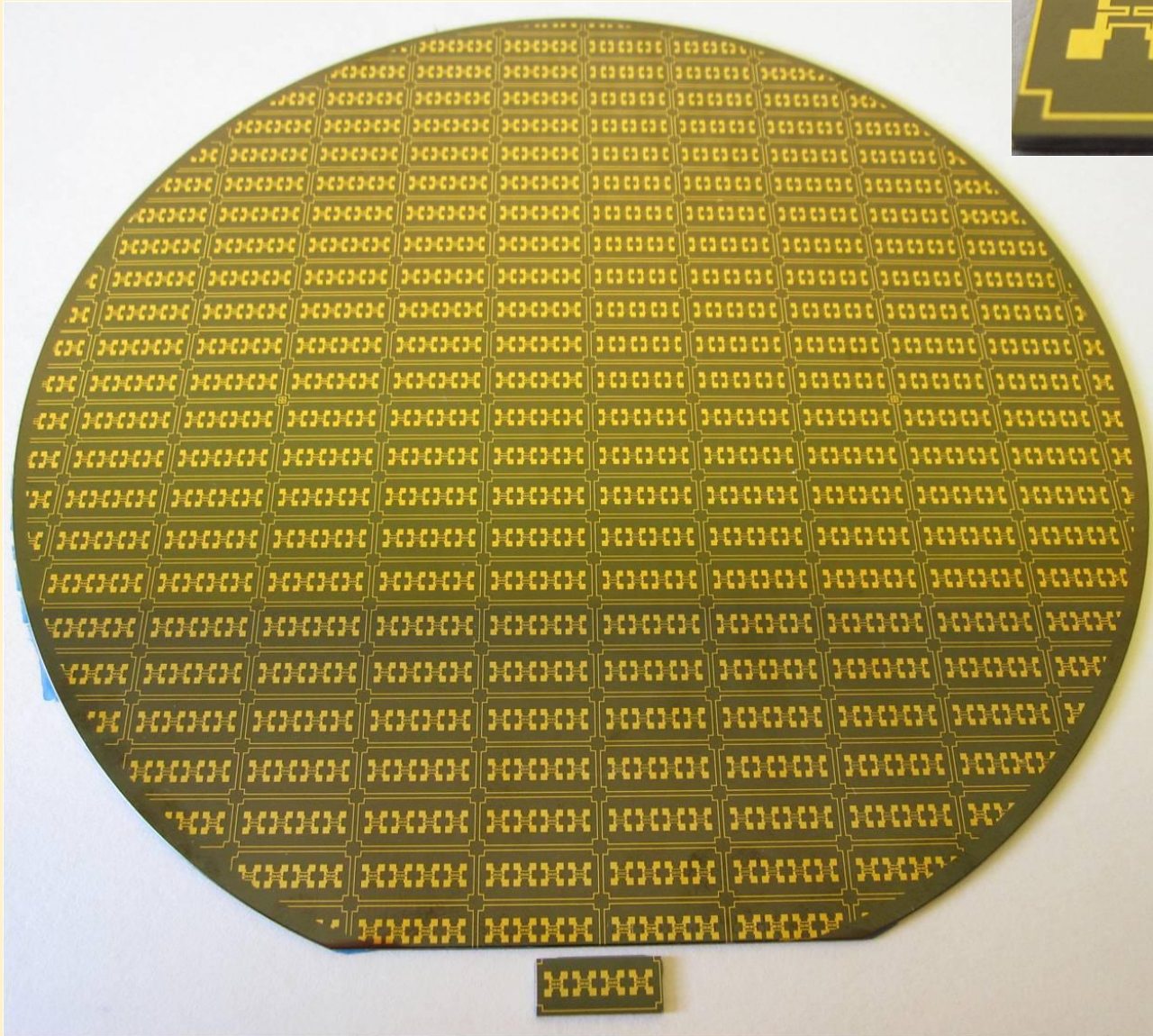


LOR Strip



Step 9

LOR Strip



Step 9

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 :

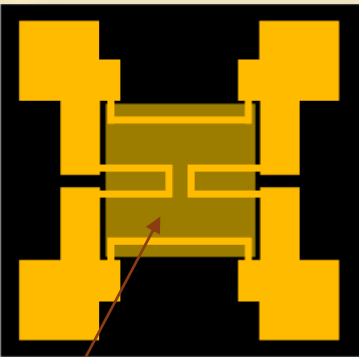
- 1. Place wafers in a Teflon boat and place very gently into a **105°C** KOH bath, **process for 2 hours**
- 2. Reduce the temperature to **95°C and leave for 90 minutes**
- 3. Reduce the temperature to **80°C for approximately 45 minutes**, or until etch is complete
- 4. Place wafers in QDR
- 5. Rinse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

Chemicals Used: KOH, IPA, nitrogen

Process Time: Approximately **4 1/2 hours**

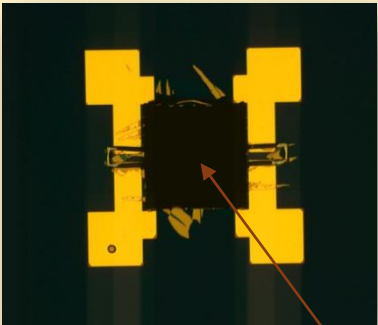


Good KOH Etch

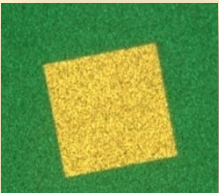


Silicon Nitride Membrane

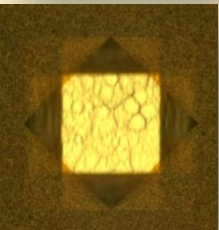
Bad KOH Etch



Blown Silicon Nitride Membrane due to over etch



cavity pattern before KOH



cavity during KOH shows silicon nitride pattern

KOH Etch

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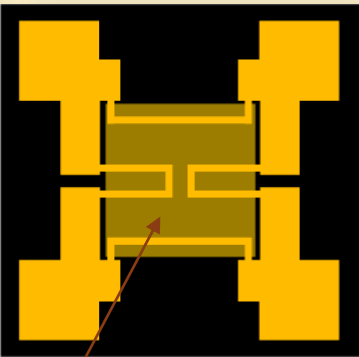
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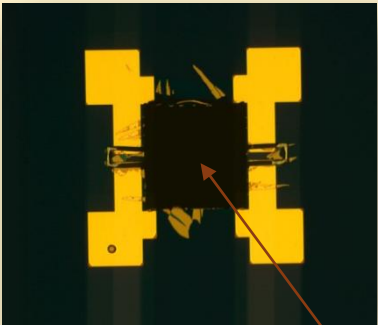


Good KOH Etch

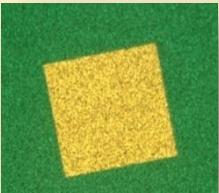


Silicon Nitride Membrane

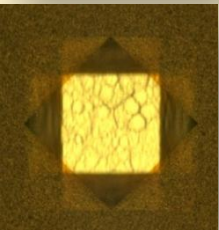
Bad KOH Etch



Blown Silicon Nitride Membrane due to over etch

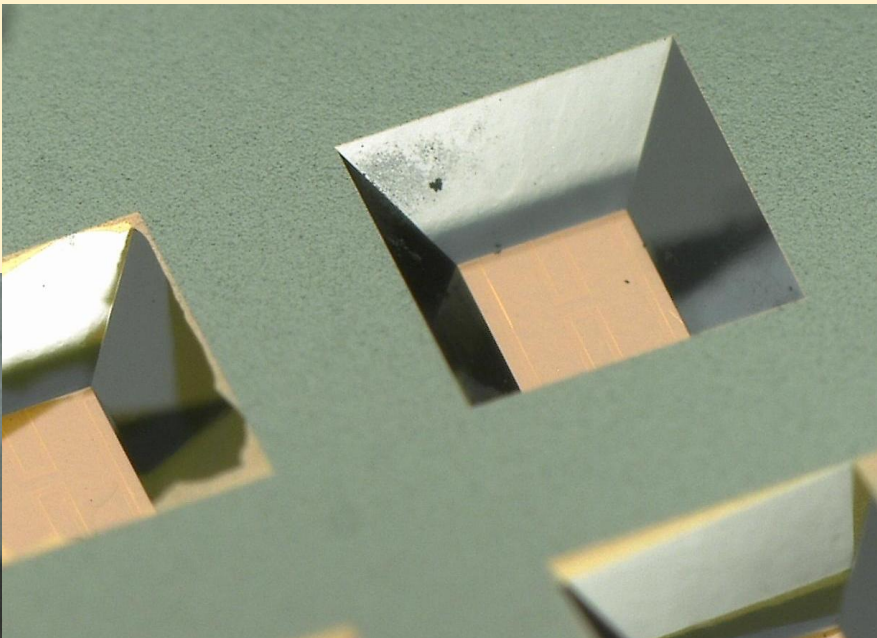
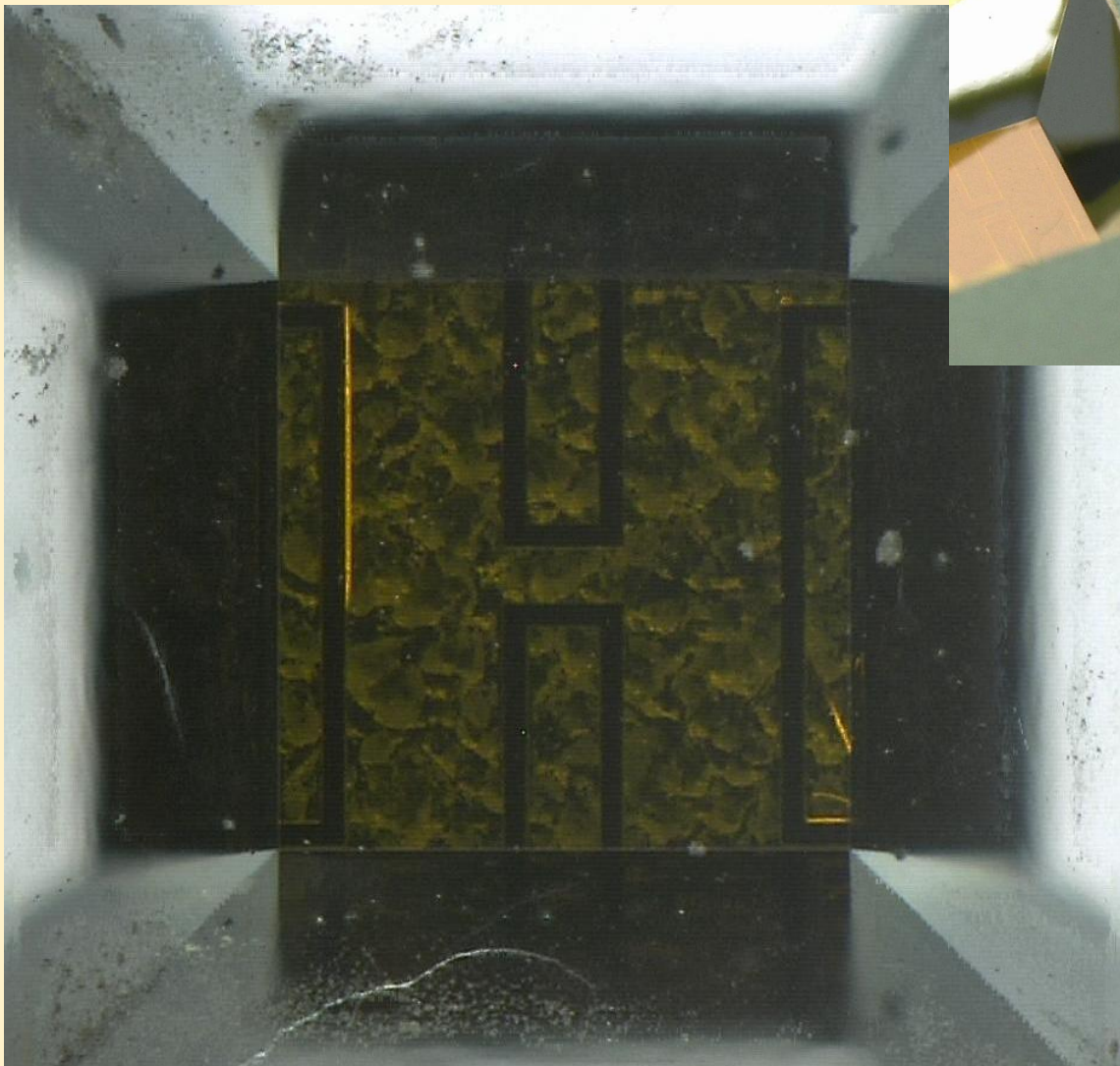


cavity pattern before KOH



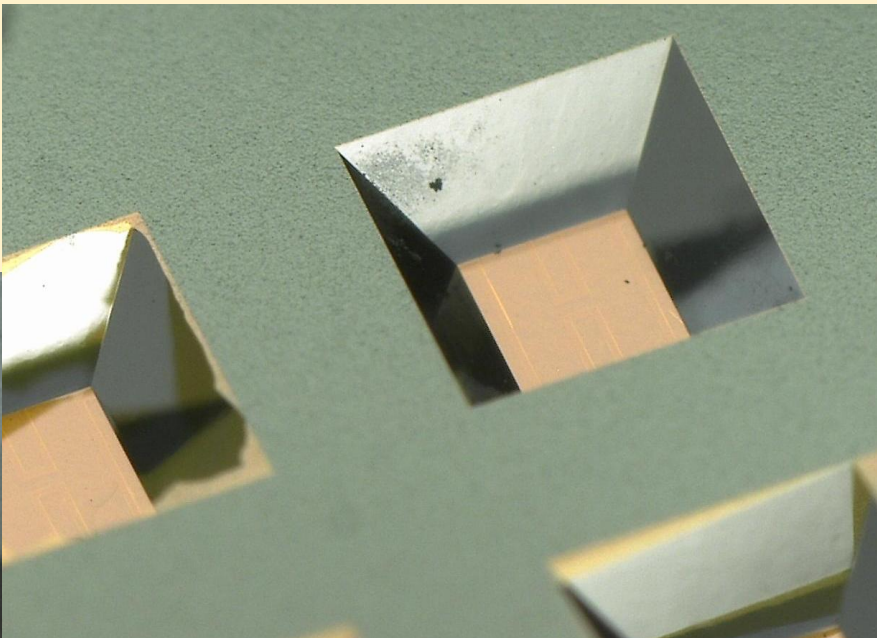
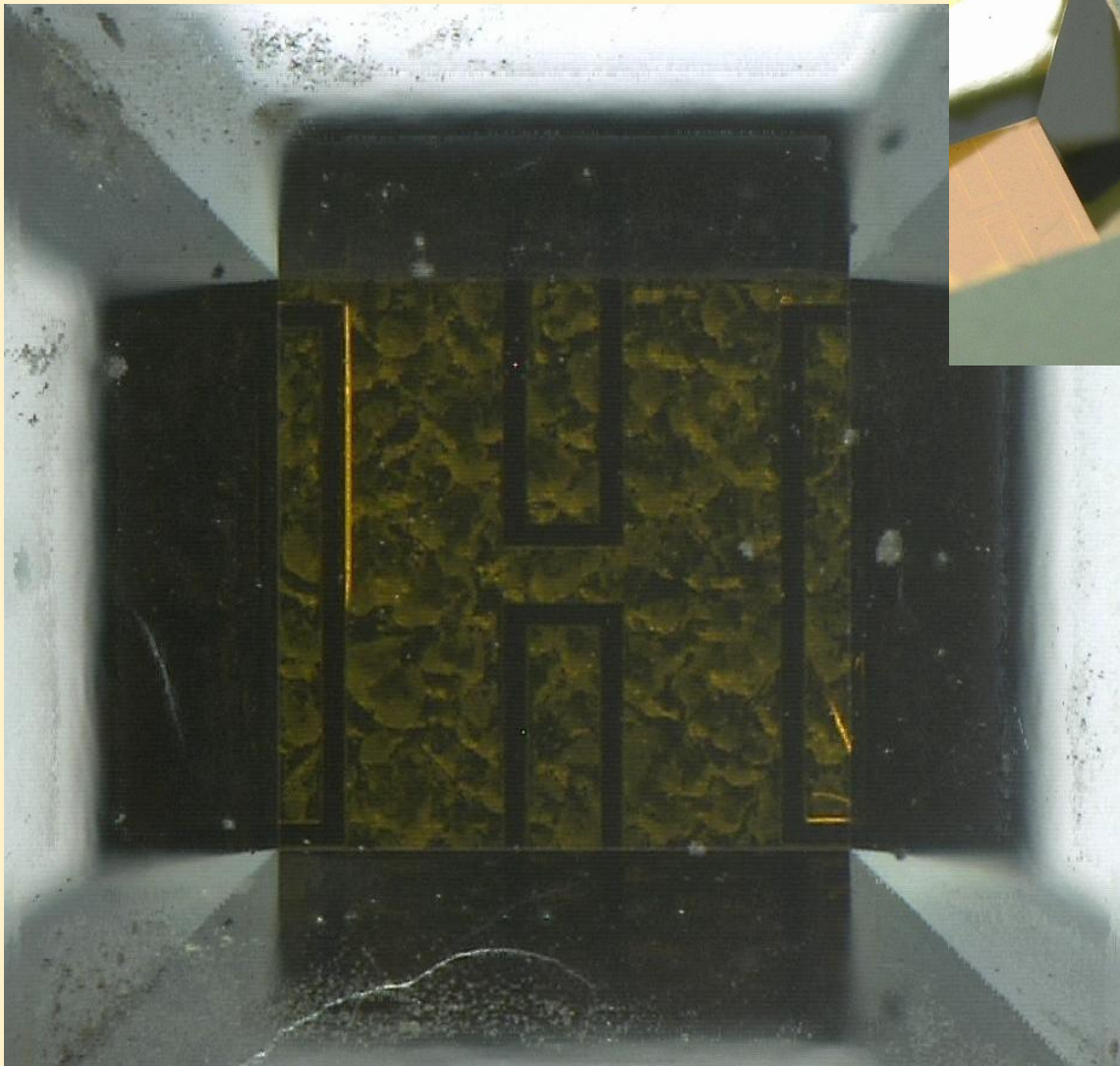
cavity during KOH shows silicon nitride pattern

KOH Etch



Step 10

KOH Etch



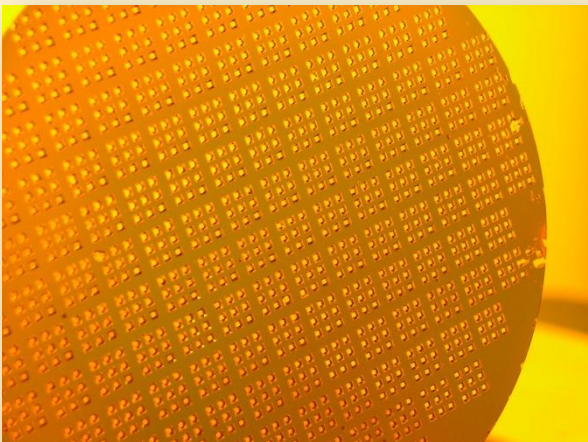
Step 10

Testing and Probing

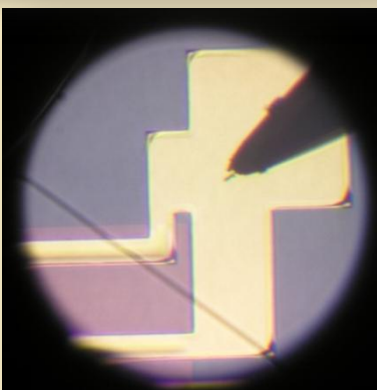
Process Description and Parameters

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

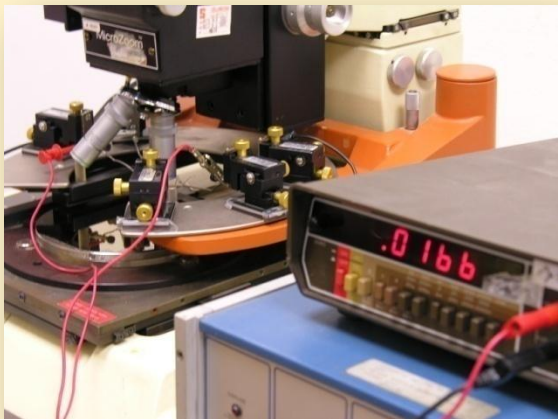
Final Product



Pressure Sensor wafer on probing station



Probe on the Wheatstone Bridge



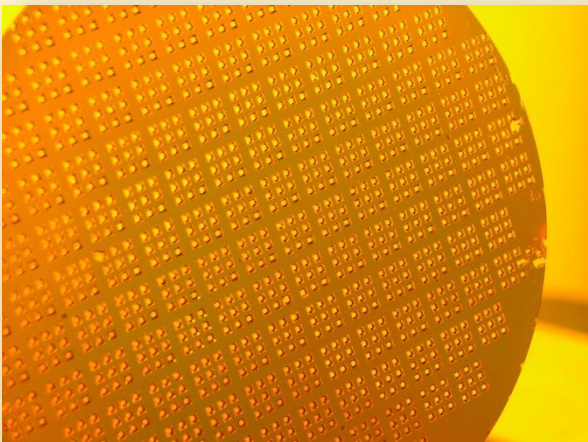
Probing station and power supply

Testing and Probing

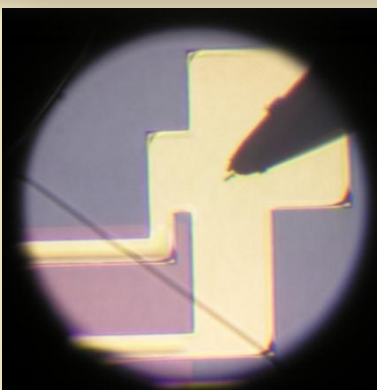
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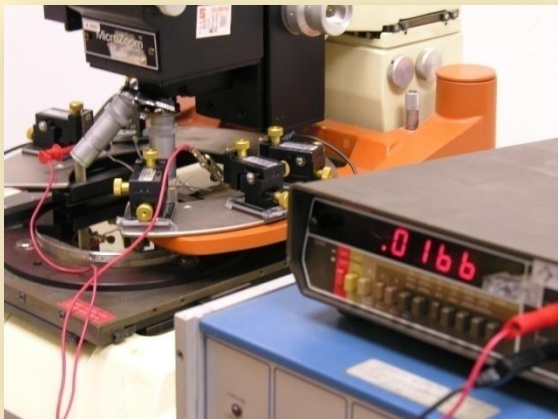
Final Product



Pressure Sensor wafer on probing station

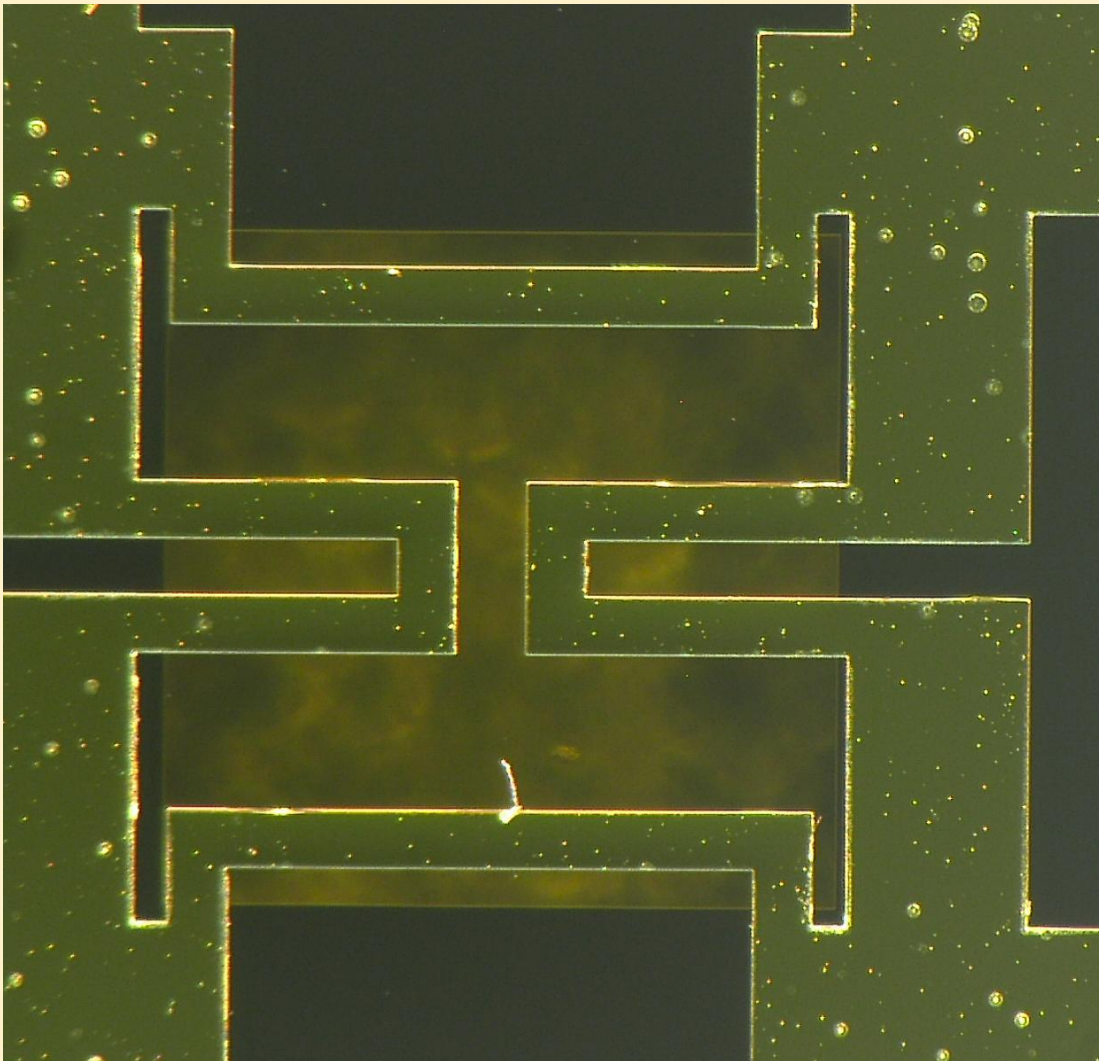


Probe on the Wheatstone Bridge

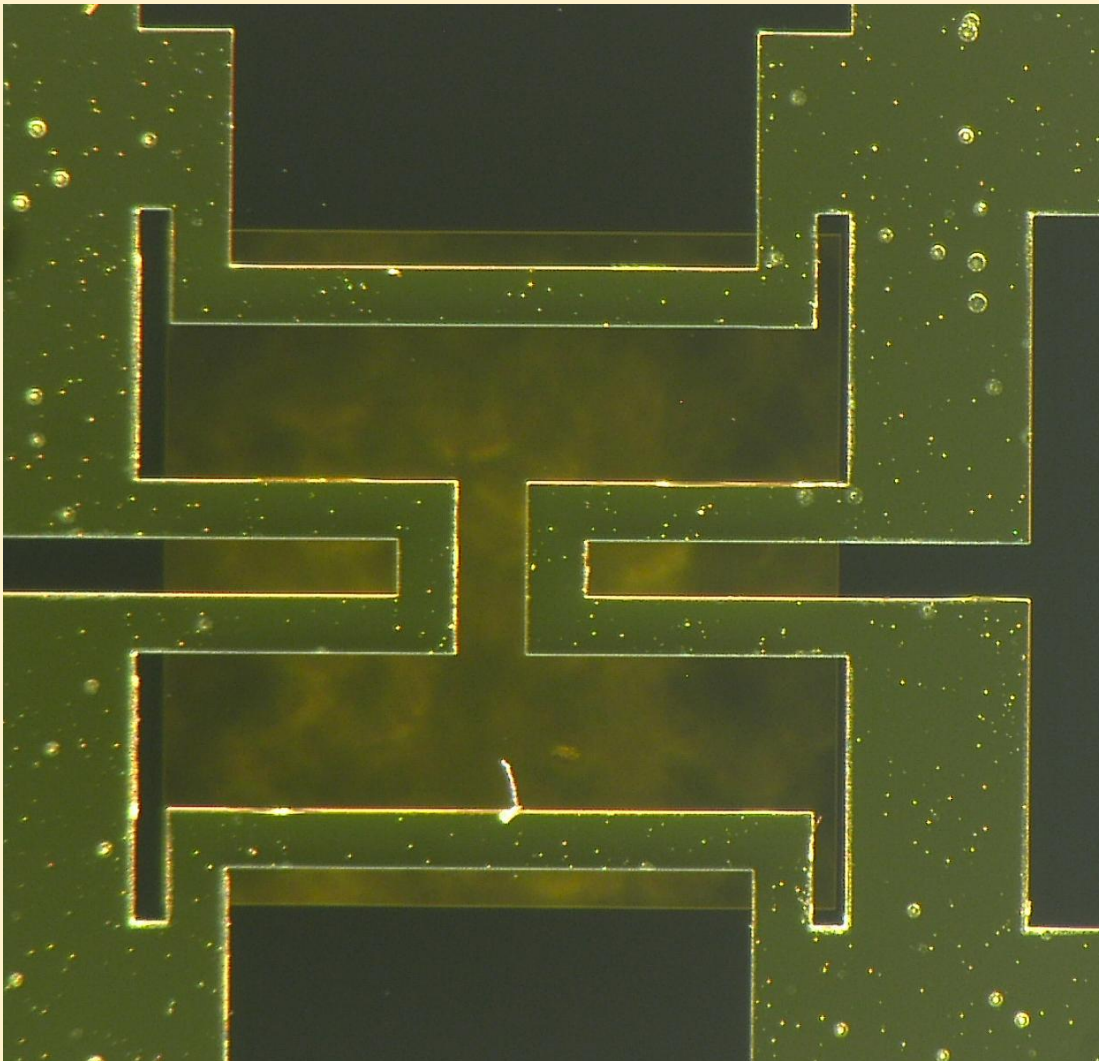


Probing station and power supply

Testing and Probing



Testing and Probing



Acknowledgements

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Phone: 505-272-7150

Website: www.scme-nm.org email contact: mpleil@unm.edu

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Revised 8/11/10

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