Multi-Layer Resist

Equipment Engineering

What is MLR?

- **MLR is an advanced photoresist process technique using a photosensitive top layer and an organic underlayer with good planarization properties, instead of a single layer of PR.**

  General Advantages -

  - Improved Planarization increases DOF
    - Imaging and Planarization are separate
  - Reduced Standing Wave issues
    - Anti-Reflective Properties Enhanced
  - Some Higher Aspect Ratio etching

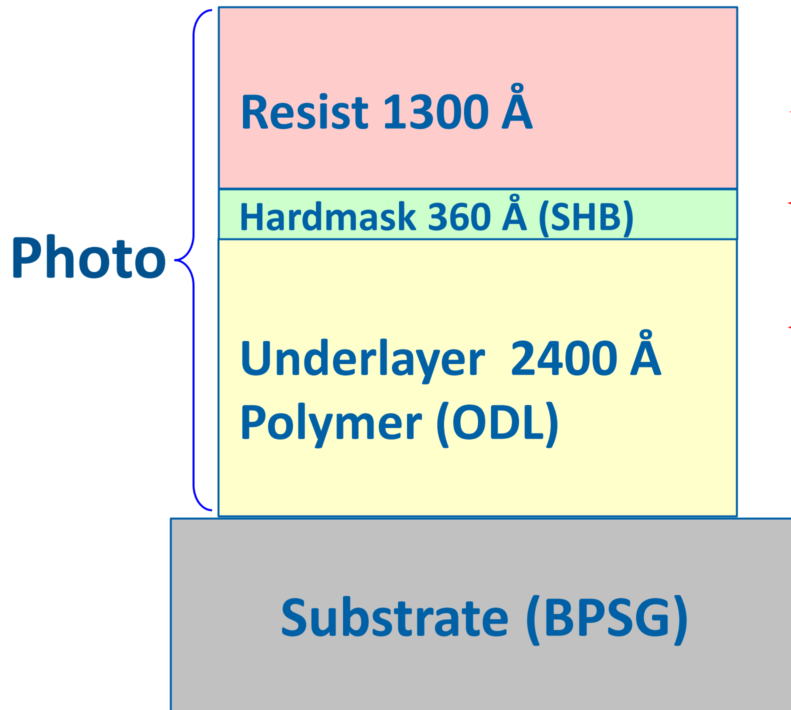
What is MLR at IMFT?

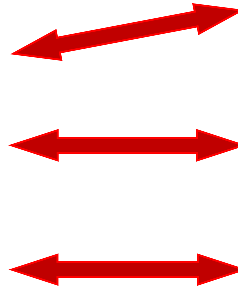
- **MLR is the alternative hardmask process to CDBR**

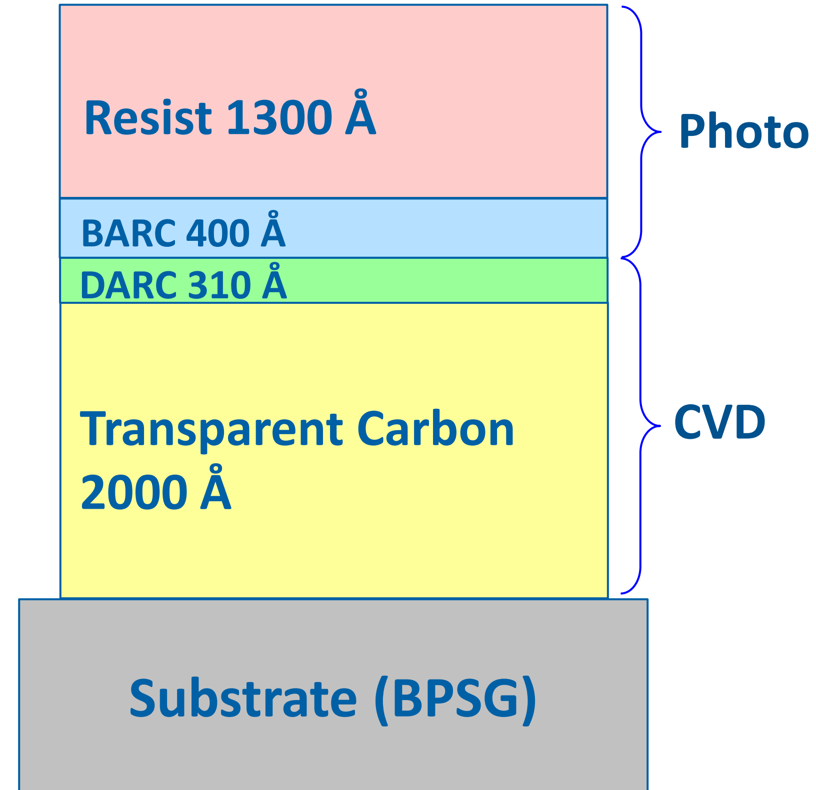
  (old IMFT process – Transparent Carbon, DARC, BARC, PR)

  which includes the following 2 films:
  - **Underlayer** - Replacement for Carbon (TC or AC)
    - Called ODL, spin-on polymer similar to I-line PR
    - No photoactive compounds
  - **Hardmask** - Replacement for DARC
    - Called SBH, spin-on Si-containing material (SSQ)
    - Intermediate layer between ODL and PR

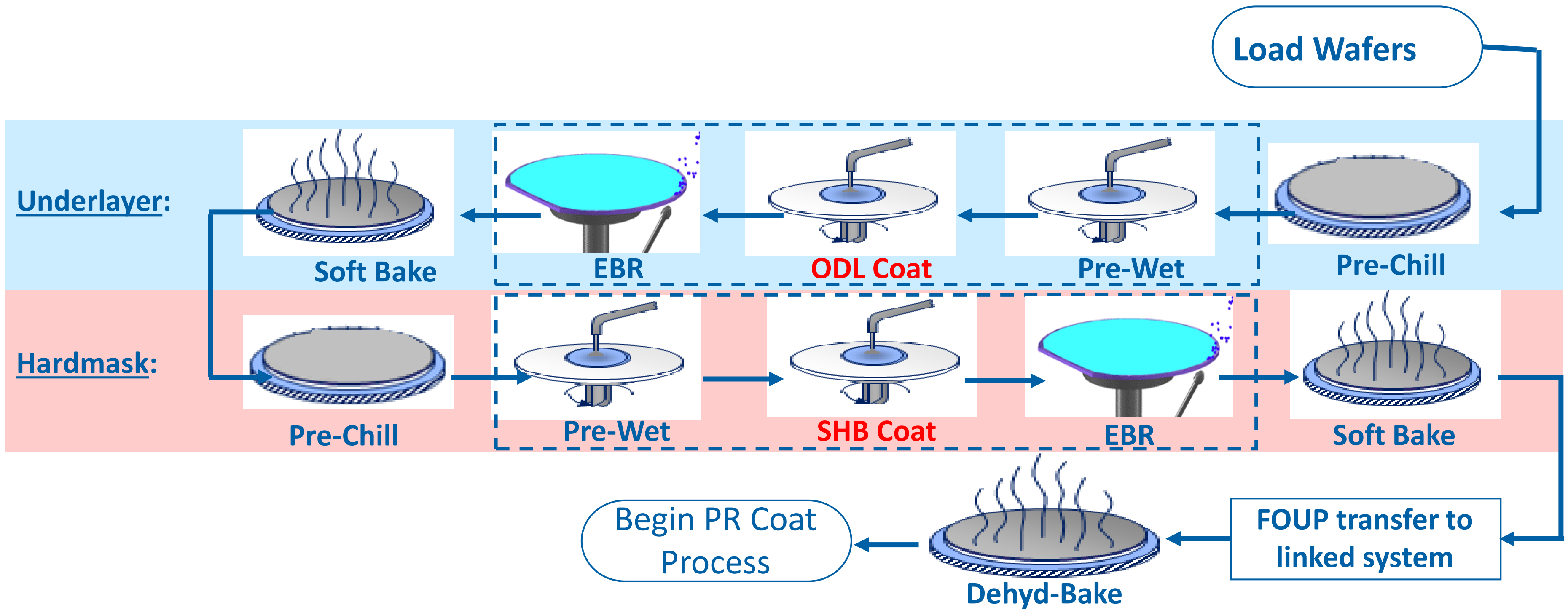
Cross-Section Comparison





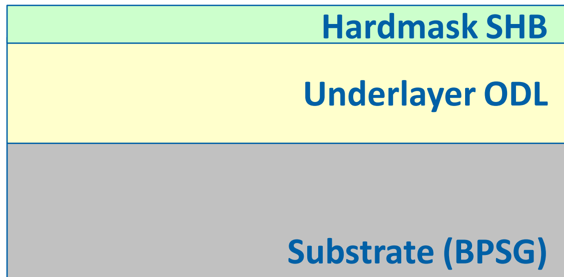


MLR Track Flow

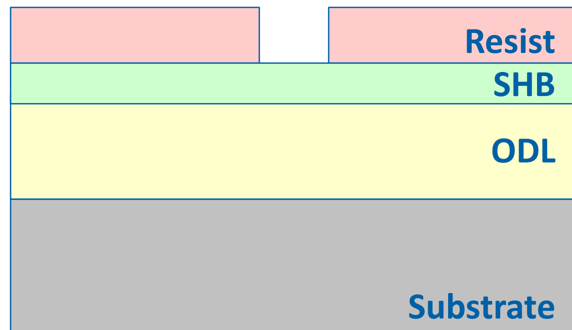


A time delay between MLR coat and PR coat is common so a Dehydration Bake is performed prior to PR coat to drive off any moisture

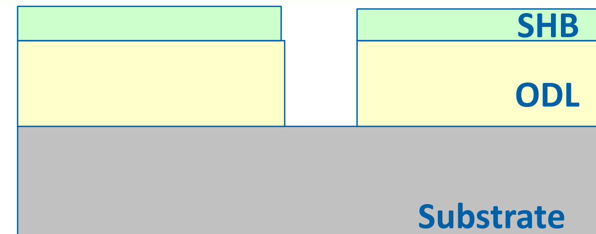
Photo Process with MLR



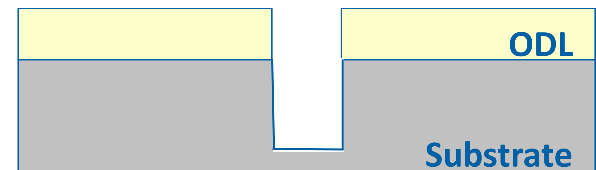
1. After MLR Coat
(Run on Track System)



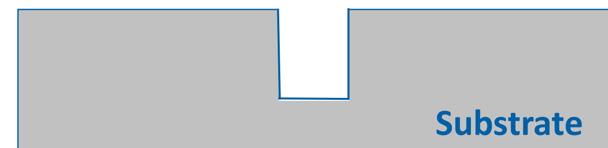
2. After Photo Pattern
(PR Coat, Expose, Develop)



3. After Dry Develop
(Pattern Transferred to MLR, PR Removed)



4. After Dry Etch
(Pattern etched into Substrate, some erosion of ODL)



5. After Dry Strip
(O_2 plasma removes remaining ODL)

Why change from CDBR?

- **Advantages of MLR over CDBR:**

Cost: MLR layers all spun on photo track

- TC, DARC both CVD layers, relatively expensive
- One less layer, no BARC needed

Planarity: Imaging and Planarization functions separate

- CVD processes enhance topography
- Track processes minimize topography

Defects: Some defect advantage of MLR over CDBR

- Track processes typically cleaner than CVD

Oxide Compatibility: TC can pit during rework

- Causes damage to underlying oxide

Why change from CDBR?

- **Disadvantages of MLR**
  - **Selectivity**: ODL etches faster than TC
    - MLR only applicable for shallow, non-aggressive etch
    - Too much erosion of MLR during nitride etches
    - Slightly more lateral etching with MLR
  - **Toppling**:
    - MLR more prone than CDBR for similar aspect ratios
  - **Reworks**:
    - Resist-only reworks if Carbon-DARC left intact with CDBR
    - Currently not possible with MLR

MLR Levels by Device Type

60s	70s	80s
41L	41L	41L
43L	60L	54L
	91L	60L
		91L

Reworks

Rework Traveler for Resist Only Layers (non MLR)

Step	Details
RWK RESIST DRY STRIP	• O_2 Plasma • Remove Resist
RWK RESIST DRY STRIP CLEAN	• Piranha 500:1+APM • Clean Surf Residue
PHOTO	• Re-Apply PR • Re-Pattern PR

Rework Traveler for MLR Hardmask Layers

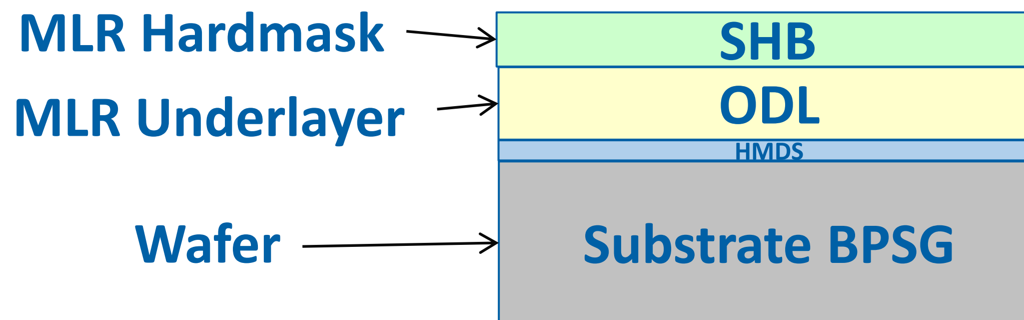
Step	Details
RWK CF4 DRY ETCH	• CF_4 Plasma • Remove MLR, PR
RWK NH3 DRY STRIP	• O_2+NH_3 Plasma • Remove ODL
RWK MLR WET STRIP CLEAN	• 500:1 + APM • Clean Surf Residue
MLR COAT	• Re-Apply ODL • Re-Apply SHB
PHOTO	• Re-Apply PR • Re-Pattern PR

Rework Traveler for CDBR Hardmask Layers

Step	Details
RWK RESIST WET STRIP	• Piranha • Remove Resist
RWK RESIST WET STRIP 2	• 20:1 BOE/Hot Phos • Remove DARC
RWK CARBON DRY STRIP	• O_2 Plasma • Remove TC
RWK DRY STRIP CLEAN	• APM • Clean Surf Residue
CARBON DEP	• Re-Deposit TC
ARC DEP	• Re-Deposit DARC
PHOTO	• Re-Apply PR • Re-Pattern PR

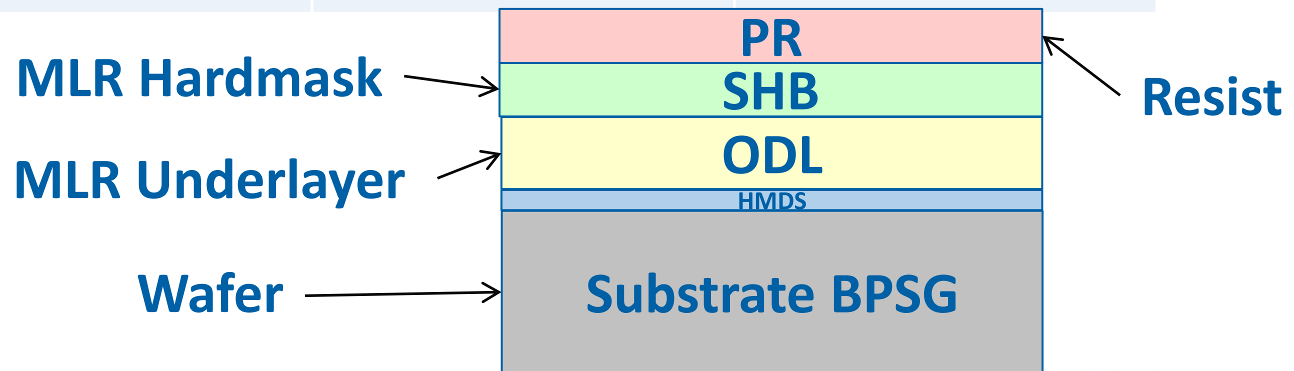
MLR Track Recipe Summary (abbreviated 43L)

Process	Module	Recipe
HMDS Coat	ADH	80C_30C_P10S
Cool after ADH	CPL	24C_30S
ODL Coat Underlayer	COT	ODL-83-2400A
Softbake ODL	CLHP	220C_60S_C20S
Cool after Softbake	CPL	24C_30S
SHB Coat Hardmask	COT	SHB1125-360A
Softbake SHB	CLHP	220C_90S_C20S

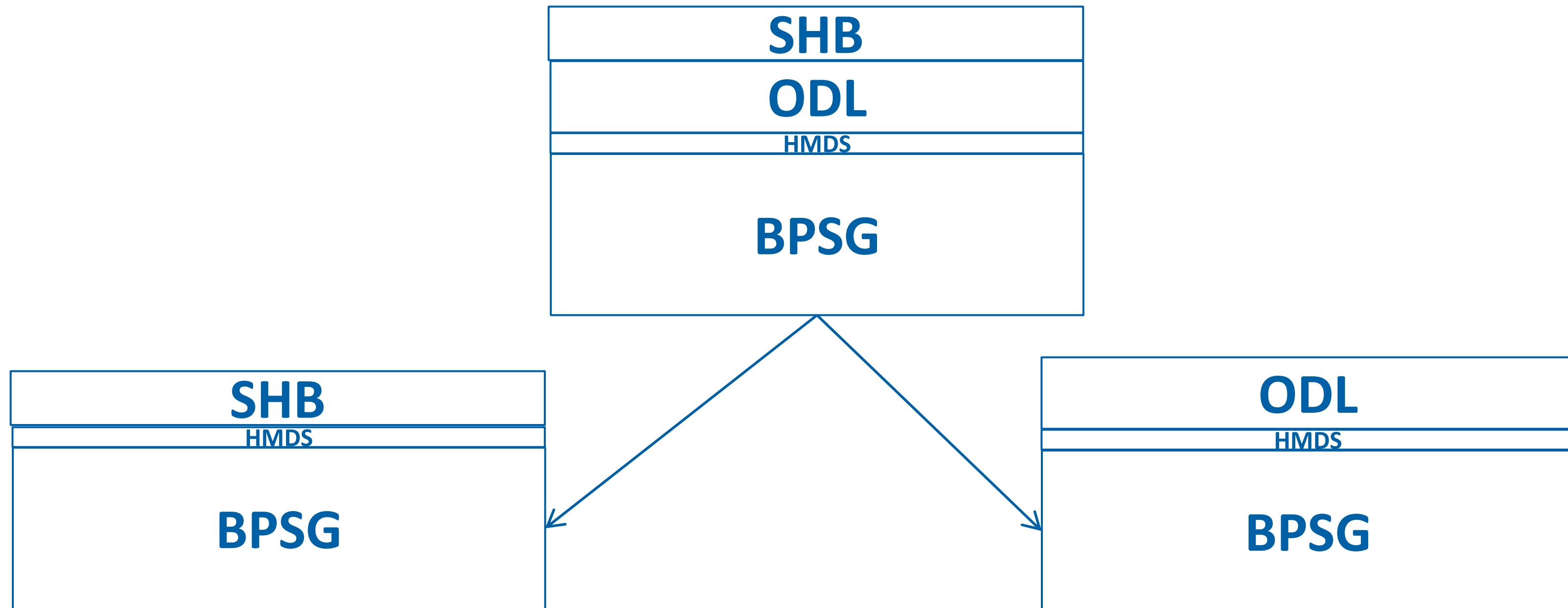


MLR PR Track Recipe Summary (abbreviated 43L)

Process	Module	Recipe
Dehydration bake	CGHA	185C_60S_C20
Cool after bake	CPL	23C30S
Resist Coat	COT	SX140-LHL-1650
Softbake resist	CLHP	110C_90S_C20S
Expose	Scanner	
Post Exposure Bake	CPHP	110C_90S_C20S
Cool after PEB	CPL	20C30S
Develop	DEV	GP-30S-SUR



Possible MLR Track Rework Scenarios



Result: No MLR underlayer (ODL)
Recovery: No rework available. Scrap wafer / lot and wait for 1st to disposition.

Result: No MLR hardmask (SHB)
Recovery: (1) Run on SHB coat only recipe and rework or (2) Skip first step on rework traveler

Dry etch selectivity prevents us from reworking w/o ODL (underlayer) being present

- **Dry etch process focuses on removing oxides from wafer.**
- **SHB is a silicon containing material, which after softbake acts like a layer of silicon oxide (essentially glass).**
- **BPSG is boron doped phosphor silicon glass (essentially a layer of oxide)**
- **If the SHB is directly on top of BPSG we have oxide on top of oxide and the dry etch process will remove both because it can't differentiate between the two**
- **Summary:**
  - Any dispense problems on the stand alone tracks must be researched vigorously and reworked cautiously or scrap may ensue.
  - Escalate any issues to the appropriate persons (photo tool owner, shift lead, etc)

MLR Review and Quiz

- **In which situations can't MLR be used?**
  - Deep or aggressive etches (such as a gate stack, deep silicon etch, deep contacts) can't use MLR because MLR erodes too much.
- **Which part of the MLR stack has high silicon content?**
  - SBH Hardmask
- **A chosen topcoat must _____ in developer and _____ in water.**
  - Soluble, Soluble
  - Insoluble, Insoluble
  - Soluble, Insoluble
  - Insoluble, soluble