DUV Anti-Reflective Coatings

Brewer Science, Inc.

Brewer Science DUV ARC® Family Overview

DUV30
- First spin bowl compatible DUV ARC®
- Thermally crosslinked on the substrate
- Reflectivity less than 1% at first minima
- Planarizing ARC® material
- Compatible with t-BOC and ESCAP DUV Photoresists

DUV30J
- Spin bowl compatible DUV ARC®
- Extended shelf-life
- Thermally crosslinked on the substrate
- Reflectivity less than 1% at first minima
- Planarizing ARC® material
- Compatible with t-BOC and ESCAP DUV Photoresists

DUV32
- Spin bowl compatible
- Reflectivity less than 1% at first minima
- Thermally crosslinked on the substrate
- Planarizing ARC® material
- Compatible with Acetal DUV Photoresists

DUV42
- Spin bowl compatible
- Thermally crosslinked on the substrate
- Reflectivity less than 1% at first minima
- Faster etch rate
- Conformal ARC® material
- Compatible with t-BOC and ESCAP DUV Photoresists

DUV42P
- Spin bowl compatible
- Thermally crosslinked on the substrate
- Reflectivity less than 1% at first minima
- Faster etch rate
- Conformal ARC® material
- Compatible with t-BOC and ESCAP DUV Photoresists

DUV44
- Spin bowl compatible
- Thermally crosslinked on the substrate
- Reflectivity less than 1% at first minima
- Faster etch rate
- Conformal ARC® material
- Compatible with Acetal Photoresists

Brewer Science DUV ARC Basic Properties

– Optical Characteristics @248nm:	DUV30/30J: n = 1.53-1.54 *k* = 0.57 -0.59
	DUV32: n = 1.59-1.60 *k* = 0.55 -0.56
	DUV42/42P: n = 1.47-1.48 *k* = 0.41-0.42
	DUV44: n = 1.47-1.48 *k* = 0.41-0.42
– 0.15µm Resist Compatibility:	Most DUV Resist
– ≤ 0.15µm Resist Compatibility:	Many Recent DUV Resist
– Oxygen Etch Rate:	DUV30/30J/32: 1.25x vs CD11
	DUV42/42P/44: 1.80x vs CD11
– EBR Compatibility:	All Photoresist EBR Solvents
– Photoresist Spin Bowl Compatibility:	All DUV Photoresist
– ARC® Type:	DUV30/30J/32: Planarizing
	DUV42/42P/44: Conformal

General Crosslinking Reaction of Brewer DUV ARC

Multi-functional Crosslinker

+

Heat

Catalyst

Chromophore Grafted Polymer

Chromophore

Crosslinking Site

Polymer Backbone

Crosslinking Attachment

Crosslinked ARC

DUV Photoresist/ARC General Compatibilities

(0.18µm)

Resist Type	Planar BARC		Conformal BARC	
	DUV30/30J	DUV32	DUV42/42P	DUV44
t-BOC	Good	Footing	Good	Footing
ESCAP	Good	Footing	Good	Footing
Acetal	Undercut	Good	Undercut	Good

DUV ARC Reflectivity Comparison on Silicon

Reflectivity (1=100%)

0.20
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00

0.0 25.0 50.0 75.0 100.0 125.0 150.0 175.0 200.0

ARC®Thickness (nm)

CD11
DUV30
DUV42

DUV ARC Spin-Bowl Compatibility

Solvents Tested: PGME
Ethyl Lactate
2-Heptanone
γ - Butyrolactone
RER-500 (EL/MEK)
Cyclohexanone
PGMEA

Testing: Alternating coats of BARC and APEX allowed to air dry on polyethylene strip. Above solvents dissolve film in 30 seconds with no residue or solids precipitated in solvent.

*Products: DUV 30, DUV30J, DUV32, DUV42, DUV42P, DUV44

DUV30/30J/32 Basic Processing Conditions

Typical Process Conditions

Spin Speed	3000 RPM/45 sec.
Cure for UV Series	180°C/45 sec.
Cure for Other Resist	205°C/60 sec.

Notes: No pre-bake may be required on hotplates with proximity baking.

Cure temperature and time must be optimized for individual resist systems.

DUV30/30J Spin Speed Curve

Hotplate Bake: 205°C/60 sec.

DUV30/30J-6
DUV30/30J-8
DUV30/30J-11

ARC®Thickness (Å)

2500
2000
1500
1000
500
0

1000 1500 2000 2500 3000 3500 4000 4500 5000

Spin Speed (RPM)

DUV32 Spin Speed Curve

ARC®Thickness (Å)

2500
2000
1500
1000
500
0

1000 1500 2000 2500 3000 3500 4000 4500 5000

Spin Speed (RPM)

Hotplate Bake: 205°C/60 sec.

DUV32-6
DUV32-8
DUV32-11

DUV42/42P Spin Speed Curve

DUV42/42P-6
DUV42/42P-8
DUV42/42P-11

Hotplate Bake: 205°C/60 sec.

ARC Thickness (Å)

2500
2000
1500
1000
500
0

1000 1500 2000 2500 3000 3500 4000 4500 5000

Spin Speed (RPM)

DUV44 Spin Speed Curve

ARC Thickness (Å) vs. Spin Speed (RPM)

Hotplate Bake: 205°C/60 sec.

Legend: DUV44-6, DUV44-7, DUV44-8

Y-axis: 0, 500, 1000, 1500, 2000, 2500

X-axis: 1000, 1500, 2000, 2500, 3000, 3500, 4000, 4500, 5000

DUV30/30J Reflectivity vs. Substrate Type

Silicon
Aluminum
Copper
Tungsten
GaAs

Reflectivity (1 = 100%)

0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50

0.0 25.0 50.0 75.0 100.0 125.0 150.0 175.0 200.0

ARC® Thickness (nm)

DUV32 Reflectivity vs. Substrate Type

Reflectivity (1 = 100%)

0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00

0.0 25.0 50.0 75.0 100.0 125.0 150.0 175.0 200.0

ARC® Thickness (nm)

Silicon
Aluminum
Copper
Tungsten
GaAs

DUV42/42P/44 Reflectivity vs. Substrate Type

0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00

0.0 25.0 50.0 75.0 100.0 125.0 150.0 175.0 200.0

ARC® Thickness (nm)

Silicon
Aluminum
Copper
Tungsten
GaAs

Reflectivity Technology of CD11 vs DUV30

Reflectivity (1=100%)

0.25	
0.2	
0.15	
0.1	
0.05	
0	

0 20 40 60 80 100 120 140 160 180 200

ARC® Thickness (nm)

- CD11/Silicon
- CD11/Aliminum
- DUV30/Silicon
- DUV30Aluminum

Reflectivity Technology of CD11 vs DUV42

Reflectivity (1=100%)

0.25	
0.2	
0.15	
0.1	
0.05	
0	

0 20 40 60 80 100 120 140 160 180 200

ARC® Thickness (nm)

CD11/Silicon
CD11/Aliminum
DUV42/Silicon
DUV42/Aluminum

DUV30/30J Optical Properties

Wavelength (nm)	n	k
248	1.5451	0.5787
260	1.8821	0.7596
270	2.1935	0.2817
280	2.0337	0.0746
290	1.9219	0.0292
300	1.8414	0.0183
310	1.7951	0.0205
320	1.7616	0.0265
330	1.7332	0.0385
340	1.7254	0.0455
350	1.7021	0.0744
360	1.7039	0.0737
370	1.7299	0.1057
380	1.7325	0.0783
390	1.7632	0.0923
400	1.7756	0.0430
420	1.7343	0.0073
440	1.7123	0.0022
460	1.6970	0.0000
480	1.6844	0.0000
500	1.6763	0.0000
550	1.6619	0.0000
600	1.6536	0.0000
633.8	1.6488	0.0002
650	1.6473	0.0004

CauchyParameters

$n = 1.6166 + (4.43E\text{-}03/\lambda^2) + (2.20E\text{-}03/\lambda^4)$
where λ = wavelength in microns

For thickness measurements, using the Cauchy parameters, the wavelength should be greater than 450nm.

DUV32 Optical Properties

Wavelength (nm)	n	k
248	1.6004	0.5642
260	1.9082	0.7410
270	2.3138	0.3242
280	2.0584	0.0703
290	1.9421	0.0268
300	1.8635	0.0155
310	1.8153	0.0152
320	1.7784	0.0206
330	1.7472	0.0327
340	1.7315	0.0399
350	1.7151	0.0677
360	1.7162	0.0664
370	1.7426	0.0962
380	1.7417	0.0712
390	1.7727	0.0826
400	1.7821	0.0346
420	1.7395	0.0000
440	1.7121	0.0000
460	1.6995	0.0000
480	1.6865	0.0000
500	1.6781	0.0000
550	1.6636	0.0000
600	1.6540	0.0000
633.8	1.6497	0.0000
650	1.6476	0.0000

CauchyParameters

$n = 1.6104 + (8.85E\text{-}03/\lambda^2) + (1.76E\text{-}03/\lambda^4)$
where λ = wavelength in microns

For thickness measurements, using the Cauchy parameters, the wavelength should be greater than 450nm.

DUV42/42P Optical Properties

Wavelength (nm)	n	k
248	1.4902	0.4171
260	1.7405	0.3694
270	1.9919	0.1198
280	1.8198	0.0226
290	1.7461	0.0036
300	1.6975	0.0044
310	1.6692	0.0078
320	1.6475	0.0132
330	1.6295	0.0236
340	1.6194	0.0292
350	1.6184	0.0480
360	1.6117	0.0576
370	1.6382	0.0648
380	1.6363	0.497
390	1.6618	0.0528
400	1.6609	0.0206
420	1.6332	0.0012
440	1.6186	0.0000
460	1.6085	0.0000
480	1.6004	0.0000
500	1.5948	0.0000
550	1.5854	0.0000
600	1.5801	0.0000
633.8	1.5766	0.0000
650	1.5753	0.0000

CauchyParameters

$n = 1.5527 + (5.66E\text{-}03/\lambda^2) + (1.24E\text{-}03/\lambda^4)$
where λ = wavelength in microns

For thickness measurements, using the Cauchy parameters, the wavelength should be greater than 450nm.

CDs for DUV30/30J/32 over Oxide

0.8µm APEX™ over BARC for oxide thickness' from 0 to 1000Å over polysilicon

CD (µm)

0.4
0.375
0.35
0.325
0.3
0.275
0.25
0.225
0.2
0.175
0.15
0.125
0.1
0.075
0.05
0.025
0

+10%

-10%

1200Å for ±10%

1600Å for ±5%

0 50 100 150 200

ARC Thickness (nm)

APEX™ Swing on DUV30/32 over Polysilicon

0Å DUV30
570Å DUV30
700Å DUV30
850Å DUV30
1000Å DUV30
1150Å DUV30
1300Å DUV30
1450Å DUV30
1600Å DUV30

Linewidth (0.25µm Nominal)

0.3
0.28
0.26
0.24
0.22
0.2
0.18

+5%
0.25µm
-5%

Optimum Thickness
0.625µm

Worst Case Thickness
0.625µm

Optimum Thickness
0.695µm

0.60 0.62 0.64 0.66 0.68 0.70 0.72 0.74 0.76

APEX™ Thickness (µm)

CD Variation with DUV30/30J/32 Thickness

0.665µm APEX
0.695µm APEX

Linewidth (0.25µm Nominal)

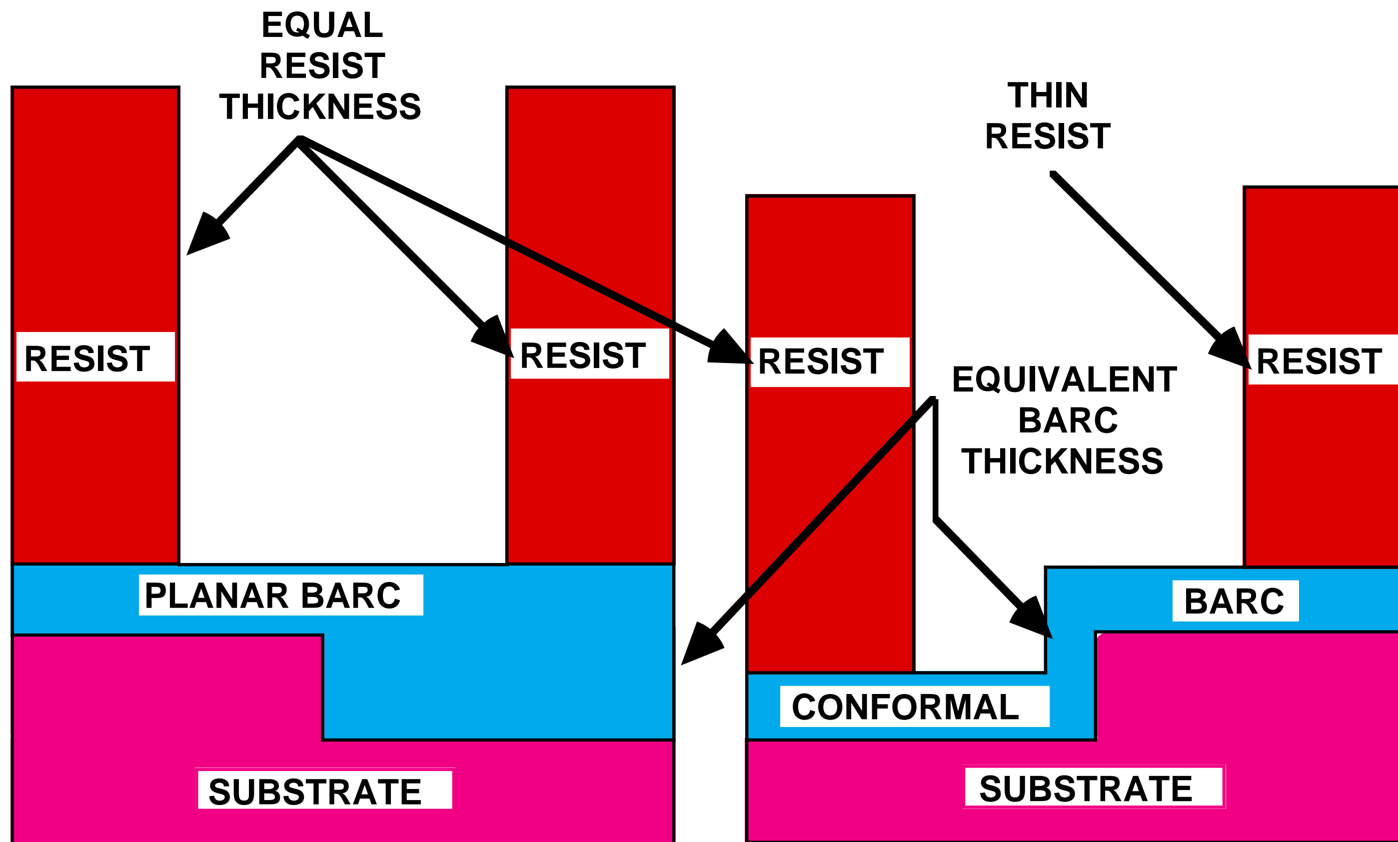
0.3
0.28
0.26
0.24
0.22
0.2
0.18

+5%
0.25µm
-5%

0 20 40 60 80 100 120 140 160 180 200

DUV30 Thickness (nm)

Planar vs Conformal BARC



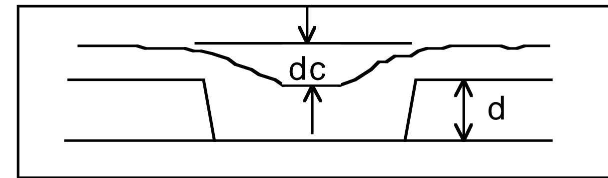
DUV30/30J/32 are planar BARCs

DUV42/42P/44 are conformal BARCs

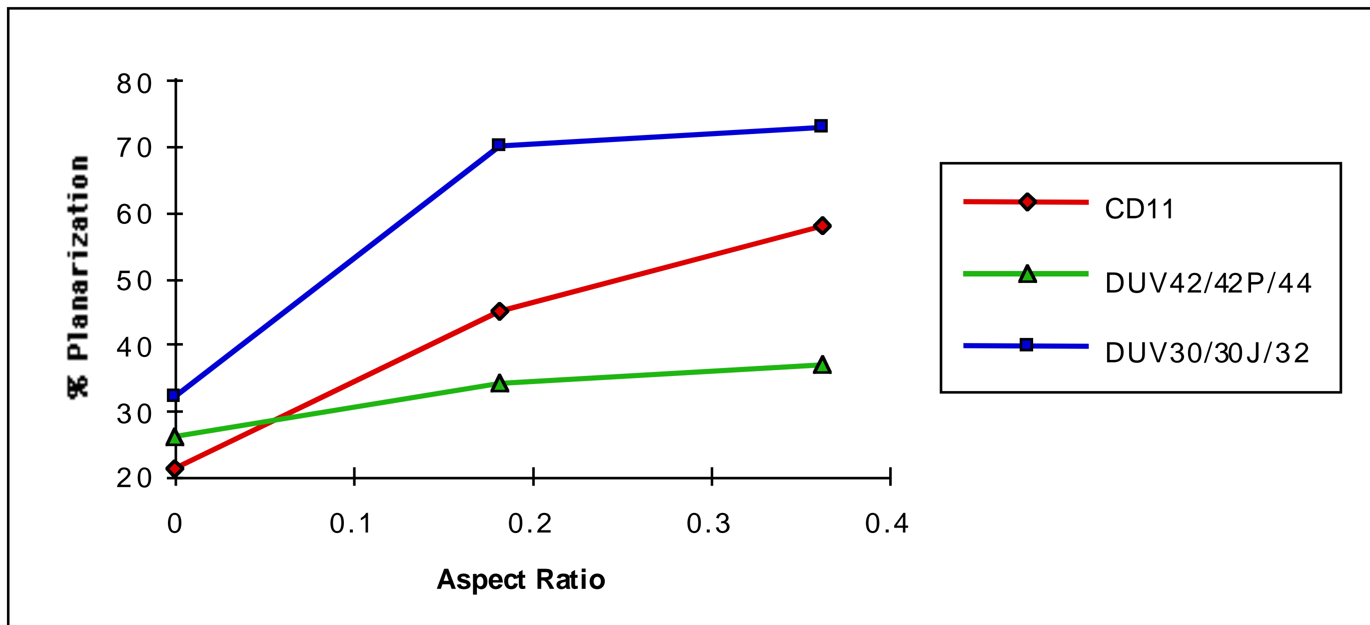
% Planarization for Brewer DUV BARCs

Space Width	Open	1µm	0.5µm
Aspect Ratio	0	0.182	0.364
CD11	21	45	58
DUV42/42P/44	26	34	37
DUV30/30J/32	32	70	73

Aspect Ratio = 0.182µm/ Space Width



% Planarization = (d-dc)*100/d



Conformal Properties

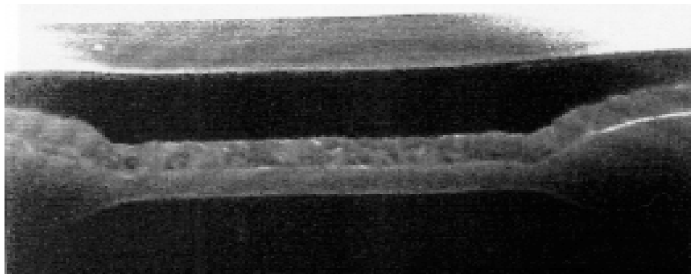
DUV30

520Å

DUV42

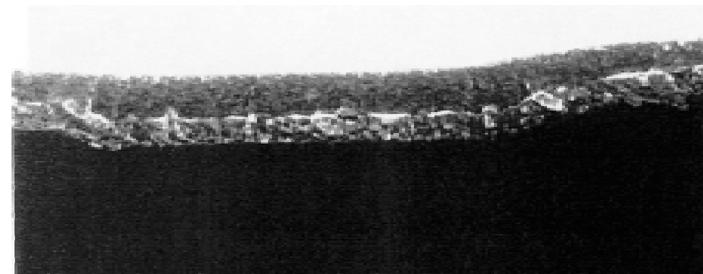
550Å

1320Å



BARC
TEOS
Field Oxide
Substrate

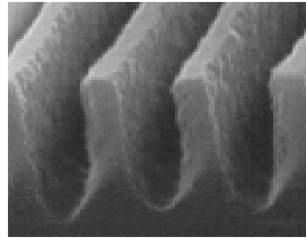
1320Å

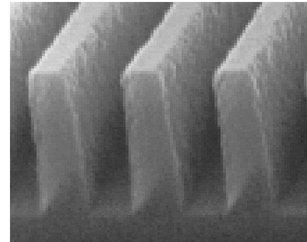


Step height 1600Å

0.25µm Lithography with UVIIHS™ on DUV30

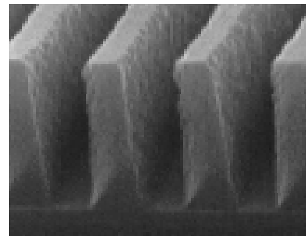
+0.6µ

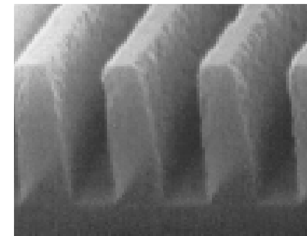




-0.2µ

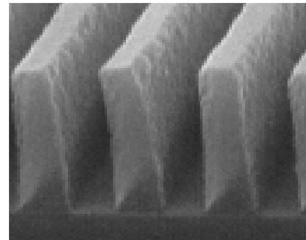
+0.4µ

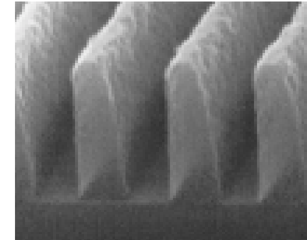




-0.4µ

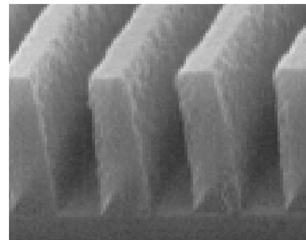
+0.2µ

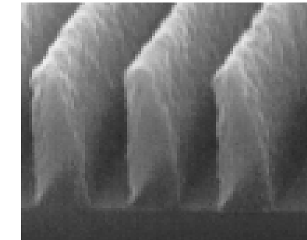




-0.6µ

0.0µ



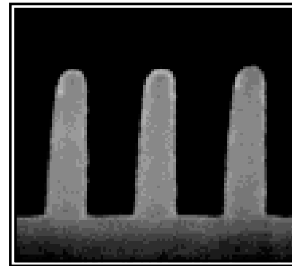


-0.8µ

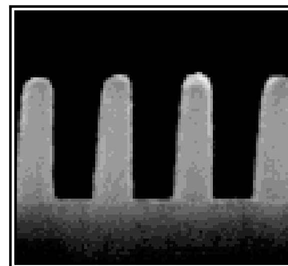
Sub 0.25μm Lithography with DUV30

ARCH3 on DUV30

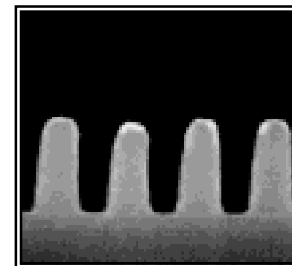
- SUB: 56 nm DUV30
- FT: 920 nm
- SB: 90 sec @130˚C)
- EXP: 34 mJ/cm^2 on /90
- PEB: 120 sec @110˚C
- DEV: OPD262 (60 sec. sp)



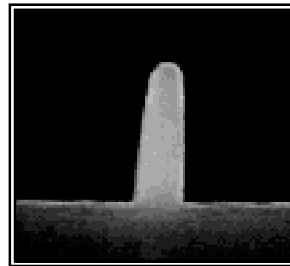
0.25 μm L/S



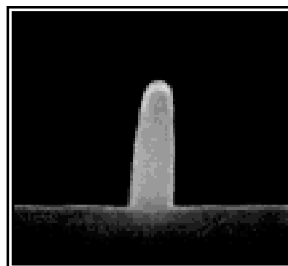
0.225 μm L/S



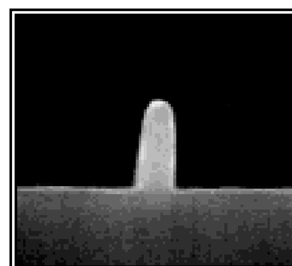
0.2 μm L/S



0.25 μm IL



0.225 μm IL



0.2 μm IL

TOK DP022 on DUV30

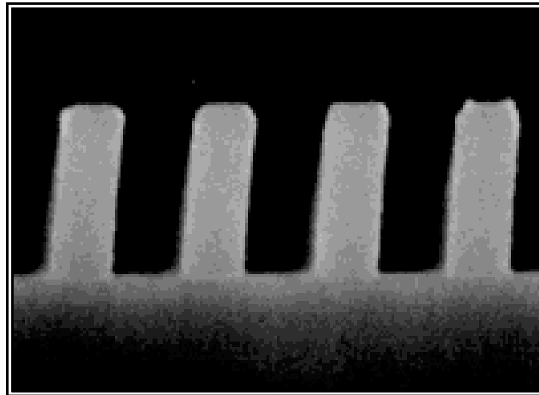
Courtesy of IMEC

ASML PAS 5500/300

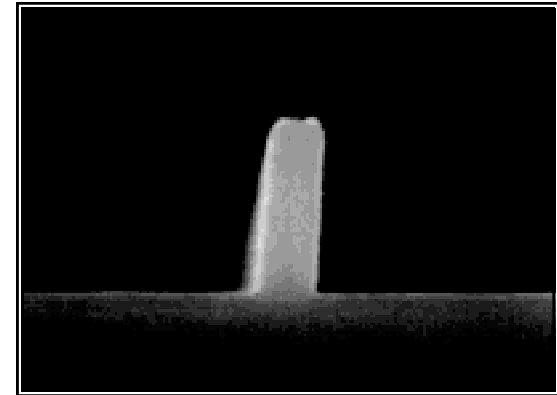
NA = 0.57, s = 0.75
24 mJ/cm2

Resist:
TOK DP022
(0.700 μm thickness)
on BARC: DUV30
(Brewer Science)

Profiles before BARC-etch

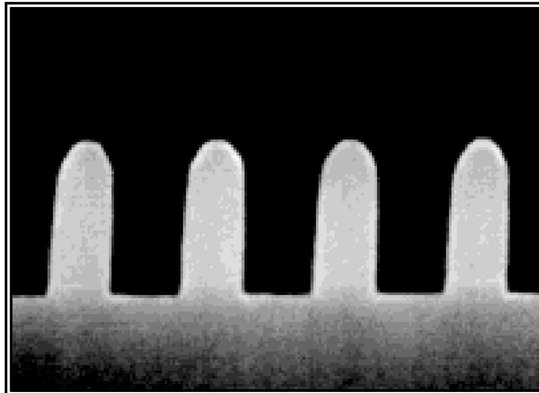


0.25 μm L/S

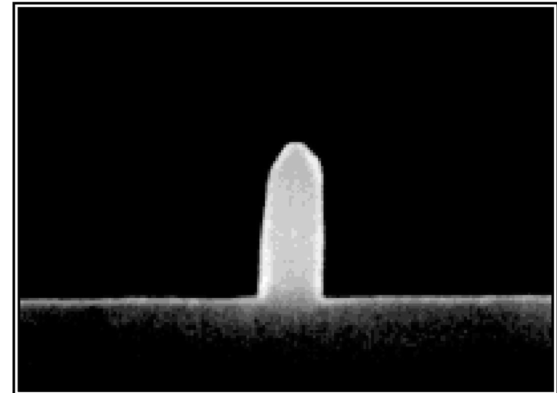


0.25 μm IL

Profiles after BARC etch



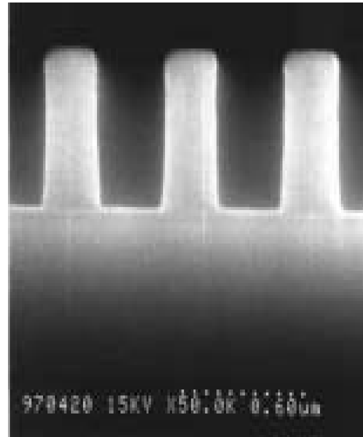
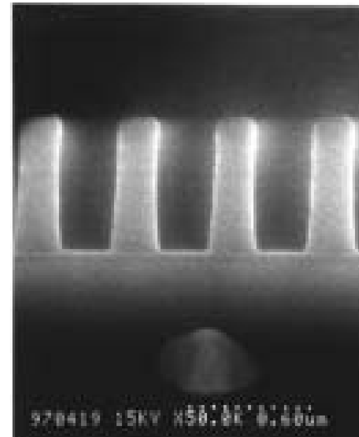
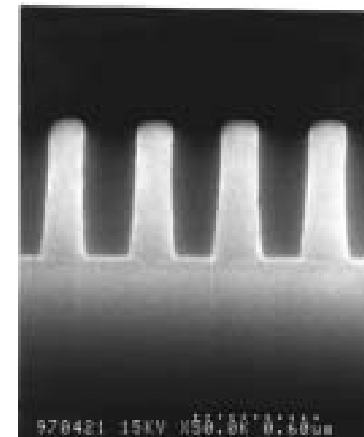
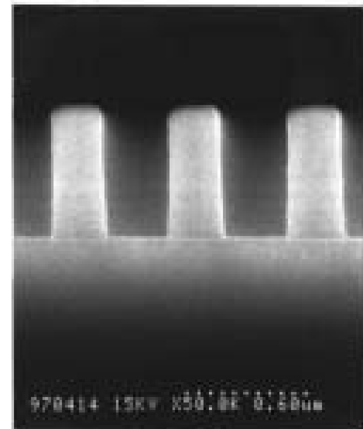
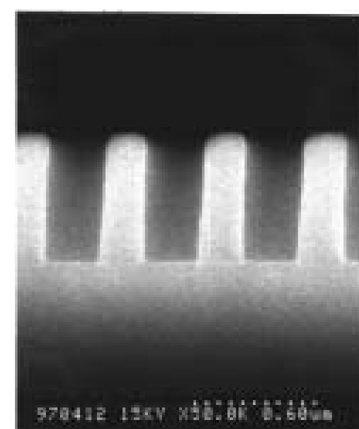
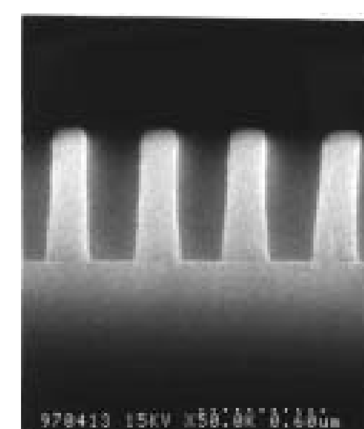
0.25 μm L/S



0.25 μm IL

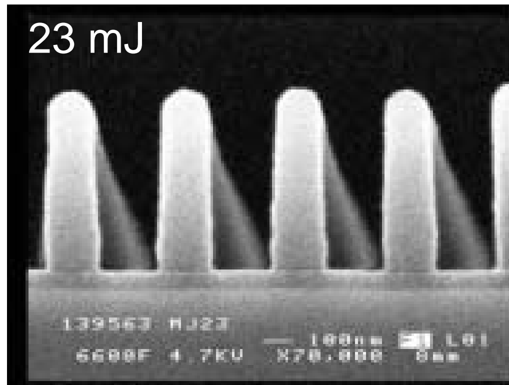
UV5™ on DUV30-6

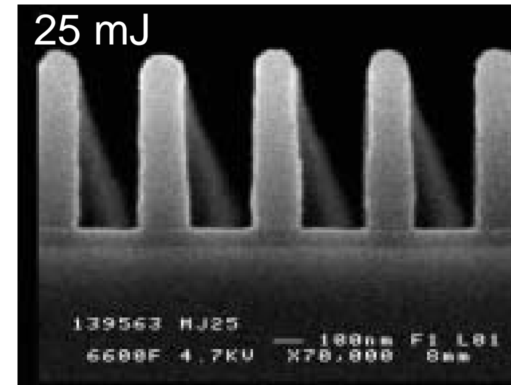
14mJ/cm2

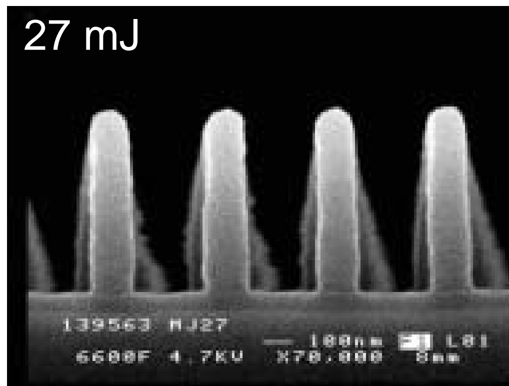
	0.30 µm l/s	0.25 µm l/s	0.22 µm l/s
Focus -0.6			
Focus -0.4			

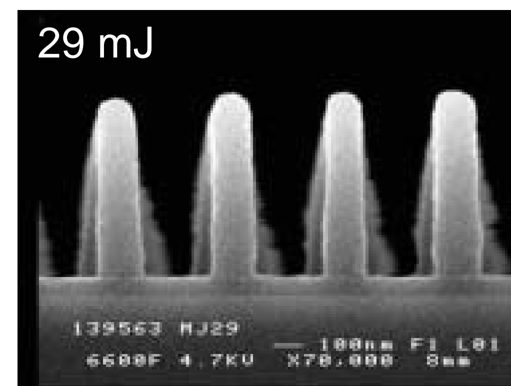
TOK DP024 on DUV32

0.2µm L/S



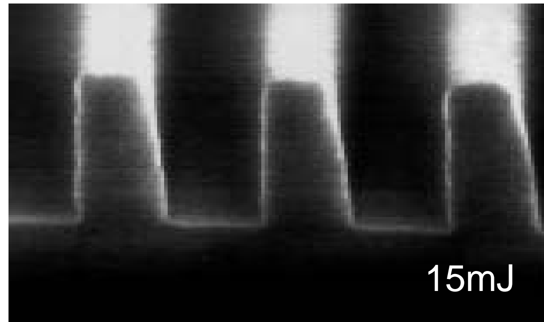




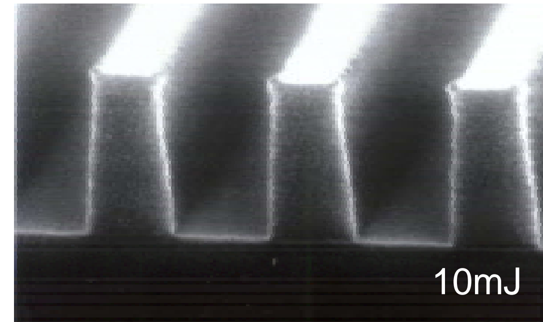


DUV42 Lithographic Performance (0.30µm L/S)

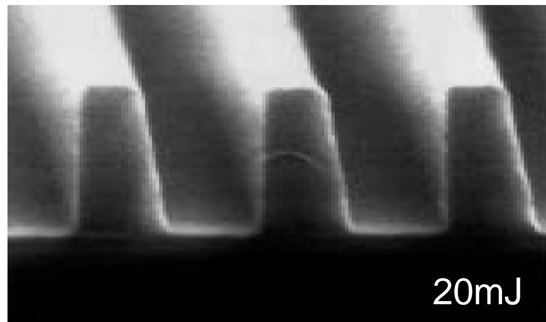
ARCH 212



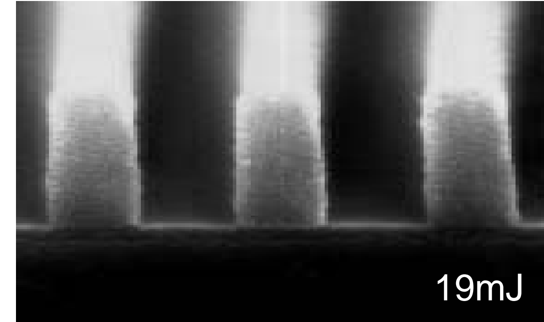
Olin 5600



TDUR P007



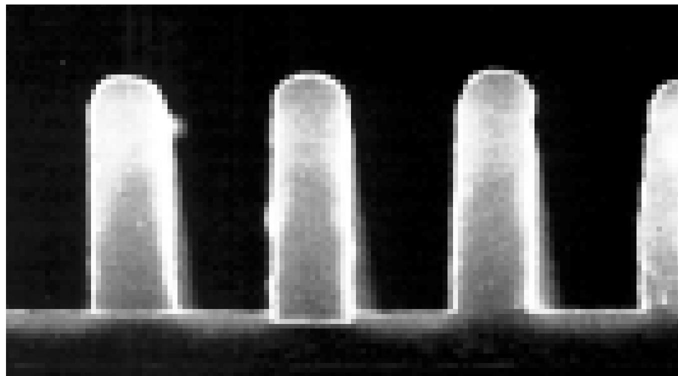
TDUR P009



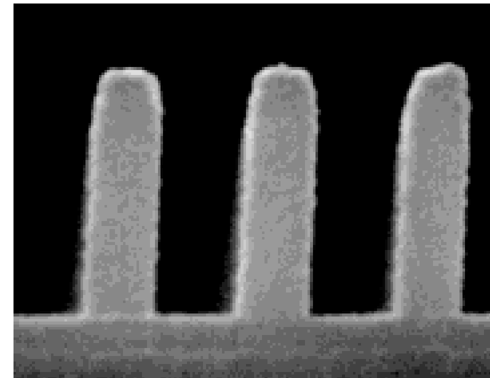
0.48 NA, Sigma 0.55, DUV42 Bake 205˚C.

DUV42 Lithographic Performance (0.20µm L/S)

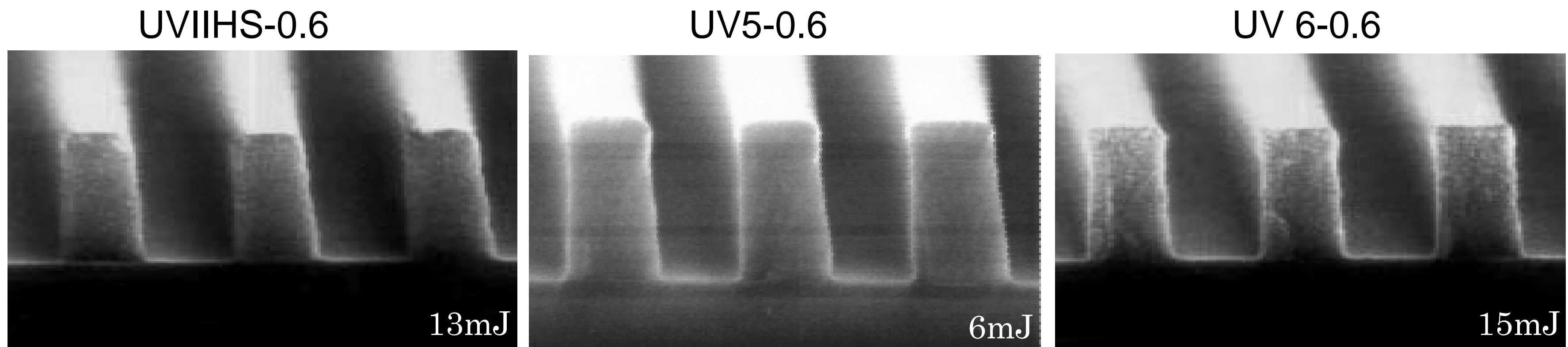
PEK-103



TDUR022

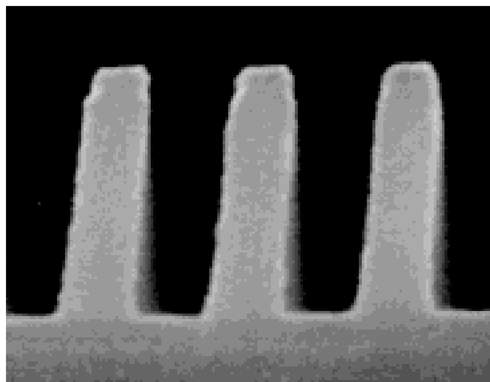


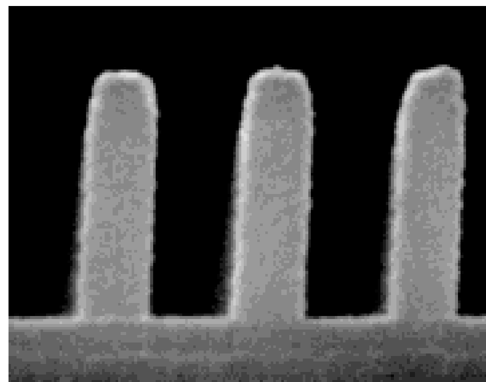
DUV42 Lithographic Performance (0.30µm L/S)

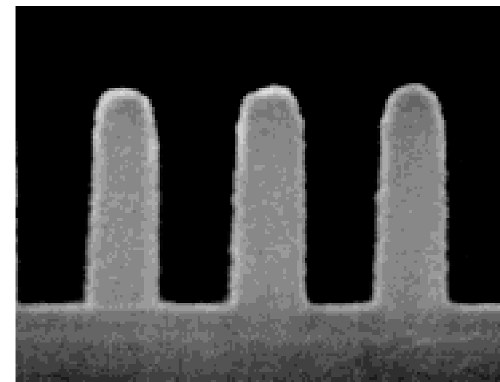


0.48 NA, Sigma 0.55, DUV42 Bake 205˚C.

DUV42 Focus Latitude (0.20μm L/S)


F = -0.3μm


F = 0μm

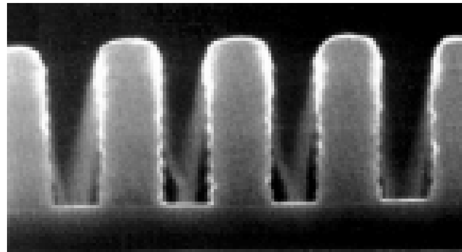

F = +0.3μm

BARC Thickness: 870Å DUV42 bake: 60s @ 205˚C
Resist: 0.72μm TOK TDUR022 @26mJ/cm^2
Exp : 0.57 NA/0.6 s Dev.: 60s sp OPD262

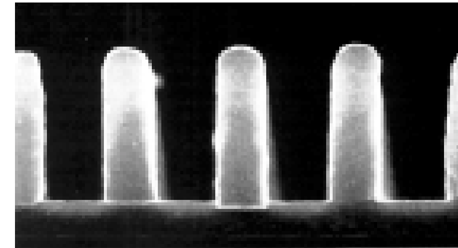
Courtesy of IMEC

DUV42 Etch Performance

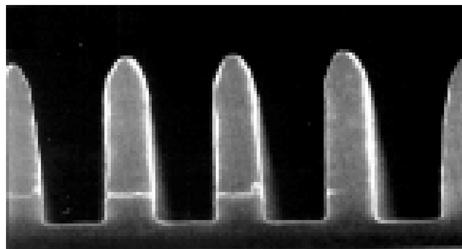
PEK-103 0.20µm L/S



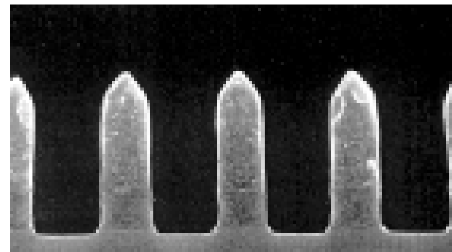
Resist on DUV42



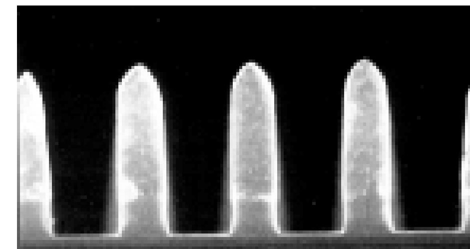
After He/O_2 etch.
ΔCD = 0.024µm.
Selectivity = 1.04



After Cl_2/O_2 etch.
ΔCD = 0.013µm.
Selectivity = 1.48



After HBr/O_2 etch.
ΔCD = 0.026µm.
Selectivity = 0.85



DUV42/42P/44 Etch Rate vs Other DUV Materials

Etch Rate (A/min)

6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0

Ar/CF4/CHF3
AR/CF4
He/CF4/O2

CD11 DUV30/30J/32 DUV42/42P/44 AR2 UVIIHS

Material Type

Effective Date: 0X/0X/02 DCIF: MKT00XX Doc. Control#: F.6.6.010X.A