Nanosystem Fabrication Facility

Contamination Control and Protocol

----NFF training (Part C)

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How to become an NFF user ?

Make an appointment with Ms Terry LAM

NFF Examination

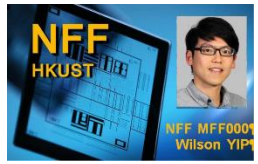
Part C- Contamination Control and Protocol

Part A- Safety Training

Part B-Chemical Safety (Self learning program MC07 and MC03 by HSEO)

Part D-NFF Web Site and Booking System

Process Flow Proved by NFF



NFF access card

NFF user

For more information, please visit NFF website: http://www.nff.ust.hk → Services → Safety training

NFF Examination

- Time：150 minutes
- Open Book
- Passing Marks:

✓	**Qualify questions**		**2 mc***	**100%**
✓	Part I	Safety (Part A)	25 mc*	60%
✓	Part II	Contamination Control and Protocol (*multiple choice—单项选择)	25 mc*	60%
✓	Part III	Process Flow 5 mistakes / PF	2 PF	60%

The syllabus of NFF examination

Part I Topics:

- Cleanroom Environment
- MSDS & Material Restriction
- Alarm System and Emergency Escape Route
- General Lab Safety
- Fire and Chemical Safety
- Equipment and Operation Safety

Part II Topics:

- Contamination Control
- Process Verification Scheme
- General Process Requirements
- Operation Guidelines
- Cleanliness Levels of Equipment and Wafer Status

Part III Topics:

- Paper II Topics
- Standard Format of Process Flows

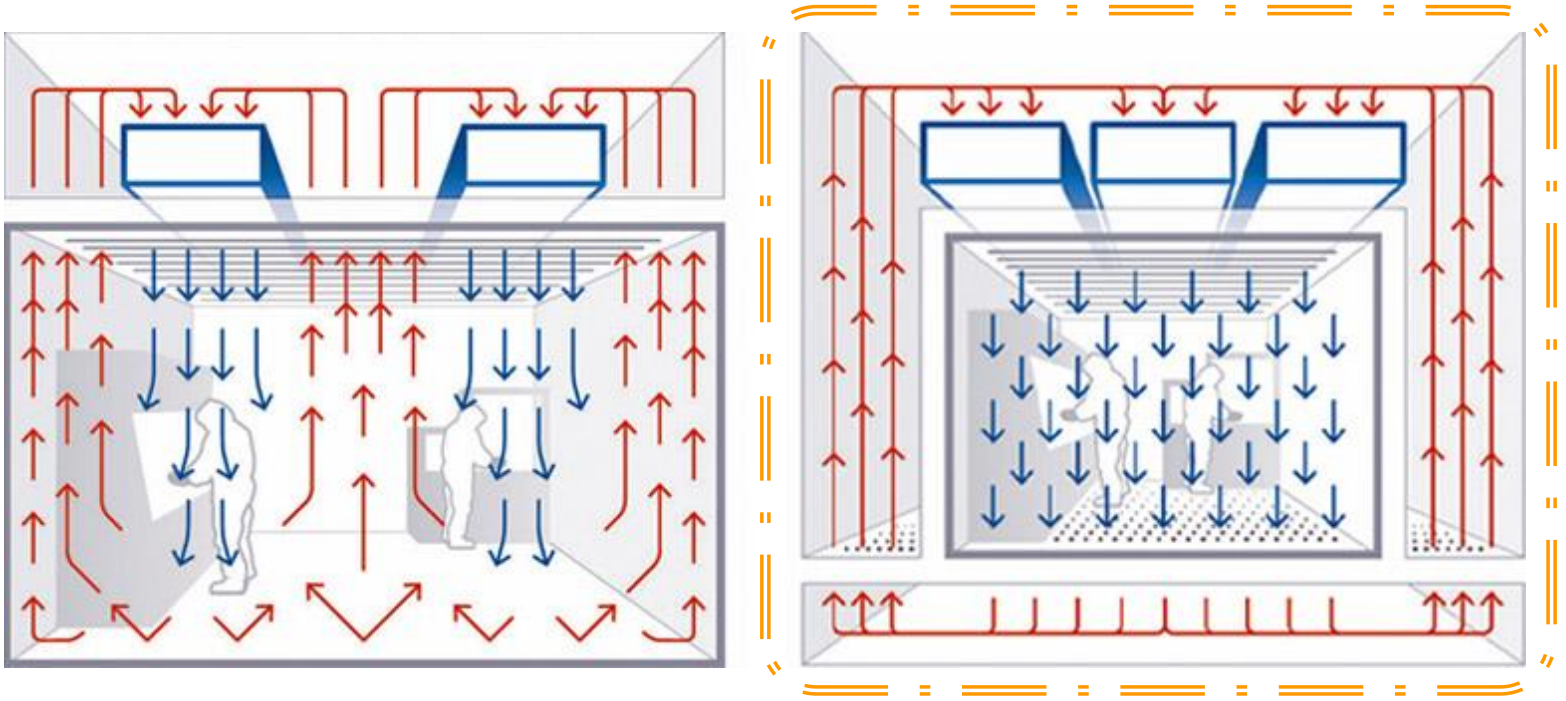
Outline

1. Introduction to cleanroom & NFF
2. Contamination Control
3. Process modules in NFF
4. Process flow
5. Discussion

Introduction to cleanroom [1]

A clean environment is designed to reduce the contamination of processes and materials. Air flow rates and direction, pressurization, temperature, humidity and specialized filtration all need to be tightly controlled.

Clean-room ventilation: Two flow systems



turbulent laminar

Introduction to Cleanroom [2]

cleanroom standard in US

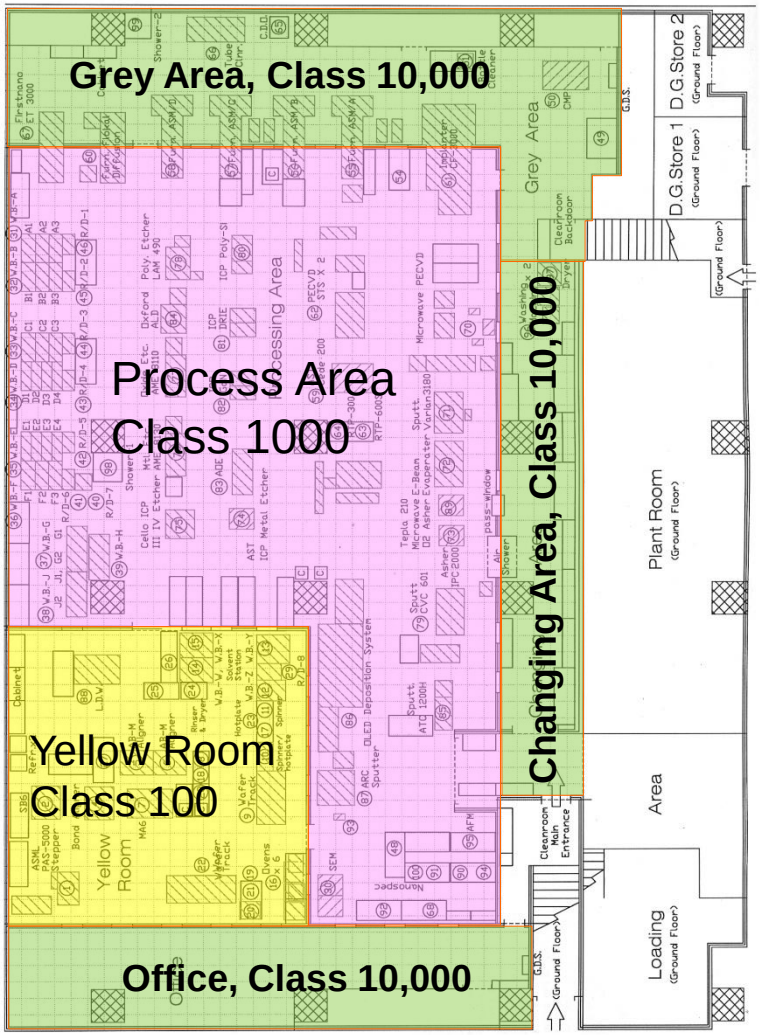
- the US government issued Fed. Std. 209 (now 209E) to standardize cleanroom design in 1963

English Units (particles/ft^3)

Class	0.1μm	0.2μm	0.3μm	0.5μm	5.0μm
1	$3.5x10^1$	7.5	3.0	1	
10	$3.5x10^2$	$7.5x10^1$	$3.0x10^1$	10	
100		$7.5x10^2$	$3.0x10^2$	100	
1,000				1,000	7.0
10,000				10,000	7.0x10

Metric Units (particles/m^3)

Class	0.1μm	0.2μm	0.3μm	0.5μm	5.0μm
M1	$3.5x10^2$	$7.6 x10^1$	$3.1x10^1$	$1.0x10^1$	
M2	$3.5x10^3$	$7.6x10^2$	$3.1x10^2$	$1.0x10^2$	
M3	$3.5x10^4$	$7.6x10^3$	$3.1x10^3$	$1.0x10^3$	
M4		$7.6x10^4$	$3.1x10^4$	$1.0x10^4$	
M5				$1.0x10^5$	$6.2x10^2$



Floor plan of NFF Phase II

Introduction to NFF [3]

- The first nanofabrication laboratory established at a tertiary institution in Hong Kong since 1991.
- Its mission is to provide fabrication facilities in support of research and teaching in micro/nano devices and systems. NFF aims to support not only individual faculty members of HKUST but also researchers from local institutions in the area of micro/nano devices and systems.
- Mainland and overseas institutions as well as private sectors are also welcome to approach NFF for technical collaborations.

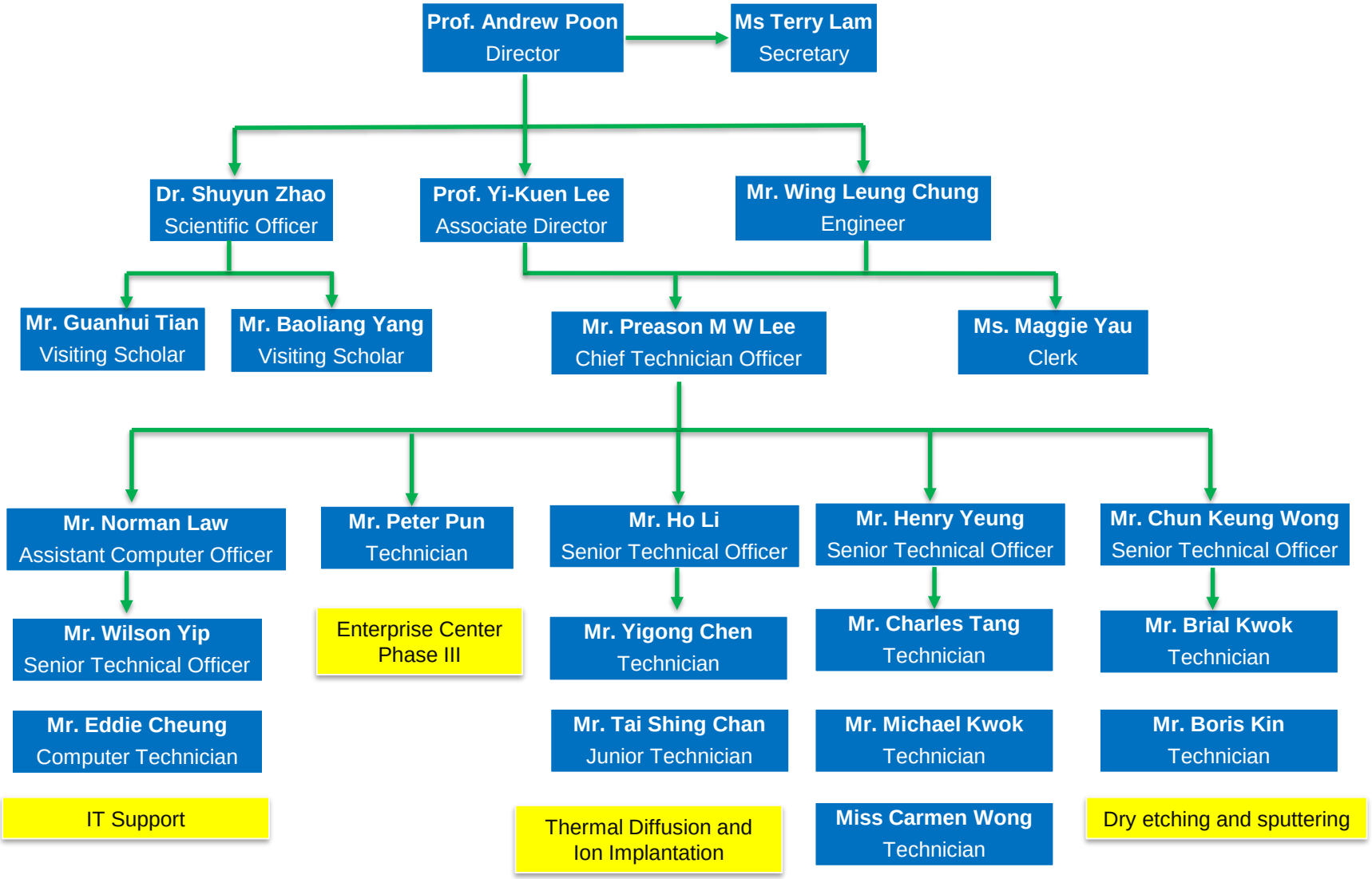
Introduction to NFF [4]

Phase II	Phase III-EC	Rm.2223/2227

• Area:750m^2,
• class 100, class1000 and class 10,000.
• **5 Equipment modules:**
  • Mask making
  • Photolithography
  • Wet etching and CMP
  • Dry Etching and Sputtering
  • Thermal processing and implantation
	• Phase III (Enterprise Center) area is 200m^2 opened in 2009.
	• **Main equipment modules** (Non-std):
	  • E-beam lithography
	  • Basic photolithography
	  • E-beam evaporation and sputtering
	  • Wet etch and lift-off
		• **Room 2223**
		• Deep RIE process center
		• **Room 2227**
		  • TSV Process Laboratory
		  • Electroplating
		  • Grinding and Polishing

Location: P200100, P201000	EC01000	Rm.2223/Rm.2227

NFF Organization Chart



Process modules in NFF

Photolithography

- Laser direct writer
- Stepper
- Contact aligner
- Substrate bonder
- Wafer tracks
- Resist coaters
- E-beam lithography
- Nanoscibe 3D printer
- SEM
- Microscopes
- Wet stations
- Ovens/hot plates

Wet etching & CMP

- Wet Stations
  - Cleaning
  - Metal etch
  - Si etch
  - PR strip
- CMP, oxide and Polysilicon
- CMP, metal
- Wafer grinder
- Wafer polisher
- Electroplating

Dry etch & Sputter

- ICP etchers
  - SiO_2
  - Polysilicon
  - Si DRIE
  - GaN
  - Metals
- RIE etchers
- XeF_2 Etcher
- Metal sputtering
- E-beam evaporators
- O_2 ashers

Thermal & Implant

- Furnances
  - Oxidation
  - Diffusion
  - LPCVDs
- RTPs
- PECVDs
  - SiO_2
  - Nitride
  - Amor-Si
  - CNT
- Silicon Epitaxy
- ALD
- Ion Implanters

Research areas in NFF

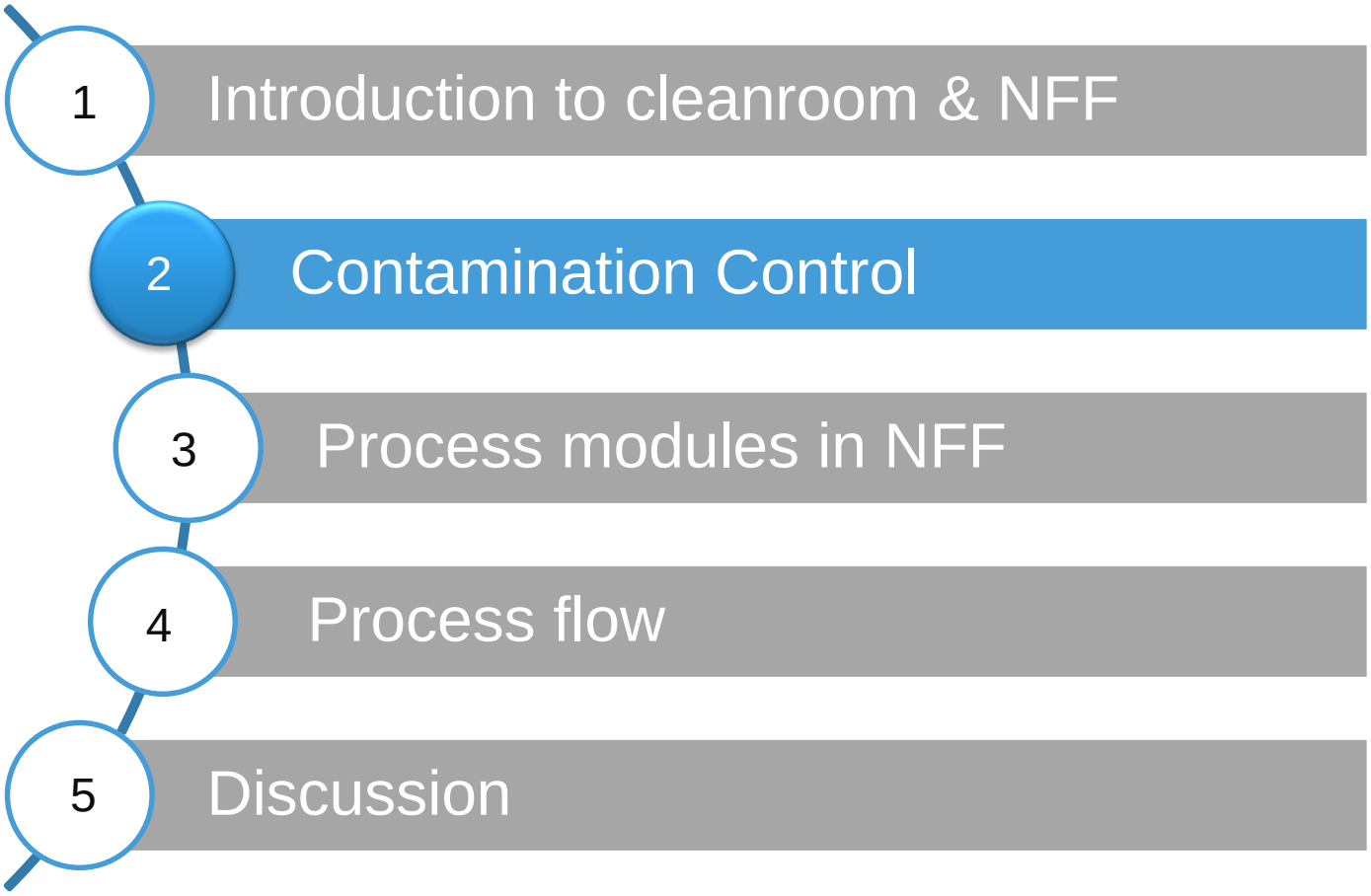
Departments we are serving:

- Electronic & Computer Engineering
- Mechanical and Aerospace Engineering
- Physics
- Chemical and Biological Engineering
- Department of Chemistry
- Division of Life Science
- Nano and Advanced Materials Institute

Main research areas we are supporting:

- Microelectromechanical Systems (MEMS)/Sensors
- III-V electronics (HEMT, LED, Laser)
- Display Technology (OLED, TFT, LCD)
- Bio/life science/ Microfluidics
- CNT, Graphene. 2D material
- MOSFET, bipolar, inductor
- Photonics
- Solar Cell
- Advanced packaging

Outline


1
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Contamination Control

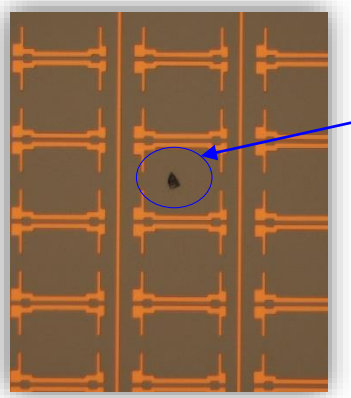
- **What is contamination?**
- **How to Minimize Contamination?**
  - Proper Cleanroom Protocol
  - Process Verification Scheme
    - Three Cleanliness Levels
      --Clean
      --Semi-Clean
      --Non-Standard
    - Downward compatible

Your awareness and observance!!

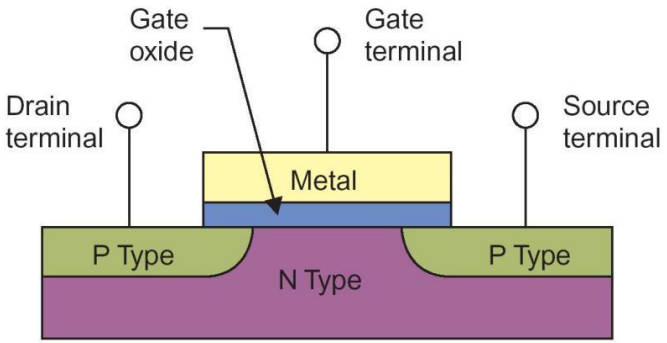
What is contamination?

- Contamination is the intrusion of impurities into devices that leads to their failure

- 3 Commonest Contaminants
  - Particles
  - Metal ions
  - Organics

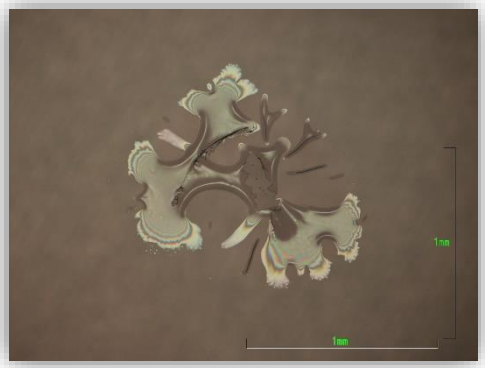


- Examples:
  - Degradation of Oxide Integrity
  - Threshold Voltage Shift
  - Leakage Current

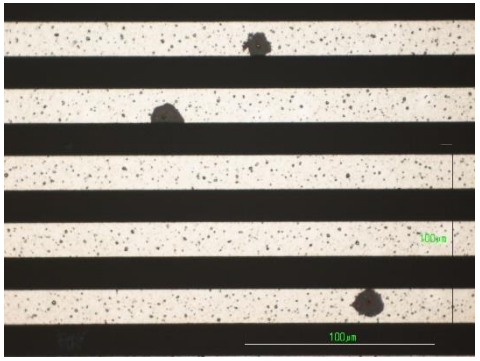


3 Commonest Contaminants

- Particles
  - People ~75%
  - Ventilation ~15%
  - Room Structure ~5%
  - Equipment ~5%
  - Metal pieces from lift-off wafers
  - You name it
- Metallic Contaminants
  - Ions of heavy and transition metals (Au, Ag, Pt, Ni)
  - Ions of standard Metal (Al, Ti, Mo)
  - Alkali Ions (K, Na)
- Organics
  - Photoresist and Polymers
  - Body Oil

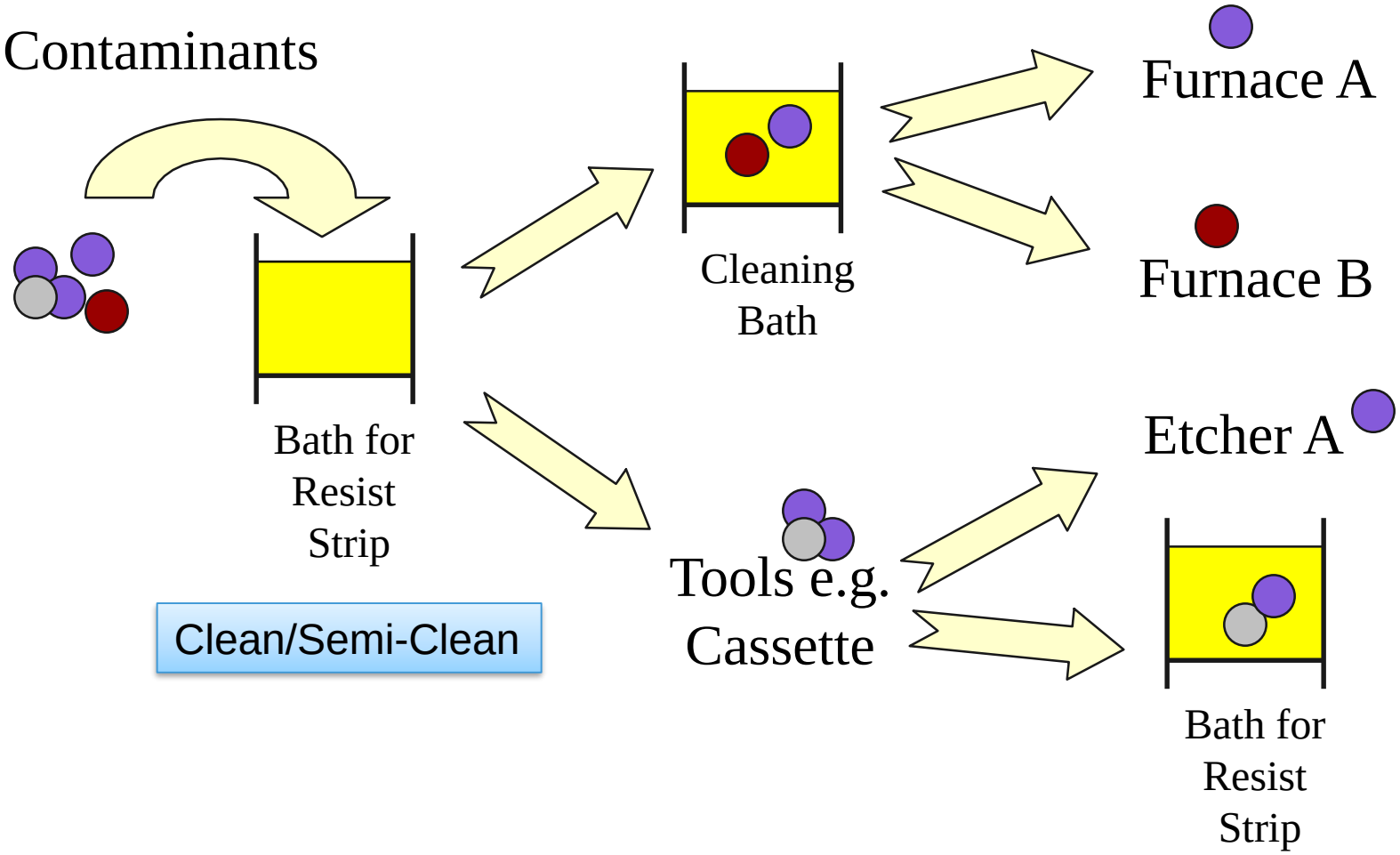


Peeling of Polymer



Particle caused defects in metal lines

Knock-on Effect



Why contamination matters to you?

- It's like disease, easy to spread across the entire laboratory
- It's hard to be found and initialized
- It's hard to be stopped once caused
- Any contamination you cause ruins others' years of efforts
- You are the only one who can help us stop it from spreading

The success of each user relies on trust, understanding and shared responsibility among all users .

Cleanroom Protocol

Purpose

- Promote successful Cleanroom Operations
- Ensure safety in the Cleanroom Environment
- Provide Operational Conditions that Meet Process & User needs

Perspective

- The protocol provides basic awareness and general guidelines for cleanroom users
- Successful clean room operation relies on each user's understanding, participation and self discipline
- The success of each user relies on trust, understanding and shared responsibility among all users

Cleanroom Gowning Procedure

Step 1: Pre-entry

A

Bouffant/Hair Net
Be sure to contain all hair.

B

Shoe Covers
Contain all laces and tassels.

Step 2: Gowning

A

Gowning Gloves
Recommended for Class 100 and better.

B

Mask
Worn over or under hood. Bend nosepiece first for a snug facial fit.

C

Hood
Ensure snug fit and proper face/neck seal.

Step 3

Coverall
Step into the coverall.

Be sure sleeves and upper garment do not touch bench or floor.

Tuck shoulder panels from hood inside coverall before zipping up.

Step 4

Boot Covers
Put on boots and pull boots (high-top shoe covers) over legs of coverall.

If cross-over bench is used, transfer each foot to cleaner side of bench as boot is donned.

Step 5

Goggles
Wear goggles/safety glasses when eye protection or additional particulate control is desired.

Step 6

Cleanroom Gloves (optional)
Place hem of glove over cuff of sleeve. Put on over gowning gloves or remove gowning gloves and then put on cleanroom gloves.

The diagram is from DuPont®

Cleanroom Gowning Removal Procedure

Step 1: In order

A

Gloves
If two pairs of gloves are worn, remove top pair of gloves, then discard.

B

Goggles/Safety Glasses
Remove and properly contain.

C

Boot Covers
Usually discard after each change.

Step 2

A

Coverall
If coverall is to be used again, either hang it in a controlled environment or prepare for storage.

B

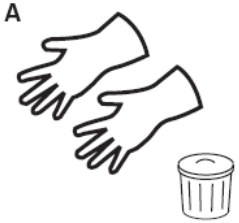
Hood
Hang in controlled environment.

C

Mask
Remove and usually discard.

Step 3

A



Gloves
It is recommended that gloves be discarded after each change.

B

Bouffant/Hair Net
Usually discard after each change.

C

Shoe Covers
Usually discard after each change.

The diagram is from DuPont®

Activity and Particle Generation

Relationship of activity to the number of particles shed from a human body

Activity	Number of particles generated (0.5µm and larger per min)
Sitting or standing still	100 000
Sitting, small movement of arms or head	500 000
Sitting, moving arms, legs or head	1 000 000
Standing up	2 500 000
Walking slowly	5 000 000
Walking normally	7 500 000
Walking with speed (2.5m/s)	10 000 000
Performing work-out	15 000 000-30 000 000

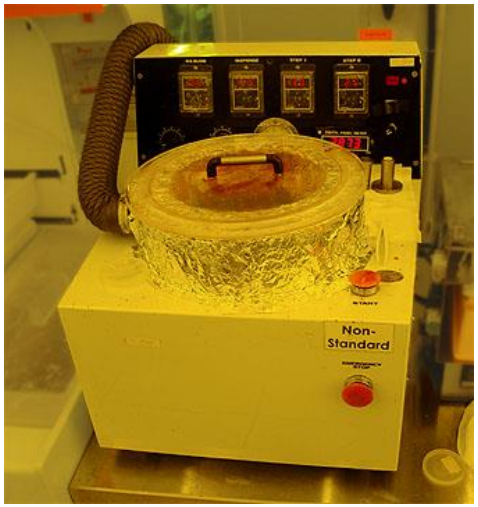
Number of particles found in cosmetics

Type of cosmetics	Number of particles per application (Particle size 0.5µm and larger)
Lipstick	1100 000 000
Rouge	600 000 000
Powder	270 000 000
Eye shadow	82 000 000
Mascara	3 000 000 000
In total for one application	5 100 000 000

Matts Ramstorp, “Introduction to Contamination Control and Cleanroom Technology”, John Wiley& Sons, 2008, P179.

Process Verification Scheme—Cleanliness levels

- Every thing in NFF
  - Chemicals
  - Materials
  - Wafers/Substrates
  - Equipment and Machines
- Three cleanliness levels classified according to their contamination risks
  - -- Clean
  - -- Semi-Clean
  - -- Non-Standard
- 6 equipment Combinations



Contamination Risks & 3 Cleanliness Levels

Low Risk

High Risk

Clean

No contaminants. Silicon wafer & SOI wafer (bought from NFF), SiO_2, SiNx, Ge, etc.

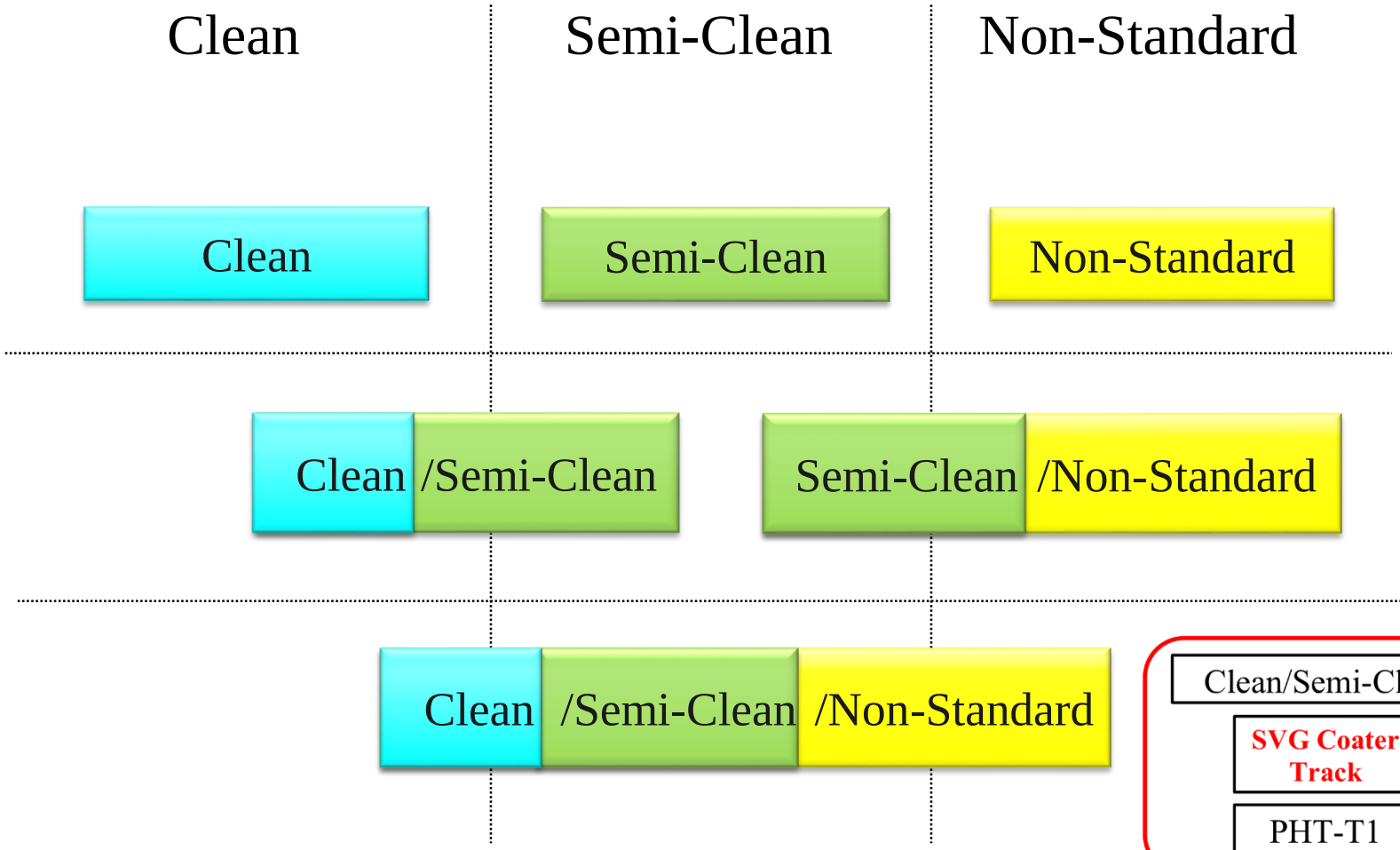
Semi-Clean

Al	Mo	Ti	Cr	Ni for MILC
ITO	ZnO	IGZO	MILC wafers	High-quality glass (Corning 1737 or better)

Non-Standard

MoS	Cu	GaAs/Ga Nitirde,
Fe	Au	Pt
Ag	KI	KOH, Na^+
Low quality glass	PCB boards, (photo only)	Wafers undergone lift-off
Wafers undergone any processes at/with Non-Standard Equipment	Non-NFF-standard chemicals, such as, Polyimide, SU-8, BCB, PDMS, and so on	Materials or chemicals not yet classified.

Equipment Cleanliness Level - 6 combinations



Equipment Label

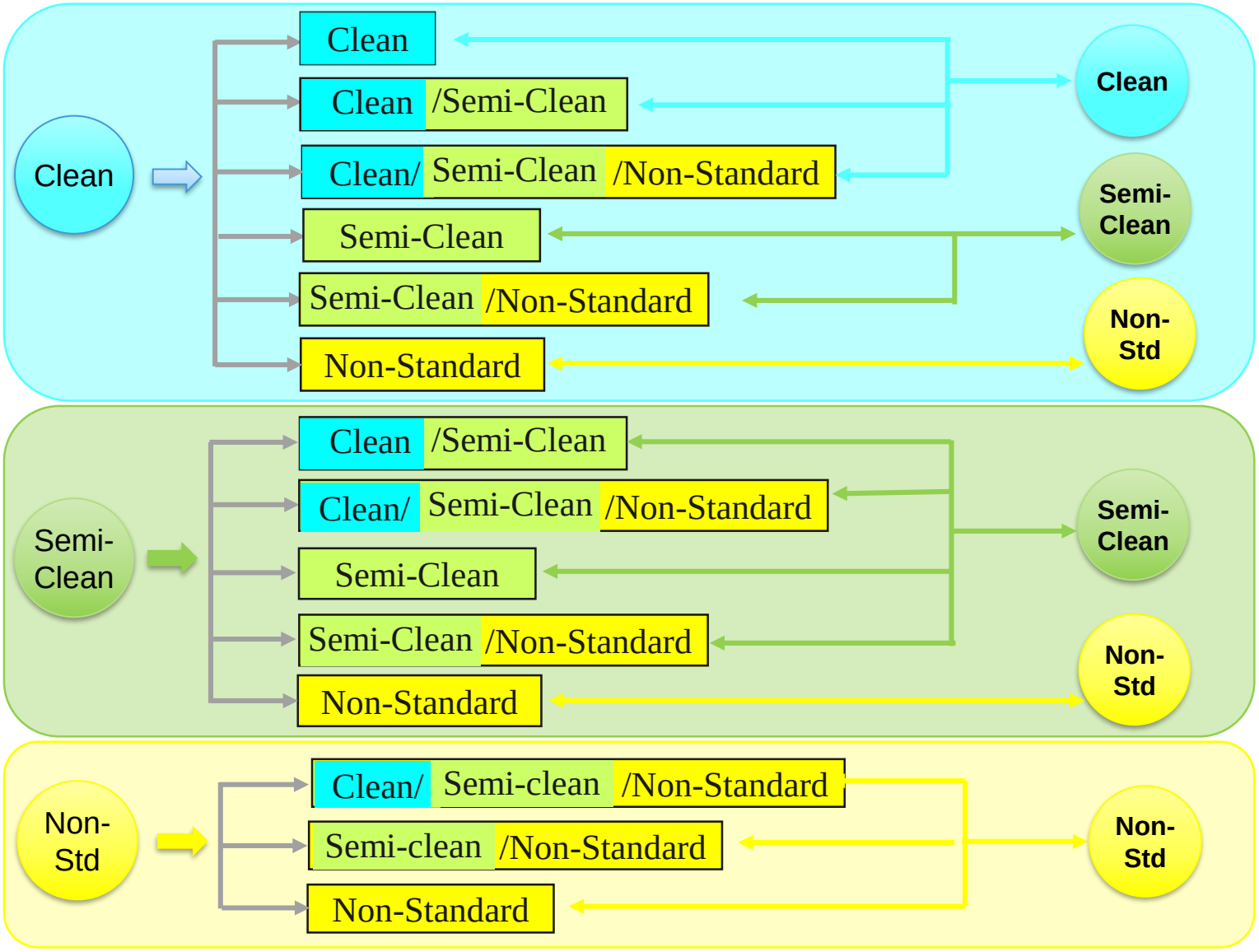
Process Verification Scheme

- Cleanliness of wafer is regarding to process history and changes as the fabrication process.
- Downward Compatible with equipment
  - Clean -> Clean or Semi-Clean or Non-Standard
  - Semi-Clean -> Semi-Clean or Non-Standard
  - Non-Standard -> Non-Standard
- But not the Reverse !!!

✗ Non-Standard -> Semi-Clean -> Clean

  - Once contaminated always contaminated

Downward Compatible Mechanism



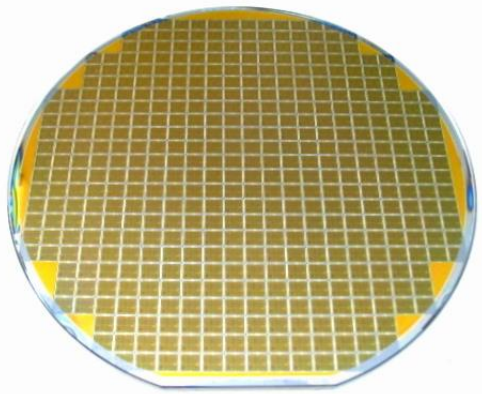
One exception--Decontamination

- Wafers for decontamination
  - Post Chemical-Mechanical Planarization (CMP) wafers
- How to do decontamination?
  - **Wet station B3（RCA1)**: $NH_4OH:H_2O_2:H_2O$ (1:1:5) 70 ºC
- Wafer Status after decontamination
  - Clean
- Not Suitable for:
  - Non-standard Wafers
  - Almost all Semi-Clean Wafers

Metallic Contaminant – Gold (Au)

Gold Ions

- Most-Contaminating because of its high mobility
- Easy to spread into the atmosphere, if heated
- From films, equipment, tools, containers and cassettes, which are in contact with Au+ ions
- Make it as close to the last step as possible.
- Never put gold-contaminated samples into Clean and Semi-Clean areas, (in particular sulfuric acid for resist stripping). Otherwise you will kill the whole laboratory!



Contamination arising from Integration

❑ Inter-level Contamination

- Caused by contaminants from incompatible cleanliness groups
- E.g. Non-standard group contaminates Semi-clean group

❑ Intra-level Contamination

- Caused by contaminants from the same cleanliness level
- Heavily Doped Photoresist/PSG Vs some CLEAN equipment
- Cr/Al/ITO vs Some SEMI-CLEAN equipment
- PCB boards vs Non-Standard Sputters

❑ Extra-level Contamination

- Caused by contamination sources other than the above
- E.g. Photoresist, Particles, Body Oils, to name but a few

How to deal with a new material or new process?

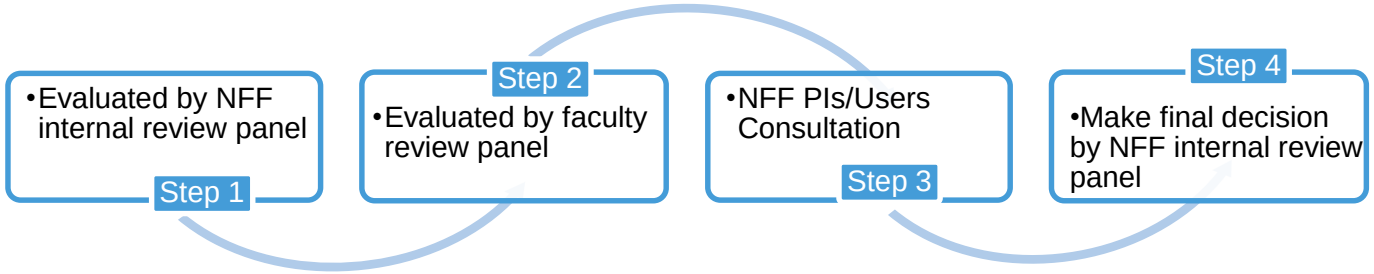
- Two-level “Contamination Control Review Panel”
  - NFF internal review panel

    Members: (NFF staff) Wing Leong CHUNG, Preason M W LEE, Shuyun ZHAO, and a Senior Technician in charge of the equipment

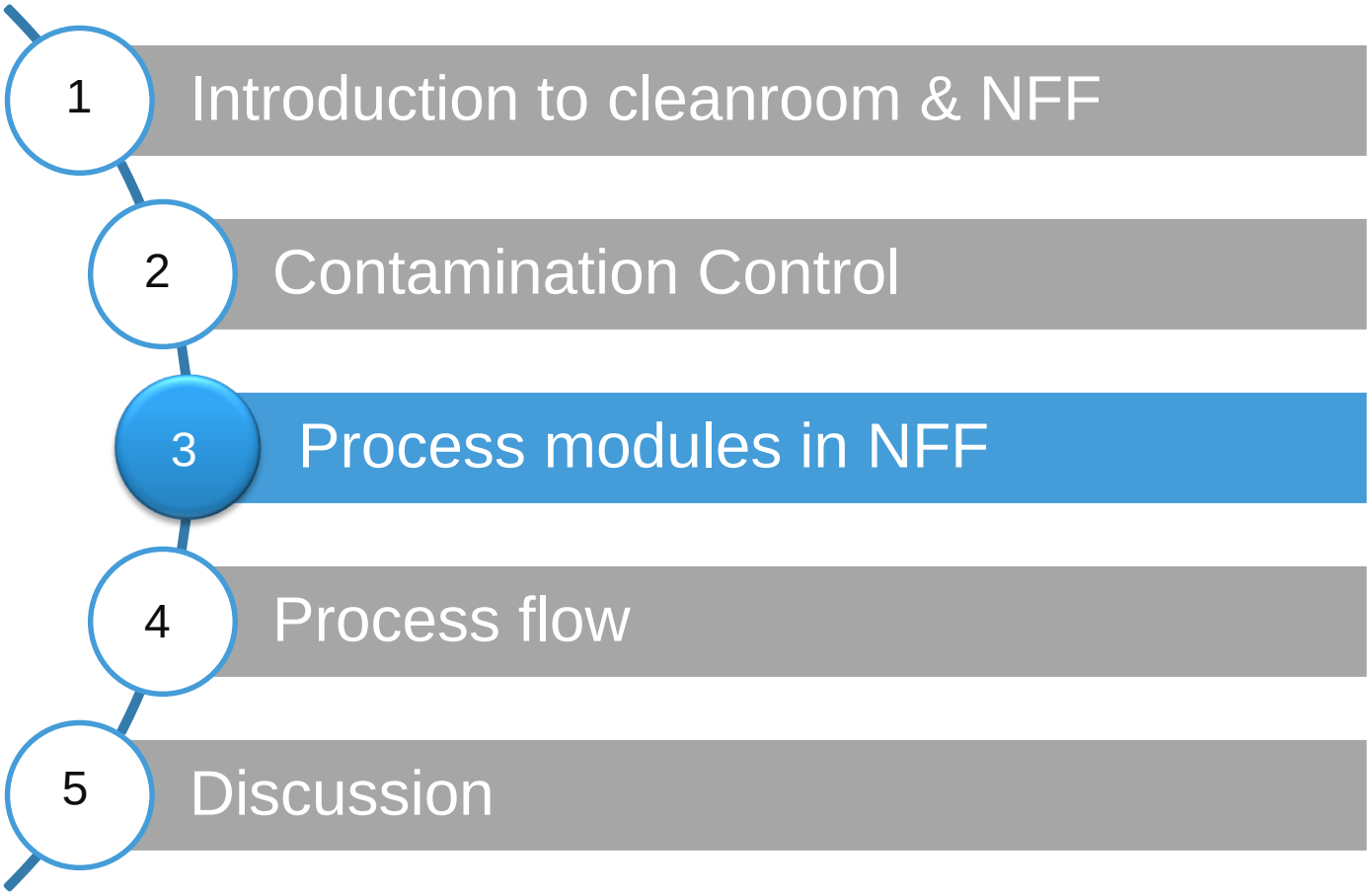
    Aim: To evaluate the new material risks to a particular equipment
  - Faculty review panel

    Members: Prof. Kei May LAU (ECE), Prof. Jiannong WANG (PHYS), Prof. Ho Bun CHAN (PHYS)

    Aim: To evaluate the new material risks to NFF lab



Outline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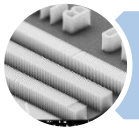
Process modules in NFF

1. Photolithography

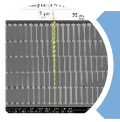
2. Cleaning and Wet etching

3. Thin film growth and Deposition

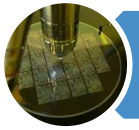
4. Implantation



5. Dry Etching



6. Grinding and Polishing



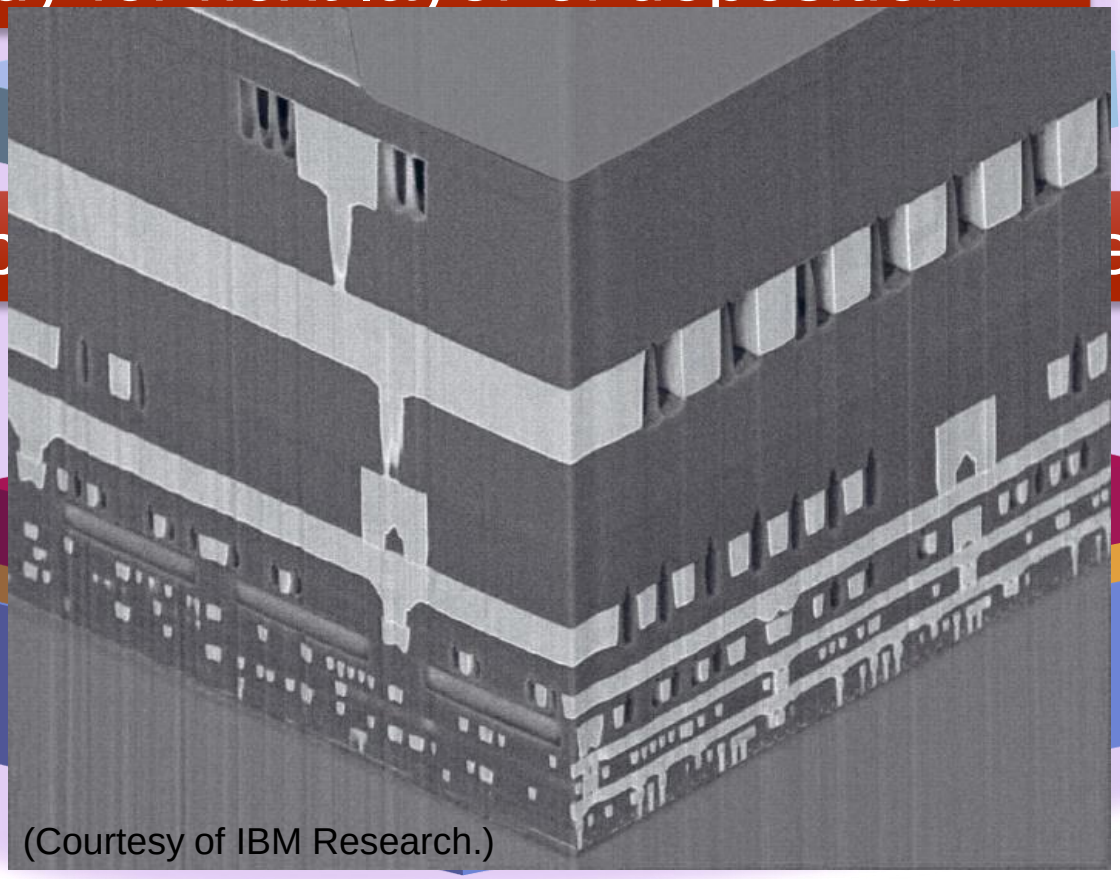
7. Metrology

Fabrication process

Realize your designed device!!

Ready for next layer of deposition

Repeat ab ers

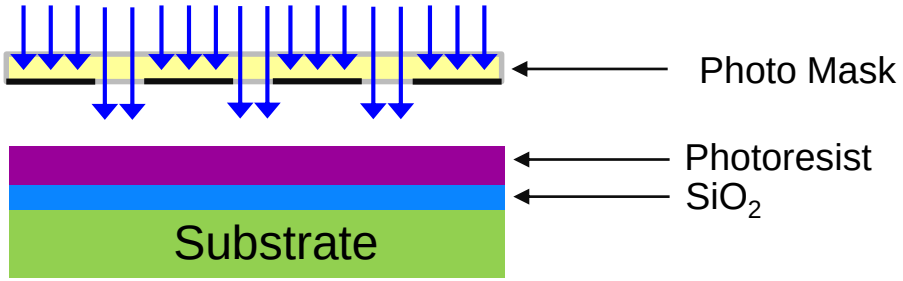


(Courtesy of IBM Research.)

Photolithography [1]

Step 1: Photoresist coating
1. Spin coating
2. Spray coating

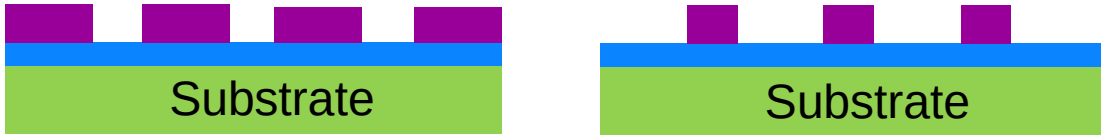
Step 2: Exposure
1. Contact Aligner (1:1)
2. Stepper (5:1)



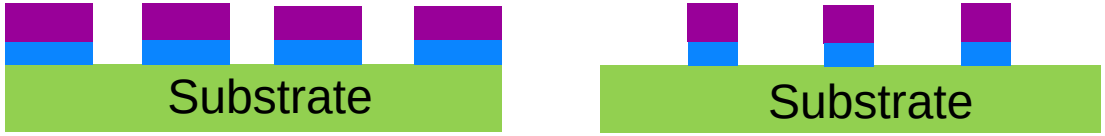
Step 3: Develop
1. SVG Developer Track
2. Manual develop

Positive Resist

Negative Resist/
Dual-tone Resist



Step 4: Etch
1. Wet etch 2. Dry etch

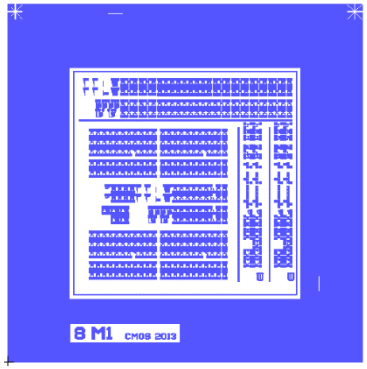


Step 5: PR strip
1. Sulfuric acid
2. MS2001
3. O_2 plasma

From design to photo mask

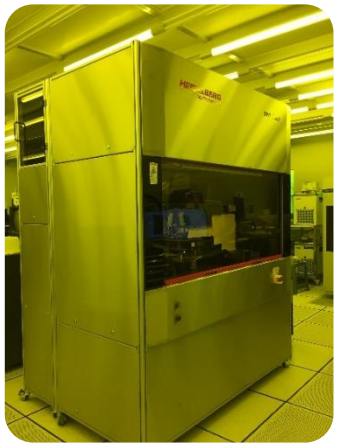
Design structure and
layout using computer

1



Stream out single layer layout
Submit job request thought website

2



Make photomask using
Laser direct writer

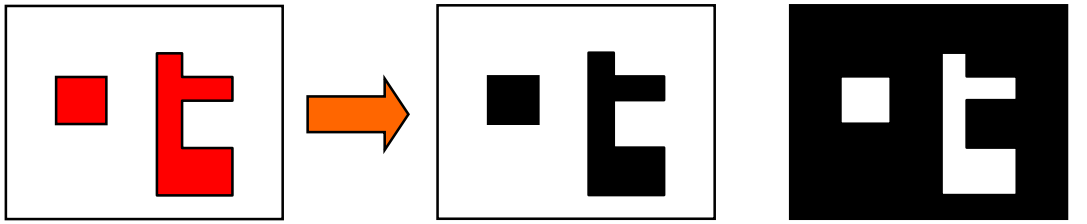
3

4

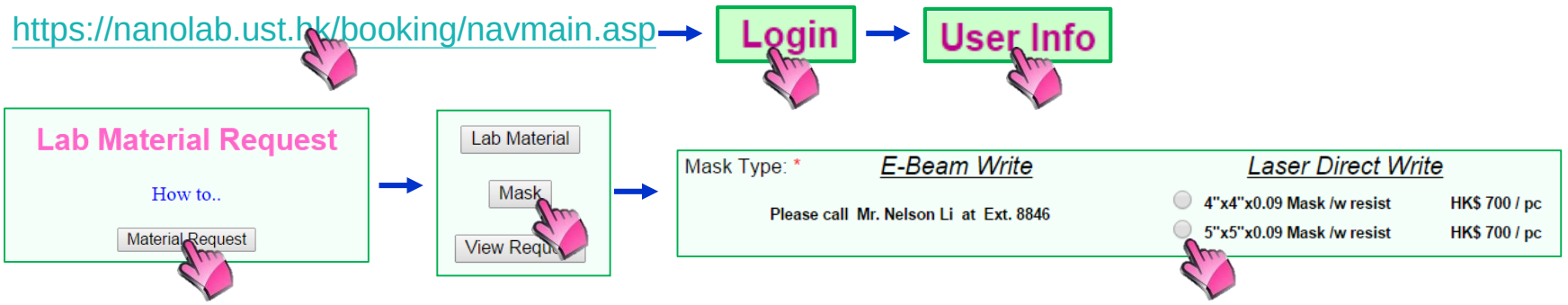
To start…

Mask Making

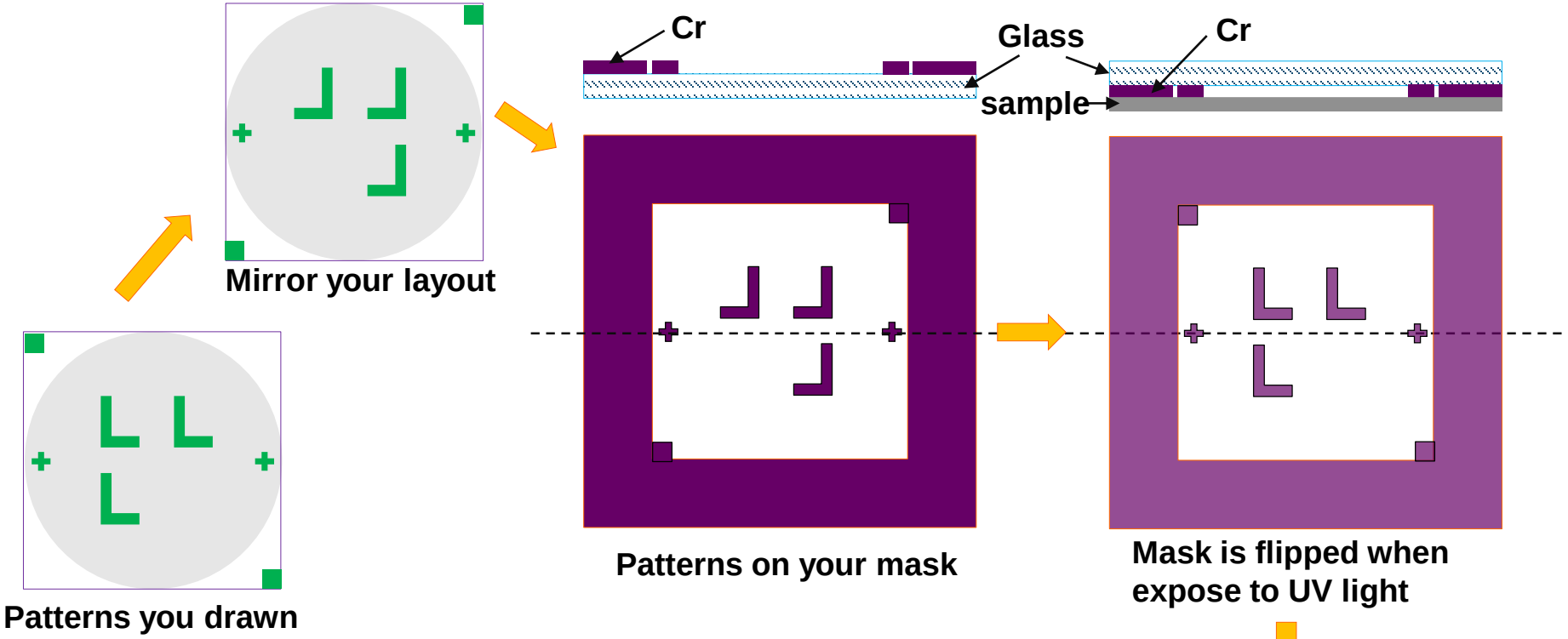
- Pattern generation using a CAD program (Cadence, L-edit, Silvaco, etc.), to get a layout file (.gds/.cif format)
- Submit your job request through NFF website
- Written by laser direct writer ($HKD750/mask)
- Different masks can be generated using the same layout



computer layout bright-field mask dark field mask



Mask for Contact Aligner (1:1)



1. Two small squares located at (0,0) and (10000, 10000) to define the original position
2. Design your own align mark and testing structures
3. Mirror your layout before submission
4. Check your new mask carefully before you use it

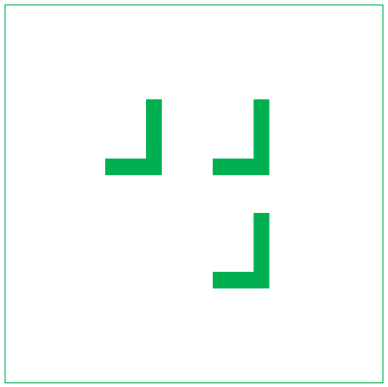
Contact Aligner

Karl Suss MA6 #1, #2

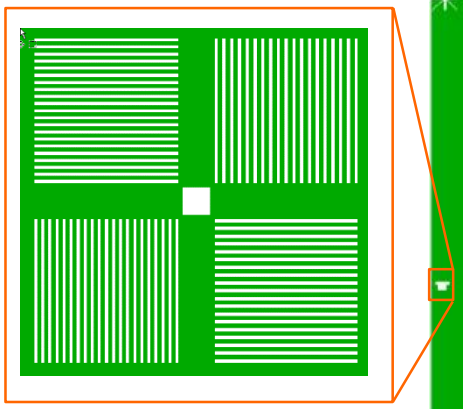
AB-M Aligner #1, #2

Mask for ASML Stepper

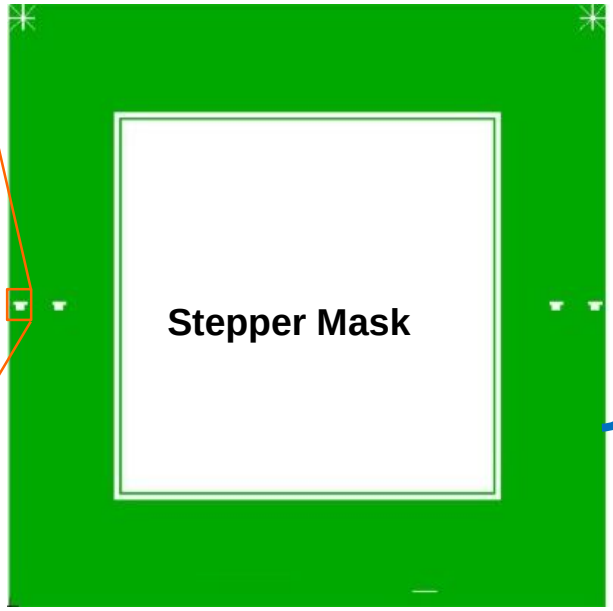
Patterns you designed



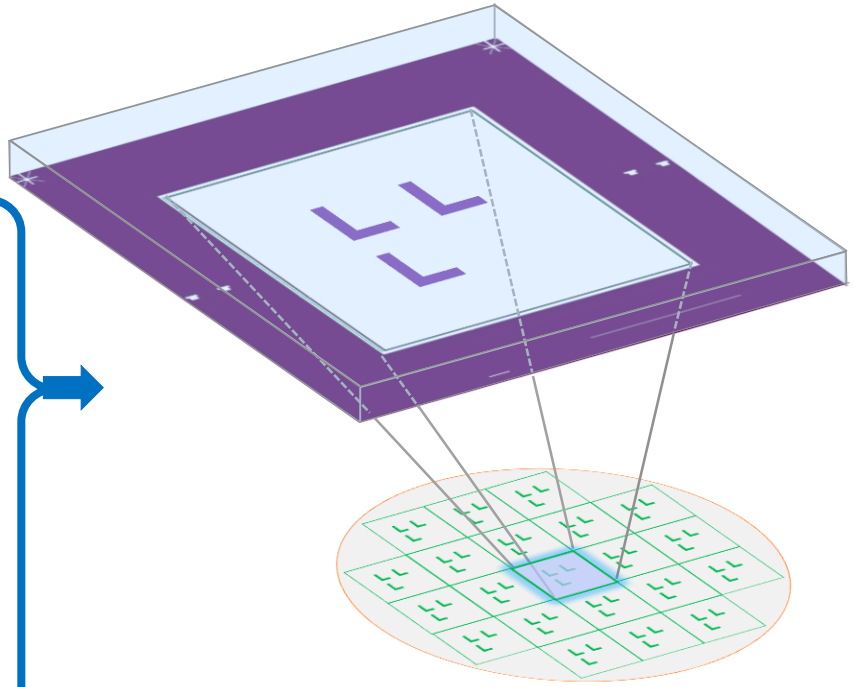
× 5 and mirror the pattern



Alignment mark



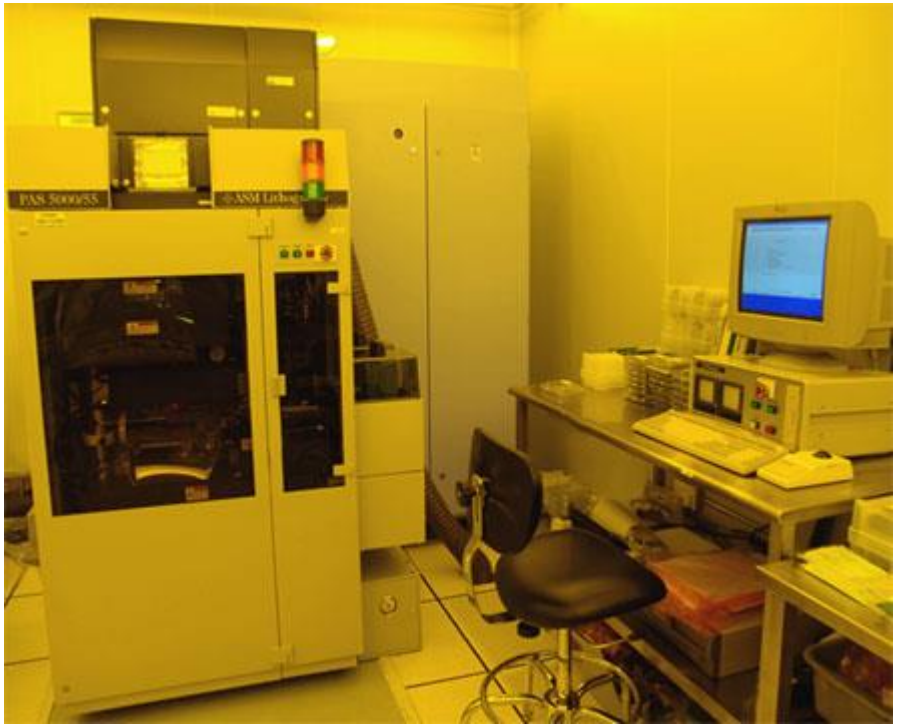
Mask in equipment



Patterns on wafer

Exposure using ASML stepper

ASML Stepper

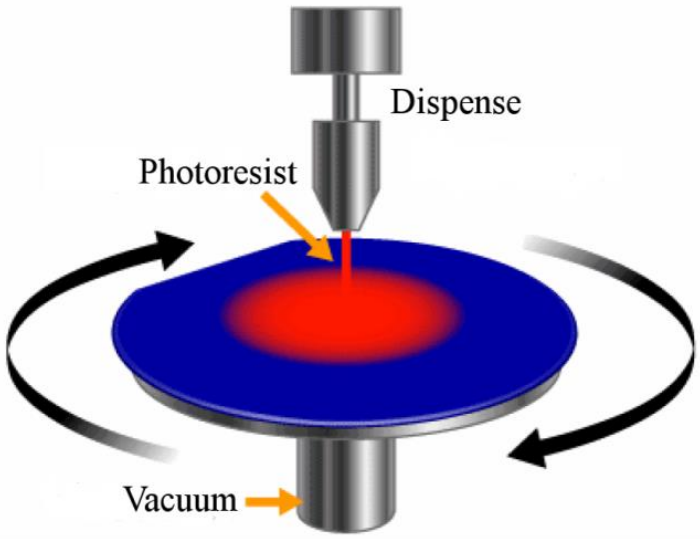


ASML Stepper
(Clean/Semi-Clean)

Light source illumination	: i-line (365 nm)
Resolution	: 0.5 μm
Maximum writing error	: ± 0.1 μm (3 sigma)
Wafer size	: 4" or 6"
Field size	: 15 mm x 15 mm or 10 mm x 10 mm (on wafer)
Reduction ratio	: 5:1
Photomask size	: 5" square

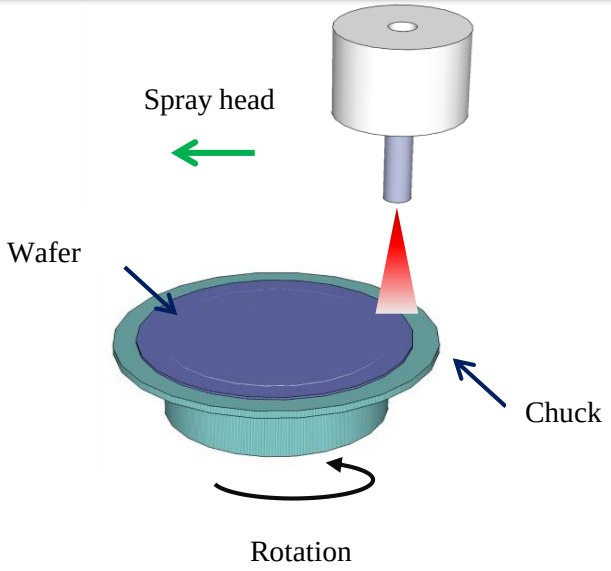
Photoresist Coating

Spin-coating

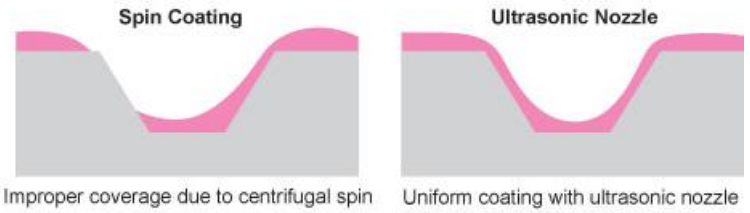


a) Dispensation
b) Acceleration
c) Flow dominated
d) Evaporation dominated

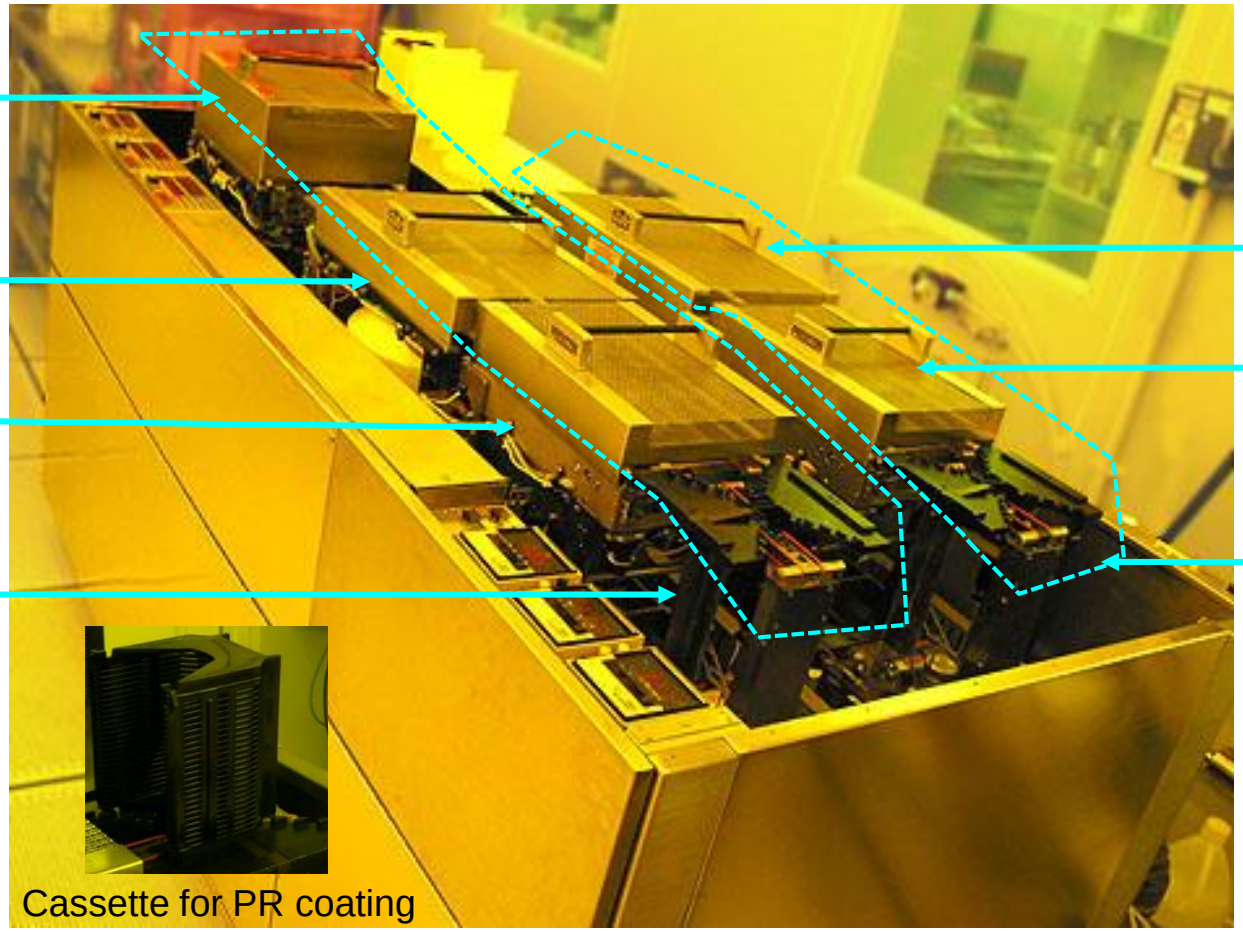
Spray-coating (EVG Spray Coater)



1) An ultrasonic spray nozzle for photoresist dispense
2) An independent rotation chuck.



SVG Coater Track & Developer Track



SVG Coater Track & Developer Track

HMDS prime

- To enhance the adhesion between PR and substrate

PR spin coating

- To get uniform photoresist on a substrate, back side and rim cleaning

Soft bake

- Partially remove the solvent in PR

Alignment and Exposure

Develop

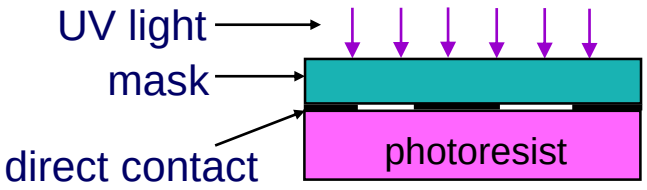
- Dissolve the exposed PR/unexposed PR to form pattern

Hard bake

- Harden the photoresist for next step

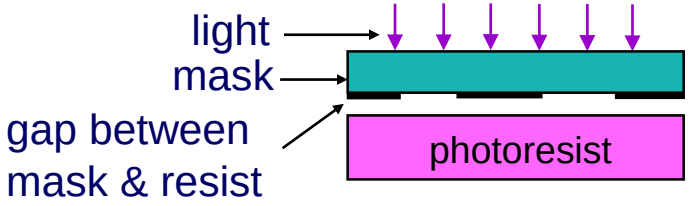
Alignment and Exposure

• contact printing



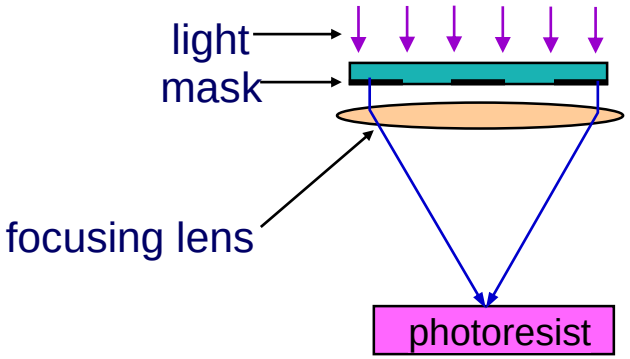
- simple, but easy to cause mask damage
- Example: Karl Suss MA6#1, #2,
  AB-M Aligner #1, #2

• proximity printing



- increase mask lifetime, reduce particle, but poor resolution
- Example: Karl Suss MA6#1, #2

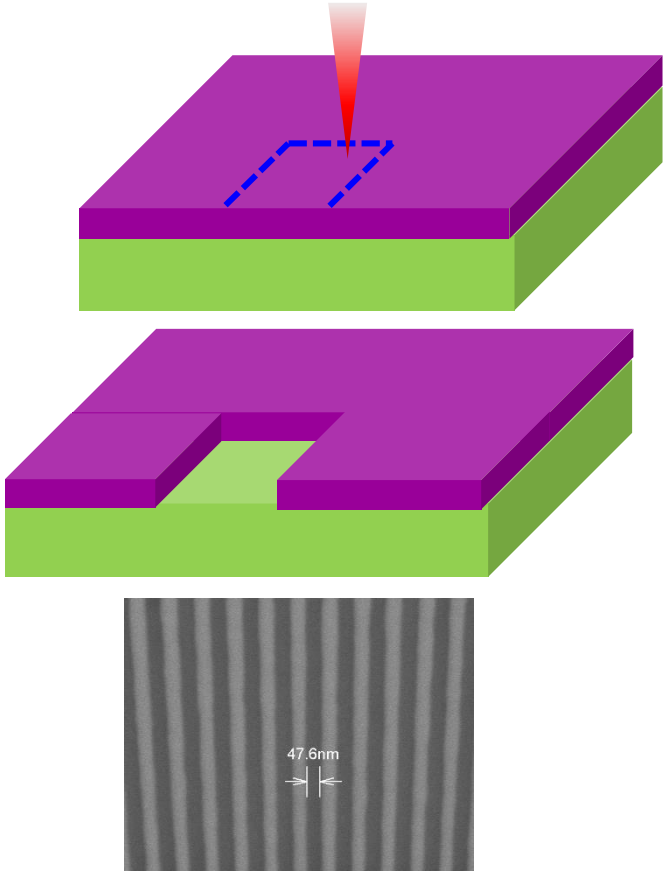
• projection printing



ASML Stepper
- with 5X reduction
- Minimum line width: 0.3-0.5μm
- High resolution
- Long mask lifetime
- No contact contamination
- Small exposure area
- High alignment accuracy

E-beam direct writing

E-beam direct writing



50nm line patterns with 0.3º rotation angle

JEOL JBX-6300FS E-Beam Lithography System

More detailed information, please contact with Mr. Nelson LI
Email : eenelson@ust.hk

Develop

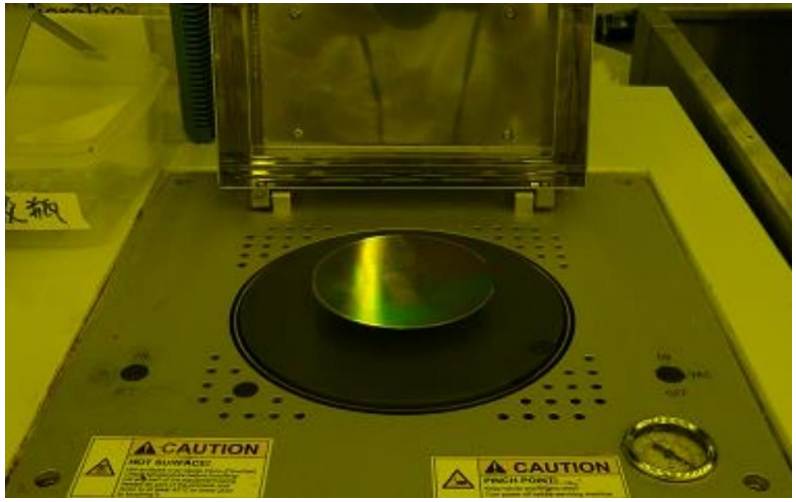
1. SVG Developer track Clean /Semi-clean
Chemical: FHD-5
Time=60s
Suitable for Most of positive photoresist

2. Wet Z1:FHD-5 Semi-Clean
Chemical: FHD-5
For Semi-Clean wafers which can not be developed on SVG track

3. Wet W2/M (EC01000): Non-Standard
Chemical: FHD-5
For Non-Standard wafers

4. Other Developer: AZ 400K (only for PR AZ 4903)
Can be operated on the Wetsation W, Z, X and M

Soft & Hard Bake (hot plate & oven)



Hot plate

Hot Plate Bake	Oven Bake
Single wafer	Batch
Short time/wafer	Long time/batch
No photoresist on backside	No requirements

Oven

Cassette for oven

Resist Strip

1. Sulfuric Acid (120 ºC H_2SO_4 + H_2O_2 10min)

Wet E4: Clean /Semi-clean , No metal or silicides

Process: Sulfuric Acid 10min ->Dump-rinse ->Spin Dry ->Inspection

Safety: Sulfuric Acid (H_2SO_4)): Corrosive
Hydrogen peroxide (H_2O_2: strong oxidizer)

2. MS2001: 70ºC 5min (after metallization)

Wet Y1: Semi-Clean

Wet W1/M1: Non-Standard

Process: Sulfuric Acid 10min ->Dump-rinse ->Spin Dry ->Inspection

Resist Strip—O_2 Plasma ash

3. O_2 Plasma Asher: (After Dry etch, ion implantation)

PS210 Asher: Clean

IPC 3000 Asher #1: Semi-Clean

IPC 3000 Asher #2: Non-Standard

Process:

Dry: O_2 plasma asher ~25min

$$C_nH_yO_z + O \rightarrow CO + CO_2 + H_2O$$

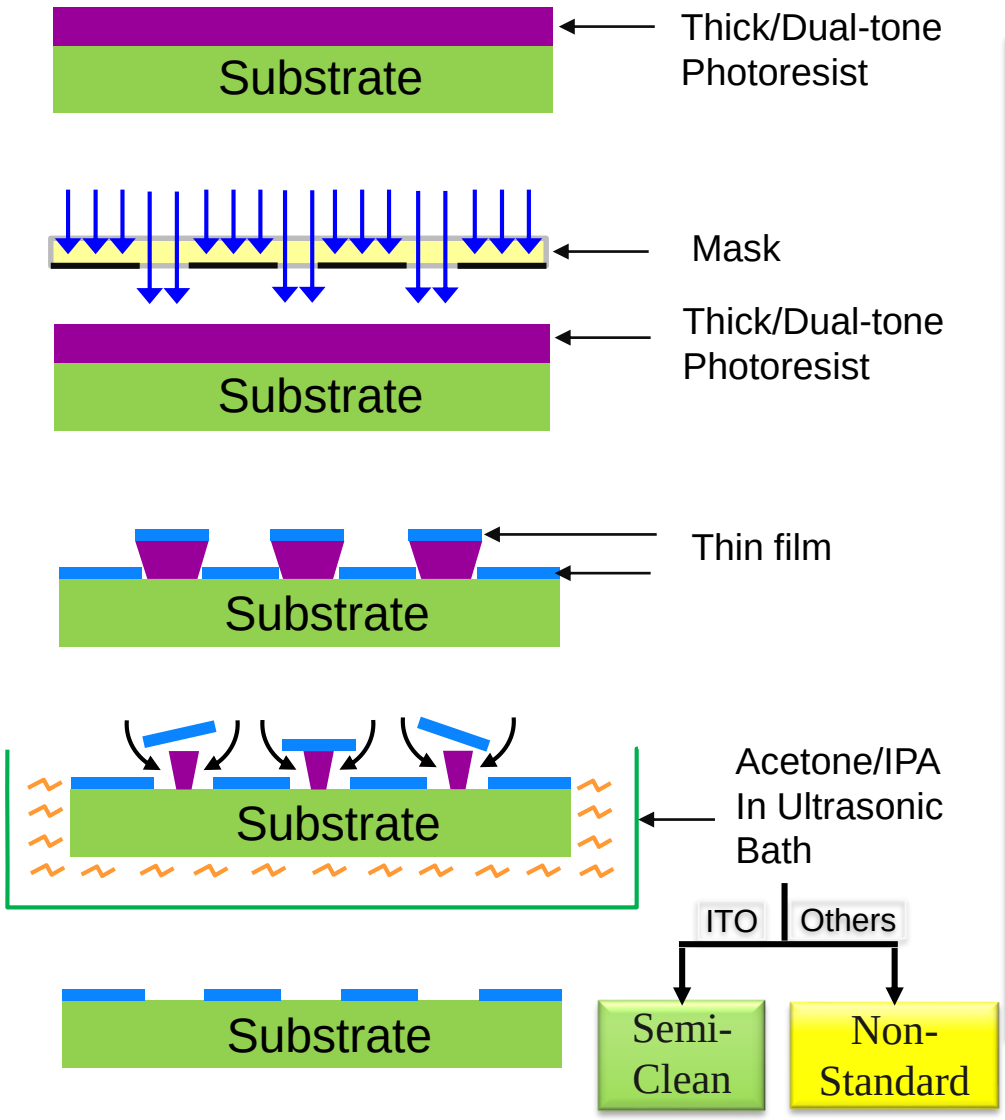
Wet: Sulfuric Acid 10min / MS2001 5min

Dump-rinse

Dry with N_2

Inspection

Lift-off process



1. Normally used for research
2. Not a standard industry process
3. Suitable for films which are difficult to be etched
4. Low yield due to the film pieces re-deposition
5. Retrograde resist edge profile or large resist/film thickness ratio is need
6. Multiple layer resist can also be used to generate the undercut (LOL 2000+PR)
7. Film thickness is limited by the resist thickness
8. Film deposition method is limited by the process (e-beam evaporation or limited sputter system)

Guideline for lift-off process

- Pattern size of lift-off process:>1μm
- Lift-off resist: Dual-tone photoresist
  - AZ5206, thickness:0.8~1.2μm;
  - AZ5214, thickness:1~3μm
- Acetone, and IPA used should be poured into dedicated waste bottles in Wetstation Z
- Make it the last step
- Once lift-off is done, the samples can’t stop generating contaminants

Safety issues about photolithography

- Contamination caused by photoresist
- Inhalation of Organic Vapors and Solvent
  a) HMDS—Flammable and explosive
  b) FHD-5—Poisonous and corrosive,
  c) UV light– Can cause eye injury if direct look at UV source
- No acid nor base in Yellow Room
- Coater and developer Tracks not for double-side photoresist coating, and negative photoresist
- Disposal of Waste (IPA, Acetone)
  - Pour the waste into waste collection bottles
  - Don’t use an aspirator to suck it into the N-tank
- Containers used for developing or any process require booking on the computer system.
- Transparency only allow on AB-M 2

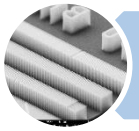
Process modules in NFF

1. Photolithography

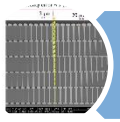
2. Cleaning and Wet etching

3. Thin film growth and deposition

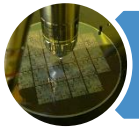
4. Implantation



5. Dry Etching

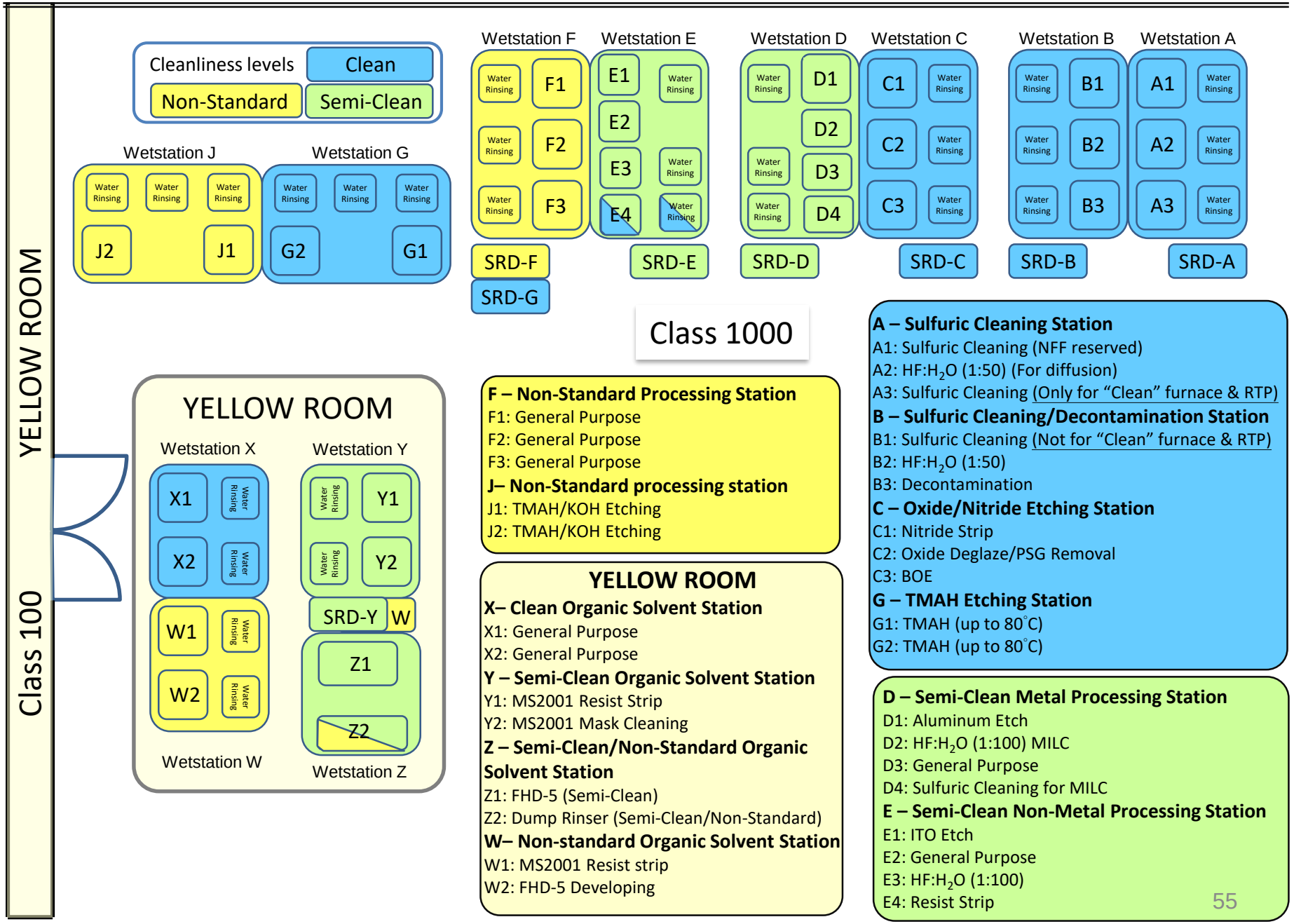


6. Grinding and Polishing



7. Metrology

Layout of Wet Stations in Phase II



Wet stations

Cabinet for container and cassette

Labels of Wet Stations

A: Sulfuric Cleaning Station

B: Sulfuric Cleaning/Decontamination Station

C:Oxide/Nitride Etching Station

G:TMAH Etching Station

X:Clean Organic Solvent Station

E:Semi-Clean Non-Metal Processing Station

D:Semi-Clean Metal Processing Station

Y:Semi-Clean Organic Solvent Station

Z1:Semi-Clean Develop Station

Z2:Semi-Clean/Non-standard Dump Rinser

F:Non-Standard Processing Station

J:Non-Standard Processing Station

W:Non-Standard Organic Solvent Station

Lowest

Risks of Contamination

Highest

Cleanings of Sample

Clean

- Sulfuric Cleaning for “Clean” furnace and RTP (A3)
- HF dip before oxide growth (A2)
- Normal Sulfuric Cleaning (B1)
- HF dip (B3)
- RCA1(Decontamination) (B3)

Semi-Clean

- Sulfuric Cleaning (D4) (Semi-Clean)
- Post-Metallization Cleaning—(MS2001) (Y1)
- Mask Cleaning (MS2001) (Y2)

Non-Standard

- Normal cleaning (MS2001 or DI water) (W2, F, M)

Sulfuric Cleaning / Piranha etch

- (Piranha solution) H_2SO_4+H_2O_2 ,120ºC 10min
- Removing organics and gross contaminants e.g. scribe dust.
  - H_2SO_4 – reduces organics to carbon
  - H_2O_2 – oxidizes carbon to form CO_2

- Very dangerous, being both strongly acidic and a strong oxidizer.
- Both liquid and vapor are extremely corrosive to skin and respiratory tract.
- When preparing the Piranha solution, always add the peroxide to the acid.

HF dip

- Process:
  - $HF:H_2O$ (1:50) Time: 1min
  - Room Temperature
  - 4-cycle Dump rinse
  - Spin Dry
- To remove the native or chemical oxide on the silicon surface.
- Prior to the growth of high quality oxide

Clean Cleaning Station A&B

- **Wetsation A**: Only for the cleaning prior “Clean” furnace and RTP process
- Wafer has to be “Clean”
- No photoresist
- All wafers have to be dried using Spin Dryer-A.
- After cleaning, wafers can ONLY be sent to “Clean” furnace and RTP

- **Wetsation B**: For other purpose except “Clean” furnace and RTP process
- Wafer has to be “Clean”
- No photoresist
- All wafers have to be dried using Spin Dryer-B.
- After cleaning, wafers CANNOT be sent to “Clean” furnace and RTP

RCA1 (Decontamination)

- “Clean” or Decontaminatable Wafers (Post CMP wafers)
- No photoresist, metals
- Wet B3: Decontamination
- $H_2O:H_2O_2:NH_4OH$ =5:1:1 at 70 ^oC (fresh)
- Drain after use
- To removes organics, particles

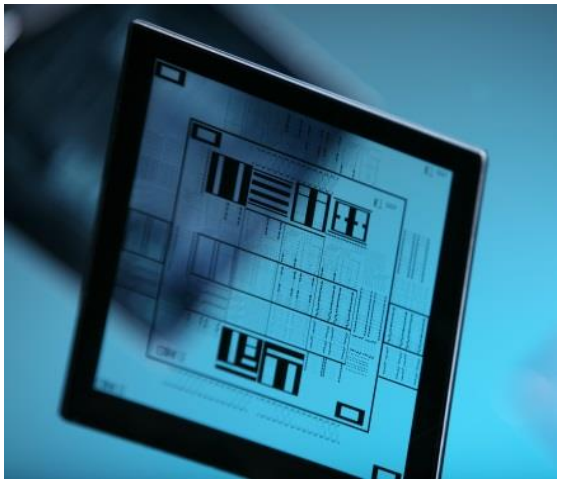
Post-Metal Cleaning

- MS2001, 70ºC, 5min
- Process:
  - Clean wafers with MS2001 in Bath Y1 (for Semi-Clean) or W2 (Non-Ntandard) (Optional)
  - 4-cycle DI water dump rinser
  - Spin wafers Dry with Spin Rinser Dryer or Dry using N_2 gun

Don’t use sulfuric cleaning after metallization!!

Mask Cleaning

- Semi-Clean
- Mask Only
- Process:
  - **Wet Y2**:MS2001,
  - @70ºC, 5min
  - Dump-rinse 4 cycles
  - Dry by an N_2 Gun
  - Oven bake (105ºC, 10min)
  - Cool down to room temperature



Oven for mask bake

Cleaning policy prior to high temperature process

- Wet Cleaning is required (For Furnace, PECVD, RTP)
- Cleans must be done less that 1 hour before equipment loading and wafers must be stored in clean Teflon cassettes in white box
- Wafers can move between equipment of equal cleanliness (or to lower cleanliness level) – if interval is less than 1 hour – wafers are in a clean Teflon cassette in white box (not plastic)

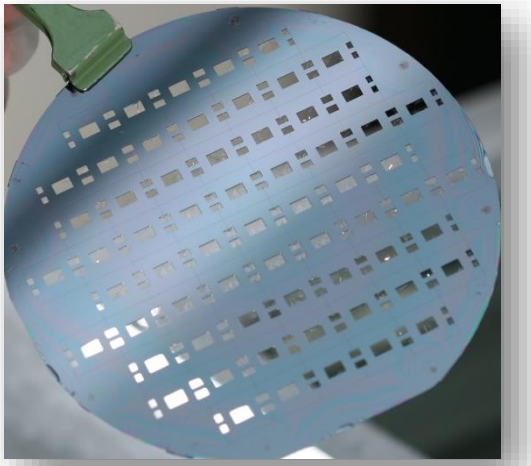
Typical Wet Etchants in NFF

Material	Chemical	Etching Rate	Mask	Selectivity
Al/Si-1%	H_3PO_4:CH_3COOH:HNO_3=100:10:1 (50ºC)	2823A/min	PR	>50
Ti-W	H_2O_2(60ºC)	1000A/min	SiO2	>50
Ti	H_2O:H_2O_2:HF (20:1:0.5) NH_4OH:H_2O_2:H_2O (1:1:5)	5400A/min 231A/min	PR	>50
Cr	MTI CEP-200 chrome etchant	1320/min	PR	>50
Si3N4	Hot H_3PO_4 (165ºC)	41.3A/min		>50
Wet SiO2	BOE 777 Pad etch HF:H2O=1:100	1000A/min 330A/min 27A/min	PR	>50
LTO	BOE 777 Pad etch HF:H_2O=1:100	3000~5000A/min 1500A/min 100A/min	PR	>50
Poly-Si	Freckle	200A/min	PR	>50
a-Si	Freckle	200A/min	PR	>50
C-Si (100)	25% TMAH (80ºC)	20μm/hr	Nitride/ oxide	>50
ITO	HCL+H_2O+HNO_3=4:2:1	80A/min	PR	>50

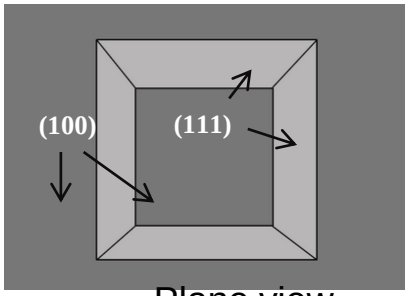
http://www.nff.ust.hk/equipment-and-process/process/WetDryEtchingTable.htm

Etching Through Wafers

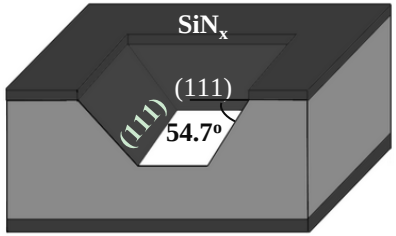
- TMAH
  - “Clean” Process
  - Nitride + Oxide as Etching Masks
- KOH
  - Etching furiously
  - Non-Standard Process
- Dry Etch
  - Deep RIE Etcher
  - Clean Process



DRIE etch though silicon wafer



Plane view



3-D view

A square-shaped cavity on (100)-Si Wafer after TMAH etching

Wet Stations

- General Safety
  - No chemicals bottle left on the floor
  - Wafers have to be dump-rinsed in the dump-rinser for at least 4 cycles immediately after any chemical processes
  - No organic solvent (IPA, Acetone) in Class 1000 area
- HF
  - Highly hazardous Chemical Solutions (HF, BOE, 777 and Freckle etch)
  - Concentration below 20% is more insidious and symptoms may be delayed for up to 24 hours (Refer to Health and Safety Manual—3 Special Guideline on HF Safety)
- Use of Chemical
  - Unconventional use of chemical requires permission and booking.
  - Mixing own chemicals is only allowed at semi-clean or non-standard wetstation
- Disposal
  - HF, Freckle Etch and BOE are needed to be drained into the HF tank by NFF staff.
  - Acid and Base are needed to be drained by users themselves with an aspirator in wetstations.
- Contamination
  - No Glass, Metals and Manual coated wafers at “Clean” wetstations
  - No Metals at the sulfuric acid bath for resist stripping
  - Separation of cassettes, tools containers and gloves from those of different stations
  - No lifted-off wafers put in baths
  - No mess left at wetstations

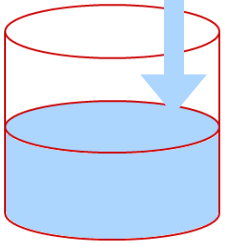
Chemical Disposal

Actone, IPA

Collection bottle

HF, BOE, Freckle
By NFF staff only

Aspirator 1

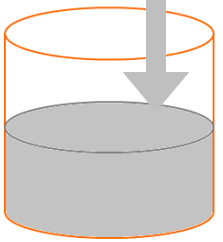


HF tank

Base, Acid

Aspirator 2

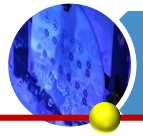
By user



N tank

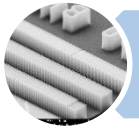
Process modules in NFF

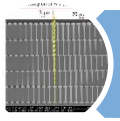
1. Photolithography

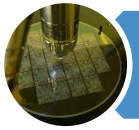

2. Cleaning and Wet etching

3. Thin film growth and deposition

4. Implantation


5. Dry Etching


6. Grinding and Polishing


7. Metrology

Thermal Oxidation

Method to form silicon dioxide

- thermally grown from silicon (good quality)
- deposit by LPCVD/PECVD (poorer quality)

Thermal oxidation of silicon

- Dry oxidation:

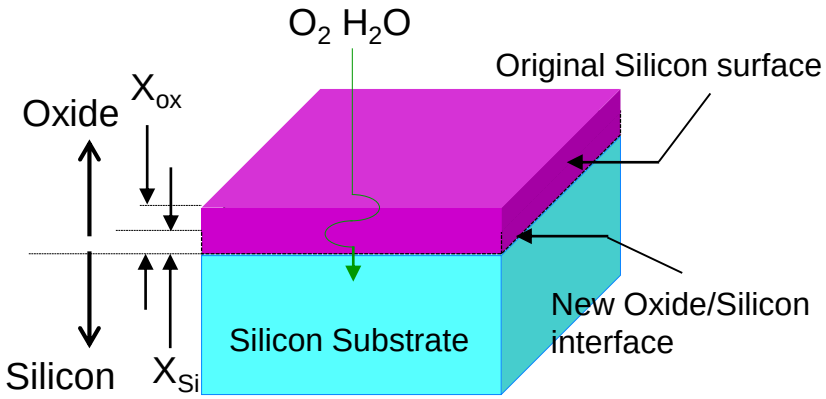
$Si(solid) + O_2(gas) \rightarrow SiO_2(solid)$

- Wet oxidation:

$Si(solid) + 2H_2O(gas) \rightarrow SiO_2(solid) + 2H_2(gas)$

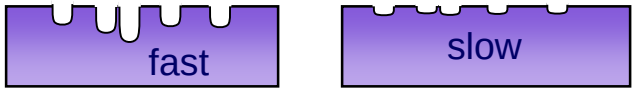
Temperature: 800˚C-1100˚C
Thickness:<3μm.

Thin oxide (<50nm): Dry oxidation
Thick oxide (>50nm): Dry-wet-dry sequence.



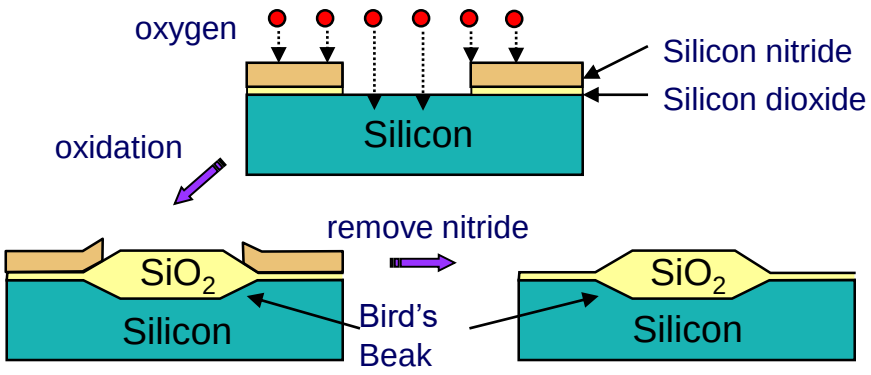
Silicon consumed during oxidation:
$X_{Si} \cong 0.45 X_{ox}$

- ✓ Wet oxidation is faster because water molecules are smaller than O_2 and easier to diffuse to the Si surface
- ✓ Fast process tends to give more surface roughness



Selective oxidation

- also known as LOCal Oxidation of S ilicon (LOCOS)



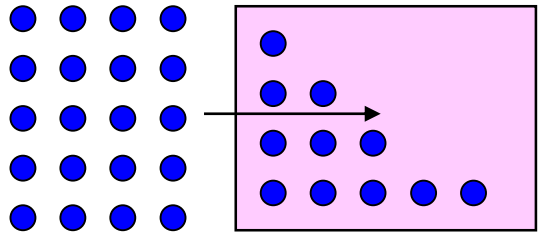
- nitride can be use as a mask to prevent oxygen/water diffusion in certain region of the wafer to achieve selective oxidation
- nitride and silicon has very different crystal structure and thermal coefficient and should be avoid to be put in direct contact (hence a buffer oxide is usually placed in between)
- should avoid using thick (>200nm) nitride

Diffusion and Annealing

Dopant Diffusion in Silicon

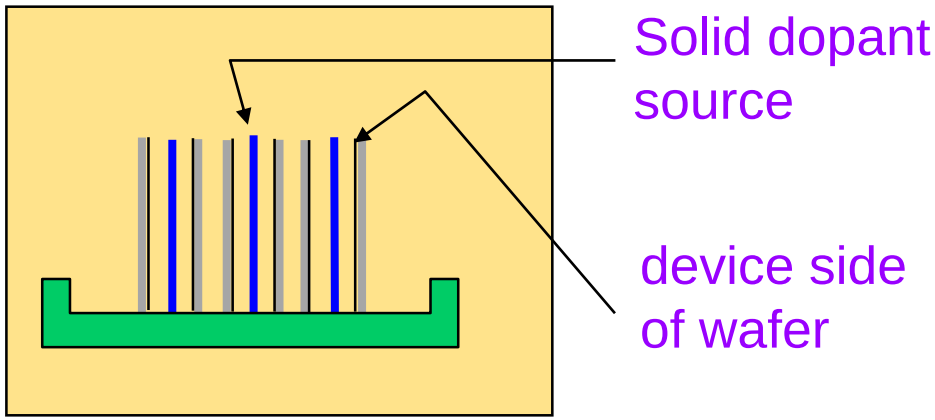
- a general diffusion process

$$Flux = D\frac{\partial n}{\partial x}$$



Solid Source

- place a solid source near the wafer in a furnace at an elevated temperature (600˚C-1100˚C)



Source of Boron C3

$$2B_2O_3 + 3Si_2 \rightarrow 4B + 3SiO_2$$

Source of Phosphorus C2

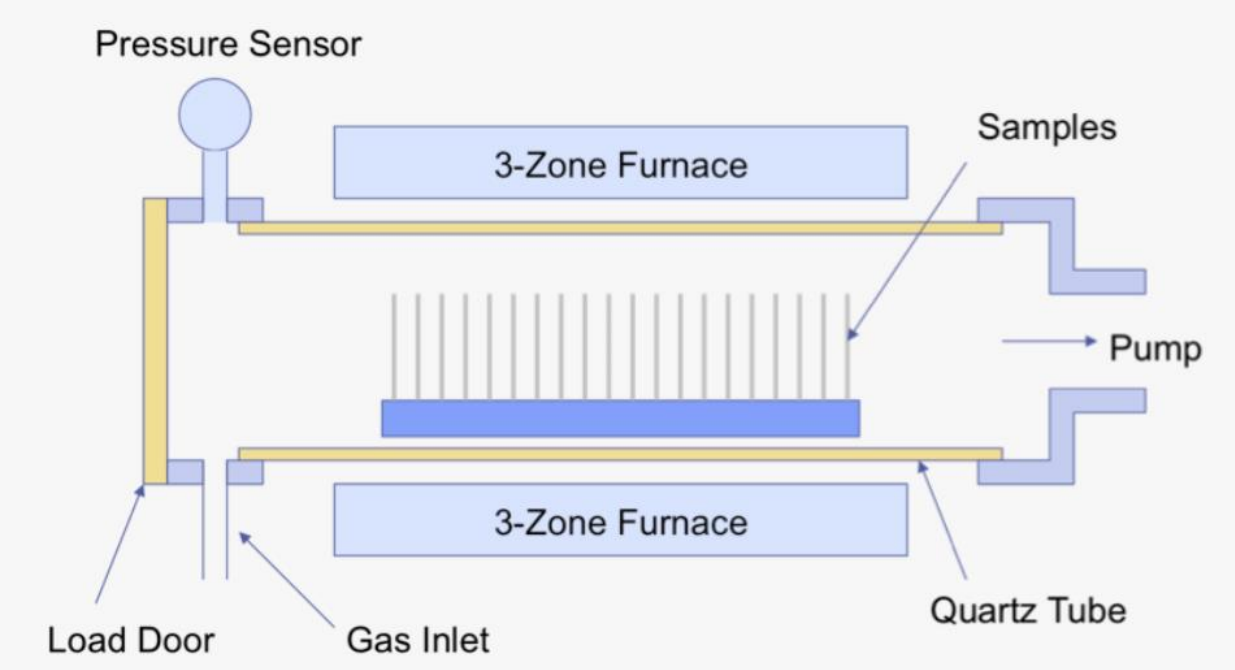
$$2P_2O_5 + 5Si_2 \rightarrow 4P + 5SiO_2$$

Thermal oxidation, diffusion and RTP

Process Code	Location	Equipment	Cleanliness level	Cleaning
Thermal Diffusion				
DIF-C1	P2-01000	Diff. Furnace-C1 FGA Annealing	Non-Standard	B1+SRD-B/D1(dump-rinser)/F(dump-rinser)
DIF-C2	P2-01000	Diff. Furnace-C2 N Pre-Deposition	Clean	A3+SRD-A
DIF-C3	P2-01000	Diff. Furnace-C3 P Pre-Deposition	Clean	A3+SRD-A
DIF-D1	P2-01000	Diff. Furnace-D1 Dry Oxidation	Clean (Only for gate oxide)	A3+SRD-A
DIF-A1	P2-01000	Diff. Furnace-A1 Anneal/Oxidation	Clean	A3+SRD-A
DIF-D2	P2-01000	Diff. Furnace-D2 Dry/Wet Oxidation	Clean	A3+SRD-A
DIF-D3	P2-01000	Diff. Furnace-D3 Annealing/Dry/Wet Oxidation	Non-Standard	B1+SRD-B/D1(dump-rinser)/F(dump-rinser)
DIF-D4	P2-01000	Diff. Furnace-D4 Annealing	GaN only	
DIF-R1	P2-01000	RTP-600S	Clean	A3+SRD- A
DIF-F1	P2-01000	Diff. Furnace-F1 Annealing/Dry/Wet Oxidation	Semi-Clean	B1+SRD-B D1(dump-rinser)
DIF-C4	P2-01000	Diff. Furnace-C4 FGA Annealing	Semi-Clean	B1+SRD-B D1(dump-rinser)
DIF-R2	P2-01000	AG610 RTP	Semi-Clean	B1+SRD-B D1(dump-rinser)

Low pressure CVD (LPCVD)

- Low pressure chemical vapor deposition



Applications:

high temperature oxide, nitride, poly, a-Si, LTO, PSG

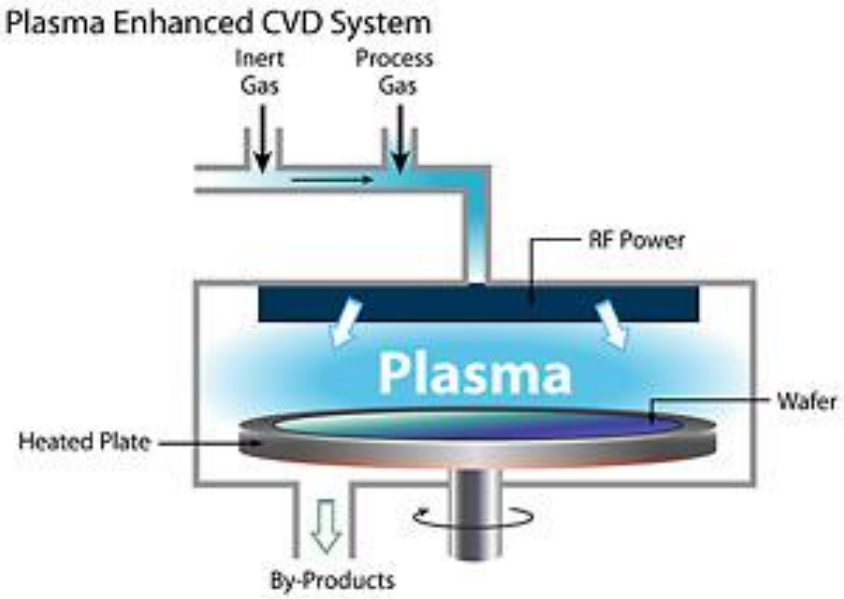
Advantages:

- better purity
- better uniformity
- conformal step coverage

Disadvantage:

- low deposition rate
- require high processing temperature to increase reaction rate

Plasma Enhanced CVD (PECVD)



- Use RF to discharge the gas and increase reaction rate
- High temperature in LPCVD prevent the use of CVD to deposit material on low temperature substrate (e.g. glass in LCD display) or material (e.g. multi-layer metal)

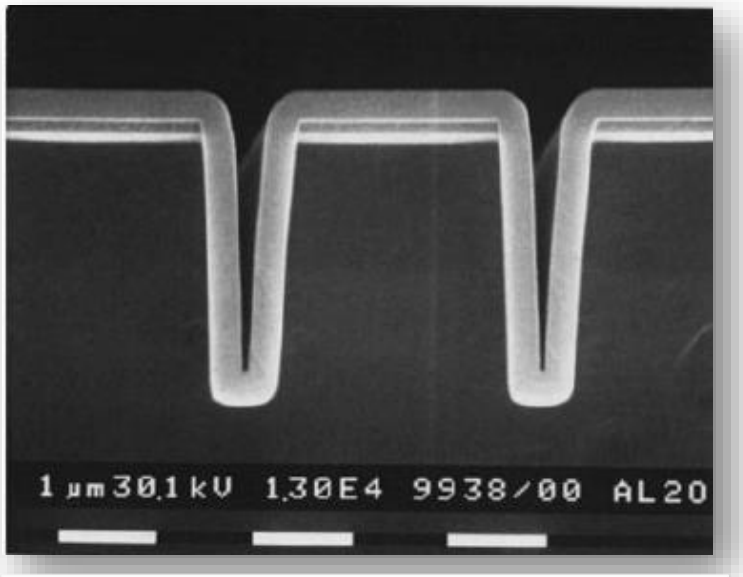
Advantage: - low temperature
- fast deposition
- good step coverage

Disadvantages: - chemical & particle contamination
- expensive equipment

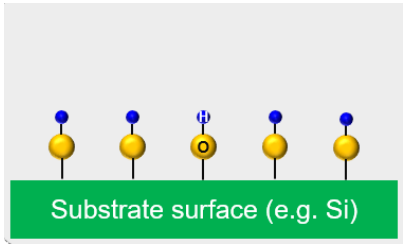
(STPS 310PC PECVD2)

Atomic Layer Deposition (ALD)

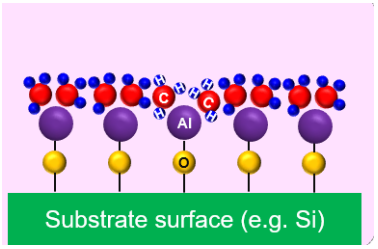
- A method of applying thin films to various substrates with atomic scale precision.
- ALD film growth is **self-limited and based on surface reactions**, which makes achieving atomic scale deposition control possible.



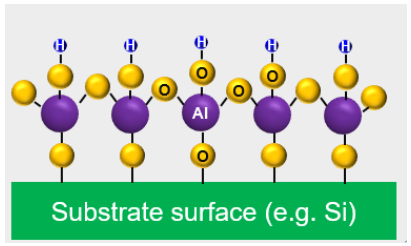
Al_2O_3 deposited on silicon trench structures [1]



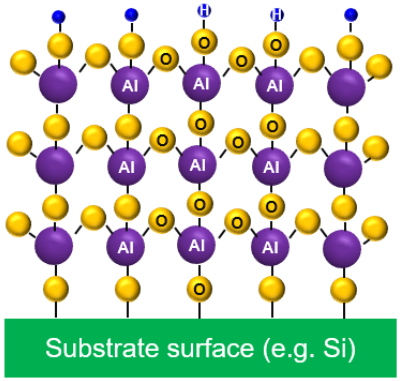
1. 1st precursor H_2O



2. 2nd precursor TMA ($(Al(CH_3)_3)$)



3. 1st precursor H_2O



[1] Mikko Ritala, Markku Leskelä, et al., Perfectly Conformal TiN and Al2O3 Films Deposited by Atomic Layer Deposition, Chem. Vap. Deposition 1999, vol. 5, No. 1, P.7-9

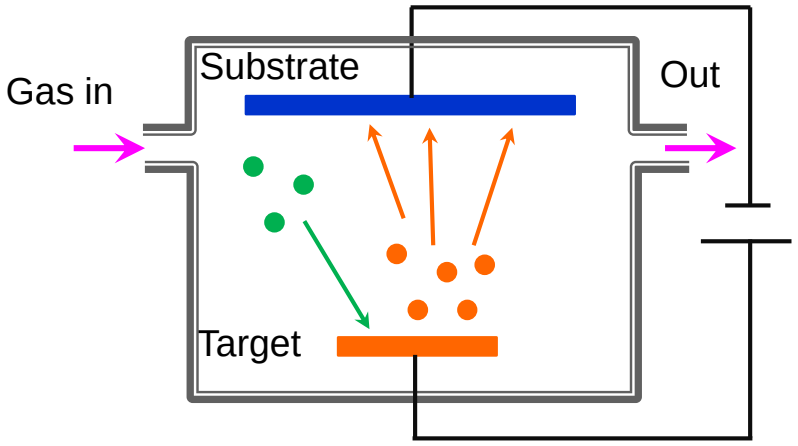
CVD equipment in NFF

Process Code	Location	Equipment	Cleanliness level	Cleaning
		CVD		
CVD-A2	P2-01000	LPCVD-A2 Doped Amor-Si	Clean	A3+SRD-A
CVD-A3	P2-01000	LPCVD-A3 Amor-Si/Poly	Clean	A3+SRD-A
CVD-B2	P2-01000	LPCVD-B2 Nitride/Low-Stress Nitride	Clean	A3+SRD-A
CVD-B3	P2-01000	LPCVD-B3 LTO	Clean	A3+SRD-A
CVD-EPI	P2-01000	ET3000 Epitaxy	Clean	A3+SRD-A
CVD-A4	P2-01000	LPCVD-A4 Si-Ge / Amor-Si / Poly	Semi-Clean	B1+SRD-B D1(dump-rinser)
CVD-B4	P2-01000	LPCVD-B4 LTO / PSG	Semi-Clean	B1+SRD-B D1(dump-rinser)
CVD-F2	P2-01000	LPCVD- F2 Nitride / Low-Stress Nitride	GaN only	
CVD-F3	P2-01000	LPCVD- F3 Amor-Si / Poly	Semi-Clean	B1+SRD-B D1(dump-rinser)
CVD-F4	P2-01000	LPCVD-F4 LTO / PSG	Semi-Clean	B1+SRD-B D1(dump-rinser)
CVD-P1	P2-01000	310PC PECVD	Semi-Clean	B1+SRD-B D1(dump-rinser)
CVD-TEOS	P2-01000	TEOS PECVD	Semi-Clean	B1+SRD-B D1(dump-rinser)
CVD-P2	P2-01000	STS PECVD	Non-Standard	B1+SRD-B/D1(dump-rinser)/F(dump-rinser)
CVD-CNT	P2-01000	CNT PECVD	Non-Standard	B1+SRD-B/D1(dump-rinser)/F(dump-rinser)
CVD-ALD	P2-01000	Oxford ALD	Non-Standard	B1+SRD-B/D1(dump-rinser)/F(dump-rinser)

Sputtering

Atoms or molecules of the target material are sputtered off and deposited on a substrate surface.
Inert gas such as Ar ions are often used.

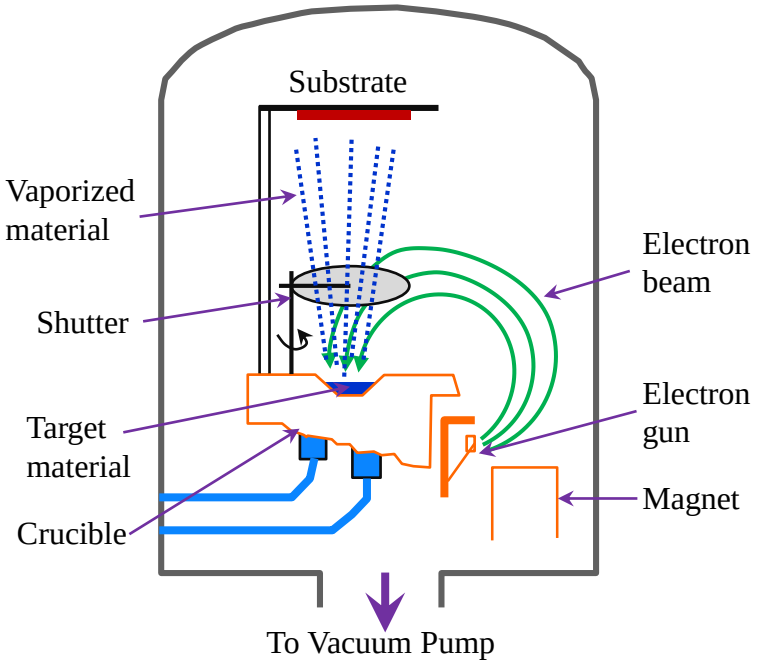
DC Sputtering: Metals
RF Sputtering: Insulator, semi-conductor
Magnetron Sputtering: High deposition rate
Reactive Sputtering: SiN_x, SiO_x, ITO



Varian 3180 Semi-clean

- Relatively good thickness uniformity and step coverage
- Easy thickness control
- Less frequent target change
- Only low-medium vacuum, easy to get impurity
- Limited Target Materials for each Equipment
- Thickness < 3μm
- No photoresist nor broken wafers in Varian 3180 Sputter
- No photoresist in CVC-601 Sputter

E-Beam Evaporation



1) Source material is melted by e-beam directly deposited on wafer
2) Simple and relatively inexpensive
3) Better thickness control
4) Higher film purity
5) Increasing of the E-beam energy yields higher density film with better adhesion to substrate
6) Widely used for lift-off process
7) Multi-layer deposition

Disadvantages:

- Poor film uniformity
- Poor step coverage

Sputtering & Evaporation				
SPT-3180	P2-01000	Varian 3180 Sputter	Semi-Clean	
SPT-NSC3000	P2-01000	NSC3000 Sputter	Semi-Clean	
SPT-EV1	P2-01000	Cooke Evaporator #1	Semi-Clean	
SPT-ARC	P2-01000	ARC-12M Sputter	Non-Standard	
SPT-CVC	P2-01000	CVC-601 Sputter	Non-Standard	
SPT-Denton	EC-01000	Denton Sputter	Non-Standard	
SPT-EV2	EC-01000	Cooke Evaporator #2	Non-Standard	
SPT-AST600	EC-01000	AST 600EI Evaporator	Non-Standard	
SPT-AST450	EC-01000	AST 450I Evaporator	Non-Standard	

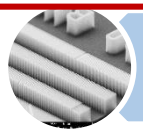
Process modules in NFF

1. Photolithography

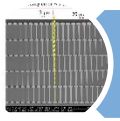
2. Cleaning and Wet etching

3. Thin film growth and deposition

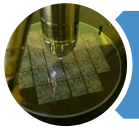
4. Implantation



5. Dry Etching



6. Grinding and Polishing



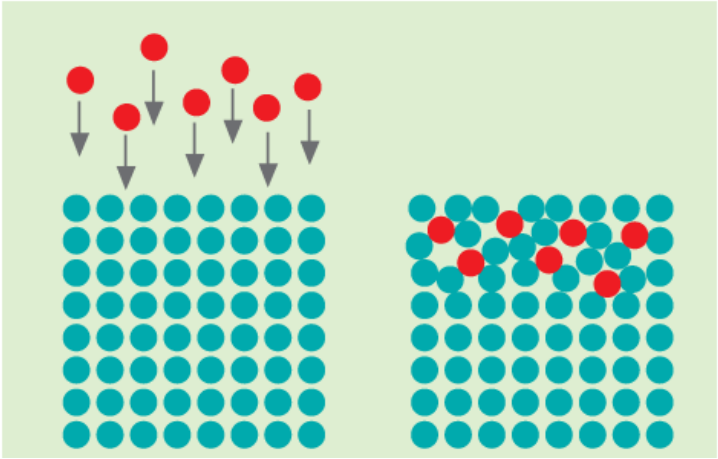
7. Metrology

4. Ion Implantation

- Ions are accelerated and forced to the substrate/film by momentum transfer

Clean /Semi-clean

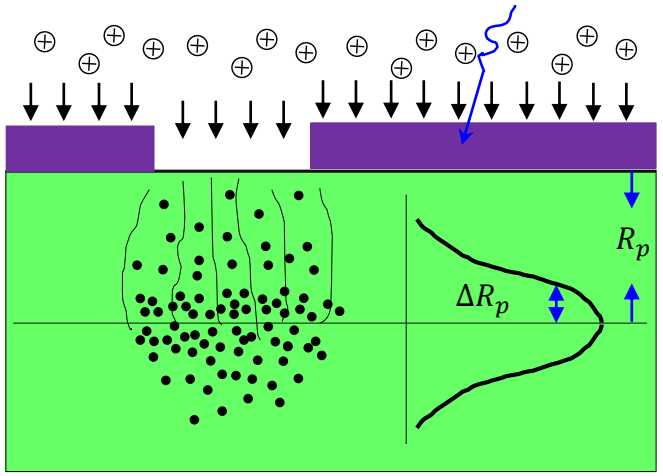
- ✓ Full wafers are preferred
- ✓ Irregular samples have to be bounded on full wafers
- ✓ Spices (B, BF_2, As, P, H)
- ✓ Dosage (1E12~1E16)
- ✓ High Temperature Photoresist (Special for implantation *FH-6400L*)
- ✓ Wafers with no resist on the rim and back side
- ✓ No exposed metals



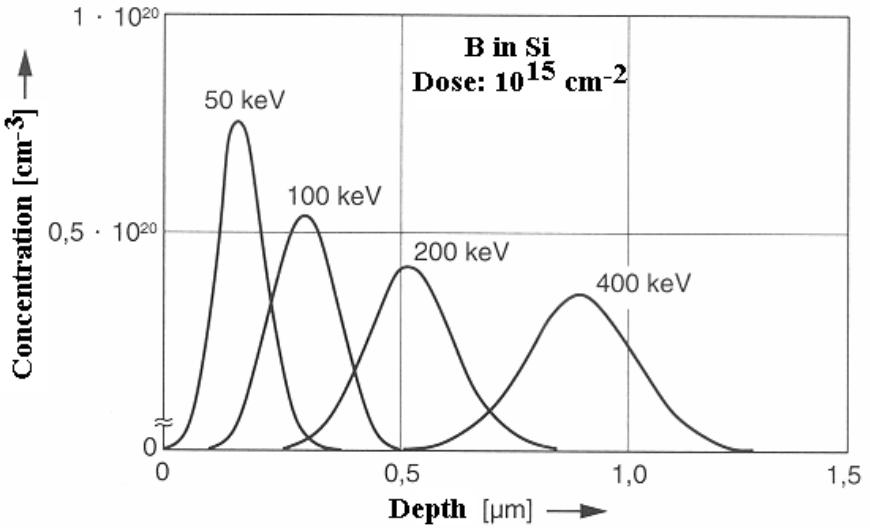
Implantation Process After Implantation

Implantation profile

Implant Mask



Gaussian distribution



Two important parameters:

Energy (KeV): Implantation depth

Dosage (cm^{-2}): Concentration

Process modules in NFF

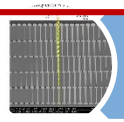
1. Photolithography

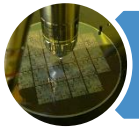
2. Cleaning and Wet etching

3. Thin film growth and deposition

4. Implantation

5. Dry Etching


6. Grinding and Polishing


7. Metrology

5. Dry Etching

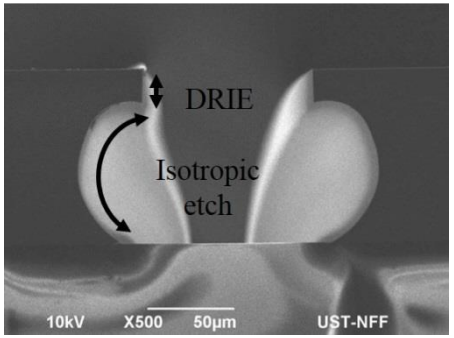
5.1 Non-plasma based

- Typically fluorine-containing gases that readily etch Si

  $2\mathrm{Xe}F_2 + Si \rightarrow 2Xe(g) \uparrow + SiF_4(g) \uparrow$
- Highly selective to masking layers (SiO_2)
- Highly controllable via temperature and partial pressure of reactants
- Widely used for MEMS fabrication

Equipment: Clean /Semi-clean

XeF_2 Isotropic Silicon Etcher (DRY-XeF_2)



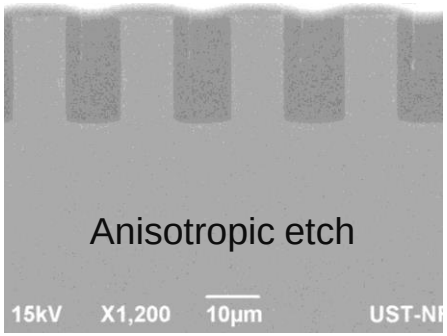
5.2 Plasma based

- Plasma etching is a process in which a solid film is removed by a chemical reaction with ground-state or excited-state neutral species.
- Types of plasma based etching:
- Physical sputtering

  Physical bombardment
- Plasma etching

  Plasma assisted chemical reaction
- Reactive Ion etching (RIE)

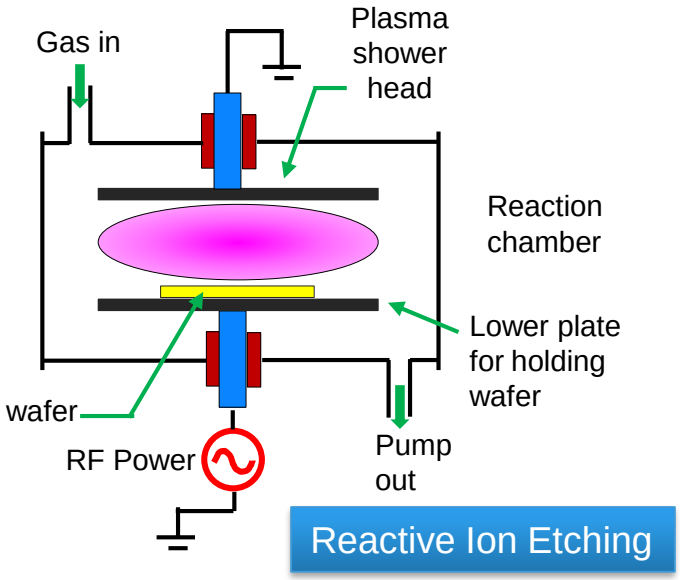
  Chemical Reaction + Ion Bombardment



Reactive Ions Etch (RIE) Process

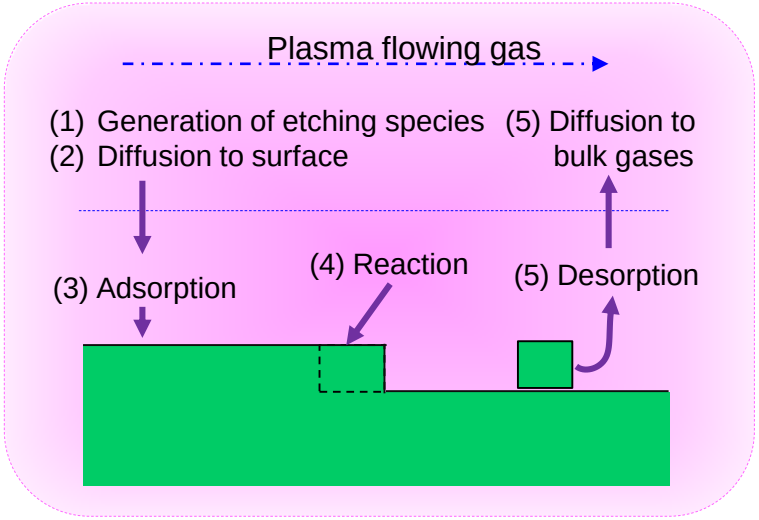
❑ What is plasma?

Plasma is partially ionized gas containing an equal number of positive and negative charges, as well as some other number of none ionized gas particles. It can be created using electrical fields.



❑ Etching Mechanism

(1) Generation of etching species
(2) Diffusion to surfaces
(3) Adsorption on surface
(4) Reaction & Bombardment
(5) Desorption (Gaseous by-product)
(6) Diffusion into bulk gases & pumped out

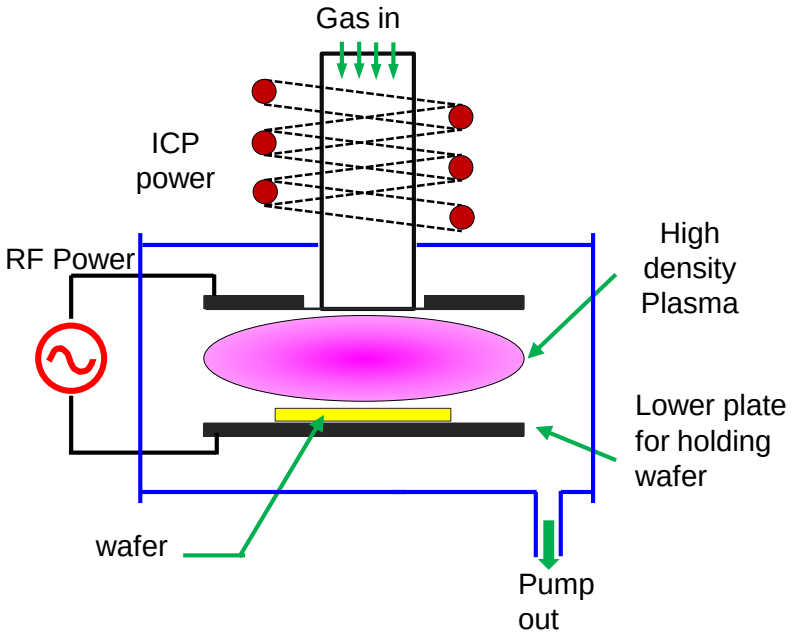


ICP Etch for high quality etch

ICP: Inductively Coupled Plasma

ICP: A 13.6 MHz RF power for Coil electrode (plasma source) producing electromagnetic induction, generating high density of ions, to realize high etch rate

RF: a 13.56 MHz RF power magnetic field to create directional electric fields to achieve more anisotropic etch



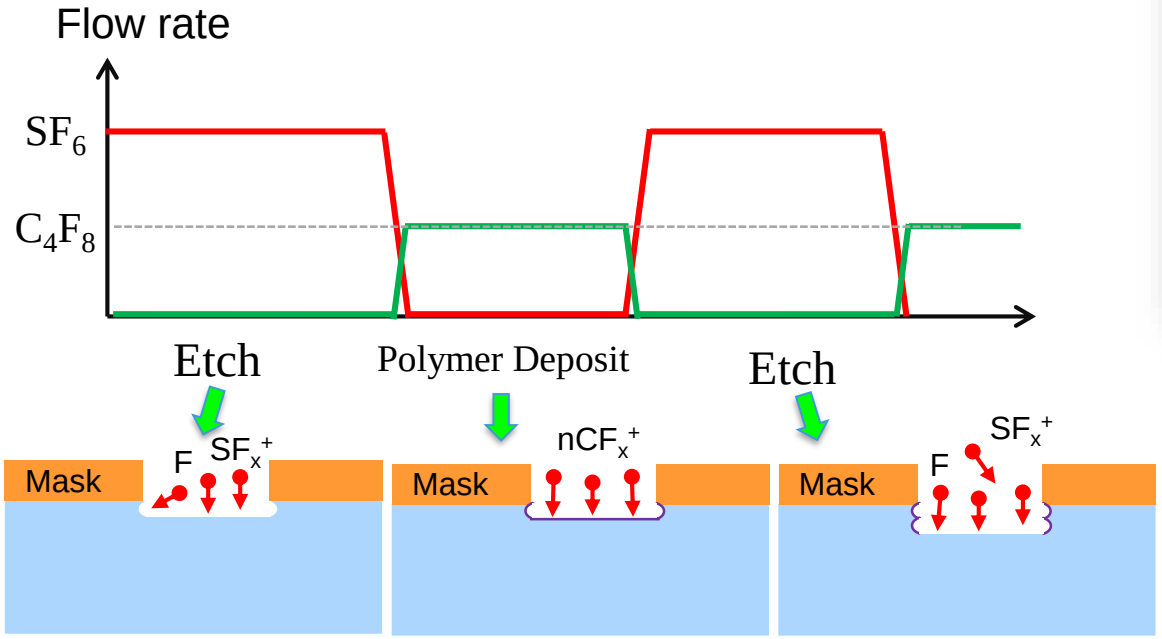
Advantages:

- Higher plasma density at low pressure
- Better profile
- Lower ion damage
- Faster etching rate

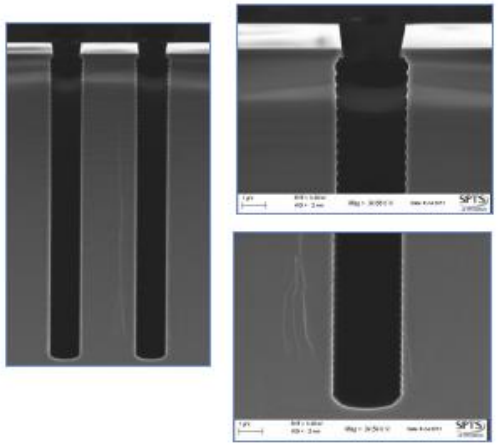
Deep silicon etch (DRIE)

Bosch process:

1. High aspect ratio of silicon etching
2. Separated etching and sidewall passivation steps



Process code	Location	Equipment	Cleanliness level
DRY-Si-1	P2-01000	DRIE Etcher #1	Clean
DRY-Si-2	Rm.2223	DRIE Etcher #2	Clean/Semi-Clean
DRY-Si-2	Rm.2223	DRIE Etcher #3	Non-Standard



Scallops after DRIE etch
Pictures from SPTS

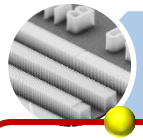
Process modules in NFF

1. Photolithography

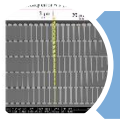
2. Cleaning and Wet etching

3. Thin film growth and deposition

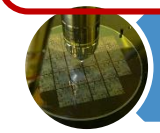
4. Implantation



5. Dry Etching



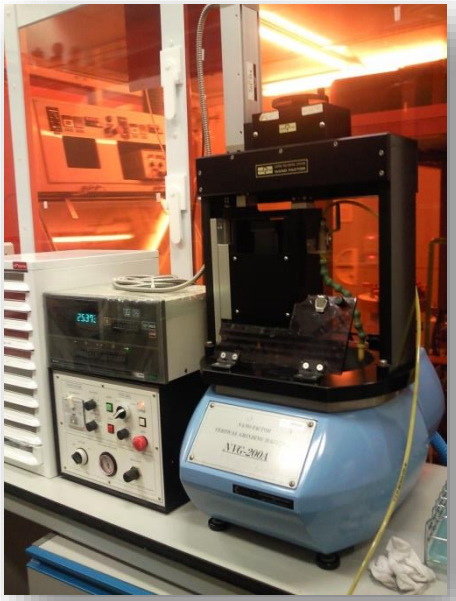
6. Grinding and Polishing

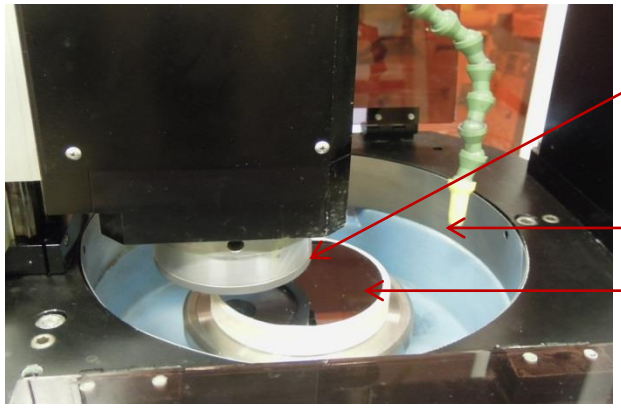


7. Metrology

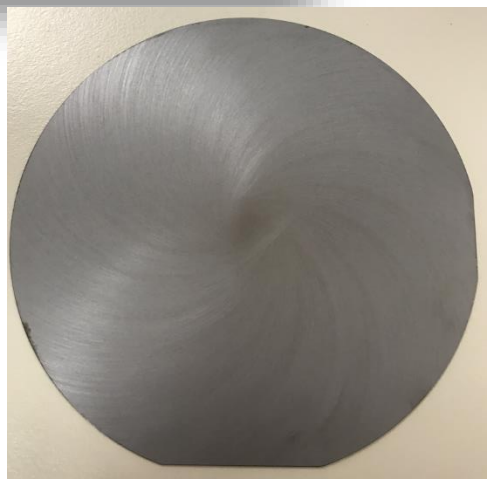
Grinding

- Silicon Grinder (NanoFactor NVG-200A) is composed of grinding main body and control panel.
- Using a rotating diamond grinding wheel to thin sample thickness with accuracy in the order of micrometers.
- Remove thickness:
  20~400μm
- Whole wafer





Diamond grinding wheel



Wafer after grinding showing characteristic scratch pattern.

Polishing

Buehler Polisher #1, #2

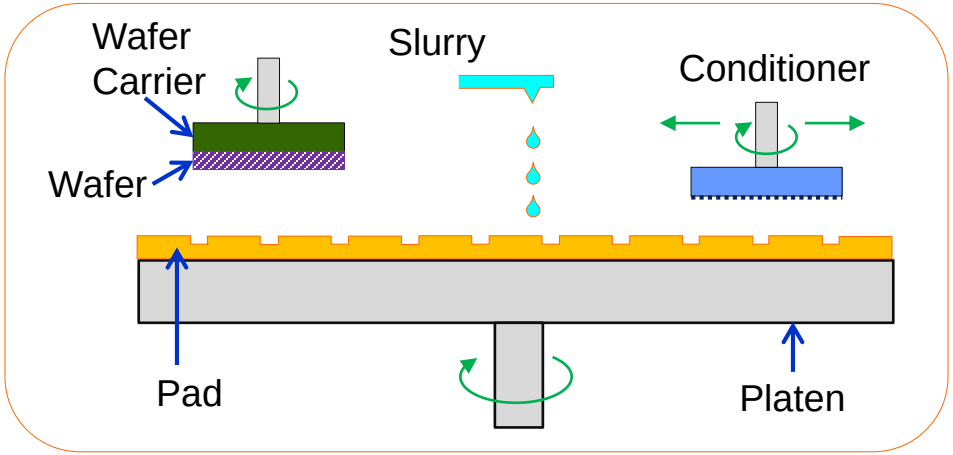
- EcoMet™300 polisher (Buehler Polisher #1, #2) is composed of power head, D-shape bowl and control panel.
- Mechanical polish of sample surface using different size of slurry and different type of polish cloth.
- Slurry size: 15μm, 9μm, 6μm, 3μm, 1μm, and 0.06μm.
- Final surface roughness: ~1nm

Polishing Cloth

Diamond abrasive slurry

CMP (Chemical Mechanical Planarization)

CMP is a process that removes material from the wafer surface by means of synergistic chemical and mechanical actions.



Schematic of a CMP system

Strasbaugh (CMP)

Polish material: SiO_2, Poly-Si
Substrate size: 4” wafer only
Wafer thickness: 400-550μm
Slurry: For Oxide: Cabot SS 25E (PH=10.2-11.2) (Silica <12-25%, KOH<1%, DI water >74-87%
For Poly-Si: P-1000 (PH=9.5-10.5) (Silica <5%, DI Water>92%)

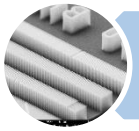
Process modules in NFF

1. Photolithography

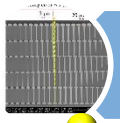
2. Cleaning and Wet etching

3. Thin film growth and deposition

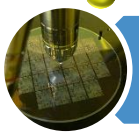
4. Implantation



5. Dry Etching



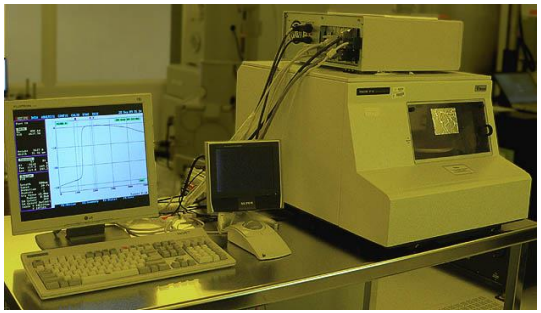
6. Grinding and Polishing



7. Metrology

Metrology

Microscope



Surface profiler

4-point probe for sheet resistance

Ellipsometer

Atomic Force Microscope AFM

Scanning Electron Microscope SEM

Outline

1. Introduction to cleanroom & NFF
2. Contamination Control
3. Process modules in NFF
4. Process flow
5. Discussion

Aim of Process Flows

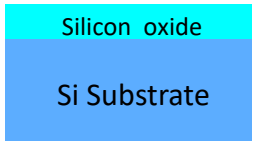
- Functions:
  - Help you to plan ahead
  - Track down wafer movement
  - Reduce uncertainty
  - keep the unqualified away from NFF
- Aim:
  - Control Contamination

Process Flow of XXX XXX XXX

Project: Name: Substrate: Date:

Cross-section

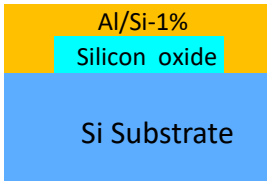
MASK 0



Wafer Cleanliness
Clean
Clean
Clean
Clean

Step No.	Equipment	Location	Cleanliness	Process	Requirements
0.1	A3: Sulfuric Cleaning	P201000	Clean	Initial Clean	H2SO4 + H2O2, 10mins, 120C
0.2	A2: HF:H2O (1:50)	P201000	Clean	HF dip	1 min
0.3	Spin Dryer-A	P201000	Clean	Dry the wafer automatically	
0.4	Diff. Furnace-D2 Dry/Wet Oxidation	P201000	Clean	Sacrificial Oxide Growth	200A

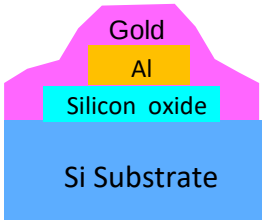
MASK 1



Wafer Cleanliness
Clean
Clean
Clean
Clean
Clean
Clean
Clean
Clean
Semi-Clean

Step No.	Equipment	Location	Cleanliness	Process	Requirements
1.1	B1: Sulfuric Cleaning	P201000	Clean	Standard Cleaning	10mins, 120C
1.2	Spin Dryer-B	P201000	Clean	Dry the wafer automatically	
1.3	SVG Coater Track	P200100	Clean/Semi-Clean	HMDS, PR coating, soft bake	AZ 504, 1.2µm, soft bake: 110C 1min
1.4	Karl Suss MA6 #2	P200100	Clean/Semi-Clean	Define oxide pad	5s
1.5	SVG Developer Track	P200100	Clean/Semi-Clean	Develop, Hard bake	FHD-5, 1min; hard bake: 120C, 1min
1.6	C3: BOE	P201000	Clean	Oxide Etch	20s
1.7	E4: Resist Strip	P201000	Clean/Semi-Clean	Sulfuric resist strip	H2SO4 + H2O2,120C, 10mins
1.8	Spin Dryer-E	P201000	Clean/Semi-Clean	Spin dry	
1.9	Varian 3180 Sputter	P201000	Semi-Clean	Aluminum Sputtering	4000A

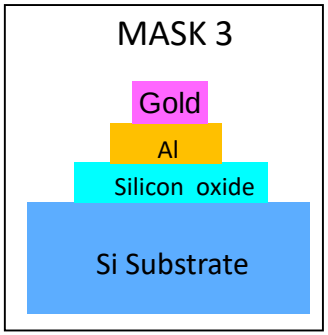
MASK 2



Wafer Cleanliness
Semi-Clean
Semi-Clean
Semi-Clean
Semi-Clean
Semi-Clean
Semi-Clean
Semi-Clean
Semi-Clean
Semi-Clean
Semi-Clean
Semi-Clean
Non-Standard

Step No.	Equipment	Location	Cleanliness	Process	Requirements
1.1	D1: Dump rinse	P201000	Semi-Clean	Wafer cleaning	4 cycles
1.2	Spin Dryer-D	P201000	Semi-Clean	Dry the sample	
1.3	SVG Coater Track	P200100	Clean/Semi-Clean	HMDS, PR coating, soft bake	AZ 504, 1.2µm, soft bake: 110C 1min
1.3	Karl Suss MA6 #2	P200100	Clean/Semi-Clean	Al Patterning	4.5s
1.4	SVG Developer Track	P200100	Clean/Semi-Clean	Develop and hard bake	1min, hard bake:120C 1min
1.6	IPC 3000 Asher #2	P201000	Semi-Clean	Descum	70C, 1min
1.7	D1: Aluminum Etch	P201000	Semi-Clean	Al etch	1.5min
1.8	D: Freckle Etch	P201000	Semi-Clean	Remove Silicon Residue	1min
1.9	Spin Dryer-D	P201000	Semi-Clean	Spin dry	
1.10	Y1: MS2001	P200100	Semi-Clean	Resist Stripping	5mins, 70C
1.11	Spin Dryer-Y	P200100	Semi-Clean	Spin dry	
1.12	ARC-12M Sputter	P201000	Non-Standard	Gold Sputtering	500A

Con't



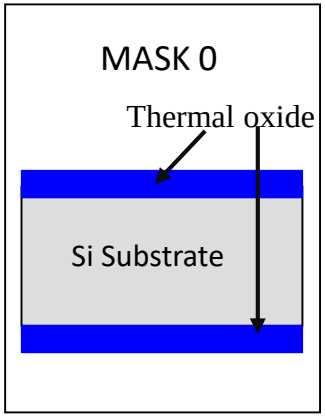
Wafer Cleanliness	Step No.	Equipment	Location	Cleanliness	Process	Requirements
Non-Standard	2.1	F1: dump rinse	P201000	Non-Standard	Cleaning	500A
Non-Standard	2.2	Spin Dryer-F	P201000	Non-Standard	Spin Dry	
Non-Standard	2.2	HMDS Primer #1	P200100	Non-Standard	HMDS Priming	10min
Non-Standard	2.3	SUSS Coater	P200100	Semi-Clean/Non-Standard	Resist Coating	AZ504, 1.2μm
Non-Standard	2.4	Hot Plate-C	P200100	Non-standard	Soft bake	1min 110C
Non-Standard	2.5	AB-M Aligner #1 (UV)/(DUV)	P200100	Semi-Clean/Non-Standard	Photo patterning	6s
Non-Standard	2.6	W2: FHD-5	P200100	Non-Standard	Develop & Rinsing	1min
Non-Standard	2.7	Spin Dryer-W	P200100	Non-Standard	Spin dry	
Non-Standard	2.8	Shellab (120C)	P200100	Non-standard	Hard bake	120C, 30min
Non-Standard	2.9	Wet-station F	P201000	Non-standard	Gold etching with KI Solution	Use a separate container
Non-Standard	2.10	Spin Dryer-F	P201000	Non-Standard	Spin dry	
Non-Standard	2.11	W1: MS2001 Resist Strip	P200100	Non-standard	Resist Stripping	70C 5min
Non-Standard	2.12	W: N2 gun	P200100	Non-standard	Dry the samples using N2 gun	

Standard Format

Title	Descriptions
Heading	Process title or project tile
Cross-sections	The cross-section schematic of devices after the process
Wafer Cleanliness	Cleanliness level of wafer after the process step
Step No.	Process step Number based on the mask number
Equipment	The equipment needs to be used in this step
Location	The equipment location
Cleanliness	Cleanliness level of the used equipment
Process	The function of the process step
Requirements	detailed requirements for process step

Mistake 1 - Oversimplification

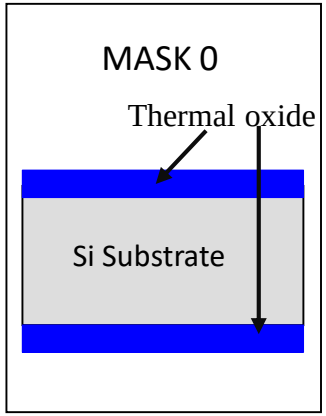
Cross-Section



Wafer Cleanliness
Clean

Step No.	Equipment	Location	Cleanliness	Process	Requirements
0.3	Diff. Furnace-D2 Dry/Wet Oxidation	P201000	Clean	Sacrificial Oxide Growth	200A

Cross-Section

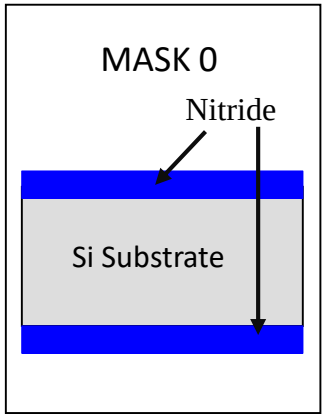


Wafer Cleanliness	Step No.	Equipment	Location	Cleanliness	Process	Requirements
Clean	0.1	A3: Sulfuric Cleaning	P201000	Clean	Initial Clean	H2SO4 + H2O2, 10mins, 120C
Clean	0.2	A2: HF:H2O (1:50)	P201000	Clean	HF dip	1 min
Clean	0.3	Spin Dryer-A	P201000	Clean	Dry the wafer automatically	
Clean	0.4	Diff. Furnace-D2 Dry/Wet Oxidation	P201000	Clean	Sacrificial Oxide Growth	200A

Mistake 2 – Improper process steps

Nitride deposition

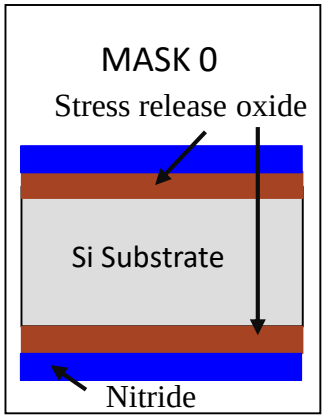
Cross-Section



Wafer Cleanliness
Clean
Clean
Clean
Clean

Step No.	Equipment	Location	Cleanliness	Process	Requirements
0.1	A3: Sulfuric Cleaning	P201000	Clean	Initial Clean	H2SO4 + H2O2, 10mins, 120C
0.2	A2: HF:H2O (1:50)	P201000	Clean	HF dip	1 min
0.3	Spin Dryer-A	P201000	Clean	Dry the wafer automatically	
0.3	LPCVD-B2 Nitride/Low-Stress Nitride	P201000	Clean	Nitride deposition	800A

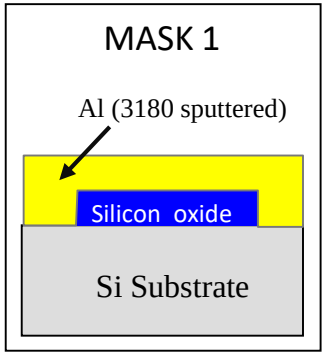
Cross-Section



Wafer Cleanliness
Clean
Clean
Clean
Clean
Clean

Step No.	Equipment	Location	Cleanliness	Process	Requirements
0.1	A3: Sulfuric Cleaning	P201000	Clean	Initial Clean	H2SO4 + H2O2, 10mins, 120C
0.2	A2: HF:H2O (1:50)	P201000	Clean	HF dip	1 min
0.3	Spin Dryer-A	P201000	Clean	Dry the wafer automatically	
0.4	Diff. Furnace-D2 Dry/Wet Oxidation	P201000	Clean	Sacrificial Oxide Growth	300A
0.5	LPCVD-B2 Nitride/Low-Stress Nitride	P201000	Clean	Nitride deposition	800A

Mistake 3 – Incompatible equipment



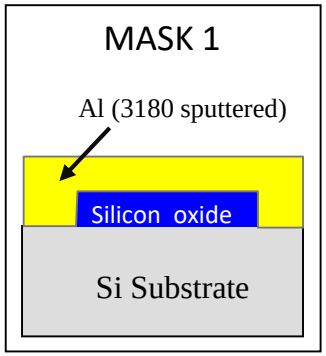
Wafer Cleanliness
Clean
Clean
Clean
Semi-Clean
Semi-Clean
Clean
Clean
Clean
Semi-Clean

Step No.	Equipment	Location	Cleanliness	Process	Requirements
1.1	B1: Sulfuric Cleaning	P201000	Clean	Standard Cleaning	10mins, 120C
1.2	Spin Dryer-B	P201000	Clean	Dry the wafer automatically	
1.3	SVG Coater Track	P200100	Clean/Semi-Clean	HMDS, PR Coating, Soft bake	AZ 504, 1.2μm, soft bake: 110C 1min
1.4	AB-M Aligner #2	P200100	Semi-Clean/Non-Standard	Define Oxide Pad	6s
1.5	SVG Developer Track	P200100	Clean/Semi-Clean	Develop and hard bake	FHD-5,1min; 120C, 1min
1.6	C3: BOE	P201000	Clean	Oxide etch	
1.7	E4: Resist Strip	P201000	Clean/Semi-Clean	Resist Stripping (wet)	10min, 120C
1.8	Spin Dryer-E	P201000	Clean/Semi-Clean	Spin Dry	
1.9	Varian 3180 Sputter	P201000	Semi-Clean	Aluminum Sputtering	4000A

How to modify?

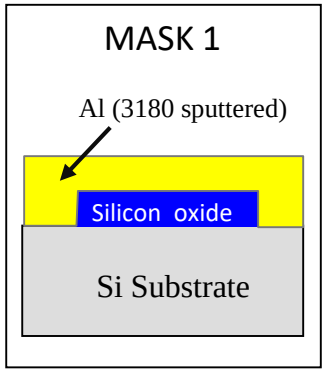
1. Use another aligner Karl Suss MA6#2 (Clean/Semi-Clean) to do exposure. The wafer status will be “Clean” before Al sputtering
2. Use Wetsation D to do oxide etch (Semi-Clean)

Mistake 3 - Incompatible equipment



Wafer Cleanliness
Clean
Clean
Clean
Clean
Clean
Clean
Clean
Clean
Semi-Clean

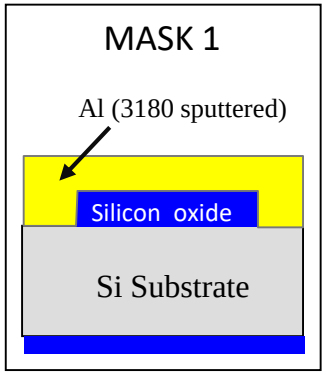
Step No.	Equipment	Location	Cleanliness	Process	Requirements
1.1	B1: Sulfuric Cleaning	P201000	Clean	Standard Cleaning	10mins, 120C
1.2	Spin Dryer-B	P201000	Clean	Dry the wafer automatically	
1.3	SVG Coater Track	P200100	Clean/Semi-Clean	HMDS, PR Coating, Soft bake	AZ 504, 1.2μm, soft bake: 110C 1min
1.4	Karl Suss MA6#2	P200100	Clean/Semi-Clean	Define Oxide Pad	6s
1.5	SVG Developer Track	P200100	Clean/Semi-Clean	Develop and hard bake	FHD-5,1min; 120C, 1min
1.6	C3: BOE	P201000	Clean	Oxide etch	
1.7	E4: Resist Strip	P201000	Clean/Semi-Clean	Resist Stripping (wet)	10min, 120C
1.8	Spin Dryer-E	P201000	Clean/Semi-Clean	Spin Dry	
1.9	Varian 3180 Sputter	P201000	Semi-Clean	Aluminum Sputtering	4000A



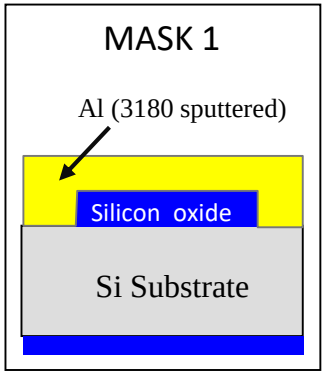
Wafer Cleanliness
Clean
Clean
Clean
Semi-Clean
Semi-Clean
Semi-Clean
Semi-Clean
Semi-Clean

Step No.	Equipment	Location	Cleanliness	Process	Requirements
1.1	B1: Sulfuric Cleaning	P201000	Clean	Standard Cleaning	10mins, 120C
1.2	Spin Dryer-B	P201000	Clean	Dry the wafer automatically	
1.3	SVG Coater Track	P200100	Clean/Semi-Clean	HMDS, PR Coating, Soft bake	AZ 504, 1.2μm, soft bake: 110C 1min
1.4	AB-M Aligner #2	P200100	Semi-Clean/Non-Standard	Define Oxide Pad	6s
1.5	SVG Developer Track	P200100	Clean/Semi-Clean	Develop and hard bake	FHD-5,1min; 120C, 1min
1.6	D: BOE	P201000	Semi-Clean	Oxide etch use separate container	
1.7	E4: Resist Strip	P201000	Clean/Semi-Clean	Resist Stripping (wet)	10min, 120C
1.8	Spin Dryer-E	P201000	Clean/Semi-Clean	Spin Dry	
1.9	Varian 3180 Sputter	P201000	Semi-Clean	Aluminum Sputtering	4000A

Mistake 4 – Double side coating



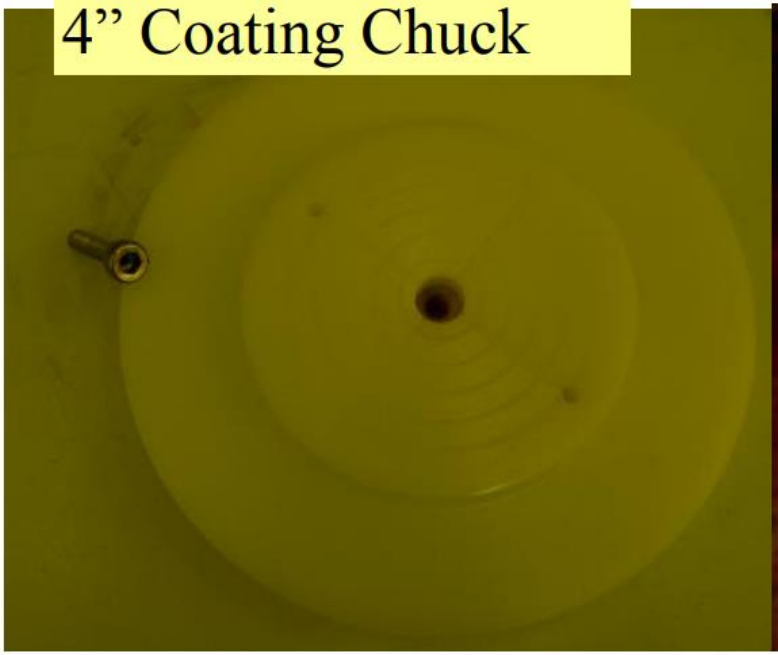
Wafer Cleanliness	Step No.	Equipment	Location	Cleanliness	Process	Requirements
Clean	1.1	B1: Sulfuric Cleaning	P201000	Clean	Standard Cleaning	10mins, 120C
Clean	1.2	Spin Dryer-B	P201000	Clean	Dry the wafer automatically	
Clean	1.3	SVG Coater Track	P200100	Clean/Semi-Clean	HMDS, PR Coating, Soft bake	AZ 504, 1.2μm, soft bake: 110C 1min
Clean	1.4	Karl Suss MA6#2	P200100	Clean/Semi-Clean	Define Oxide Pad	6s
Clean	1.5	SVG Developer Track	P200100	Clean/Semi-Clean	Develop and hard bake	FHD-5,1min; 120C, 1min
Clean	1.6	C3: BOE	P201000	Clean	Oxide etch	
Clean	1.7	E4: Resist Strip	P201000	Clean/Semi-Clean	Resist Stripping (wet)	10min, 120C
Clean	1.8	Spin Dryer-E	P201000	Clean/Semi-Clean	Spin Dry	
Semi-Clean	1.9	Varian 3180 Sputter	P201000	Semi-Clean	Aluminum Sputtering	4000A



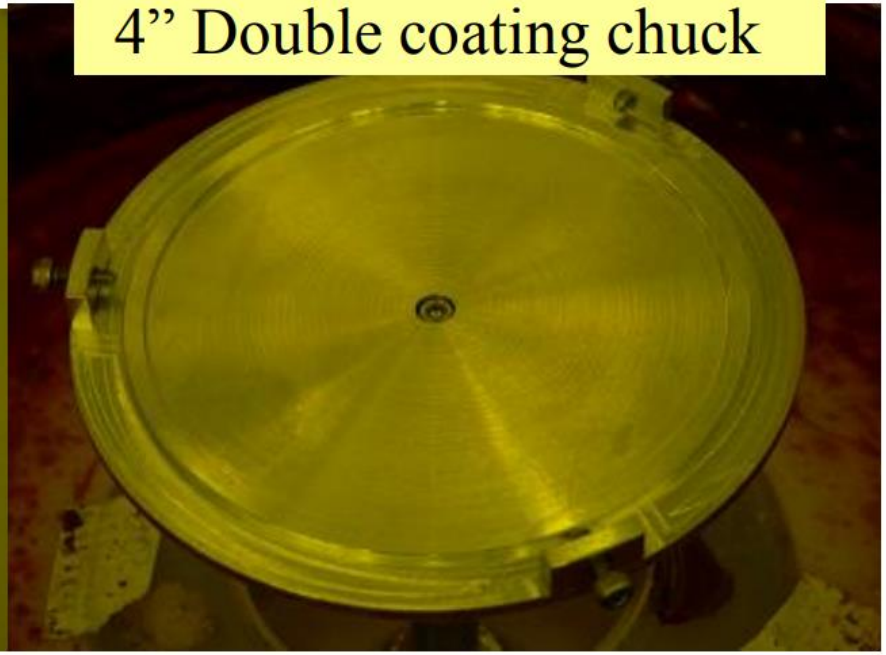
Wafer Cleanliness	Step No.	Equipment	Location	Cleanliness	Process	Requirements
Clean	1.1	B1: Sulfuric Cleaning	P201000	Clean	Standard Cleaning	10mins, 120C
Clean	1.2	Spin Dryer-B	P201000	Clean	Dry the wafer automatically	
Clean	1.3	SVG Coater Track	P200100	Clean/Semi-Clean	HMDS, PR Coating, Soft bake	AZ 504, 1.2μm, soft bake: 110C 1min
Clean	1.4	Karl Suss MA6#2	P200100	Clean/Semi-Clean	Define Oxide Pad	6s
Clean	1.5	SVG Developer Track	P200100	Clean/Semi-Clean	Develop and hard bake	FHD-5,1min; 120C, 1min
Clean	1.6	CEE Coater	P200100	Clean/Semi-Clean	Backside coating	AZ 504, 1.2μm
Clean	1.7	Oven-C (120C)	P200100	Clean/Semi-Clean	Hard bake	120C, 30min
Clean	1.8	C3: BOE	P201000	Clean	Oxide etch	
Clean	1.9	E4: Resist Strip	P201000	Clean/Semi-Clean	Resist Stripping (wet)	10min, 120C
Clean	1.10	Spin Dryer-E	P201000	Clean/Semi-Clean	Spin Dry	
Semi-Clean	1.11	Varian 3180 Sputter	P201000	Semi-Clean	Aluminum Sputtering	4000A

Wafer chuck for PR coating

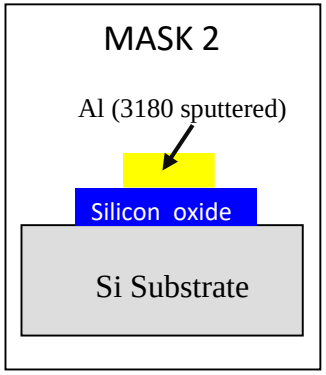
4” Coating Chuck



4” Double coating chuck



Mistake 5 – Wrong PR Stripping



Wafer Cleanliness	Step No.	Equipment	Location	Cleanliness	Process	Requirements
Semi-Clean	2.1	Y1: MS2001 Resist Strip	P200100	Clean	Standard Cleaning	10mins, 120C
Semi-Clean	2.2	Spin Dryer-Y	P200100	Clean	Dry the wafer automatically	
Semi-Clean	2.3	SVG Coater Track	P200100	Clean/Semi-Clean	HMDS, PR Coating, Soft bake	AZ 504, 1.2μm, soft bake: 110C 1min
Semi-Clean	2.4	Karl Suss MA6#2	P200100	Clean/Semi-Clean	Define Oxide Pad	6s
Semi-Clean	2.5	Z1: FHD-5	P200100	Semi-Clean	Develop and hard bake	FHD-5,1min; 120C, 1min
Semi-Clean	2.6	Z2: Dump Rinser	P200100	Semi-Clean/Non-Standard	DI water dump rinse	4 cycles
Semi-Clean	2.7	Z: N2 Gun	P200100	Semi-Clean/Non-Standard	Dry the wafer using N2 gun	
Semi-Clean	2.8	Oven-C (120)	P200100	Clean/Semi-Clean	Hard bake	120C 30min
Semi-Clean	2.9	D1: Aluminum Etch	P201000	Semi-Clean	Aluminum etch	55C
Semi-Clean	2.10	D: Freckle Etch	P201000	Semi-Clean	Remove Si residue (Separate container)	1 min
Semi-Clean	2.11	E4: Resist Strip	P201000	Clean/Semi-Clean	Resist Stripping (wet)	10min, 120C
Semi-Clean	2.12	Spin Dryer-E	P201000	Clean/Semi-Clean	Spin dry	

- Once there is metal on your sample, it can not be put into E4: Resist Strip (Sulfuric Acid) for PR strip!!!
- Otherwise, the Bath will be contaminated.

After Metal Sputtering, there are two ways to do PR stripping:

1.MS2001

2.O2 Asher

3. Sulfuric Acid

Other Mistakes

- Mistake 6 -- Misuse of Decontamination
- Mistake 7 -- Wafer Edge Coating
- Mistake 8 -- Missing backside rinsing prior to implantation
- Mistake 9 -- Improper etching mask for dry or wet etch
- Mistake 10 -- Improper process parameters beyond the limitation of equipment

Chemicals and Wetstations

- Don’t bring your own chemicals or materials into NFF unless you have approval
- Don’t take any chemicals or materials away. That is theft.
- Don’t leave chemical bottles on the floor
- Never put into “Clean” baths wafers that have undergone metallization.
- Don’t leave anything, especially incompatible materials, on the top of wet-stations.
- Disposal of HF and BOE must be done by trained persons
- Don’t be so irresponsible as to leave down the tools you have used and go away
- Don’t mix up the gloves, cassettes and tools of one station with those of others. You should look at the labels!
- Clean all the tools and containers you have used and place them back to where they are
- No ORGANIC Solvent at wetstations in Class 1000
- No acid and base in Yellow Room

Operation

- Store wafers of different wafer status in separate boxes
- Always inspect your wafers after a resist strip to ensure cleanliness
- Don’t put Non-Standard materials, especially gold into Semi-Clean and Clean baths
- Don’t put liftoff samples in any processing baths
- Always keep your samples in your own containers or cassette boxes in case they contaminate others or be contaminated.
- Always be careful with photoresist which is very contaminating.
- Arrange Non-Standard steps as close to the end of process flow as possible.
- After cleaning, wafers must go straight to furnaces without being touched by any objects.

Process Flows

- Plan before work. If you fail to plan you are planning to fail
- Follow the process flow format
- Write what you do and do what you write.
- Once your process becomes different from what you have planed, submit us a new flow
- Never copy others' process flow
- Never let others copy your process flow
- Do let us know, if you find your processes departing from our scheme.
- Proofread before submitting them

Personal

- Don’t shortcut any policy and rules
- Keep yourself abreast of information about rules and regulations, as it is dynamic and subject to change.
- Report to us any mistakes you or others have made. Don’t hide it!
- Be aware of contamination that you may cause and others cause
- Remember, this is a shared lab. Everyone must follow lab policy to keep it clean
- Use your judgment. Avoid contamination of wafers or equipment
- Don’t stay in the laboratory if not necessary. NFF is not a meeting place!
- Follow the buddy system after office hour

Collection of research publications

- **Acknowledge** NFF using **"We acknowledge Nanosystem Fabrication Facility (NFF) of HKUST for the device / system fabrication."** in your future publications involving work conducted in NFF. (http://www.nff.ust.hk/en/about-nff/publication.html)
- Upload new publications through our website

Submission

Publication list

Publications will be shown on NFF news letter and NFF entrance displays

Q and A