Fabricating a MEMS Pressure Sensor – You Can Do This!

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What are MEMS Pressure Sensors?

MEMS = Microelectromechanical Systems



Small device that converts pressure differences into an electrical signal

Why do we care?

2019-2026 MEMS pressure sensor market dynamics

(Source: MEMS Pressure Sensors - Technology and Market Trends 2021 report, Yole Développement, 2021)



AYOLF

Who Makes These?

OLE

Développemen

2020 MEMS pressure sensor players revenues (\$M)



(Source: MEMS Pressure Sensors - Technology and Market Trends 2021 report, Yole Développement, 2021)

Pressure Sensor Application

https://www.boschsensortec.com/news/accurate-indoorlocalization-can-save-thousands-of-livesenabled-by-pressures-sensing-solution.html



The use of Bosch Sensortec's latest BMP390 pressure sensor in smartphones, enables a high precision localization service that ultimately has the potential to save thousands of lives.



A Cool App for your phone Check out your pressure sensor!

E Everyone Sensor **Kinetics** Family Library 1

Sensor Kinetics

INNOVENTIONS, Inc. Tools

(1) This app is available for your device

You can share this with your family. Learn more about

Installed

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Pressure Sensor How it Works



MTTC Pressure Sensor Process Overview

- Two mask process
 - Backside Chamber pattern
 - Frontside Wheatstone Bridge
- Process Steps
 - SiN Deposition
 - Backside Pattern (thick resist)
 - RIE Etch
 - Frontside Liftoff Pattern
 - Sputter Deposition (metal)
 - Liftoff



SCME/MTTC Pressure Sensor Process -Video

LOF	and	PR F	xposure			
201	. and					
		XXX				
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H H	HH		HHH	HHH	888	ANA A
1	HH-					
11 11	12 13	25 25 25	25 25 25	13 13 13	25 25 25	

Backside Pattern (Chamber) – Hard Mask

- Transfer the Chamber pattern into the SiN protective layer
- Requires
 - Photolithography
 - RIE Etch
 - Resist Strip



Photolithography











Wafer Prep - Clean



•Clean -QDR/SRD •HMDS Deposition

> Apply HMDS – Hexamethaldisilazane Why?







- Resist Dispense
- Spin Speed
- Soft Bake
- Rehydration

Apply Photoresist

Photoresist contains a photoactive compound, polymer and solvent.

It is spun on in a coater, usually followed by a soft bake to remove the solvents.



Expose

Exposure

Transfer the mask pattern to the wafer

First layer masks don't need alignment









Develop

- Develop Pattern
- QDR
- SRD

Microscope Inspection

Inspect

Microscope CD's





Profilometer Inspection - DekTak



After Pattern, Before RIE Etch – Profiles





RIE – March CS-1701 Etcher







- STD Program 2 steps:
- · Pressure 300
- • Power 250W
- • End Point 100
- • Time 2X5min
- • Temp 0 (not controlled)
- • BP/RP 80 (bleed pressure)
- · Flow
- o Gas 2: CF_4 80% open of 50sccm
- o Gas 4: O₂ 8% open of 250sccm





After first 5min

Remaining Nitride

Due to non-uniformity of the etch plasma, we etch ½ the wafer and then rotate.

Starting to Clear



After Etch before Resist Strip



After Etch but before resist strip shows stack of remaining resist and nitride ~ 2.7um total



Etch Inspect





Inspect

•Clear •DekTac

After resist strip shows etched Silicon Nitride ~1.2um Note, back of the wafer is rough, not polished.

Selectivity: What you want etched Vs Masking Material



After resist strip shows etched Silicon Nitride ~1.2um Note, back of the wafer is rough, not polished.

Before the strip, total stack was ~2.7um

Resist Thickness starting out ~7um

Therefore, resist lost, 5.5um, SiN etched ~1.2um which means the selectivity is about 1:5



Backside is now etched



Frontside Pattern – Dark or Bright Field?





Colored is dark, used with nLOF2070

Colored is clear – Used with LOR5B/AZ1518

Karl Suss MA6/BA6



Backside Alignment Microscopes KERISM

50

Pattern the Wheatstone Bridge – Align the patterned back of the wafer to the frontside mask.





Photolithography – Liftoff LOR5B



Key Points

Process is different than the backside pattern

Positive Resist AZ1518 - "What shows goes"

Dark Field Mask





LOR5b Results - Inspect







Photolithography – Liftoff nLOF2070



Key Points

Process is different than the backside pattern

Negative Resist nLOF2070

Clear Field Mask



Figure 6. Expected resultant cross-section of the nLOF2070 frontside pattern process

nLOF2070 Results



So Far....

- Backside hard mask is patterned and etched, resist removed
 - Will be the Chamber



- Frontside is patterned with either negative or positive photoresist
 - Will be the Wheatstone Bridge circuit after metal deposition and liftoff



Deposition of the metal

• Different than the SEMI process – the metal is deposited on top of the photoresist and later lifted off.



Sputter – CrAu or NiCr

- ✓ Ar+ Ions DC Plasma
- ✓ Target Bias Voltage
- \checkmark lons collide with the target
- ✓ Metal is ejected from target
- \checkmark Deposits on wafer



Sputter Process

Load	Load Wafer in Load Lock •Pump down •Open Gate Valve •Transfer to main chamber				
Select	Select Target and Deposition process Choose power 				
Start	Start wafer rotation and substrate heater				
Start Process	Select and run recipe				
Unload Wafer	Unload sequence				

Load Wafer in Load Lock

- Pump down
- Open Gate Valve
- Load Transfer to main chamber



Sputter Wafer Stage and Target







Start

Select Target and Deposition process

Choose power

Start wafer rotation and substrate heater

StartSelect and run recipeProcess



Metal on Photoresist

These Deletin

3.55 µm

Liftoff

- Acetone bath
- IPA Rinse
- QDR
- SRD
- Inspect



Inspect





What's Next?



Chamber Etch – Anisotropic Wet Etching of Silicon in KOH!





Dicing















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QUESTIONS?

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