ECE Final Year Project 2022-2023

Microfabrication of Radio Frequency Filter Chips

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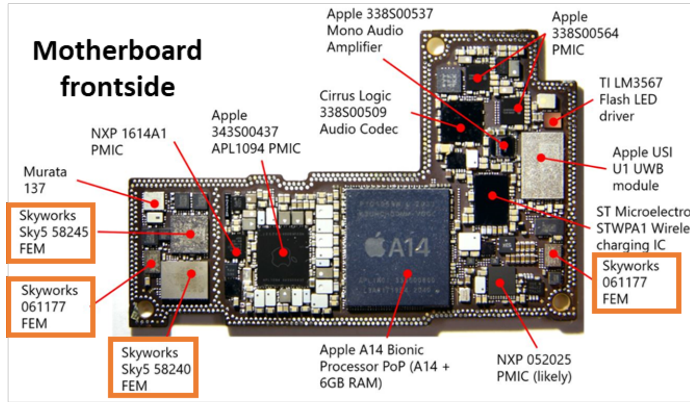
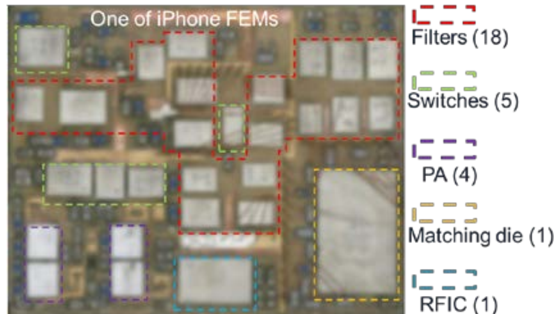
Background, Methodology and Objectives

PROJECT INTRODUCTION

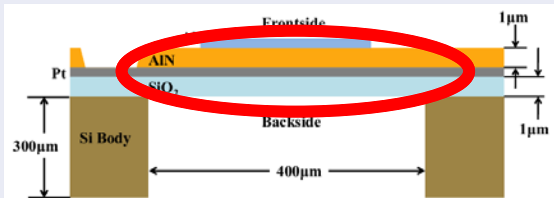
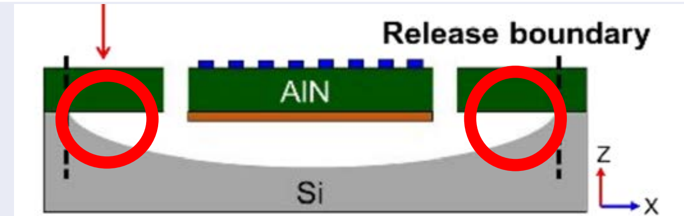
Radio Frequency (RF) Chips



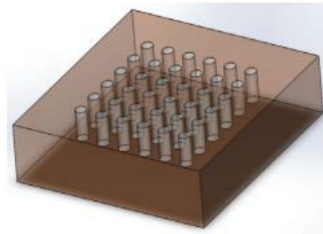
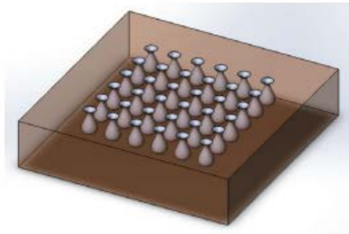
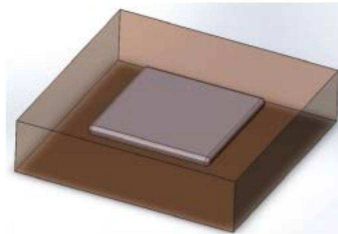
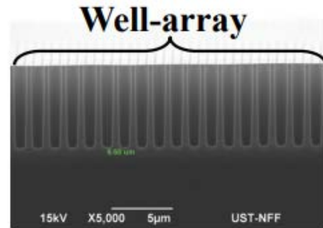


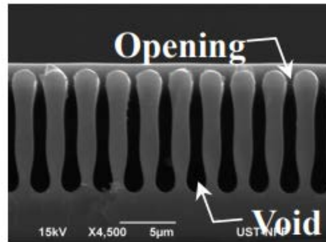
- Fundamental element in modern communication technology.
- Can also be used in medical, military, power systems, and more.
- Performance limited by fabrication technologies.

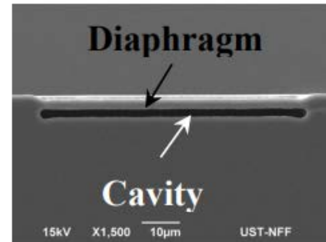
Piezoelectric Micromachined Ultrasonic Transducer (PMUT)

A Comparison Between Traditionally Micromachined PMUTs	
Bulk Micromachining	Surface Micromachining
	
Etch from Bottom	Etch with Interim Layers
Time-Consuming	Complex Process Steps
Cause energy leakage	Ambiguous acoustic boundary

Silicon Migration Technology (SiMiT)





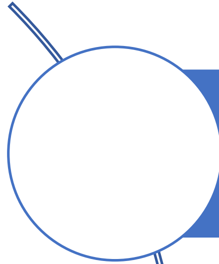
(a) (b) (c)

a) Create dense and narrow well arrays;
b) Silicon atoms start to diffuse upon high temperature;
c) At the end achieves self-sealing.

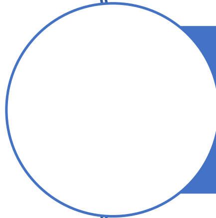
A promising solution to existing issues

Figure: Courtesy of ZENG Fan, HKUST

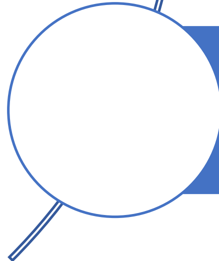
Objectives



Design and verify a compatible process flow for the PMUT fabrication;



Fabricate suspended and buried structures using Silicon Migration Technology;



Complete the PMUT fabrication.

Objective 1

PROCESS PLANNING, DESIGN, AND VERIFICATION

Nano/Microfabrication

Thin Film Formation

Photolithography

Etching

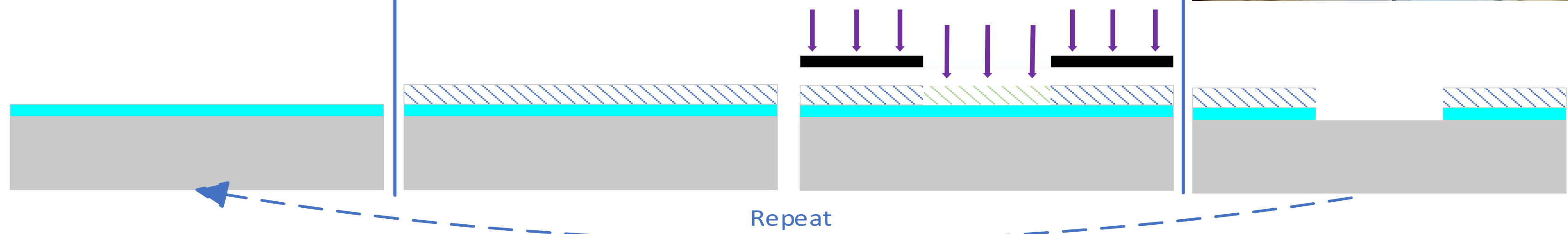
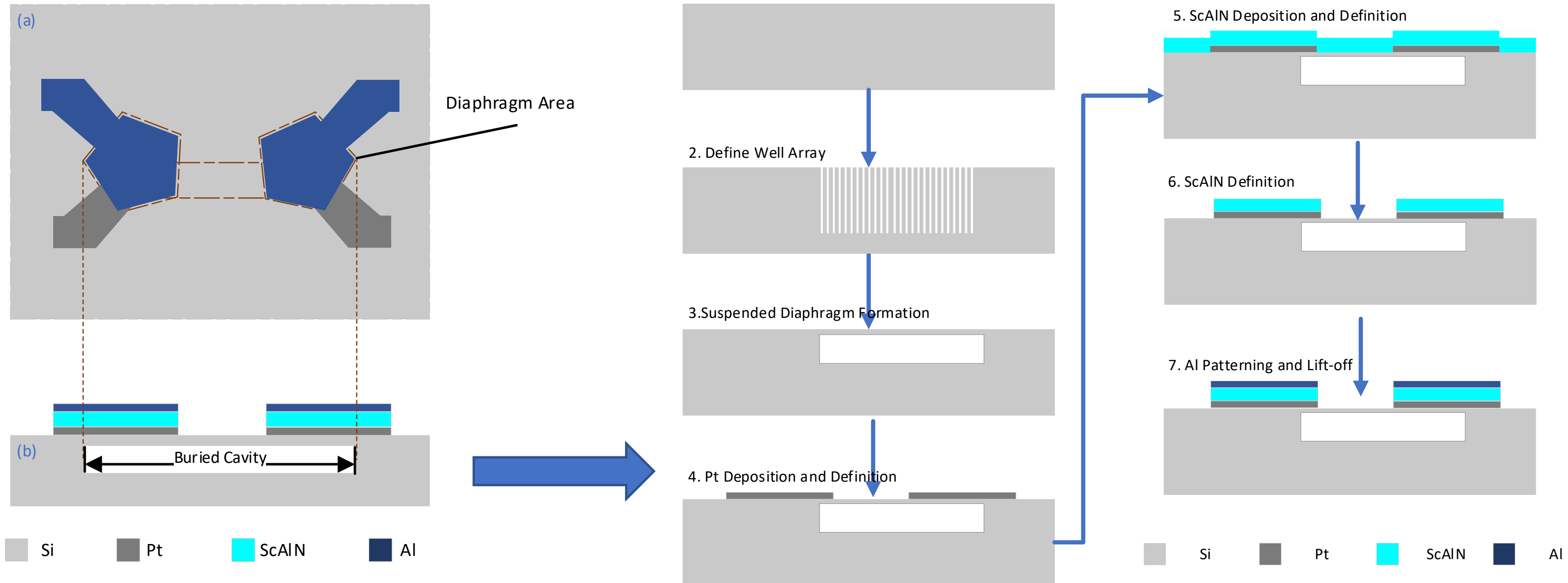


Photo: Courtesy of Nanosystem Fabrication Facility(CWB) , HKUST

From Structural Design to Process Flow

We derived the process flow by reversely look up each layer of this given design.



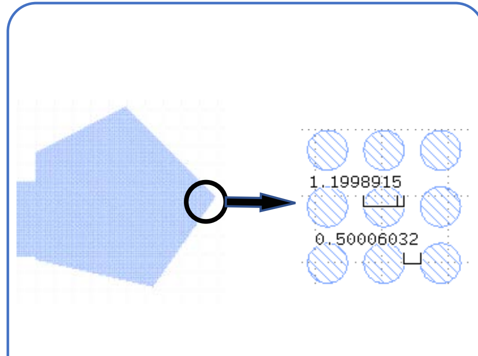
Equipment Matching

Wafer Cleanliness	Step	Equipment	Location	Cleanliness	Process	Requirement
Clean	1.1	B1: Sulfuric Cleaning	P201000	Clean	Initial Clean	
Clean	1.2	B2:HF:H20(1:50)	P201000	Clean	Oxide clean	
Clean	1.3	SRD-B	P201000	Clean	Sample Dry	
Clean	1.4	Oven-C(120C)	P200100	Clean/Semi-Clean	Dehydrating bake	120C 10mins
Clean	1.5	SVG88 Coater Track	P200100	Clean/Semi-Clean	PR Coating	AZ5214 2um /w HMDS
Clean	1.6	SVG88 Coater Track	P200100	Clean/Semi-Clean	Soft Bake	1min 110C
Clean	1.7	ASML Stepper	P200100	Clean/Semi-Clean	Photolithography	TBD
Clean	1.8	SVG88 Developer Track	P200100	Clean/Semi-Clean	Develop	w/o PEB and HB
Clean	1.9	PS210 Asher	P201000	Clean	Descum	TBD
Clean	1.10	DRIE Etcher #1	P201000	Clean	DRIE	TBD
Clean	1.11	PS210 Asher	P201000	Clean	PR Strip	TBD
Clean	1.12	E4:Resist Strip	P201000	Clean/Semi-Clean	PR Strip	
Clean	2.1	A3: Sulfuric Cleaning	P201000	Clean	Pre Anneal Clean	
Clean	2.2	A2:HF:H20 (1:50)	P201000	Clean	Pre Anneal Oxide Clean	
Clean	2.3	SRD-A	P201000	Clean	Sample Dry	
Clean	2.4	RTP-600S	P201000	Clean	Anneal	TBD

Objective 2

SIMIT STRUCTURE FABRICATION

Well Array Formation



Mask Design and Production

1

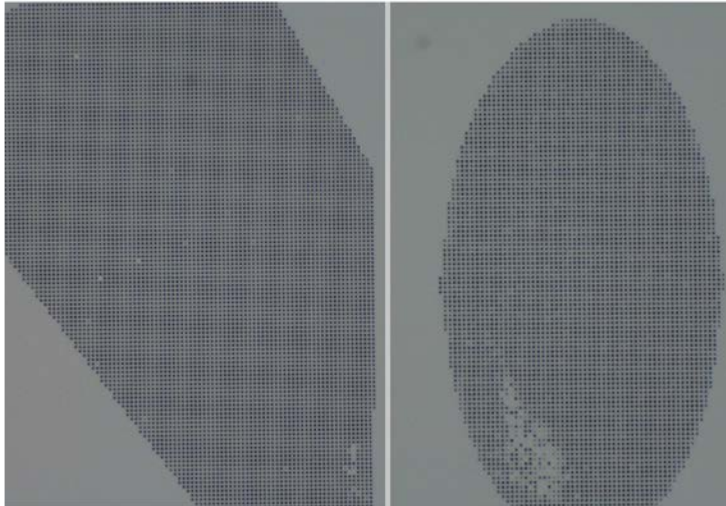
Stepper Photolithography

2

Deep Reactive-ion Etching

3

Well Array Formation

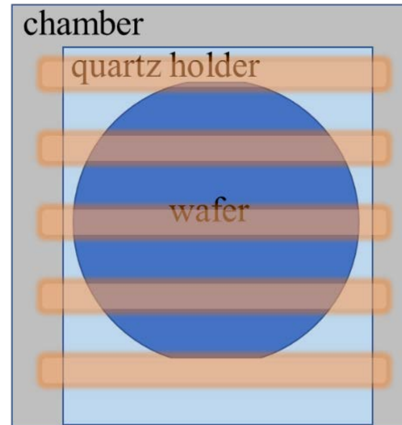


Fabricated Well Arrays

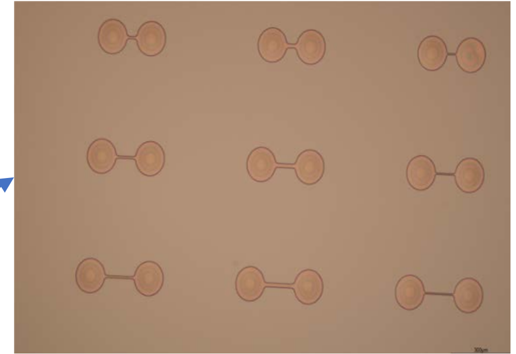
- Well arrays are fabricated with a yield of about 40% per die
- Exposure is non uniform across arrays

Suspended Structure Formation

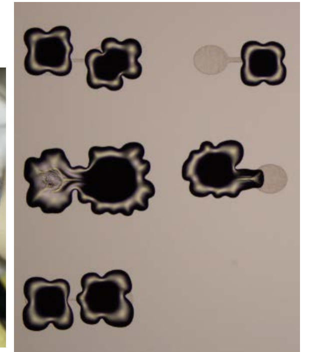
- Initialize Migration With Rapid Thermal Processing
- Temperature control is critical.



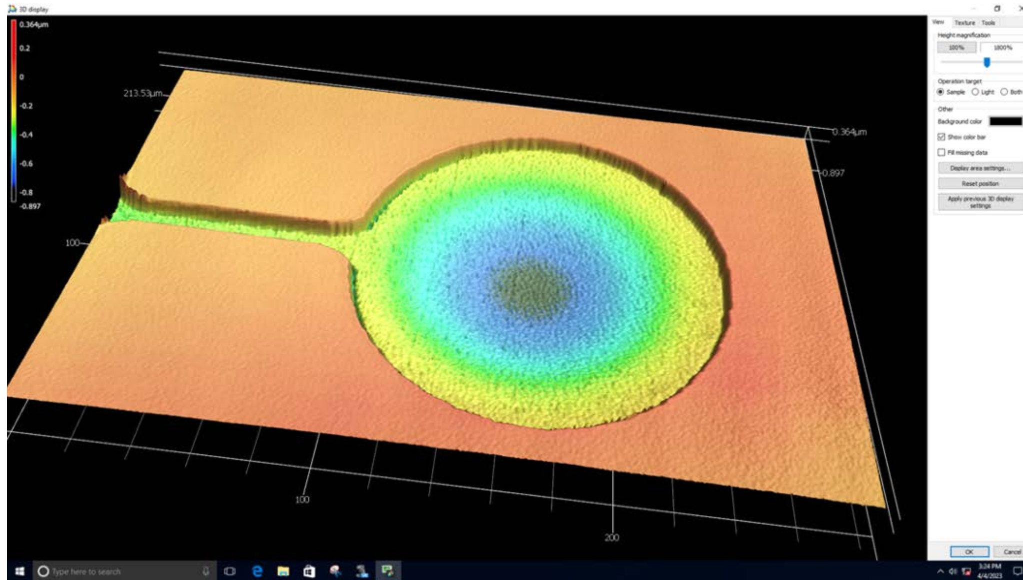
Exact Temp. Control



Temperature Too High



Completed SiMiT Structure

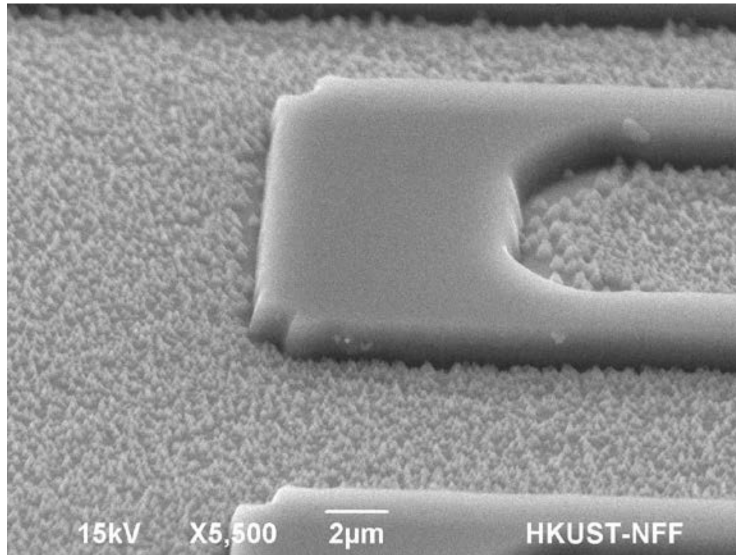


- The curvature indicates the diaphragm is fabricated suspended;
- Concave shaped due to pressure imbalance;
- Argon-filled cavity

Objective 3

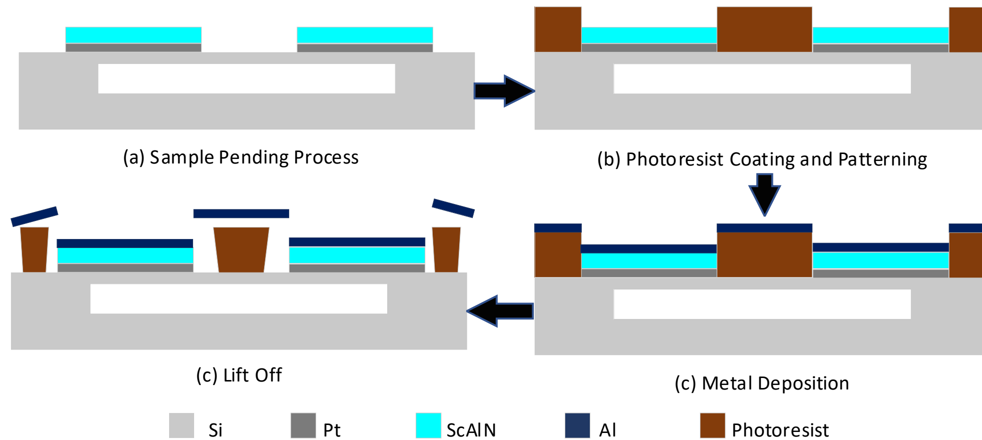
PMUT STRUCTURE FABRICATION

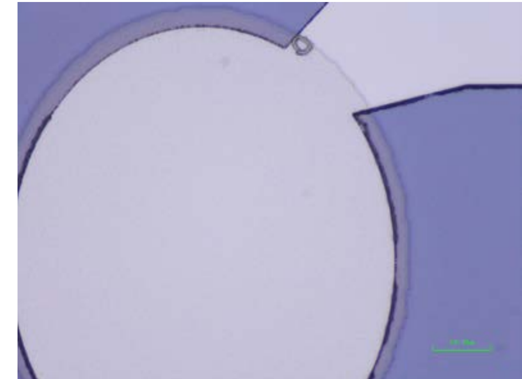
ScAlN Layer Definition



- Deposition work done by external collaborators;
- Layer thickness 622nm;
- Used dry etching to preserve clear and sharp boundary;

Electrode Definition





- Platinum as bottom electrode.
- Aluminium as top electrode.
- Deposited with evaporating.
- Patterned with lift-off.

Conclusion

Proved feasible to make PMUT with SiMiT technique

- Greatly simplified PMUT fabrication process.
- Enables lower cost devices with higher performances.

Found rooms of improvement

- Enhance structural reliability
- Boost yield

Thank You!

Acknowledgment

The fabrication work of this project is supported by the Nanosystem Fabrication Facility(CWB).