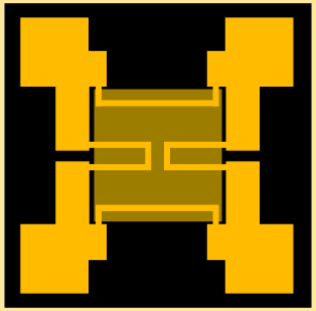
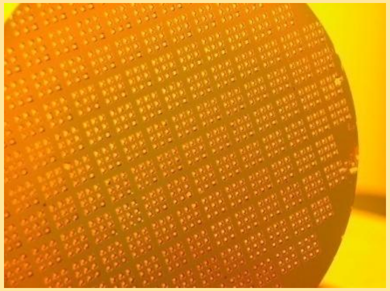
MTTC PRESSURE SENSOR OVERVIEW



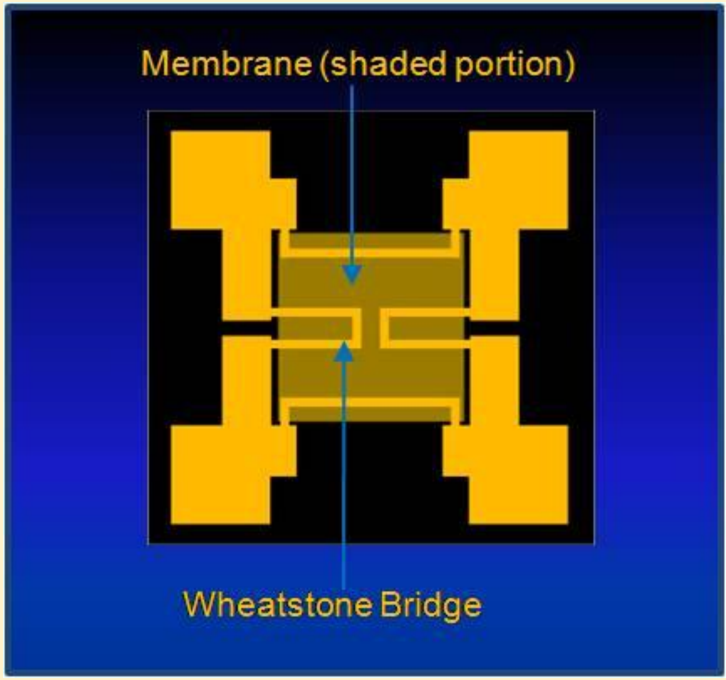


SCME Southwest Center for Microsystems Education

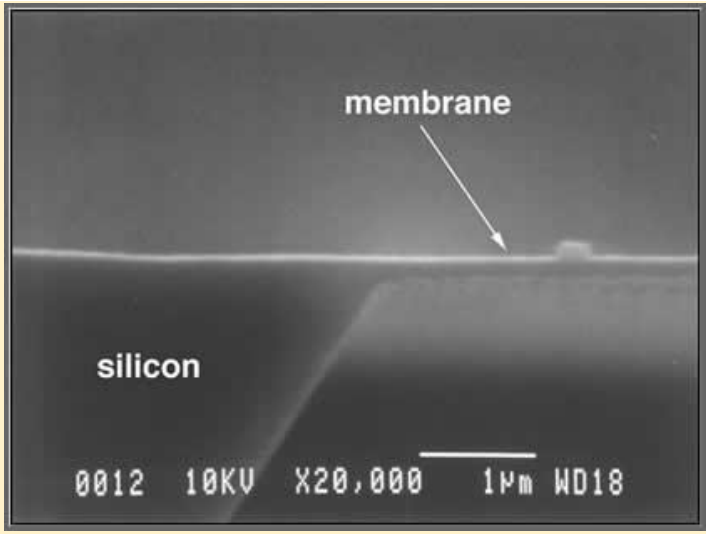
Process Introduction

Pressure Sensor

- Process developed at the UNM MTTC/CNM
- Design incorporates a Wheatstone bridge as an electronic sensing circuit
- 4 Resistors (2 fixed, 2 variable)
- Conducting metal is gold
- 4 pads as leads



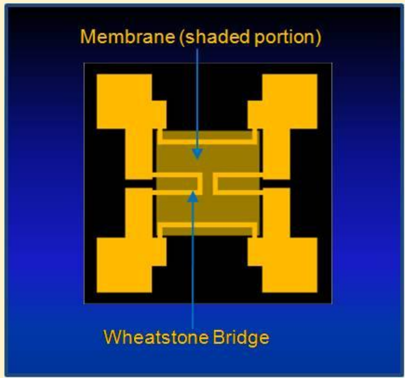
Finding Change in Pressure



- A thin membrane of silicon nitride is the sensing membrane
- Cavity acting as reference pressure
- Membrane stretches when pressure on opposite sides of the membrane are different.
- As the membrane deflects, the resistance will change in the variable resistors
- As the pressure changes, the resistance changes due to change in length

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

- A calibration curve is created using known pressure differences and resistance values



Pressure Sensor Features

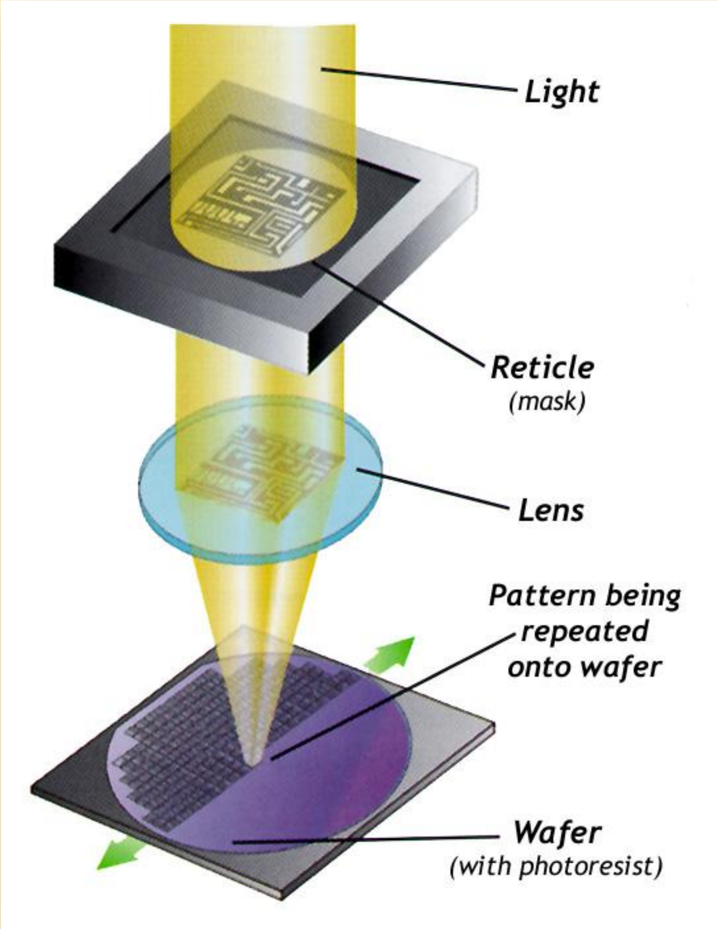
- Wheatstone bridge electronic sensing circuit
  - Deposit metal (chrome/gold)
- Sensing Membrane
  - Silicon Nitride
- Reference chamber
  - Etch away a hole to act as the chamber

How do we make it?

- MTTC Pressure Sensor Process uses 2 micromaching process techniques
  - Surface micromachining
  - Bulk micromachining
- Wheatstone bridge electronic sensing circuit
  - Deposit metal (chrome/gold)
  - *Surface micromachining techniques*
- Sensing Membrane
  - Deposit Silicon Nitride thin film
  - *Surface micromachining techniques*
- Reference chamber
  - Etch away a hole to act as the chamber
  - *Bulk micromachining techniques*

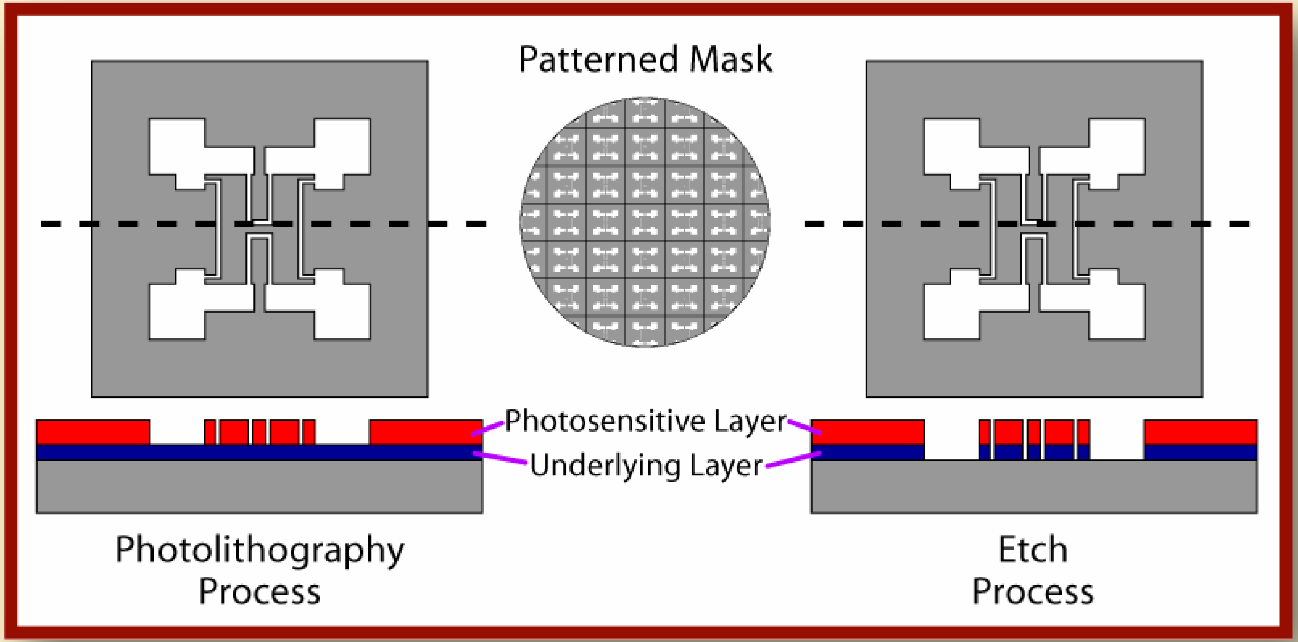
Surface Micromachining Process Outline

- Basic CMOS processing
- Pattern (Photolithography)
  - Coat wafer with photoresist
  - Expose resist to a pattern
  - Develop resist
  - Bake to harden resist
- Etch (Wet and/or Dry Etch)
- Deposit next film
- Repeat Pattern, Etch, then Deposit again



[Image Courtesy of MATEC]

Photolithography and Etch



- Pattern from mask is transferred into photoresist.
- Photoresist pattern is transferred into underlying layer using an etch process.
- After etch, the photoresist is removed.

Bulk Micromachining

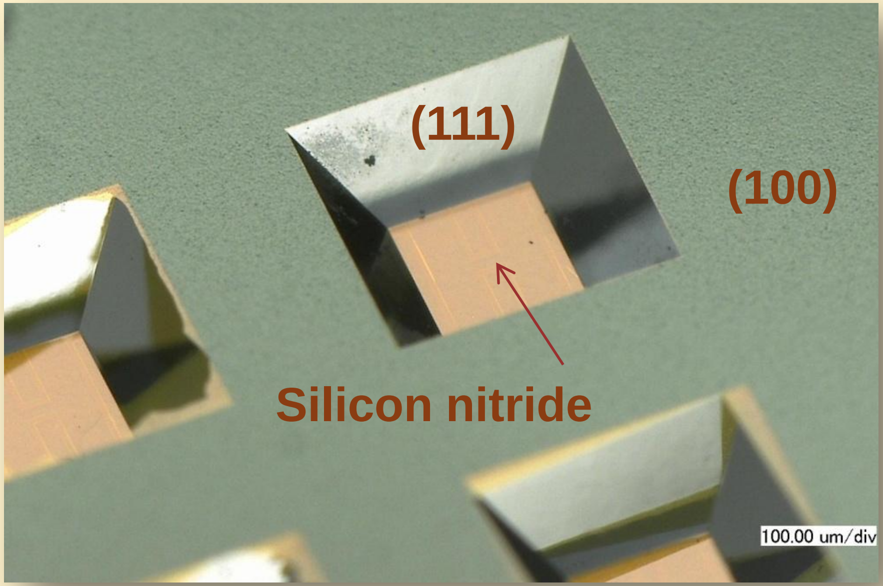
- Bulk micromachining defines structures by selectively etching inside a substrate, usually by removing the "bulk" of a material.
- This is a subtractive process.
- Take for example the cliff dwellings at Mesa Verde which were formed below the surface of the flat topped mesa. Man and nature have "bulk etched" these dwellings into the side of the cliff.
- Micro-machined structures are formed into the wafer substrate in the same manner.

[Image printed with permission from Barb Lopez]

Bulk Micromachining

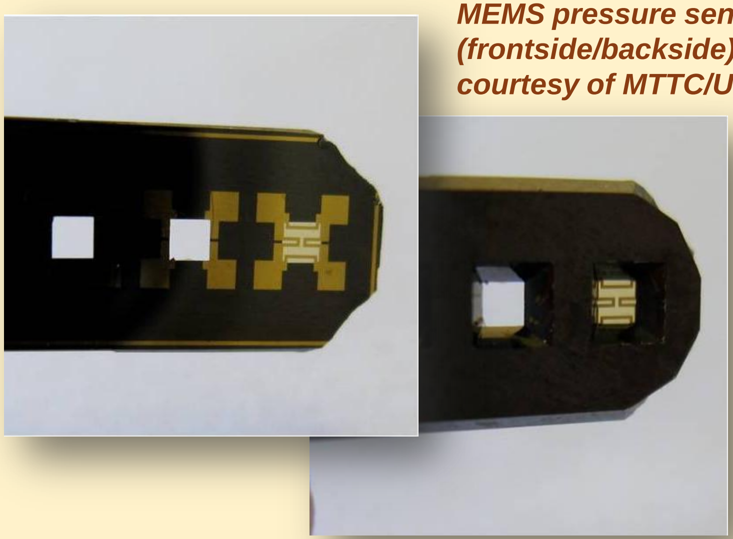
- Monocrystalline silicon wafers are mostly etched to form three-dimensional MEMS devices.
- The silicon in the wafer substrate is specifically removed using anisotropic chemistries.
- Sensors such as piezoresistive pressure sensors have been manufactured in high volume.
- Bulk micromachined devices typically have high aspect ratios.

Backside of MTTC Pressure Sensor

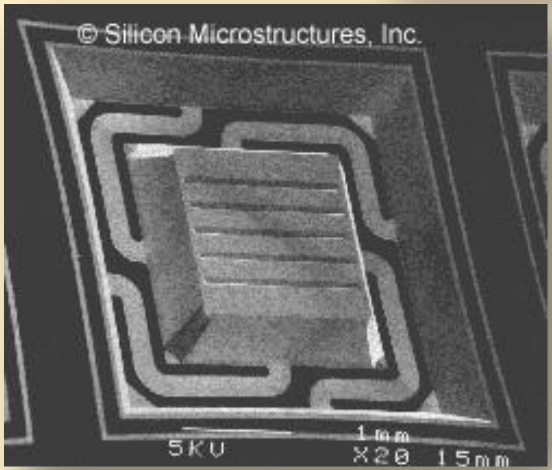


Bulk Micromachining

- Bulk Micromachining involves deposition, patterning and etching of structural and sacrificial layers.
- It also includes bulk dry or wet etching of relatively large amounts of silicon substrate.
- Structures include high aspect ratio fluidic channels, alignment grooves, pits.



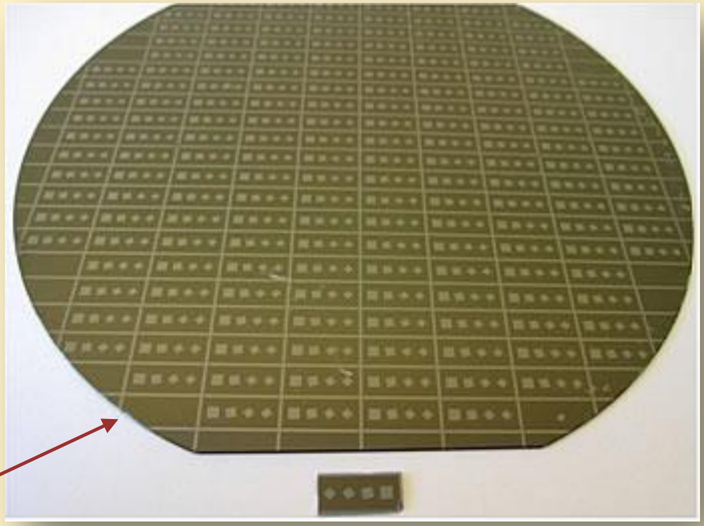
MEMS pressure sensor (frontside/backside) [Images courtesy of MTTC/UNM]



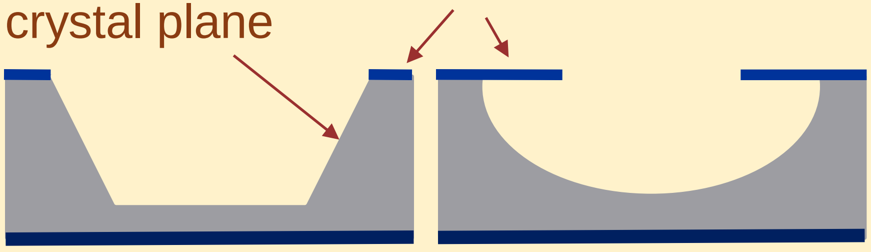
[Image courtesy of Khalil Najafi, University of Michigan]

Bulk Micromachining

For silicon wafers, silicon dioxide or nitride are most commonly used as an etch mask. The film is then patterned to allow the removal of undesired portions of the film.

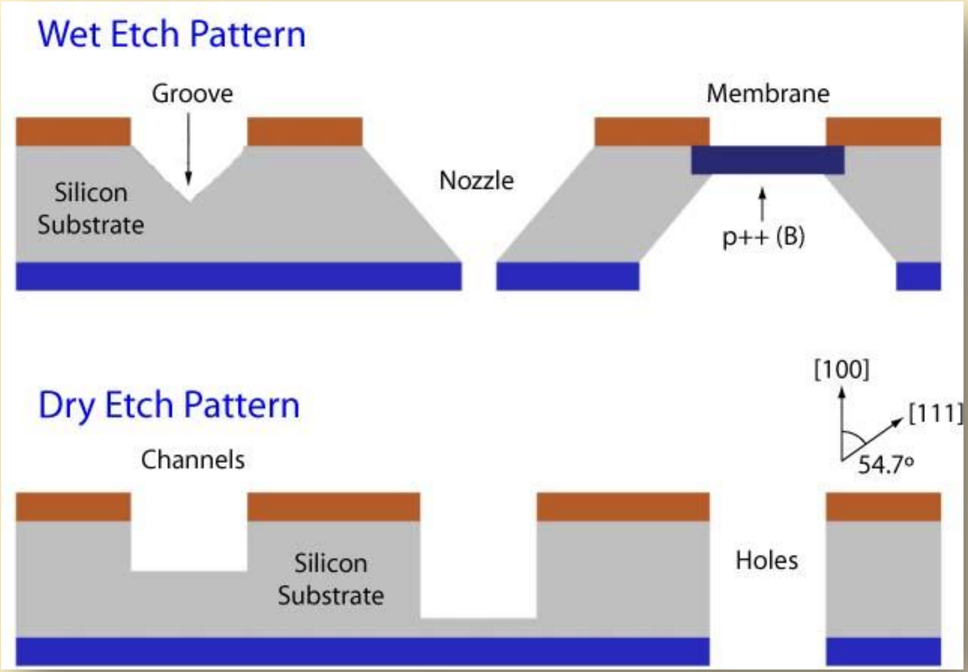


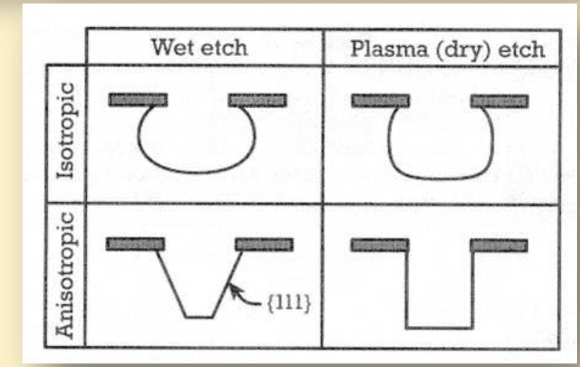
A Silicon Nitride etch mask on the backside of a wafer used for pressure sensors. A subsequent etch process anisotropically removes the bulk silicon not protected by the nitride mask.



Bulk Micromachining – Wet and Dry Etch

- Two types of etching can be used in Bulk Micromachining
  - Wet Etch
  - Dry Etch
- Both wet and dry etch can produce either
  - Isotropic Etch
  - Anisotropic Etch
- Etch profiles will be different depending upon type of etch and the etchant





Bulk Micromachining – Wet Etchants

Chemicals are used to anisotropically etch crystalline substrates

- Potassium Hydroxide (KOH)
- Ethylene Diamine Pyrocatechol (EDP)
- Tetramethyl Ammonium Hydroxide (TMAH)
- Sodium Hydroxide (NaOH)
- N_2H_4-H_2O (Hydrazine)

Summary

The MTTC Pressure Sensor process uses a gold Wheatstone bridge electronic sensing circuit and a silicon nitride membrane. The reference chamber is created using an anisotropic etch which removes the bulk of the silicon on the backside of the wafer. The manufacture of these features require both surface micromachining and bulk micromachining techniques.