반도체용 포토레지스트의 연구 개발 동향

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Contents

- Photopolymer
- Microelectronics Fabrication Process
- Development Trend of Lithography and Resist
- Classification of photoresist
- Typical of Photoresist

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    Typical KrF resist (248 nm)

    Typical ArF resist (193 nm)

    Immersion Lithography

    Basic F2 resist (157 nm)

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감광성 고분자의 용도

화상형성 분야 (Photoimaging)

•인쇄제판
- 평판 PS판
- 감광성 凸판
- 감광성 flexo판
- 스크린 인쇄판
- Off-press color proof

• Photoresists (PR) for Microlithography
- G/I-line PR
- Deep UV, Excimer laser resists
- 전자선, 감광성 polyimide resists
- Laser direct writing (LDW)

•인쇄회로기판(PCB)용 PR
- 감광성 dry film PR (DFR)
- Photo solder mask (resist) - 납땜
- Photoetching ink (스크린 잉크) - 식각, 도금
- 전착성 PR

•광가공 (Photofabrication) : Photoetching (광식각)
- 고정밀 전자, 기계부품
- TV shadow mask, IC lead frame
- Micromachine

•전자 표시장치 (Display)
- TV 형광면 (RGB color 화상)
- TFT LCD (flat panel) color filter
- Video camera 고체촬상소자

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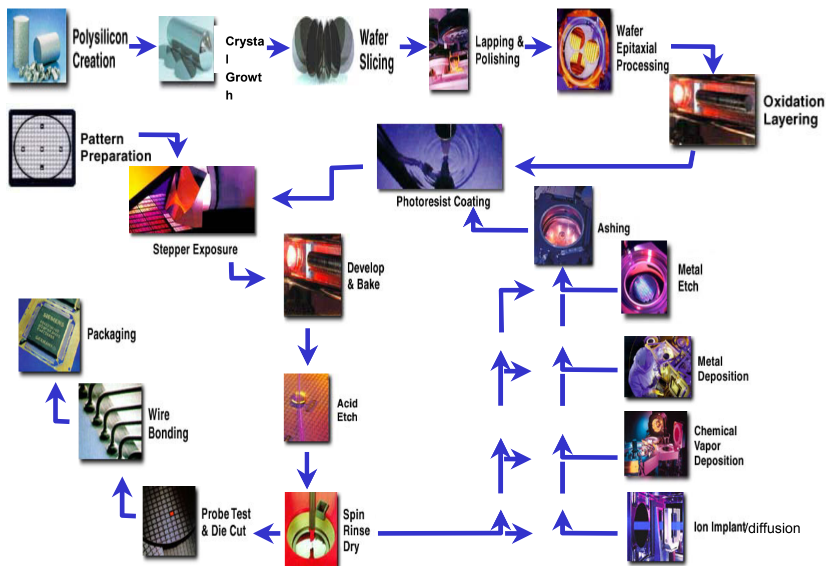
Microelectronics Fabrication Process



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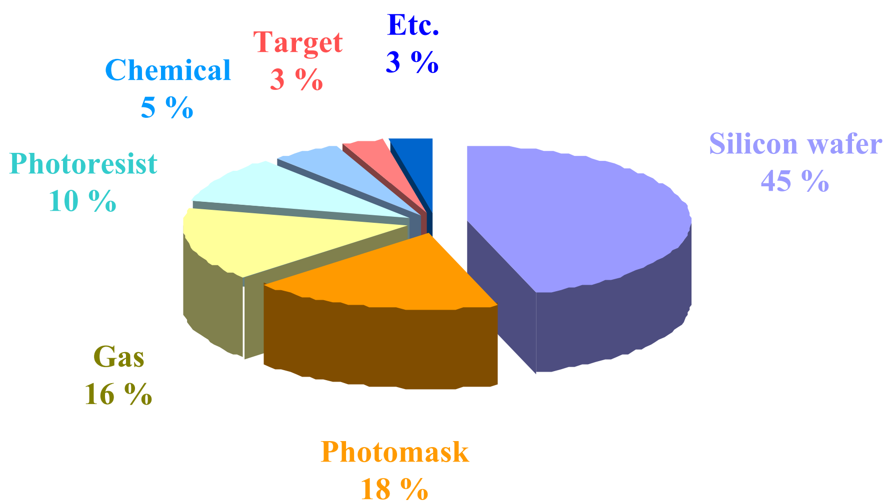
반도체 전공정 재료비 구성



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Classification of photoresist

Source			Resin
Near UV	g-line	436nm	Novolac
	i-line	365nm	Novolac
Deep UV	KrF	248nm	PVP
	ArF	193nm	Acrylate
	F_2	157nm	Material issues
ArF immersion		193nm → **134nm**	1. Top coat on ArF resist 2. Water attack free resin
F_2 immersion		157nm → **115nm**	Material issues
EUV		10-14nm	Material issues
E-beam		0.1 Å	Acrylate, Novolac, Polystyrene
X-ray		5-15 Å	Acrylate, Novolac, Polystyrene

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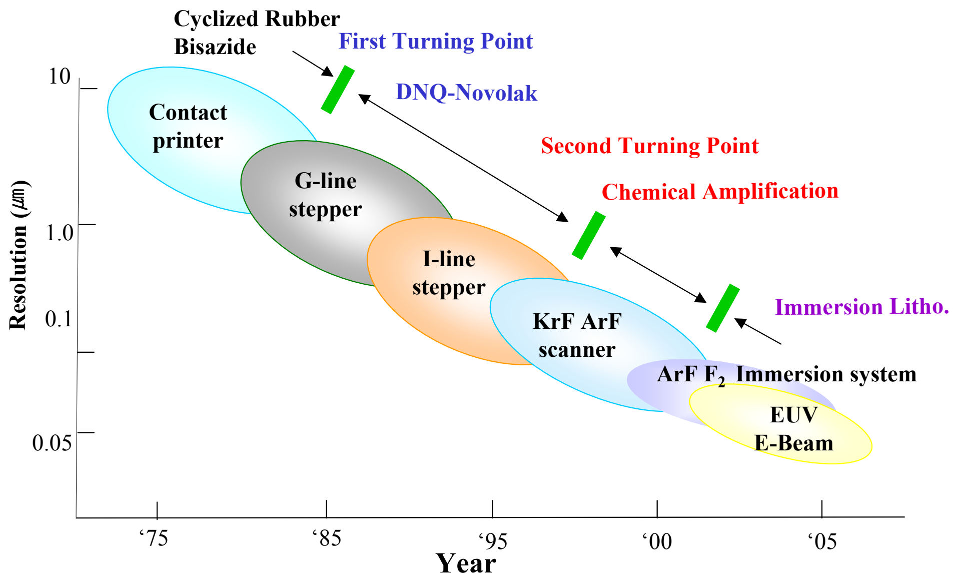
Development trend of lithography and resist



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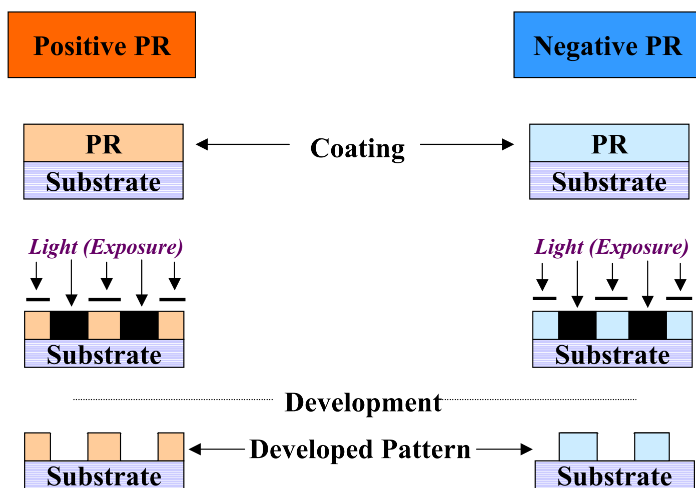
Positive & Negative photoresist



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General Components

i-line Photoresist	DUV Photoresit (KrF)
Novolak Resin	Protected Poly-vinyl-Phenol Resin
PAC (Photo Active compound)	PAG (Photo Acid Generator)
Additive	Quencher
	Additive
Solvent	Solvent

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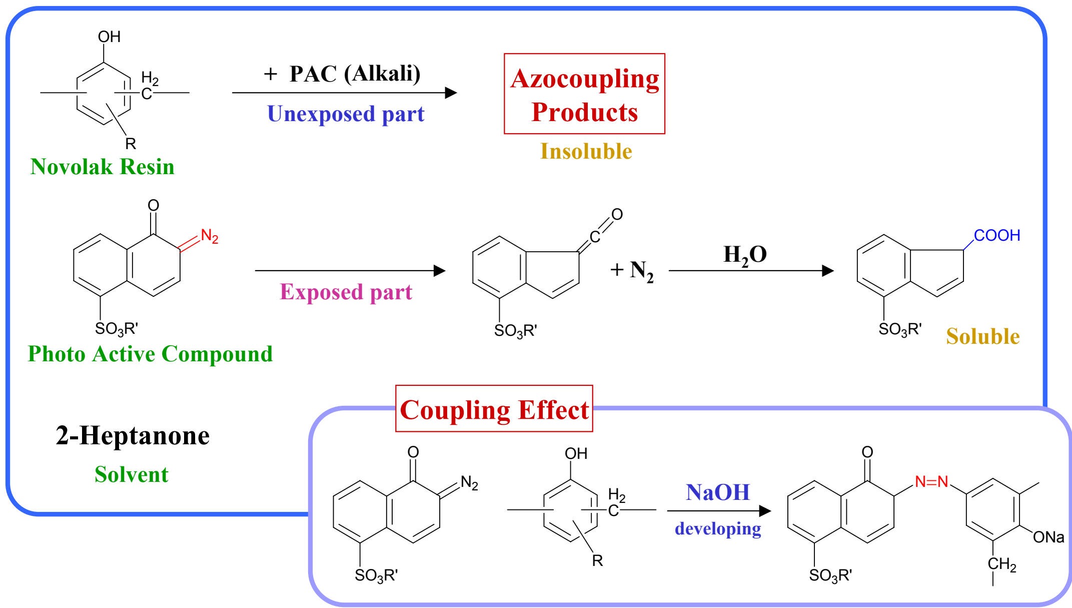
i-line Positive Photoresist Composition



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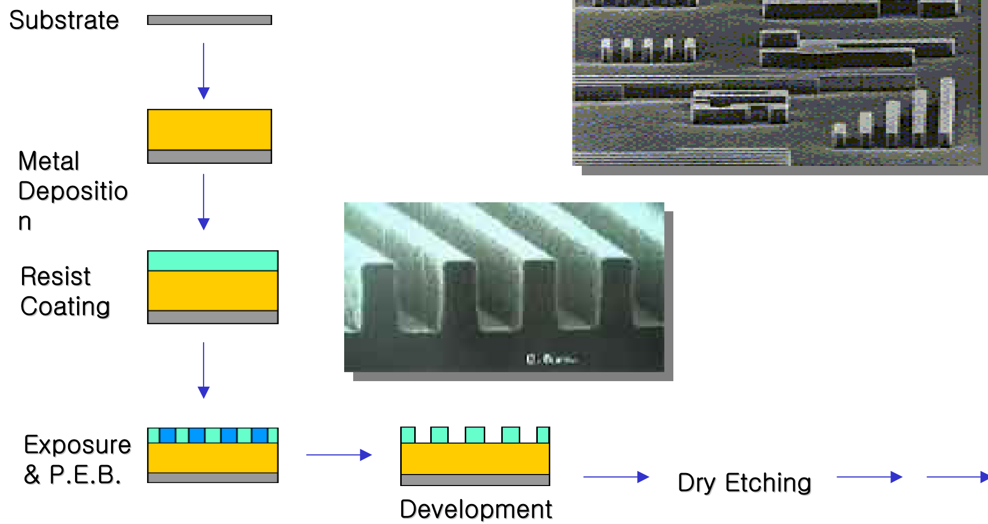
PHOTORESIST (PR)



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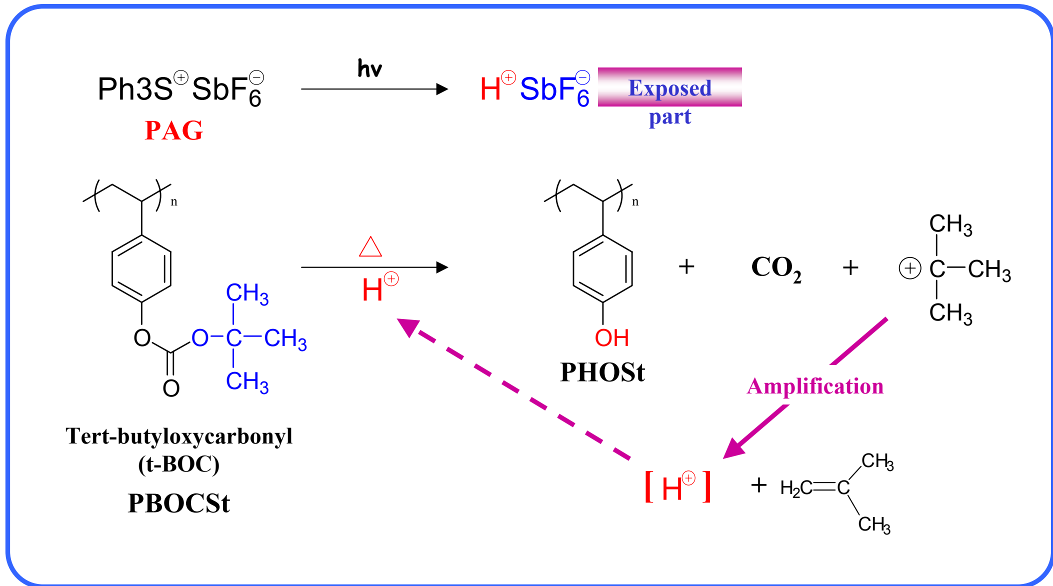
Chemical amplification concept



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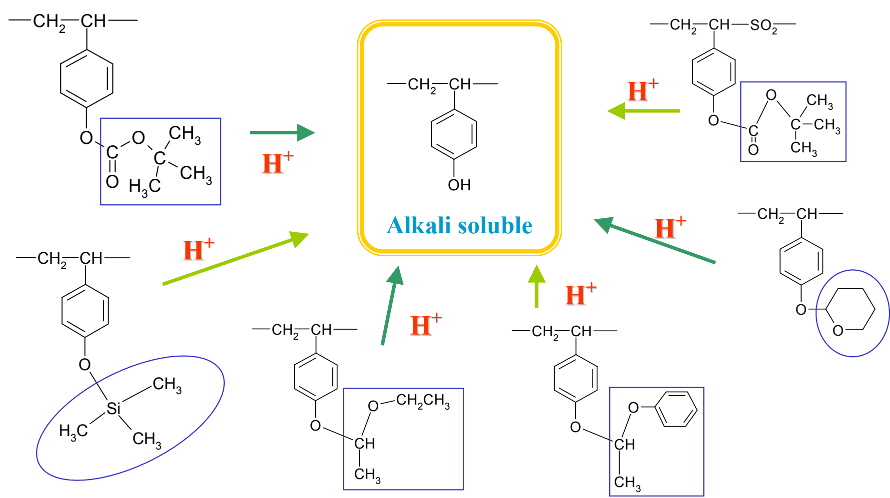
Various mechanism in chemical amplified resists



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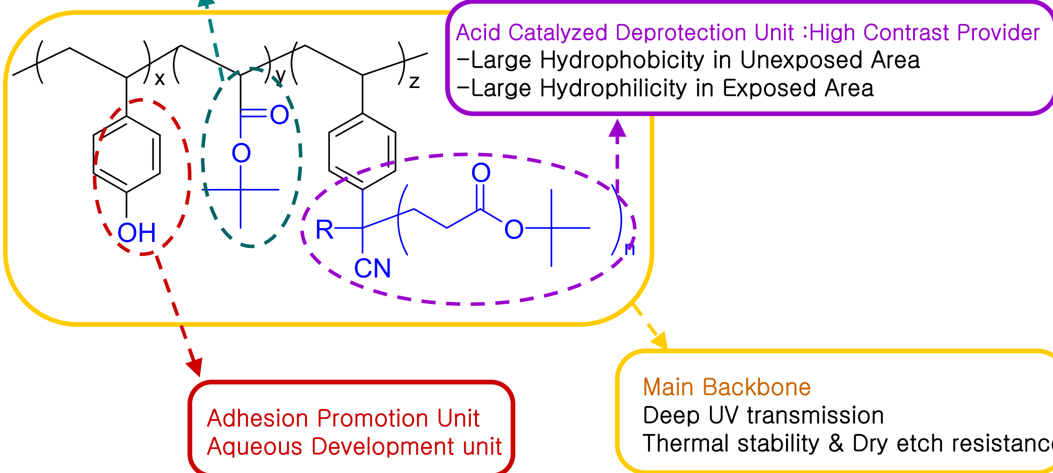
KrF Resin Structure Design



Adhesion Promotion Unit
Aqueous Development unit

Main Backbone
Deep UV transmission
Thermal stability & Dry etch resistance

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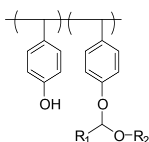
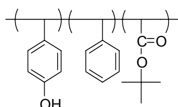
Typical KrF resist (248nm)



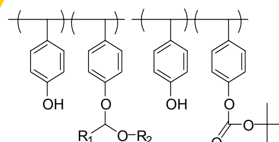
Acetal

- Low Activation Energy
- Good Resolution
- Good CD-Bias
- Low PEB Sensitivity
- Line Edge Roughness
- Out Gassing



Annealing

- High Activation Energy
- Themally Stable
- Less LER
- Good Etch Performance
- Relatively Low Margin
- High PEB Sensitivity



Hybrid

- Good Etch Performance
- High Resolution
- Environmental Stability
- Wide Process Margin
- Polymer synthesis

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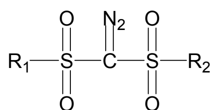
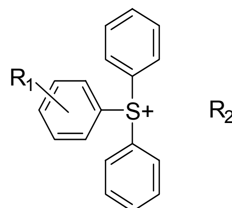
Selection of Diazo PAG & Onium PAG



Diazo Type

Better resolution and DoF
Higher transparency



Onium Type

Higher sensitivity
Thermally Stable
Lower transparency

Combination of two PAGs.

High resolution with high photospeed

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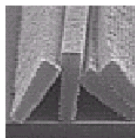
Resist의 개발

레지스트 설계 목표

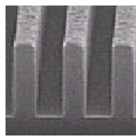
Pivotal Point control → DOF margin 확대

1. +Defocus (Thinning)
2. –Defocus （Scum） 、Pattern (Lifting)

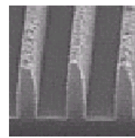
(**Resist의 공통 과제**)



− Defocus
Lifting



Best Defocus



+ Defocus
Thinning

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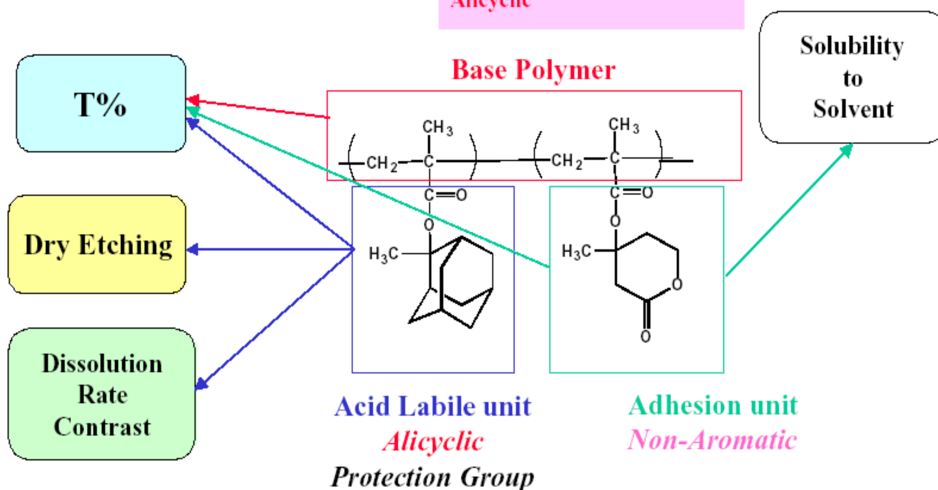
Design concept of Polymer



Example : **2MAdMA/ MLMA** by Fujitsu

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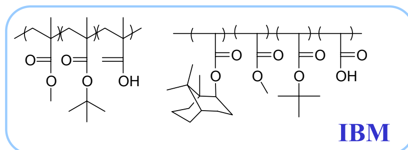
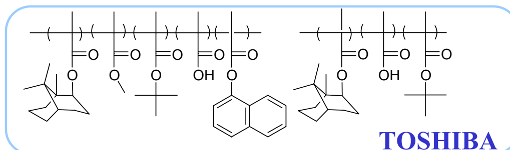
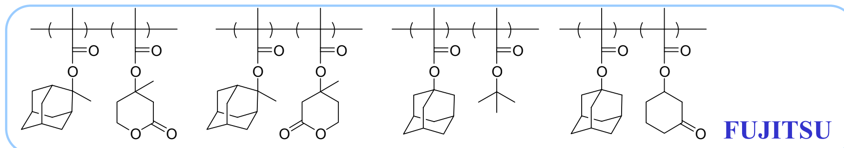
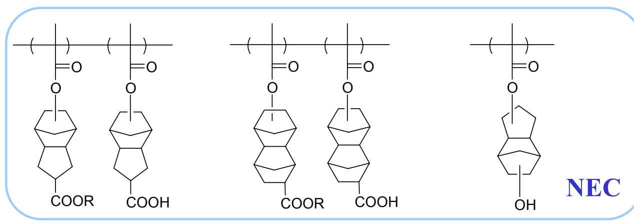
Matacrylate type ArF resist (193 nm)









IBM : Low Etch resistance
Poor adhesion
FUJITSU : High etch resistance
High Resolution
Conventional developer
NEC : High etch resistance
Poor adhesion
Special developer

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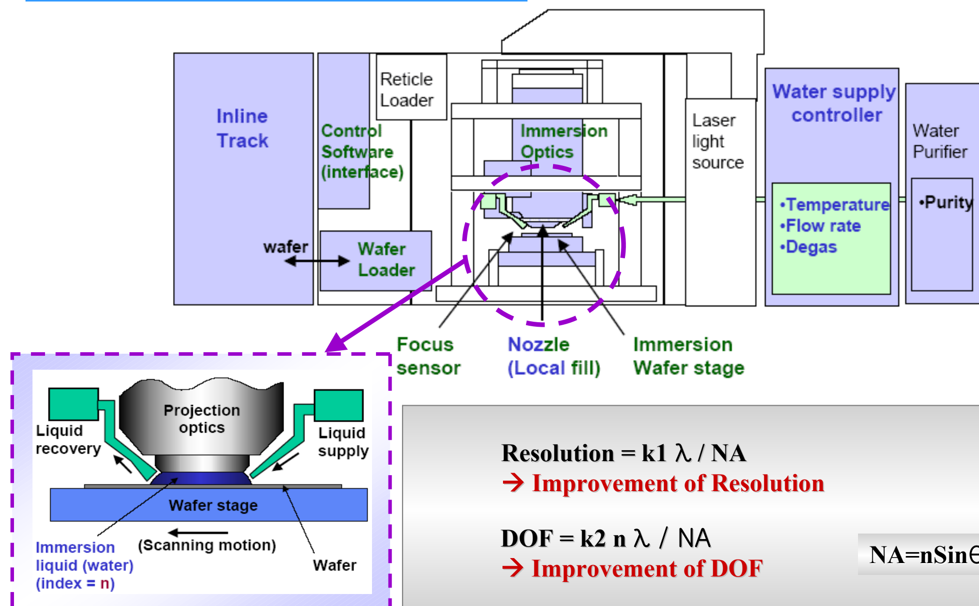
Immersion Scanner (193nm)



Reference : Nikon, Tokyo Electron

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Development of Top Coat

- Not dissolve resist film during coating.
  → Need appropriate solvent
- Not dissolved to water but dissolved to alkaline
- Higher hydrophobic surface of the film for speedy scanning
- Prevent PAG and quencher from dissolving to water
- Optical characteristics : appropriate optical constant n should be 1.333 (n of water)

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Issue to Realize Immersion Lithography

- **Existing ArF scanner is not compatible with immersion lithograph.**
  → Excess capital investment in new Fab.

- **Requirement of material development for new resin system**
- **Adjustment PR transparency for different wavelength (134nm)**

Solution : Development of new ArF resist

- **Scanner lens contamination by dissolved photoresist component**
- **Immersion water attack photoresist top surface.**

Solution : Top coat

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