**Pattern Transfer - photolithography**

(a) Oxidation

(b) Lithography preparation

(c) Exposure

(d) Unexposed photoresist removed by developer

(e) SiO₂ etched with NH₄F + HF

(f) Exposed photoresist removed with H₂SO₄

SiO₂ (~1µm)

n-type silicon

Negative photoresist coat (~1 µm)

SiO₂

Si

UV light

Glass plate

Opaque pattern

Hardened resist

DUV: 248 (KrF), 193 (ArF), 157 (F₂) nm

EUV: 13 nm

H line: 400 nm

I line: 365 nm

G line: 436 nm

Ref: Campbell: 7
Why Cleaning Room?

Class n: particle count < n particles/ft³ with particle size 0.5 μm or larger.
Particle size < 1/10 of the minimum feature size of the device

- Human hair: 30-80 μm
- Dead skin, make-up
- Walking, sneezing, breathing
Cleaning Room Layout

Class: 10,000

- Fresh Air
- Fan
- Service Chase
- Slab Floor
- Vibration-stiff optical mount
- Clean Room
- IHEPA Filters
- Evaporator
- Nanospec 3000
- Profilometer
- Fab Area
- Gowning Area
- Air Shower
- Bench
- Lockers
- Service Aisle
- Access to Maintain Equipment
- Pass-through for Chemicals
- Cleanroom
- Shelves
- Cleanroom Layout
Wafer Cleaning

Particulates

Organic residues

Inorganic residues: Na, Fe, Ni, Cu, Zn

Unwanted oxide layers

Piranha: remove inorganic and organic residues and particulates

\[ \text{H}_2\text{SO}_4 : \text{H}_2\text{O}_2 = 5:1 \text{ at } 100-110 \degree \text{C for 10 min, DI rinse (5 min) x2} \]

PTFE (teflon) tweezers, Chemical gloves, face shield, cap, lab coat, close-toe shoes

RCA:

1. SC-1: \( \text{NH}_4\text{OH: H}_2\text{O}_2: \text{H}_2\text{O} = 1:1:5 \) at RT, heat up to 75-85 \degree \text{C for 10 min, rinse 5 min} to remove organic residues

2. HF: 10\% for 15-30s to remove oxide  PTFE beakers or dishes and tweezers only

3. SC-2: \( \text{HCl: H}_2\text{O}_2: \text{H}_2\text{O} = 1:1:6 \) at 75-85 \degree \text{C, 10 min, rinse 5 min} to remove metal ions and complex residuals, hydroxides to grow chemical oxide
More Cleaning

Tweezers handling and cleaning

• All tweezers should be degreased by ultrasound bath acetone + isopropanol 10 min each.
• Plastic tweezers should be cleaned by RCA methods, stored in a storage box
• Only use teflon coated wafer tweezer for clean wafers.
• Always wear gloves to handle tweezers.
• Never touch the tip of a tweezer.
• Don’t drop a tweezer. If you do, leave the dropped tweezer in a dirty box.

Glassware cleaning

• After each use, glassware should be rinsed by solvent or DI water before dipping in KOH/Isopropanol bath overnight.
• After rinse, glassware should be dried on a hotplate. For photolithography use, all beakers should be covered immediately by Al foil to reduce particulates.
• Glassware can also go through SC1 and SC2 to remove organic and metallic residues.
• Glassware can also dip in diluted HF to remove particular sticky contaminants.
Photoresist

Positive resist: photochemistry weakens the polymer by scission the polymer chains so the exposed resist becomes more soluble in developing solutions.
PMMA, AZ1512

Negative resist: photochemistry strengthens the polymer by cross-linkage of the chains becoming less soluble in developing solutions. SU-8, nLOF2020, 2035
Wafer Prime - hexamethyldisilazane

- PR adhere better on hydrophobic surfaces
- HMDS: \( (\text{CH}_3)_3\text{SiNHSi(}\text{CH}_3)_3 \) forms Si-O-Si bonds

- HMDS is flammable and carcinogen – do it in the hood.

Dehydration bake: 150 °C, 30 min

HMDS coating + spin dry

Bake: 110-125C, 60s

Vapor primarization: YES oven
Photoresist Deposition

Spin coater

Possible reasons for non-uniform coating.

- Insufficient PR
- Particles and air bubbles in the fluid
- Fluid velocity too high
- Spin bowl exhaust rate too high
- Resist sits on wafer too long
- Particles exist on the wafer
- Turbulence in the spin bowl
- Chuck size too small

Soft bake: evaporate solvent in the PR

110 °C, 60-90s

Spin coater cleaning: squirt AZ EBR 70/30 (PGME/PGMEA) in the bowl but not on the chuck.
Photomask

Glass: transmit light from ~300 nm
Fused silica: transmit light from 270 nm.
800Å Cr layer for absorption

Light field  
(clear)

Dark field

Shadow printing mask  
projection printing mask

Mask polarity  
dark  
Hole  
Island

clear  
Island  
Hole

PR polarity  
negative  
Hole  
Island

positive  
Island  
Hole

1:1  
1:10