
A MEMS Process Model Activity

Instructor Guide

Notes to Instructor

This activity allows the participants to demonstrate their understanding of the MTTC Pressure Sensor Process developed at the Manufacturing Technology Training Center (MTTC) at the University of New Mexico (UNM). Participants will create a simulation of the process using either a graphics program or simple materials such as construction paper and foam core.

This activity is part of the *MTTC Pressure Sensor Process Learning Module*. All of the units in this learning module are listed below.

- Knowledge Probe (KP) or pre-quiz
- MTTC Pressure Sensor Process Primary Knowledge
- MTTC Pressure Sensor Process Activity (Cleanroom or fabrication facility required)
- **A MEMS Process Model Activity**
- Micro Pressure Sensor Process Activity*
- Surface Micromachining: Lift-Off Process Activity*
- Bulk Micromachining: An Etch Process Activity*
- Final Assessment

*Kit available through scme-nm.org while supply lasts

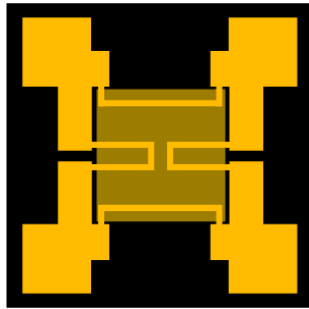
Description and Estimated Time to Complete

In this activity you will demonstrate your understanding of the process steps for fabricating a microelectromechanical systems (MEMS) pressure sensor by creating a graphic illustration or physical model of the process. The process that you will simulate is described in the *MTTC Pressure Sensor Process Primary Knowledge (PK)*. You should review the PK before beginning this activity. Another resource that may be helpful is the *MTTC Pressure Sensor Process Storyboard*. It summarizes the process described in the PK.

Estimated Time to Complete

Allow 1 to 2 hours to complete this activity.

Introduction



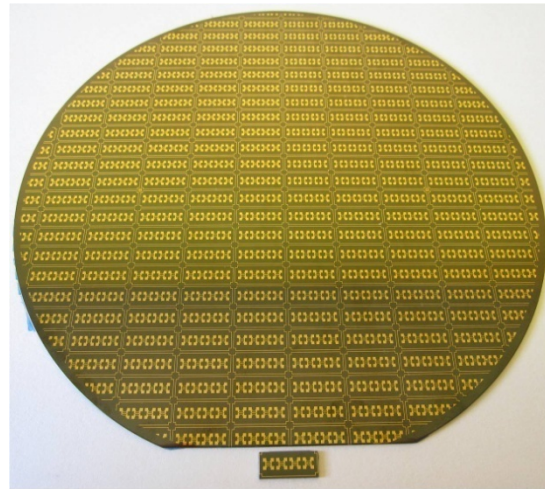
MTTC Pressure Sensor with a Wheatstone Bridge Configuration

The process described in this activity was developed at the University of New Mexico – Manufacturing Technology Training Center (UNM MTTC) and Central New Mexico Community College (CNM). This ten (10) step process is used to fabricate a micro-pressure sensor that is designed to measure changes in pressure applied to a thin membrane or diaphragm.

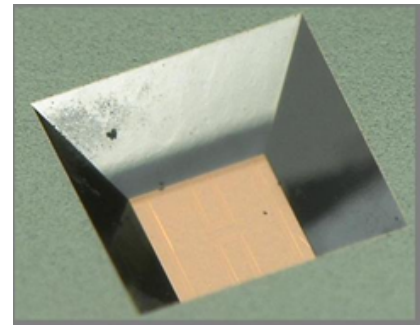
The MTTC design incorporates a Wheatstone bridge configuration as an electronic sensing circuit (above graphic). The Wheatstone bridge circuit is fabricated on top of a silicon nitride thin film that is the membrane or diaphragm for the pressure sensor. This membrane also is used as the top enclosure for a reference pressure chamber that is sealed below the membrane. The pressure within the chamber remains constant. The silicon nitride membrane deflects when the pressures on opposite sides of this membrane are different. The amount of deflection is sensed by variable components (strain gauge resistors) of the Wheatstone bridge.

The pressure sensor fabrication process consists of several steps. The process starts with a bare silicon wafer, and ends with a wafer of approximately 800 micro-pressure sensors with a Wheatstone bridge sensing circuit on top and a bulk etched reference chamber on the backside of the wafer, below the sensing circuit.

The frontside of a completed wafer with approximately 800 micro-pressure sensors (Each small square shown is a micro-pressure sensor. The “X” configuration is the Wheatstone bridge sensing circuit.)



*This image shows the reference chamber that is bulk etched on the backside of the wafer below **each of the Wheatstone bridge sensing circuits**. When the sensor is packaged, the chamber is sealed, trapping the air inside the chamber and creating a constant pressure reference.*



The Pressure Sensor Process

There are several steps involved in fabricating a micro-pressure sensor. In this activity you will create a simulation that illustrates these steps in the correct process order. The process steps are summarized below.

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 Plasma Etch – RIE (Reactive Ion Etch)
5. Frontside and Backside Photoresist Strip
6. Frontside Photolithography
 - a. Frontside Photolithography – Coat (Lift-off resist and Photoresist)
 - b. Frontside Photolithography - Expose
 - c. Frontside Photolithography – Develop
7. Metal Deposition (Chrome and Gold)
8. Metal Lift-off
9. LOR Strip (Lift Off Resist)
10. Backside bulk etch - KOH (Potassium Hydroxide) Anisotropic Etch

Activity Objectives and Outcomes

Activity Objectives

Create a graphic simulation or a model that illustrates the sequential process steps for fabricating a MEMS pressure sensor.

Activity Outcomes

At the end of this activity you will be able to explain how a MEMS pressure sensor is fabricated and what happens to the wafer at each step.

Resources

The SCME *MTTC Pressure Sensor Process Primary Knowledge* unit and the related *MTTC Pressure Sensor Process Storyboard*, is available for download at scme-nm.org.

Team

This activity would benefit from the communicative collaboration of two to three member teams.

Supplies / Equipment

Procedure I - Graphic simulation: You will need a graphics or presentation program.

Procedure II – Model: Below is a suggested list of materials for the model:

- 3 to 4 pieces of foam core (about 8"x8")
- Several sheets of construction paper or cardstock (at least 4 different colors)
- Aluminum foil
- Double-sided tape
- A single-side tape (e.g., Scotch tape, painters tape)
- Spray mount
- Gold glitter
- Scissors
- Box cutters

Preparation / Setup

For the model, you will need a worktable and possibly newspaper that can be used to protect the tabletop.

Activity: MEMS Process Model Activity

Complete one of the following two procedures:

- Procedure I - Graphics simulation
- Procedure II - Model

Procedure I – Graphics Simulation of a MEMS Pressure Sensor Process

Using a presentation program or graphics program,

- create an animated simulation of the pressure sensor process developed by the MTTC at the University of New Mexico.
- Your simulation should show all of the process steps in the correct order.
- You must include labels and descriptions of each process step.
- Your simulation must start with a bare silicon wafer and end with a wafer or chip that shows a Wheatstone bridge circuit on the front side and an etch pressure chamber on the backside.

Present your simulation to your instructor and other participants.

Procedure II – Model of a MEMS Pressure Sensor Process

Using a variety of materials that represent different thin films (e.g., silicon nitride, photoresist, chrome, gold) and different process components (e.g., silicon wafer, masks), construct a model that illustrates each step of the pressure sensor process in the correct sequence.

A list of suggested materials can be found above in **Supplies / Equipment**. You are free to use other materials as you find appropriate for your particular model.

Present your model to your instructor and other participants.

***Note to instructor** – Two examples of a graphic presentation and pictures of a model are provided online @ scme-nm.org with the other instructional guide materials for this learning module. Examples can be found in the folder called “MEMS Model AC examples:”.*

Summary

This activity allowed you to demonstrate your understanding of a MEMS fabrication process, specifically a process used to fabricate a MEMS pressure sensor. As a result of this activity you should be able to list the sequential steps of the process as well as explains what happens in each step of the process.

Support for this work was provided by the National Science Foundation's Advanced Technological Education (ATE) Program through Grants. For more learning modules related to microtechnology, visit the SCME website (<http://scme-nm.org>).