SHIPLEY

AR2™ and AR3™ DUV ANTI-REFLECTANTS

AR2 and AR3 DUV Anti-Reflectants are organic, thermally cross-linking bottom anti-reflectants designed to provide outstanding reflection control under DUV photoresists for excellent CD control over topography. Relative to other organic anti-reflectants, AR2 and AR3 provide excellent conformality over topography.

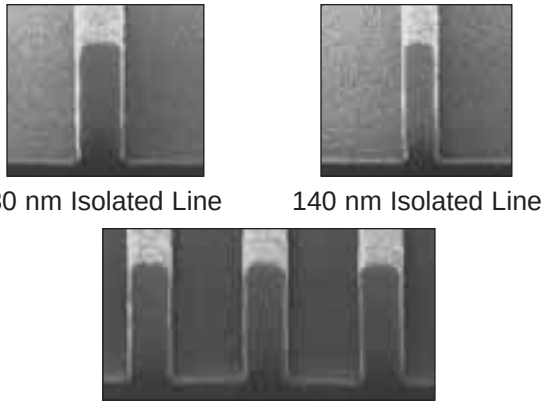
AR2 and AR3 have been formulated to work as a system with Shipley advanced DUV photoresists to meet sub-180 nm design rules. They also act as a chemical barrier between the photoresist and substrate, presenting a common substrate for all layers.

AR2 and AR3 are available in two dilutions. AR2-600 and AR3-600 are formulated for coatings in the range of 550–750Å over reflective substrates. AR2-900 and AR3-900 are fomulated for coatings in the range of 800–1,200Å over thick dielectrics.

Features:

- First minimum thickness at 600Å on Si
- High optical density at 248 nm
  - AR2 ≅ 9.0/µm
  - AR3 ≅ 9.6/µm
- E_0 swing curve ≤3%
- Excellent CD control over topography
- Wider process windows than planar silicon
- Steep sidewalls and excellent profiles with Shipley DUV photoresists
- Good conformality for excellent step coverage
- Compatibility with common spin-coating and EBR solvents
- Fast etching

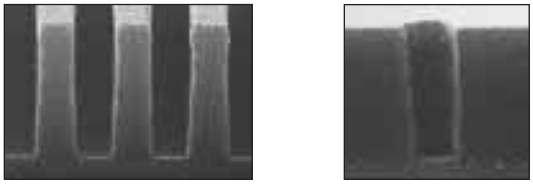
Figure 1. UV5 Lithographic Performance on AR2 (0.53 NA, 0.74σ)



180 nm Isolated Line | 140 nm Isolated Line

180 nm 1:2 Lines/Spaces

Figure 2. UV6 Lithographic Performance on AR2 (0.53 NA, 0.74σ)



180 nm 1:1 Lines/Spaces | 200 nm 1:1 Contact Holes

Equipment Preparation

When converting plumbing from BARL™ or CD-11™ to AR2 or AR3, first flush lines with cyclohexanone or gamma-butyrolactone solvent to thoroughly remove previous BARC residues. Next, flush lines again with propylene glycol methyl ether, AR2 or AR3 to provide a compatible solvent medium.

Substrate

AR2 and AR3 are compatible with a wide range of substrates, including silicon, SiO_2, polysilicon, Si_3N_4, TiN, and aluminum. Do not use adhesion promoters, such as hexamethyldisilazane (HMDS).

Coat

AR2 and AR3 are spin bowl compatible with common spin-coating and EBR solvents (see *Table 1*). Dedicated spin bowl and drain lines are not required.

Table 1. Compatible Solvents

Ethyl lactate	Methyl Ethyl Ketone
Propylene Glycol Methyl Ether	3-Pentanone
Propylene Glycol Methyl Ether Acetate	Cyclohexanone
60% PGME/40% PGMEA	γ-Butyrolactone
50% PGMEA/50% Methyl Ethyl Ketone	

Figure 3 shows the relation between spin speed and film thickness for 6-inch substrates. Nominal film thickness may vary slightly due to process, equipment, and ambient conditions.

Table 2. Kinematic Viscosity

AR2-600, AR3-600	2.5 cSt
AR2-900, AR3-900	2.9 cSt

Do not use adhesion promoters, such as HMDS, between anti-reflectants and resist layers.

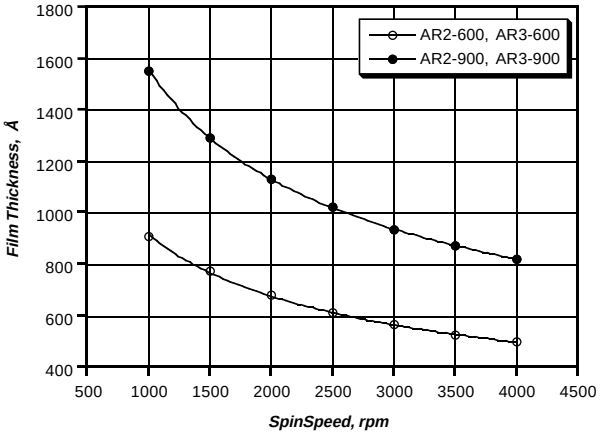
Table 3. Recommended Process Conditions

Film Thickness†:	600Å or 900Å
Cure*:	195-220°C/60 sec. Proximity Hotplate

†Optimum AR2/AR3 film thickness will depend on substrate reflectivity and topography, film transparency and thickness, and desired etch performance.

*Optimum cure temperature will depend upon resist type and equipment parameters.

Figure 3. AR2 and AR3 Spin Speed Curves



Cure

For Shipley resists, linewidth profile at the substrate interface can be controlled by AR2 or AR3 cure temperature. For positive resists, increasing cure temperature minimizes linewidth pinching; decreasing cure temperature minimizes footing. Cure effects on resist profiles are identical for AR2 and AR3. APEX-E and UVN2 profiles are minimally affected by ARC cure temperature.

Shipley has observed optimum performance with DUV Series Photoresists at AR2 and AR3 cure temperatures between 195°C and 220°C. Please contact your TSR for specific recommendations with your equipment and process. Actual results may vary with process, equipment, and ambient conditions such as hotplate proximity gap, resist type, relative humidity, etc.

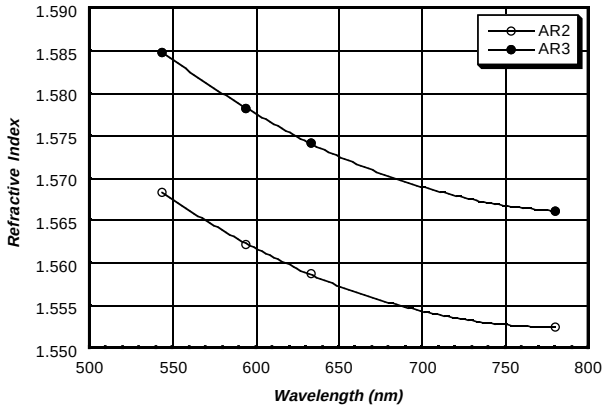
Film Thickness Measurement

Optical constants, n and k, at 248 nm appear in *Table 4*.

Table 4. Optical Constants at 248 nm		
	AR2	**AR3**
n	1.47	1.46
k	0.42	0.47

Figure 4 shows the refractive index of AR2 and AR3 as a function of wavelength.

Figure 4. Dispersion Curves, 205°C Cure



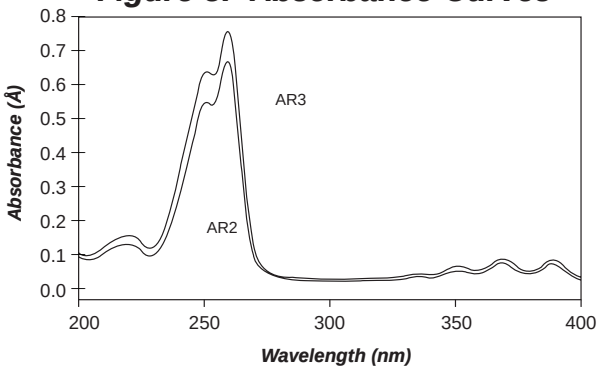
Cauchy coefficients for AR2 and AR3 are listed in *Table 5*.

Table 5. Cauchy Coefficients		
205°C Cure Temperature		
	AR2	**AR3**
n_1	1.548	1.556
n_2	-3.7e4	3.6e5
n_3	1.9e13	1.4e13

Reflection Control

AR2 and AR3 absorbance spectra appear in *Figure 5*. AR2 and AR3 films are transparent in the visible region.

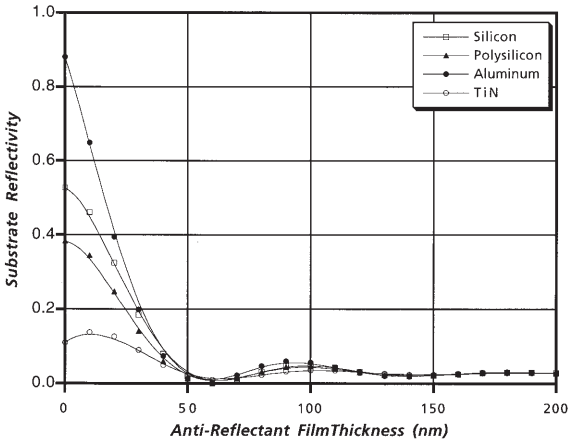
Figure 5. Absorbance Curves*



*600Å AR2 and AR3 Film Thicknesses

A plot of substrate reflectivity is shown in *Figure 6*. The plot was generated from Prolith/2™ for silicon, polysilicon, aluminum, and TiN.

Figure 6. AR2 and AR3 Reflectivity over Reflective Substrates



Contour plots of reflectivity over varying thicknesses of SiO_2 and Si_3N_4 (both over silicon) appear in *Figures 7* through *10*.

Figure 7. AR2 Reflectivity over SiO2 (on Si)

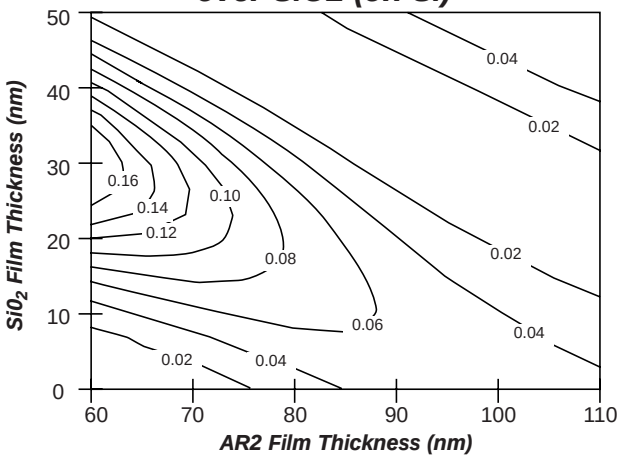


Figure 8. AR2 Reflectivity over Si_3N_4 (on Si)

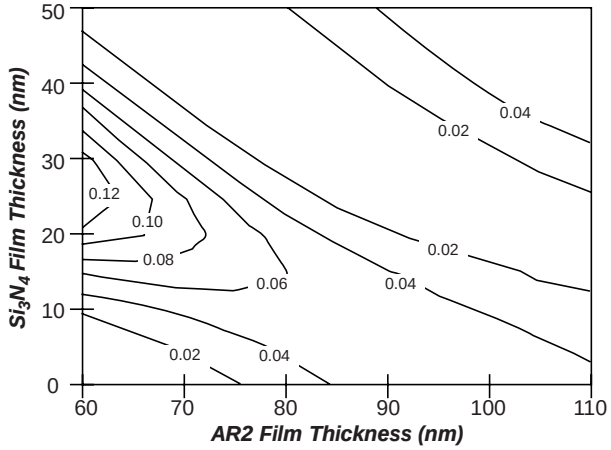


Figure 9. AR3 Reflectivity over SiO_2 (on Si)

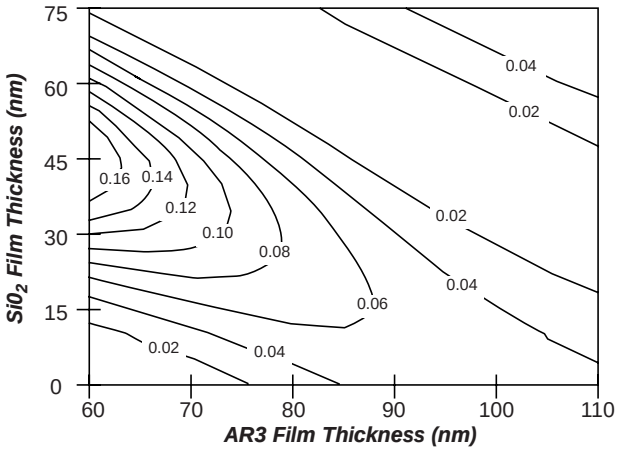
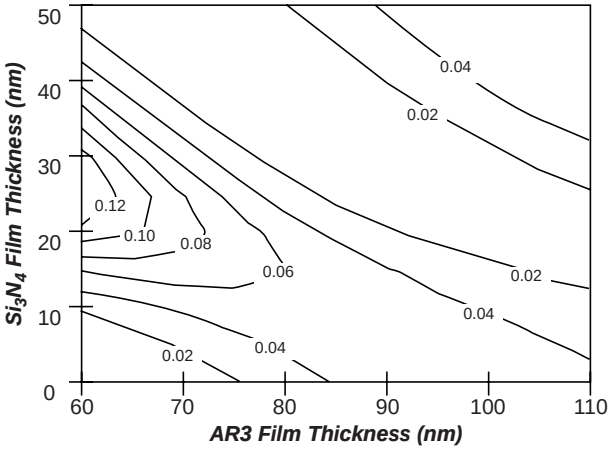


Figure 10. AR3 Reflectivity over Si3N4 (on Si)



Figures 11 and *12* display swing curves for UV6 over silicon, AR2-600, AR3-600, and BARL.

Figure 11. UV6 Interference Curves, Bulk E_0

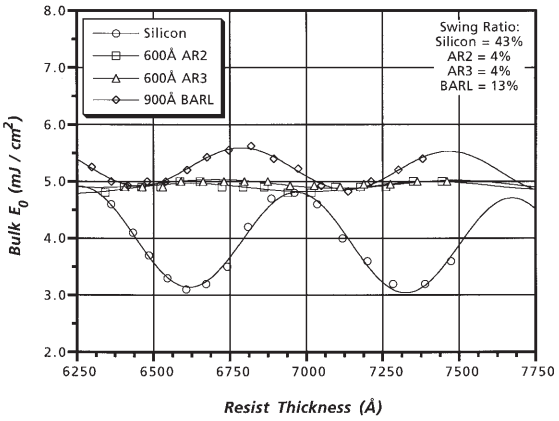
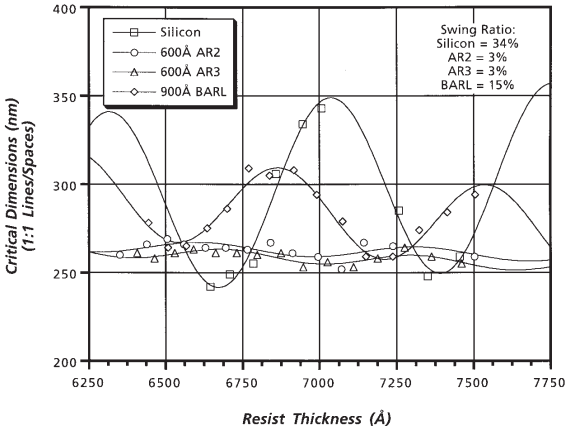
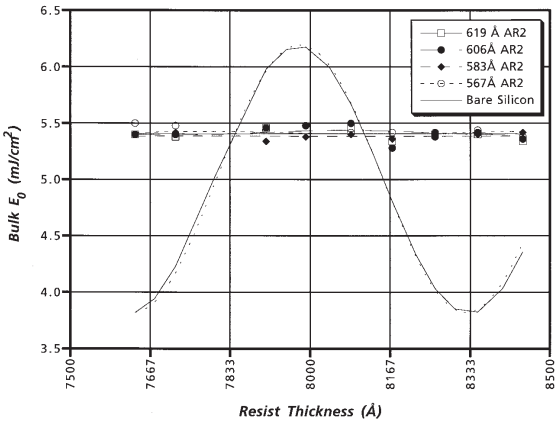


Figure 12. UV6 Interference Curves, 250 nm 1:1 Lines/Spaces CD



E_0 swing curves for UVIIHS on silicon and on varying AR2 film thicknesses are shown in *Figure 13*.

Figure 13. Swing Curves for UVIIHS on Silicon and Four Film Thicknesses of AR2-600



Etch

AR2 and AR3 exhibit excellent etch rates relative to BARL or CD-11. Relative etch rates for four RIE processes appear in *Figure 14*. Corresponding etch recipes appear in *Table 6.* Etch rates for AR3 typically will be 5–10% slower than AR2.

Figure 14. Etch Rates of AR2 and AR3 Relative to CD-11

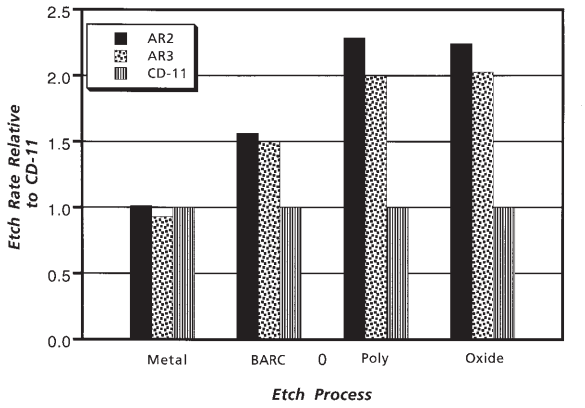


Table 6. Etch Recipes	
BARC Etch	**Applied 5000™ (Mark II™Oxide Etch Chamber)**
Pressure (mT)	25
Top Power (Watts)	600
CHF_3 (Sccm)	33
O_2 (Sccm)	7
Ar (Sccm)	80
Metal Etch	**LAM TCP 9600™**
Pressure (mT)	10
Top Power (Watts)	500
Bottom Power (Watts)	250
BCl_3 (Sccm)	50
Cl_2 (Sccm)	100
He	8
Oxide Etch	**LAM/Drytek ASIQ™**
Pressure (mT)	100
Top Power (Watts)	1300
C_2F_6 (Sccm)	15
CHF_3 (Sccm)	35
Poly Etch	**Applied 5000 (MXP™ Poly Etch Chamber)**
Pressure (mT)	150
Top Power (Watts)	500
Cl_2 (Sccm)	106
HBr (Sccm)	124

Removal

AR2 and AR3 can be removed with standard photoresist ashing processes and standard H_2SO_4/H_2O_2 type processes.

A plasma ash recipe for AR2 and AR3 appears in *Table 7.*

Table 7. GaSonics Aura 2000LL™ Downstream Plasma Strip Recipe*	
Base Pressure (T)	2.0
O2 Flow Rate (L/min.)	3.75
N2 Flow Rate (L/min.)	0.35
Step Time (sec.)	30
Low Lamp on Time (sec.)	30
High Lamp on Time (sec.)	18

*200 nm wafer size

Handling Precautions

WARNING! AR2 and AR3 are flammable liquids containing propylene glycol methyl ether. Keep liquid and vapor away from heat, sparks, and open flame. Irritation to eyes, nose and respiratory tract can occur. Do not get in eyes or on skin. Avoid breathing vapors. Use with adequate ventilation and avoid breathing vapors and mists. Wash thoroughly after handling and always wear chemical goggles, gloves, and suitable protective clothing. In case of eye or skin contact, flush affected areas with plenty of water for at least 15 minutes.

Consult Product Material Safety Data Sheet before using.

Waste Treatment

AR2 and AR3 contain propylene glycol monomethyl ether. They may be included with other wastes containing similar organic solvents to be discarded for destruction or reclaim in accordance with local, state, and federal regulations.

Storage

Store AR2 and AR3 in an upright, sealed original container in a dry area at 30–50°F away from heat and sunlight. Keep away from alkaline materials, acids, and oxidizers.

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