Manufacturing Technology Training Center (MTTC)
Pressure Sensor Process Primary Knowledge
Participant Guide

Description and Estimated Time to Complete

The MTTC Pressure Sensor Process learning module provides a detailed, step-by-step fabrication process of a MEMS (MicroElectroMechanical System) pressure sensor. One of the activities is designed for a cleanroom environment where you perform each step of the process and end up with a working MEMS pressure sensor. If you don't have access to a cleanroom, the other activities provide the opportunity to better understand each process step as well as the process as a whole.

The Manufacturing Technology Training Center (MTTC) is a process cleanroom at the University of New Mexico (UNM). The MTTC is used for hands-on activities relative to microsystems fabrication. This unit introduces and provides a brief overview of the processes involved in building the MTTC micro-pressure sensor. The following topics and process steps will be briefly discussed:

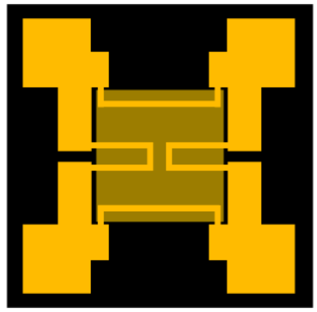
- The Pressure Sensor Membrane
- Pressure Sensor Circuitry
- How Does a Pressure Sensor Work?
- The Making of a Pressure Sensor

  1. Bare Silicon
  2. Silicon Nitride Deposition
  3. Backside Photolithography
     a. Frontside and Backside Photolithography - Coat
     b. Backside Photolithography - Expose
     c. Backside Photolithography – Develop
  4. Backside Etch – RIE (Reactive Ion Etch)
  5. Frontside and Backside Photoresist Strip
  6. Frontside Photolithography
     a. Frontside Photolithography – Coat
     b. Frontside Photolithography - Expose
     c. Frontside Photolithography – Develop
  7. Metal Deposition
  8. Metal Lift-off
  9. LOR Strip (Lift Off Resist)
  10. KOH (Potassium Hydroxide) Etch

- Testing and Probing

Estimated Time to Complete - Allow at least 60 minutes.

Introduction



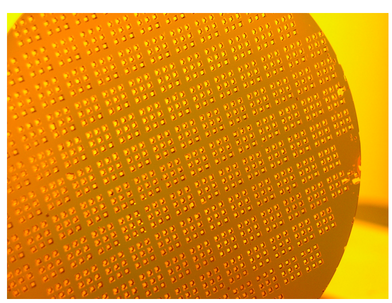
MTTC Pressure Sensor with a Wheatstone Bridge Configuration

Do you ever wonder how different environmental conditions that affect our daily lives are measured or quantified? There are tools all around us to measure temperature changes, pressure changes, and many, many other types of changes. Sometimes it is necessary to measure very small changes, and MEMS sensors are great tools for this task.

Instructors at the UNM MTTC and Central New Mexico Community College (CNM) have jointly developed a process to fabricate a micro-pressure sensor to measure changes in pressure applied to a thin membrane or diaphragm. The MTTC design incorporates a Wheatstone Bridge configuration as an electronic sensing circuit. A thin membrane of silicon nitride deflects when the pressures on opposite sides of this membrane are different. The amount of deflection is sensed by variable components of the Wheatstone Bridge.

The pressure sensor fabrication process consists of several steps. The process starts with a silicon wafer pre-deposited with silicon nitride, and ends with a wafer of approximately 800 micro-pressure sensors.

The pressure sensor fabrication process was designed at the University of New Mexico's MTTC. The Southwest Center for Microsystems Education (SCME) offers a five day workshop for instructors and students to learn about this process and actually fabricate a wafer of micro-pressure sensors. The workshop is approximately five days and includes instruction on the process, fabrication time, and testing and probing the final product.



An example of a completed wafer with approximately 800 micro-pressure sensors
(Each small square shown is a micro-pressure sensor)

The purpose of this unit is to outline the individual sub-processes necessary to create the MTTC micro-pressure sensor.

Objectives / Outcomes

Objectives

- Outline the major steps in building the MTTC Pressure Sensor.
- Describe the basic concepts of how the MTTC pressure sensor works.

Outcomes *(You should be able to answer these questions after completing this unit.)*

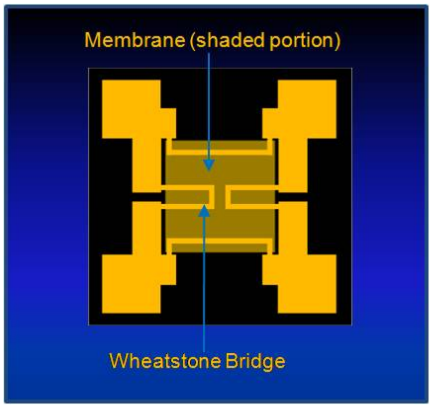
- What part of the pressure sensor acts as the sensing membrane?
- What material is used to create the resistors in the Wheatstone bridge electronic sensing circuit?
- How many photolithography steps are involved in building the MTTC Pressure Sensor, and what is the purpose of each step?

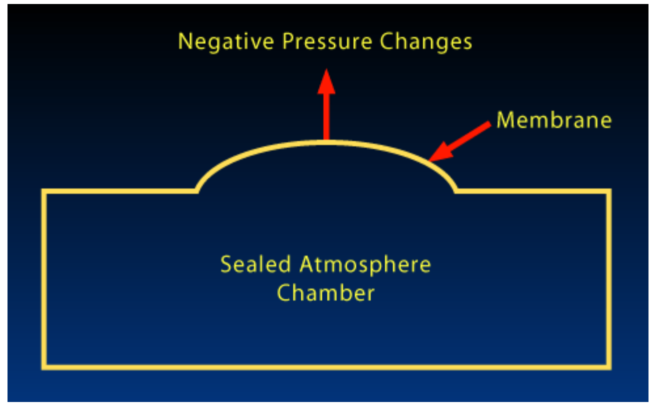
Terminology ***(Definitions are provided in the Glossary at the end of this unit.)***

anisotropic etch
atmospheric pressure
bulk micromachining
chemical vapor deposition
dopant
KOH (potassium hydroxide)
Ohm's Law
photolithography
photoresist
plasma etch
pressure sensor
reactive ion etch (RIE)
resistance
resistivity
UV light
Wheatstone Bridge

The Pressure Sensor Membrane

So how does a micro-pressure sensor actually work? Let's take a look at the pressure sensor's components then we'll pull them all together and show you how it works.

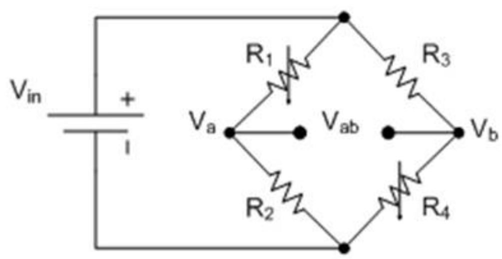




Pressure Sensor Membrane

The MTTC micro-pressure sensor consists of a thin membrane of silicon nitride, a sealed chamber, and an electronic sensing circuit (Wheatstone bridge) fabricated on top of the membrane. The membrane helps to form a sealed chamber of air at room temperature and atmospheric pressure (1 atm). The chamber is actually a "hole" etched into the silicon substrate then sealed by the membrane. The sealed chamber is the reference pressure. When the air pressure above the membrane changes (increases or decreases), the sensing circuit measures the change in pressure.

Pressure Sensor Circuitry

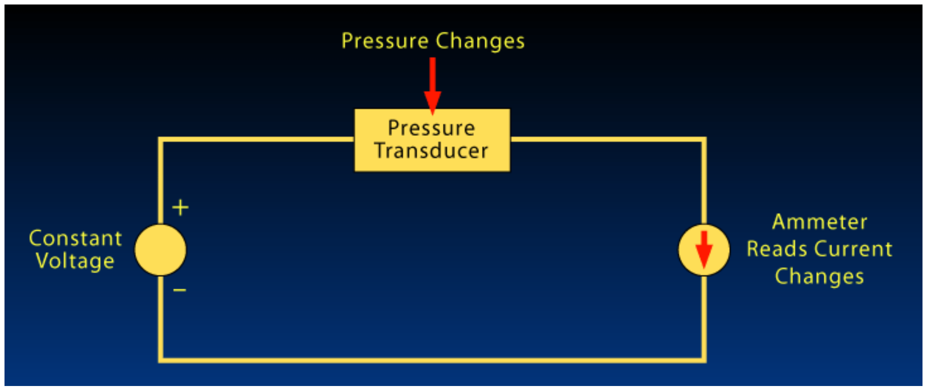


Wheatstone Bridge configuration with two variable resistors

To sense the changes in pressure, the pressure sensor uses a Wheatstone bridge configuration fabricated in a gold layer on the membrane. Gold has an electrical resistance, as do all materials. Resistance is a factor of the geometric length, width, and thickness of the gold. It is also relative to a physical property of the material called resistivity, ρ. The resistance equation for R is

$$R = \rho \frac{L}{Wt}$$

where *L, W*, and *t* are the length, width, and thickness, respectively, of the gold resistors. The resistivity, ρ, is a physical property of gold which remains constant under constant temperature. As the gold stretches, the length increases causing a measureable change in resistance. Changes in the thickness and width are negligible.



Pressure Sensor Circuitry

The figure above shows a pressure sensor's electronic sensing circuitry. The pressure transducer consists of the four gold resistors in the Wheatstone bridge. Two of the resistors are variable, two are fixed. A constant voltage is applied across the bridge circuit. A reference current (with no pressure applied) is recorded. Changes in the current are measured as resistance changes in response to the membrane stretching (thus the gold stretching). The measured current is determined using Ohm's Law (I= V/R). The accuracy of the response is dependent upon maintaining a constant reference pressure (atmospheric pressure) within the sealed chamber.

Question 1

What material (or thin film) is used for the pressure sensor membrane or diaphragm?

____

Question 2

What material is used to create the resistors in the Wheatstone bridge electronic sensing circuit?

____

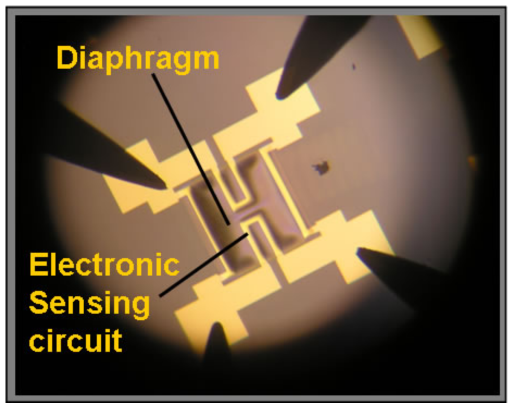
Question 3

What physical property of the resistors in the Wheatstone bridge remains constant under changing pressure and constant temperature?

____

How Does the Pressure Sensor Work?

Now let's put it all together. The silicon nitride membrane stretches (or bows) when a difference in pressure exists between one side of the membrane and the other. This occurs when the pressure above the membrane is greater than or less than the sealed atmospheric pressure below the membrane. As the membrane stretches, so do the gold resistors on top of the membrane. The length of the gold changes, resulting in a change in the electrical resistance of the Wheatstone bridge. This change in resistance causes a change in current which is representative of the change in pressure. If the gold continues to be stretched by the membrane, the resistance continues to change (increase or decrease) indicating a further increase (or decrease) in pressure.



Pressure Sensor illustrating the Wheatstone Bridge and the Silicon Nitride Membrane (Diaphragm)

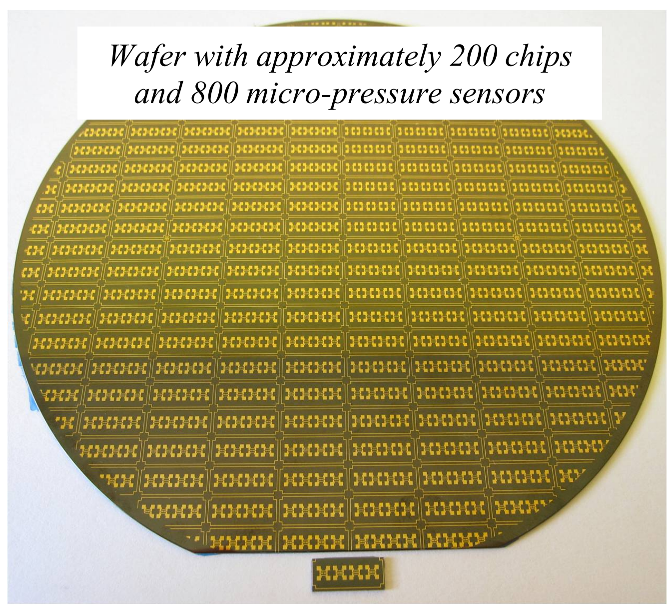
The Making of a Pressure Sensor

There are several steps involved in fabricating a micro-pressure sensor. In this lesson, we discuss the making of a silicon wafer and the deposition of the silicon nitride layer. We then take you through the process steps that lead to a working micro-pressure sensor. The process steps are summarized below. The MTTC purchases bare silicon 6 inch diameter wafers (Step 1), but all other process steps are performed in the MTTC cleanroom.

Process Steps for MTTC Pressure Sensor

1. Bare Silicon
2. Silicon Nitride Deposition
3. Backside Photolithography
    a. Frontside and Backside Photolithography - Coat
    b. Backside Photolithography - Expose
    c. Backside Photolithography – Develop
4. Backside Etch – RIE (Reactive Ion Etch)
5. Frontside and Backside Photoresist Strip
6. Frontside Photolithography
    a. Frontside Photolithography – Coat
    b. Frontside Photolithography - Expose
    c. Frontside Photolithography – Develop
7. Metal Deposition
8. Metal Lift-off
9. LOR Strip (Lift Off Resist)
10. KOH Etch (Potassium Hydroxide)

Upon completion of ALL process steps, each 6 inch wafer is sectioned into approximately 200 complete chips or die, with 4 pressure sensors on each chip. The final processed wafer has approximately 800 micro-pressure sensors. Once the process is completed, the wafer is diced into individual chips. An example of a wafer and its 200 chips is shown to the right. Below the wafer is an individual chip containing 4 micro-pressure sensors. This is considered “a chip”.



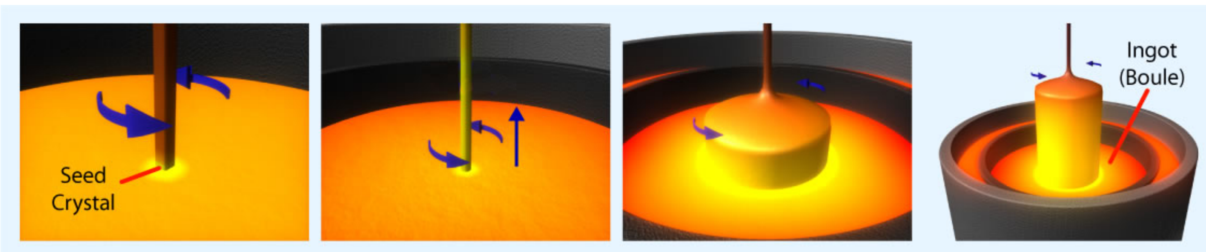
Wafer with approximately 200 chips and 800 micro-pressure sensors

This pressure sensor process uses two types of micromachining processes - surface and bulk. In surface micromachining, the processes take place on the surface of the wafer. In bulk micromachining, the process takes place within the silicon substrate by removing select portions of the wafer.

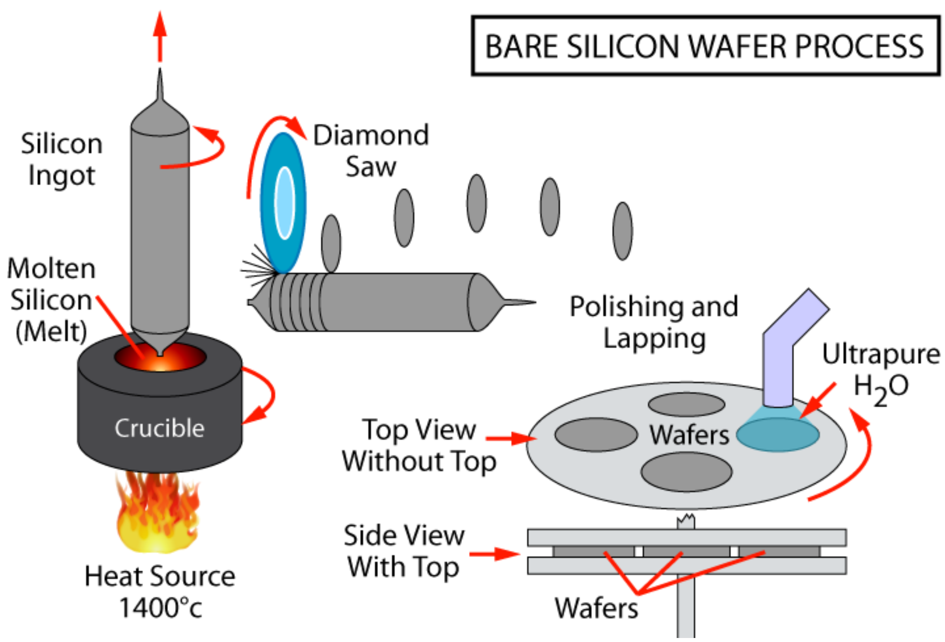
Bare Silicon Wafer – Step 1

Manufacturing bare silicon wafers begins with the formation of a cylinder of pure silicon, or ingot. The ingot is grown from a perfect "seed" crystal. The seed is immersed into a crucible of molten silicon (i.e., melt), then slowly rotated and pulled upward, forming a silicon ingot or boule *(as shown in the graphic below)*. The "charge" of the silicon (N-type or P-type) is determined during this growing process. A small amount of impurity (dopant) is added to the melt to determine its charge. The dopants used are

- Boron or gallium for P-type silicon, or
- Phosphorus or arsenic for N-type silicon.



The ingot is sliced into very thin wafers using a diamond saw. Each wafer then goes through a polishing and lapping process. This removes the surface silicon, creating a flat, smooth surface.

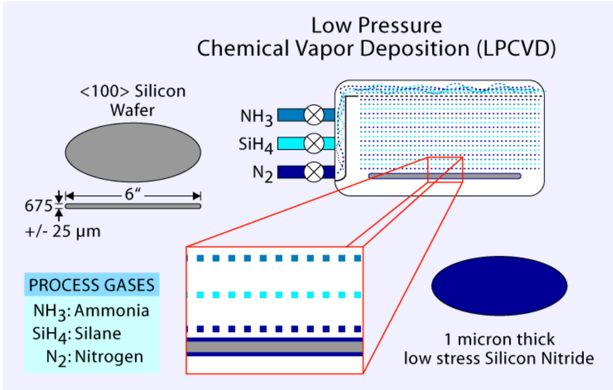


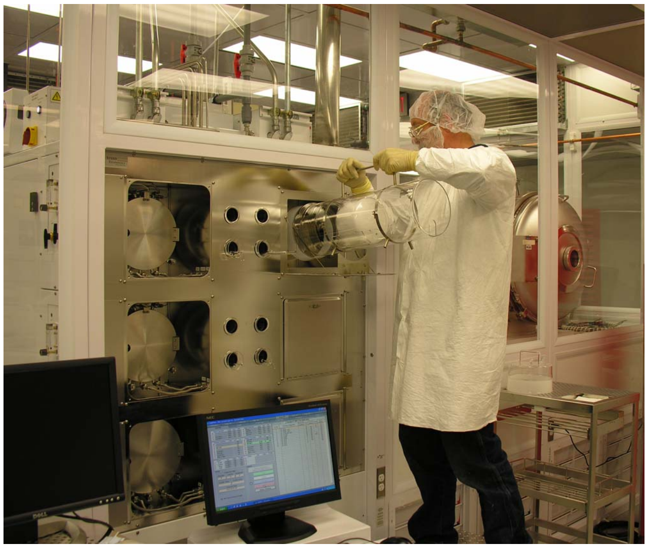
The MTTC pressure sensor process begins with a bare silicon wafer of the following specifications:

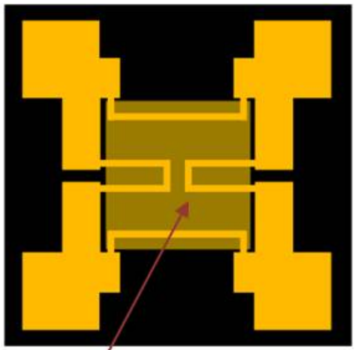
- Standard 6 inch (100) Silicon wafer
- Thickness: 675 ± 25 µm
- Dopant: Boron (P-type)
- Resistivity: 20 Ωcm

Silicon Nitride Deposition – Step 2

Both sides of the polished bare silicon wafers are deposited with a 1 µm film of low stress silicon nitride using Low Pressure Chemical Vapor Deposition (LPCVD). The picture below shows a technician loading a quartz tube with boats of process wafers into a CVD furnace. *(For more information on CVD, review [SCME's Deposition Overview Learning Module](#).)*







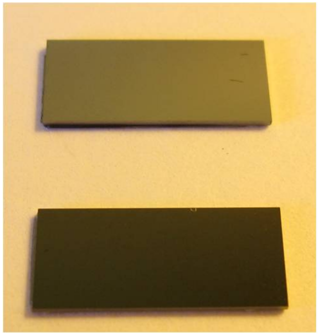
Silicon Nitride Membrane

Because of its specific expansion coefficient, the silicon nitride layer is used to form the pressure sensor's membrane on the wafer's frontside. The expansion coefficient of the silicon nitride film is needed so that a pressure can be correlated to a specific change in the bowing or stretching of the silicon nitride membrane.

Silicon nitride is a very dense film. One of its properties is that oxygen will not pass through it. This property protects the underlying layer of silicon from oxidation.

On the wafer's backside, the silicon nitride is used as a hard mark to identify the openings for the pressure sensor's reference chamber.

To the right is a photograph comparing a bare silicon chip, and a silicon nitride coated chip. As you can see, the bare silicon has a lighter colored surface.



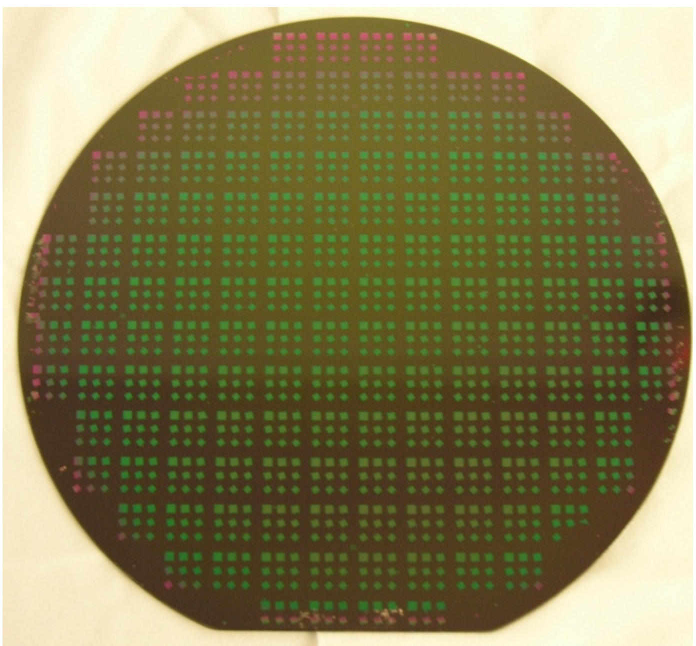
Step 1 - Bare Silicon

Step 2 - Silicon Nitride Coated

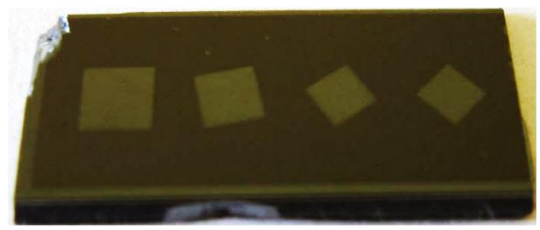
Question 4
What properties make silicon nitride a good material for the pressure sensor membrane?

Backside Photolithography – Step 3 Overview

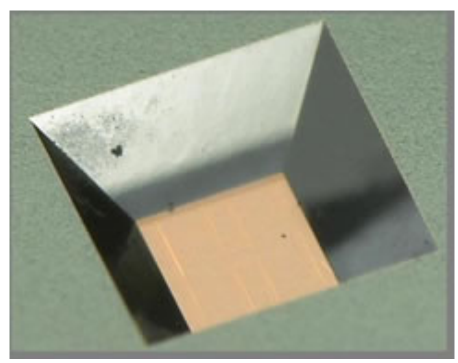
The backside of the wafer is patterned using a three step photolithography process: coat, expose, develop. This process identifies the areas to be etched to create the reference chamber below the silicon nitride membrane. The first image below shows the backside of a wafer and an individual chip after backside photolithography. The next image it is a close up of an individual chip showing the four areas to be etched (or opened). The image on the bottom is one of the four areas after it has been bulk etched to expose the silicon nitride (blue). This etching occurs in the KOH (potassium hydroxide) etch process which is the last step of the pressure sensor fabrication process.



Wafer after backside photolithography step



Individual Chip after Backside Photolithography



One of the Open Areas after it has been Etched

Backside Photolithography – Coat (Step 3a)

Before the backside patterning process begins, the frontside of the wafer is coated with a primer. The primer, hexamethyldisilazane (HMDS), allows the photoresist to stick to the wafer. Once the primer is applied, a coating of photoresist is spun onto the wafer. The coated wafer is baked for 2 minutes at 110ºC to remove solvents in the photoresist. The wafer is then cooled to room temperature. The pictures below show the steps of coating process. The resist on the frontside of the wafer helps protect the silicon nitride while the backside of the wafer is being processed.

Aligning Wafer on Vacuum Chuck

Dispensing HMDS

Dispensing Photoresist

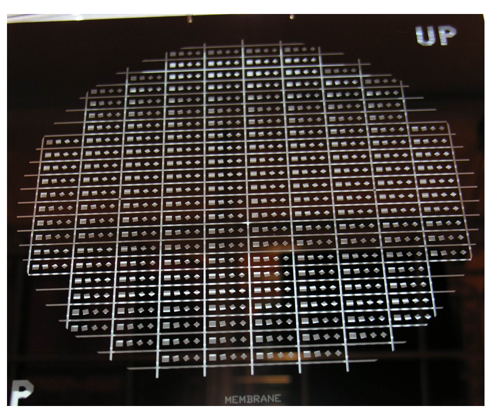
Baking the Wafer at 110ºC

Frontside and Backside Coat

Backside coat: The backside of the wafer is processed using the same coat process: HMDS prime, photoresist coat, bake, cool.

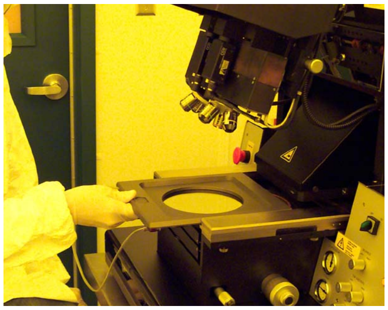
Backside Photolithography - Expose (Step 3b)

In this step select areas of the photoresist are weaken by exposure to Ultraviolet (UV) light. A patterned mask is used to identify these select areas. Only those areas which are exposed to UV light will have the photoresist removed in the subsequent develop process. These select areas identify the reference chambers that are formed in a KOH etch at the end of the pressure sensor fabrication process.

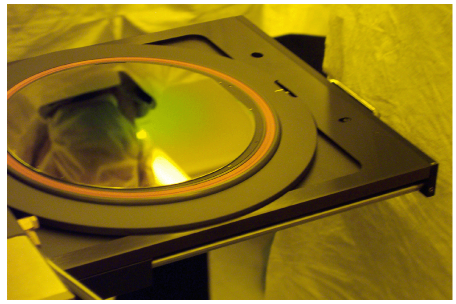


Backside Pattern Mask

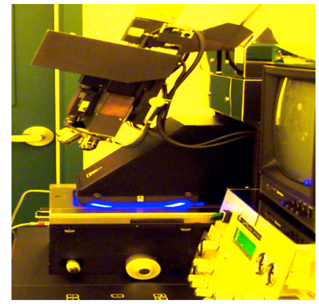
The following pictures show the steps of the expose process.



Loading Mask onto Holding Tray



Load wafer into Karl Suss Aligner



Expose Wafer for 300 Seconds

Backside Expose

<u>Backside Photolithography - Develop (Step 3c)</u>

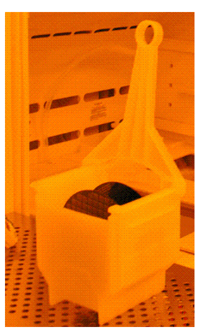
In this step, the pattern on the backside of the wafer is developed. The steps of the develop process are shown in the pictures below.

The develop process involves the use of a developer that removes the exposed photoresist. Handling of this chemical requires the use of proper acid PPE (personal protective equipment).

The wafer is placed in a Teflon boat which is submerged in a bath of developer. The exposed photoresist dissolves, uncovering the silicon nitride to be etched. The unexposed photoresist that remains on the wafer serves as an etch mask for the next process step which is etch. The etch mask protects sections of the nitride layer during the etch process.

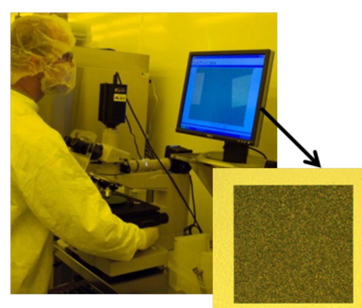
Once the wafers are developed, they are inspected under a microscope for defects.

Acid PPE



Wafers in Teflon Boat

Wafers Submerged in Developer Solution

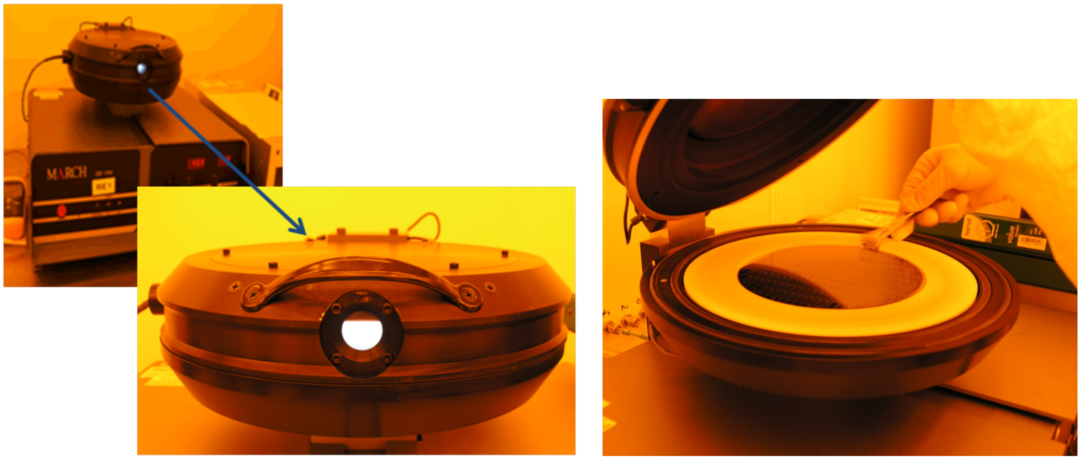


Develop Inspection

Backside Develop

(For more information on the photolithography process, review [SCME's Photolithography Overview Learning Module](#).)

Backside Etch – Reactive Ion Etch (RIE) – Step 4

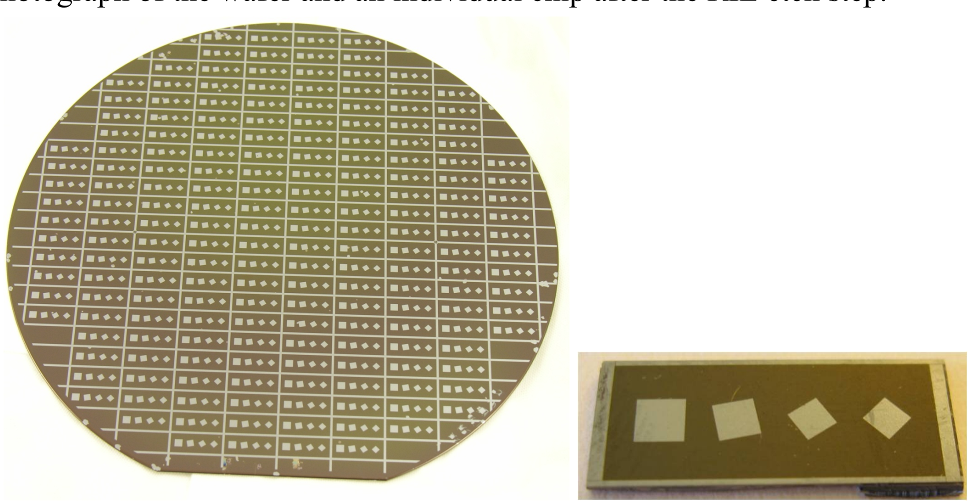


Reactive Ion Etcher

This step uses a plasma etcher to etch the silicon nitride layer on the backside of the wafer. Only the open areas created in the previous photolithography steps are etched. A Reactive Ion Etcher (RIE) is used for a very highly selective etch pattern. Changing the power and pressure settings of the plasma etcher allow the silicon nitride to be selectively etched without etching the underlying silicon substrate or the photoresist mask.

A RIE etcher uses a dry etching technique where positive ions from the plasma bombard the wafer's surface removing silicon nitride from the unprotected areas of the silicon nitride layer. The RIE uses 13.56 MHz (RF) to generate the plasma. This plasma is visible through the window in the RIE etcher shown in the image above.

Below is a photograph of the wafer and an individual chip after the RIE etch step.



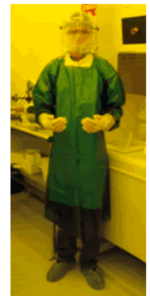
Backside of Wafer and Individual Chip after the Reactive Ion Etch

The photoresist is "greenish" and the silicon substrate is what you see inside the squares.

(For more information on etch processing, review SCME's Etch Overview Learning Module.)

Backside Photoresist Strip – Step 5

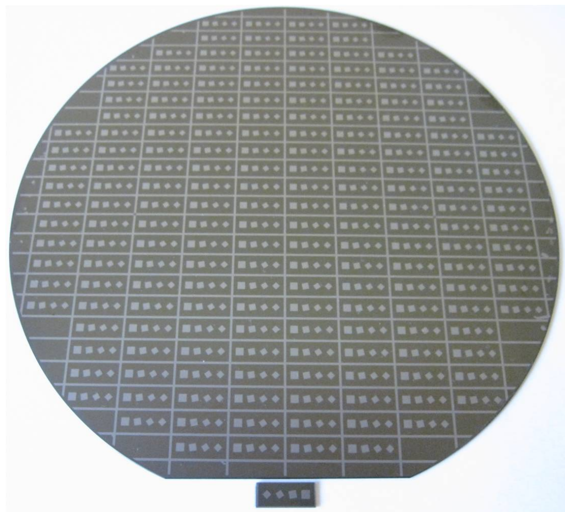
The wafers are now placed in a piranha bath. This chemical solution aggressively removes photoresist. Piranha refers to the mixture of H_2SO_4 (sulfuric acid)/ H_2O_2 (hydrogen peroxide). Extreme care should be taken any time you use a piranha solution. This acid interacts with skin very quickly. Appropriate personal protective equipment (PPE) is required when performing the photoresist strip.



Acid PPE

Mixing the piranha bath

Below is a photograph of the wafer and an individual chip after the backside photoresist strip step.

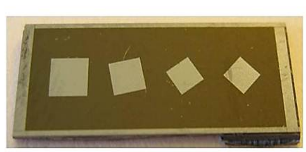


Backside of Wafer and Individual Chip after the Backside Photoresist Strip

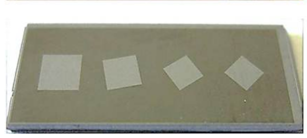
Comparing this image to the previous wafer image, you can see that the photoresist has been completely removed exposing the silicon nitride it was protecting.

Although the backside of the wafer has now gone through several process steps, it is difficult to distinguish the changes with a naked eye. When the process is performed in the MTTC cleanroom, a microscope is available to examine the wafer after each step. Below is a photograph which compares steps 3, 4, and 5. Step 3 provides the open area patterns, step 4 etches the silicon nitride and the silicon dioxide layers in the open areas, and step 5 removes the remaining photoresist

Step 3 – Backside Photolithography (after develop



Step 4 – Backside Etch (RIE)



Step 5 – Backside Photoresist Strip

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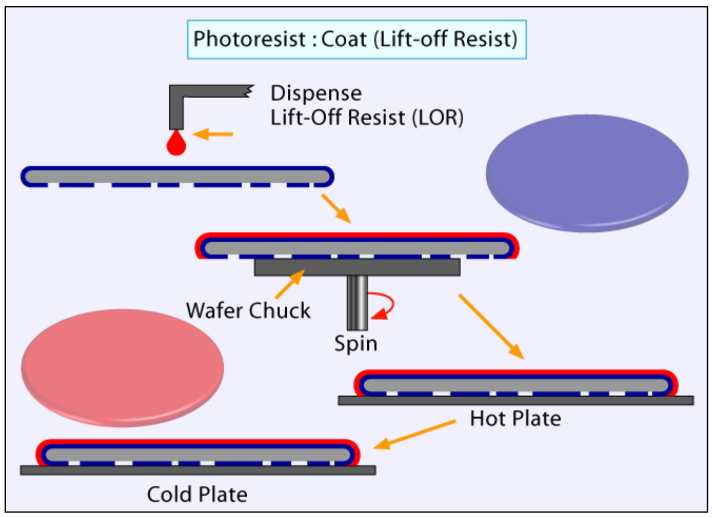
Frontside Photolithography – Step 6

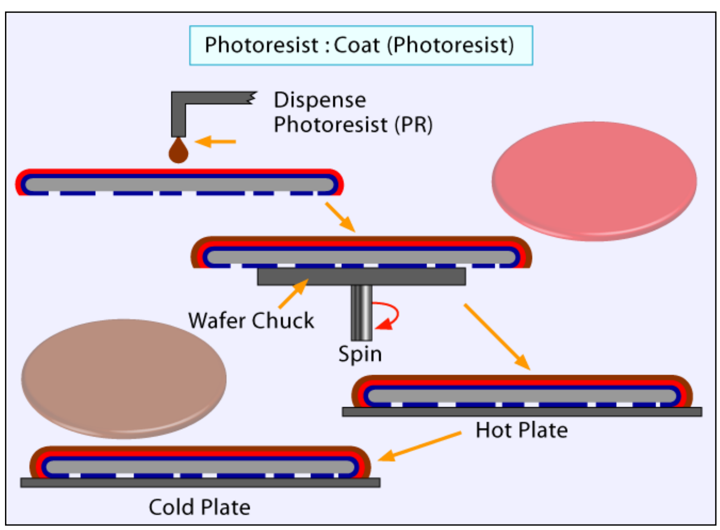
The next step in the process is to pattern the frontside of the wafer with the Wheatstone bridge pattern. In this step, a lift-off resist in addition to the normal pattern resist is applied in order to create a desired undercutting during the develop process.

Frontside Photolithography – Coat (Step 6a)

The photolithography coat process is again performed on the frontside of the wafer. However, in this process step, two different resists are applied. This first resist is a "lift off resist (LOR)", followed by a second photoresist (PR). LOR has a faster develop rate than the PR. This creates a desired undercutting during the develop process. After each application of photoresist, the wafer is baked, then cooled to room temperature.



Frontside Coat (LOR)

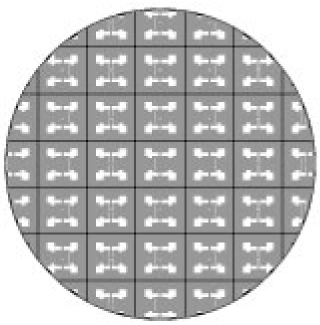


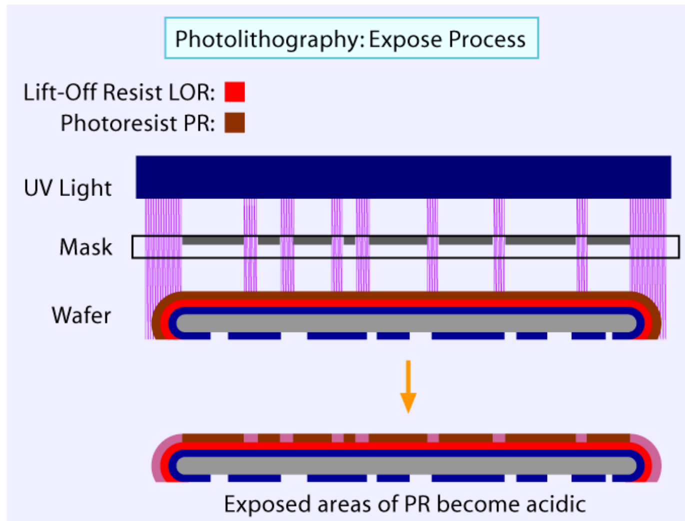
Frontside Coat (Photoresist)

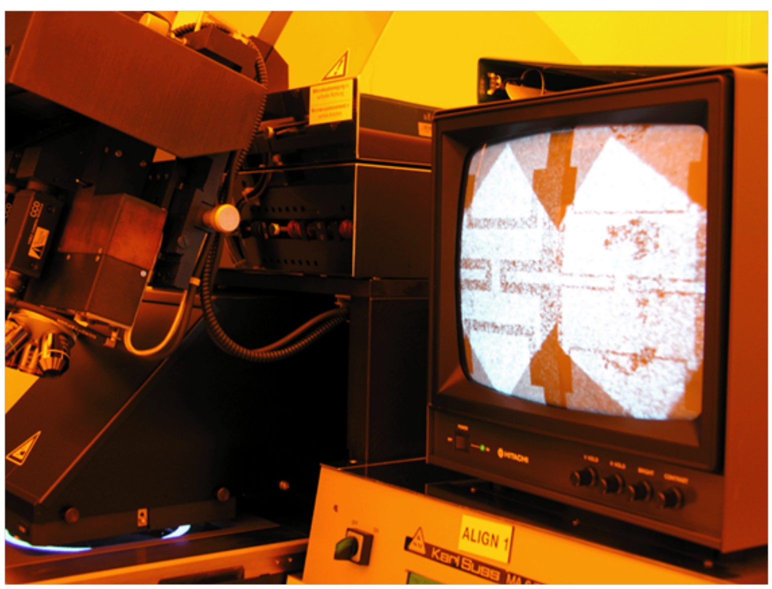
Frontside Photolithography – Expose (Step 6b)

Using the photolithography expose process, the photoresist is exposed with a Wheatstone bridge patterned mask (mask pattern shown below) and UV light. A critical step is the accurate alignment of the mask to the backside etched wafer. Alignment positions each of the Wheatstone bridge circuits directly above one of the squares that was etched into the silicon nitride on the wafer's backside. This is done using the Karl Suss alignment system shown below. Misalignment results in misprocessing, leaving the wafer useless.

Wheatstone Bridge patterned Mask

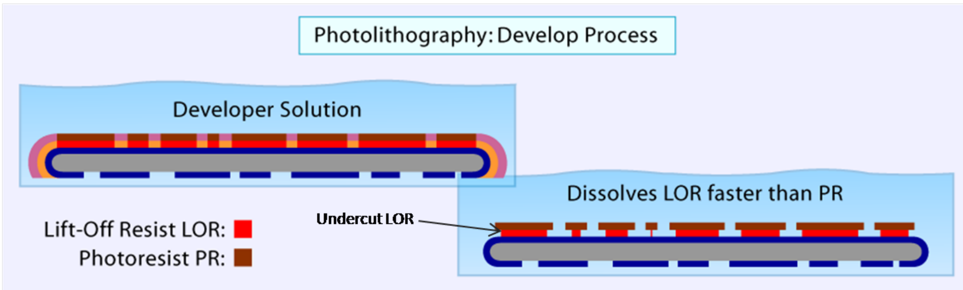


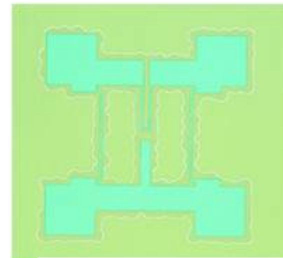




Karl Suss Alignment System

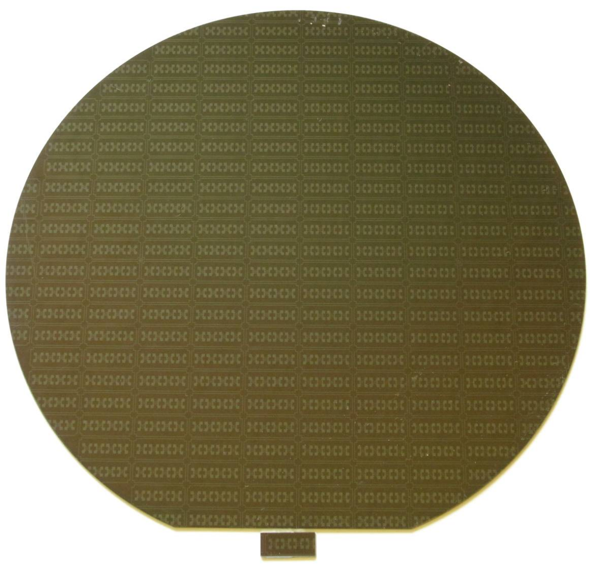
Frontside Photolithography – Develop (Step 6c)





Bad LOR Develop

The photoresist is developed, removing the exposed photoresist and dissolving the LOR beneath the openings in the PR. As seen in the above graphic, the LOR dissolves faster than the exposed PR. This creates an undercutting beneath the top photoresist layer (PR). This step is essential to subsequent process steps. If the LOR did not undercut the photoresist, the metal layer deposited in the next process step would be completely removed during the following lift-off step of the metal layer.



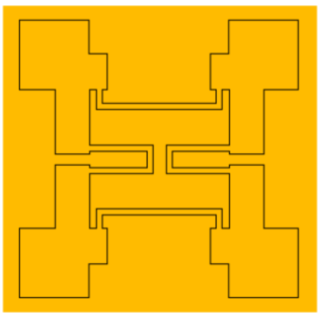
Wafer and Individual Chip after Frontside Photolithography

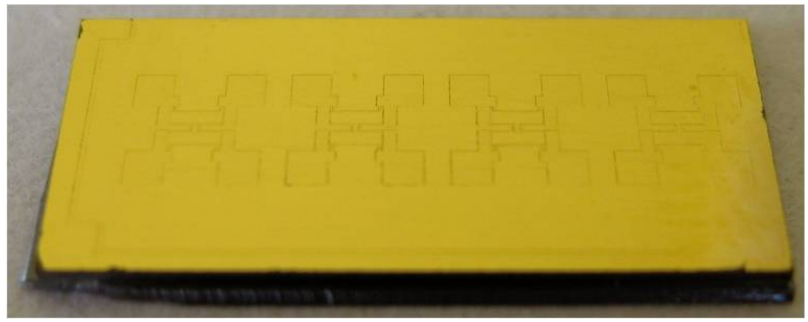
Question 5
How many photolithography steps are involved in building the MTTC Pressure Sensor, and what is the purpose of each?

Metal Deposition – Step 7

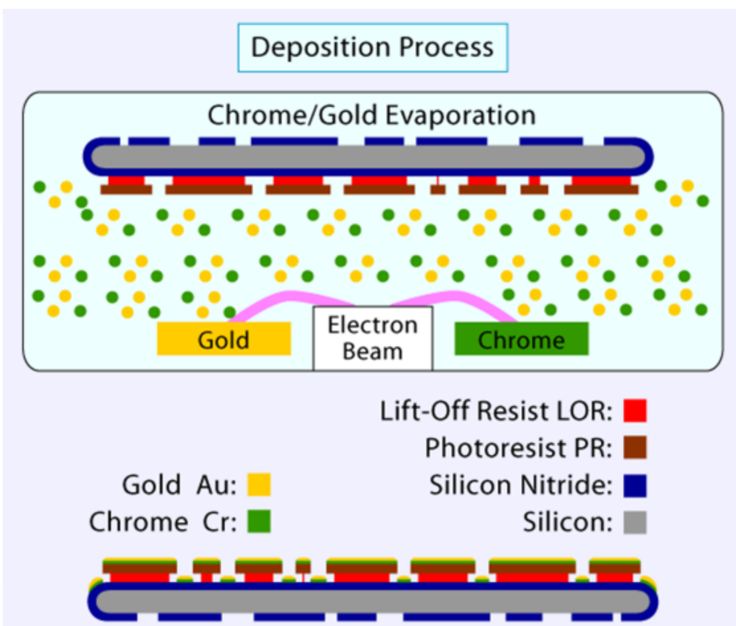
The purpose of this process step is to deposit the conductive metal layer used for the resistor bridge and contacts in the Wheatstone bridge.

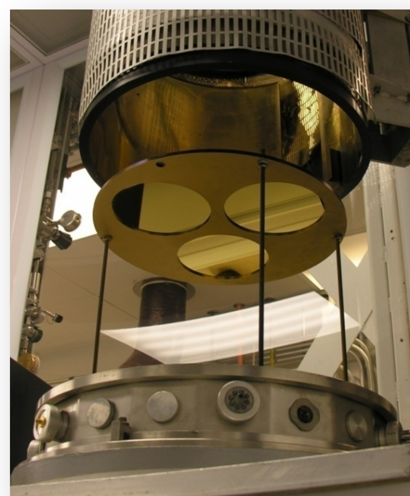
An evaporator is used to deposit a 100 angstroms layer of chrome followed by a layer of 4000 angstroms of gold onto the wafer. Chrome is used because it adheres better than gold to the silicon nitride. Gold is used because it is a good conductor and it adheres well to chrome.





Microscope Image of Wheatstone Bridge Pattern (left) and Individual Chip (right) after Metal Deposition





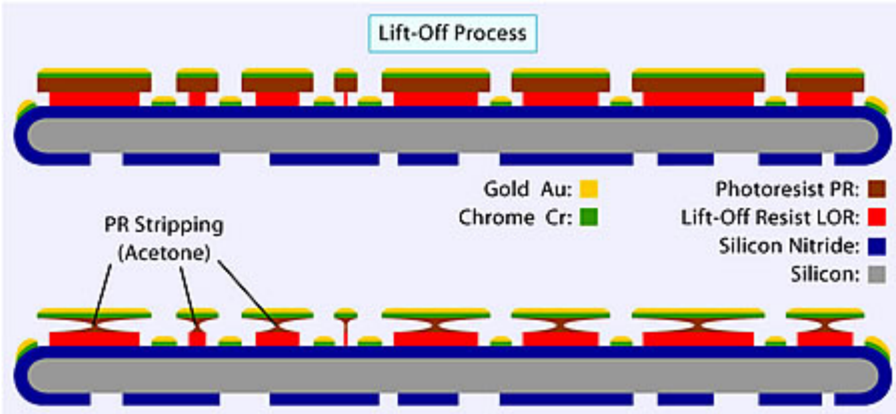
Chrome/Gold Deposition (left), Wafers in the evaporator after processing (right)

Question 6

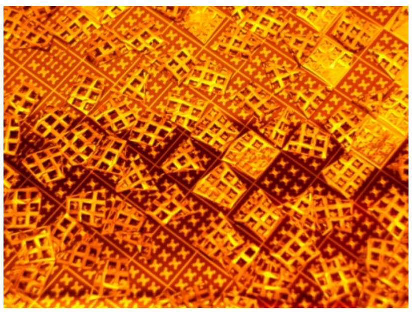
Why is chrome deposited before the gold?

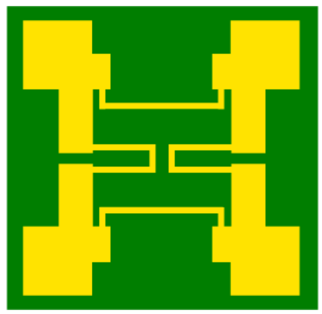
Metal Lift-off – Step 8

Metal lift-off removes select areas of chrome and gold, leaving only the chrome and gold for the Wheatstone bridge pattern. The wafer is immersed in acetone which dissolves the PR layer. As the PR dissolves, the chrome/gold layer on top of it "lifts off". The LOR and the chrome/gold on the silicon nitride remain on the wafer. During lift-off the wafer must stay immersed in the acetone to prevent the removed metal pieces from sticking to the wafer surface.

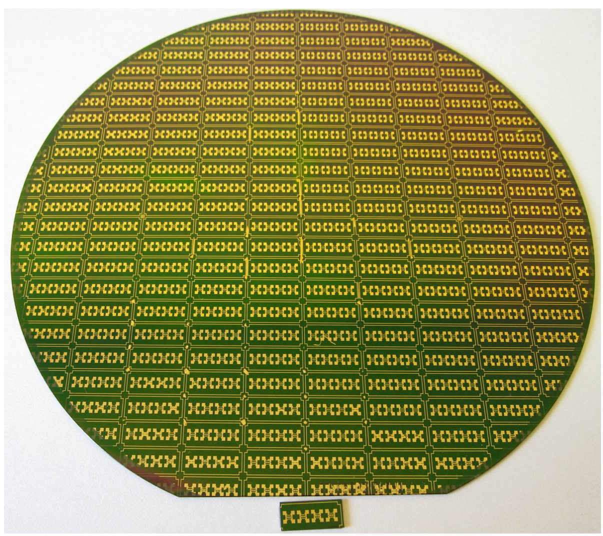


Excess gold and chrome lifting off





Wheatstone bridge pattern after lift-off

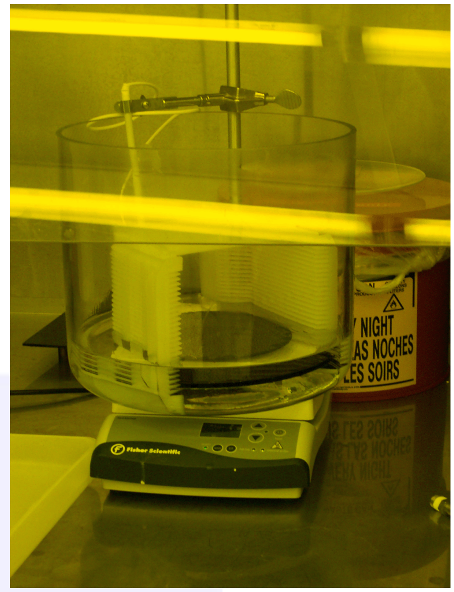


Wafer and Individual Chip after Metal Lift-off

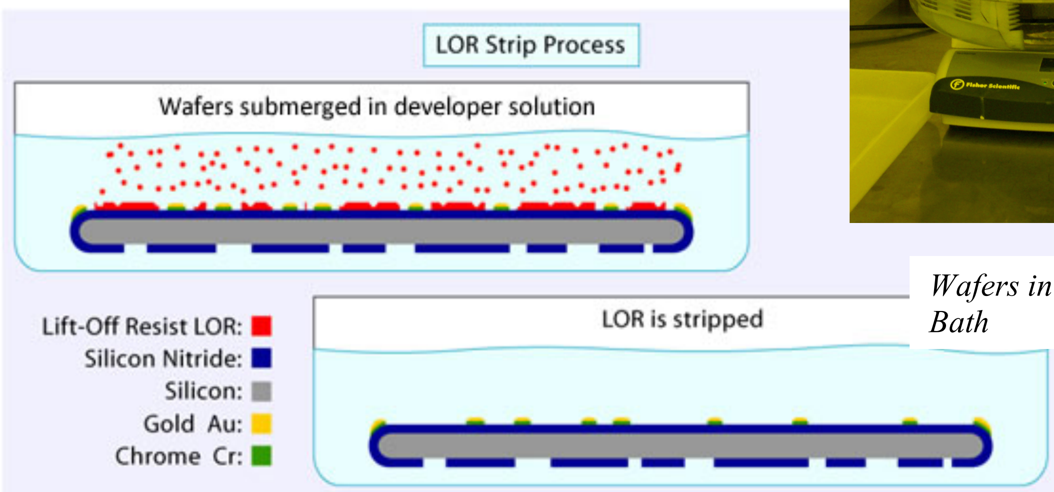
LOR Strip – Step 9

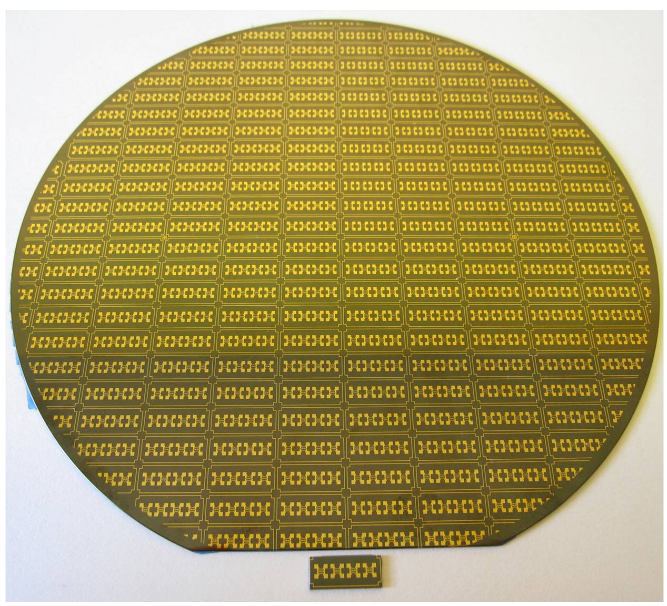
Once the PR has dissolved and the excess metal has lifted off, the remaining lift off resist (LOR) is removed using a developer solution.

The wafers are carefully placed face up in the developer bath at room temperature for approximately 2 minutes.



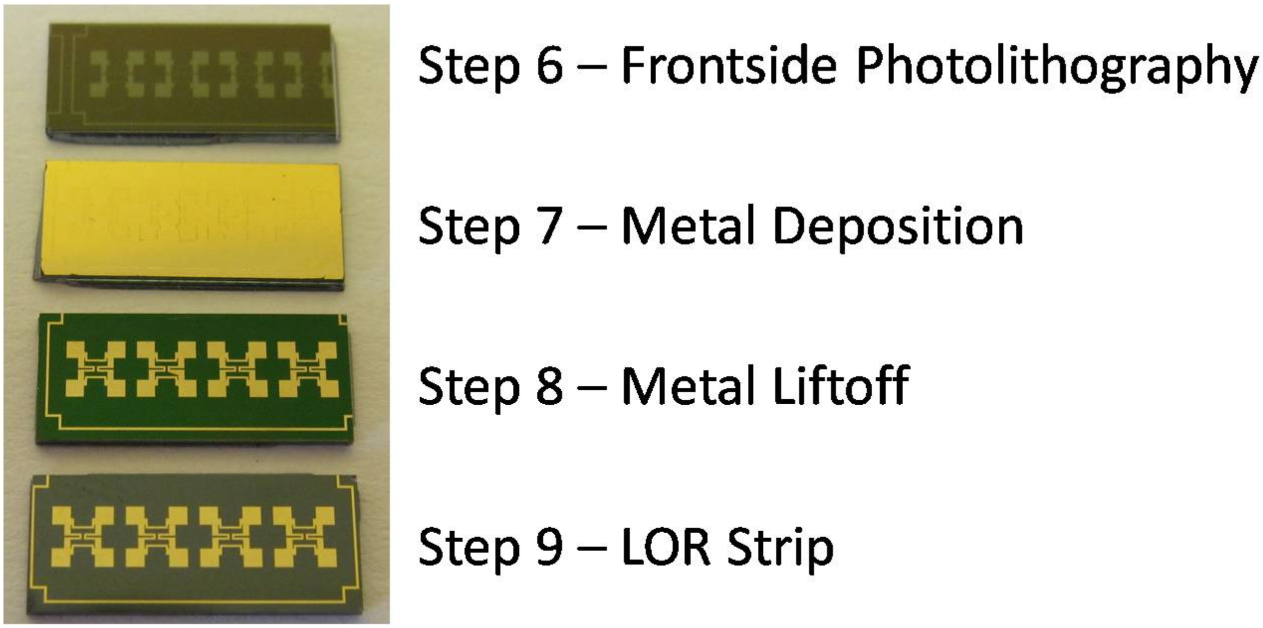
Wafers in Developer Bath





Wafer and Individual Chip after LOR Strip

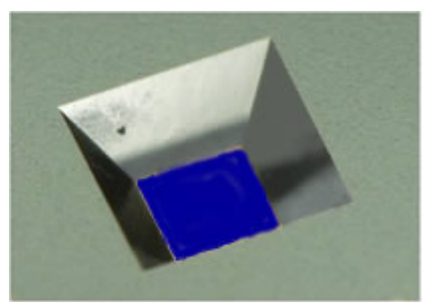
At this point the frontside of the wafer has been through many changes. Below is a photograph which compares the process steps, 6, 7, 8, and 9. Step 6 provides the Wheatstone bridge pattern on the frontside of the wafer. Step 7 deposits the chrome and gold for the Wheatstone bridge circuitry. Step 8 lifts off the chrome and gold that is not needed for the circuitry. Step 9 strips off the remaining LOR.



KOH Etch – Step 10

Wafer in KOH

Pressure Sensor after KOH Etch



Backside of wafer showing the anisotropic etch

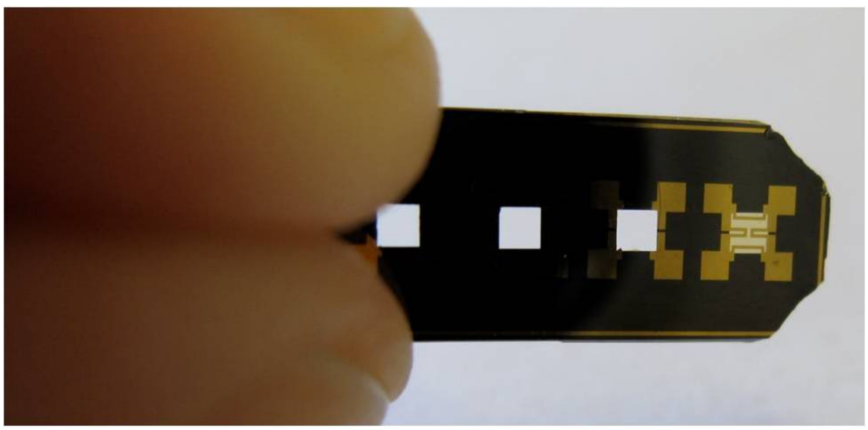
KOH Etch

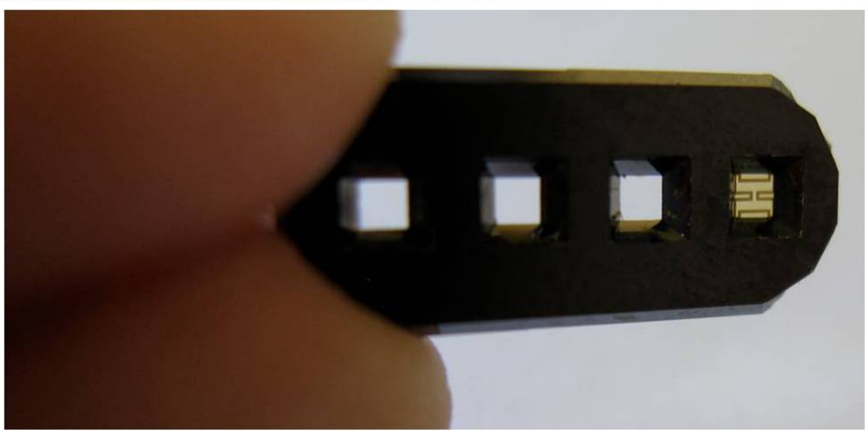
As the last step, the exposed silicon on the non-metal (back) side of the wafer is etched using Potassium Hydroxide (KOH). In the KOH etch process, wafers are submerged in a heated KOH bath. KOH is used because it etches the silicon anisotropically *(see graphic above on the far right)*.

The silicon nitride on the non-metal (back) side of the wafer acts as a hard mask. This mask exposes select areas of the silicon to the KOH. The KOH etches the exposed silicon anisotropically. The etch continues until the exposed silicon is removed. In this process step, the thin silicon nitride membrane on the frontside of the wafer acts as an etch stop layer. KOH cannot etch silicon nitride; therefore, the etch stops when the silicon nitride layer is reached.

This is an example of bulk micromachining, a process where a bulk of the silicon substrate is removed during the fabrication of the device. At this point in the process the wafers become very fragile since a bulk of the silicon has been removed.

The two images below are the front and back of an individual chip after KOH etch. This chip is the final product, containing four separate pressure sensors. Notice how the sensor on the right of both photos shows the Wheatstone bridge pattern and the silicon nitride membrane, thus being a complete micro-pressure sensor. The three to the left however do not show the Wheatstone bridge pattern, nor the membrane. These membranes have been blown out, resulting in holes. These sensors are very fragile. Handling them excessively can destroy these tiny sensors.



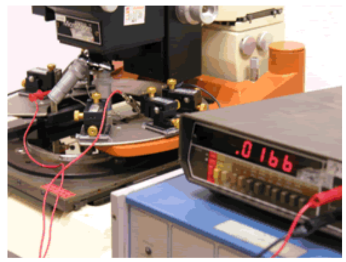


Frontside of an Individual Chip after Processing is Complete (top)
Backside of an Individual Chip after Processing is Complete (bottom)

Testing and Probing

Now that the pressure sensor fabrication process is complete, the final pressure sensors can be probed and tested. A probing station with a microscope is used to observe the deflection of the silicon nitride membrane when it is subjected to a power source. A deflection of the membrane indicates a successful process. No deflection of the membrane indicates misprocessing at one or more process steps.

Pressure Sensor wafer on probing station



Probing station and power supply

Probe on the Wheatstone Bridge

Testing and Probing

Summary

The MTTC pressure sensor process produces a pressure sensor with a Wheatstone bridge sensing circuit. This process illustrates the bulk micromachining process sequence used commercially to produce MEMS pressure sensors. It also provides a basic understanding of photolithography, plasma etch, metal deposition, metal lift-off, and KOH etch.

Food for Thought

Using observation, what wafer characteristics can you use to distinguish between the different processing steps?

References

MTTC Pressure Sensor.doc, Harold Madsen, Albuquerque UNM.
MTTC KOH Flow.xls, Harold Madsen, Albuquerque UNM.
Lift-Off.ppt, Fabian Lopez, Albuquerque CNM.
Transducers MEMS.doc , Dr. Chuck Hawkins, Albuquerque UNM

Glossary

Anisotropic Etch - A selective etch that exhibits an accelerated etch rate along specific crystallographic planes. The etch rates are different at the surface and the underlying layers. It results in straight wall geometries.

Atmospheric Pressure - The force per unit area exerted against a surface by the weight of air above that surface at any given point in the Earth's atmosphere.

Bulk Micromachining - A MEMS manufacturing process which defines structures by selectively etching inside a substrate.

Chemical Vapor Deposition - A chemical process used to produce high-purity, high-performance solid thin film material on a wafer's surface.

Dopant - An impurity element added in low concentrations to a crystal or semiconductor lattice in order to alter the optical/electrical properties of the semiconductor.

KOH (potassium hydroxide) - The inorganic compound with the formula KOH.

Ohm's Law - States that the current through a conductor between two points is directly proportional to the potential difference or voltage across the two points, and inversely proportional to the resistance between them. The mathematical relationship is $I=V/R$, where V is voltage, I is current, and R is resistance.

Photolithography - The transfer of a pattern or image from one medium to another, as from a mask to a photoresist layer on a wafer.

Photoresist – A light sensitive material used in photolithography to transfer a pattern to an underlying substrate.

Plasma Etch - A type of etch where ions bombard the surface of the wafer, causing molecules to sputter off the surface. It is a physical etch process with no chemical reaction occurring.

Pressure Sensor - Measures pressure, typically of gases or liquids. A pressure sensor generates a signal related to the pressure imposed.

Reactive Ion Etch (RIE) – A type of plasma etch that uses both ions and radicals in the plasma to respectively physically and chemically etch the wafer's surface.

Resistance - The electrical resistance of an object is a measure of its opposition to the passage of a steady electrical current.

Resistivity - A measure of how strongly a material opposes the flow of electric current.

UV Light - Electromagnetic radiation with a wavelength shorter than that of visible light, but longer than x-rays.

Wheatstone Bridge – An electronic circuit used to measure an unknown electrical resistance by balancing a four resistor bridge circuit.

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