Sub-Resolution Assist Fea for Contact Windows Using

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ture Tolerances
193 nm Lithography

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Experiment

- Specially designed and fabricated a test mask which contains different contact window patterns with and without assist features.
- A thin 1800 A single-layer resist (K111030) used to evaluate the impact of assist features on aerial image.
- Bottom multi-layer inorganic anti-reflective layer on Si wafers used.
- Three illumination conditions used: conventional σ = 0.7, σ = 0.29, and quadrupole off-axis.

ISI 193nm Microstepper Specifications

Numerical Aperture: 0.4 - 0.6

Sigma: Max 1.0 @ 0.6 NA and off-axis illumination

Field size: 1.5 x 1.5mm (2.12 diameter)

Intensity: 250-450 mW/cm^2 (measured at wafer plane)

Lens transmission: ~12.25%

Alignment: Global only

Onboard metrology: auto focus calibration, global baseline

Reticle handling: auto load (10 reticle library)

Reticle stage: auto align of reticle to wafer stage

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160 nm Contact Window Designs and Configurations Studied

Contact Window Design Type	Pitch (nm)		Assist Slot Size (nm)		Assist Pitch (nm)	
	in X	in Y	in X	in Y	in X	in Y
Isolated	2500	2500	-	-	-	-
Isolated with Assists	2500	2500	120(160)	160(120)	320	320
Isolated with Assists	2500	2500	100(160)	160(100)	320	320
Isolated with Extended Assists	2500	2500	120(200)	200(120)	320	320
Semi-Dense	560	320	-	-	-	-
Semi-Dense with Assists	560	320	120	160	280	-
Dense	320	320	-	-	-	-

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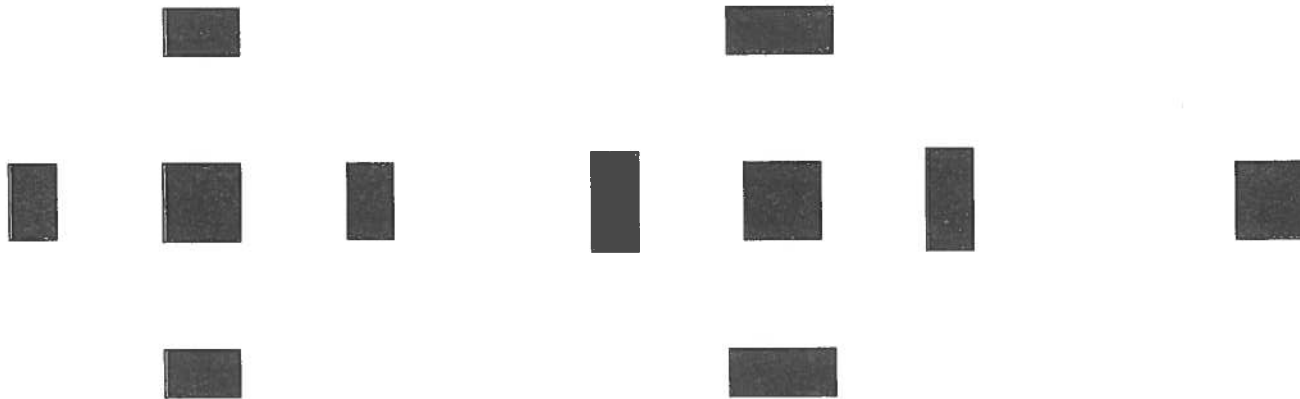
Different Designs of Isolated Contact Windows on the Mask



Isolated Contact Window with Sub-Resolution Assist Features

Isolated Contact Window with Extended Sub-Resolution Assist Features

Isolated Contact Window

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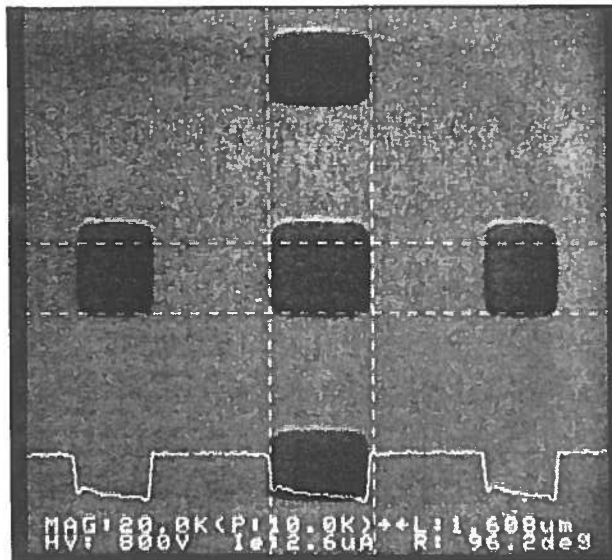
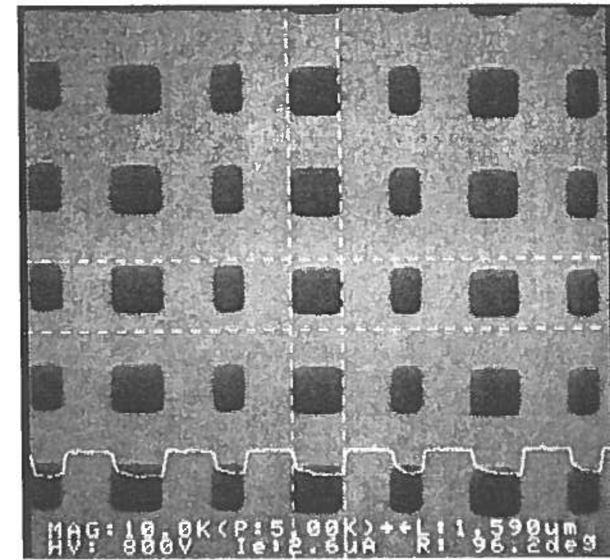
SEM Images of Contact Windows on the Mask



Isolated 160 nm Contact Window with 320/120/160 Assist Features



Semi-Dense 160 nm Contact Windows with 280/100/160 Assist Features

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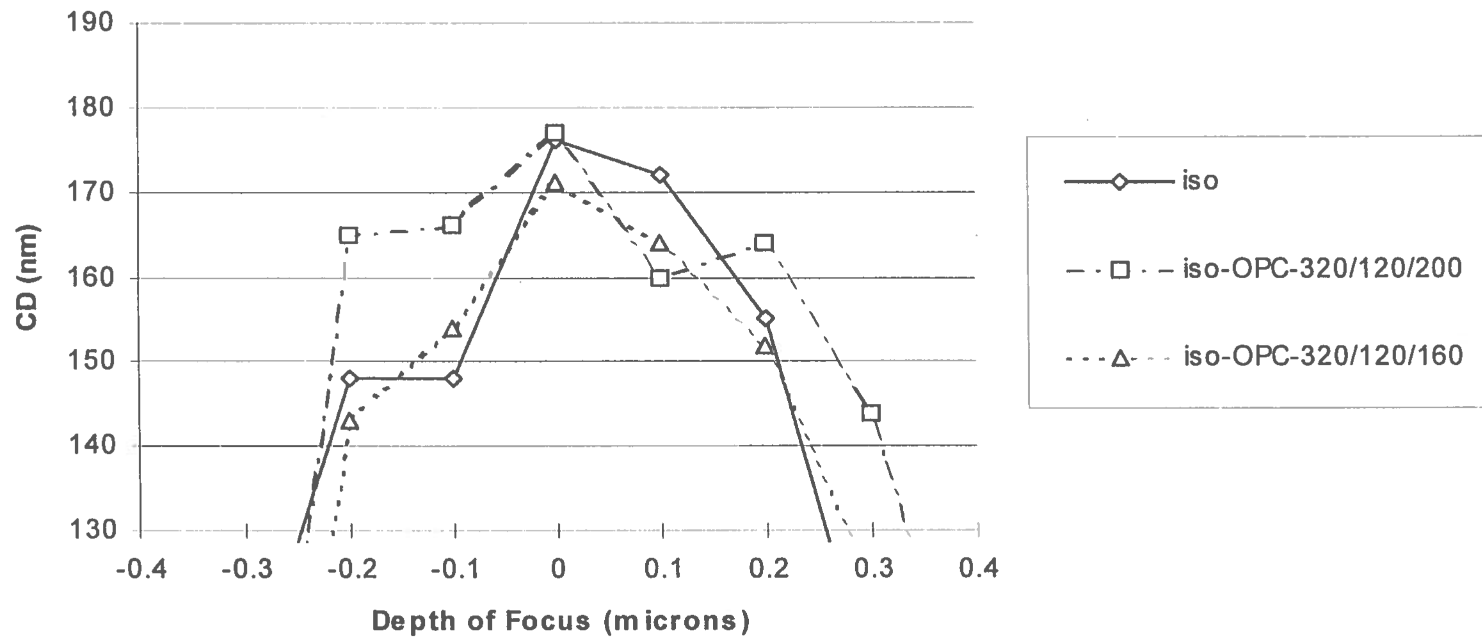
160 nm Contact Window CDs Through Focus (Conventional Illumination, $\sigma = 0.7$)



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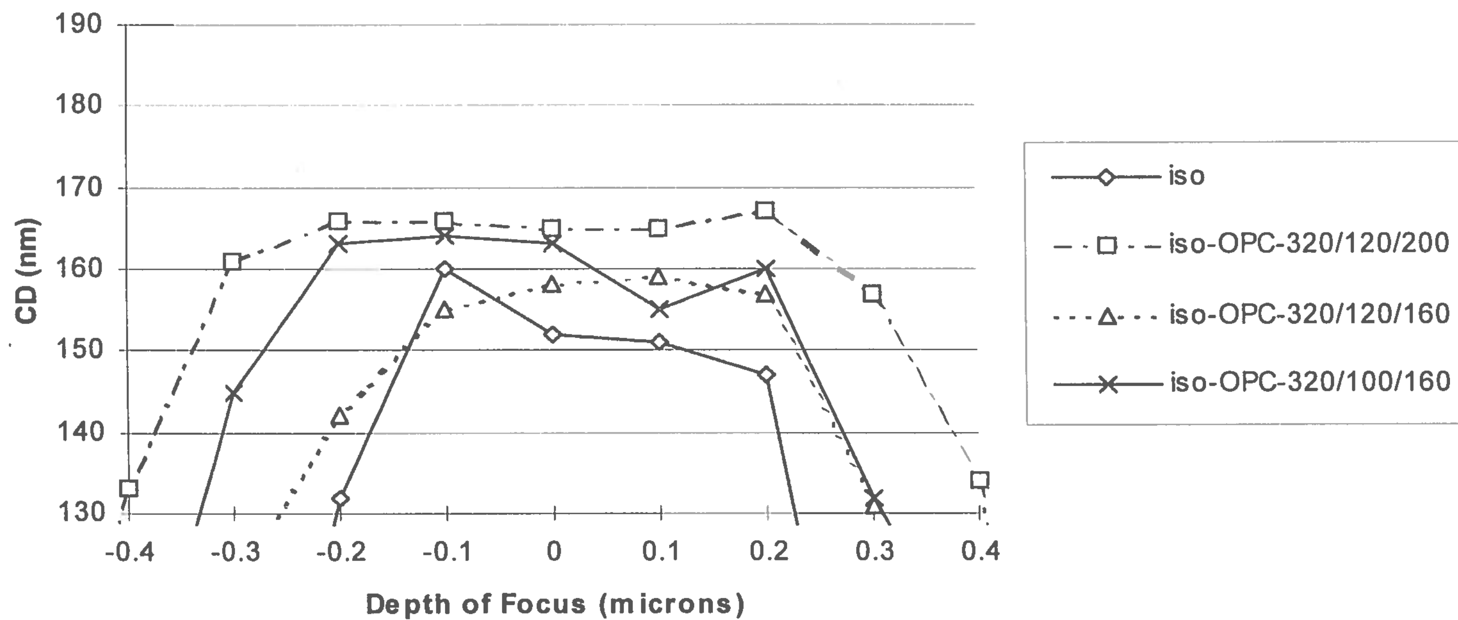
160 nm Contact Window CDs Through Focus (Quadrupole Illumination)



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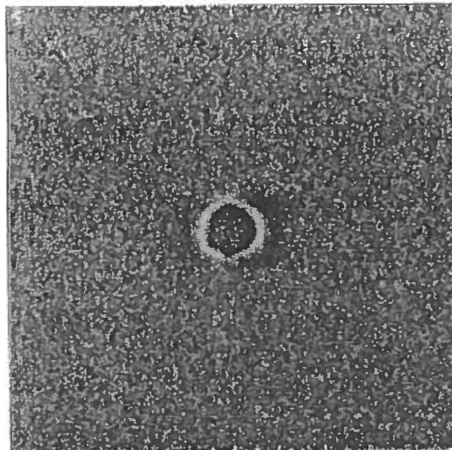
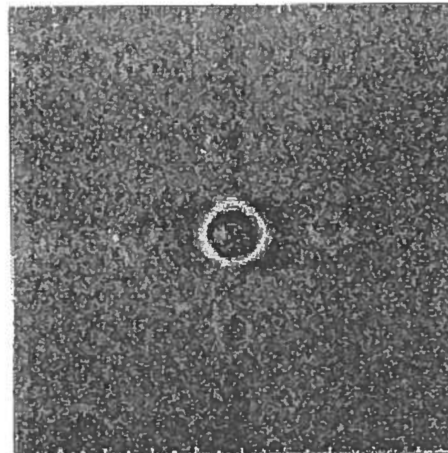
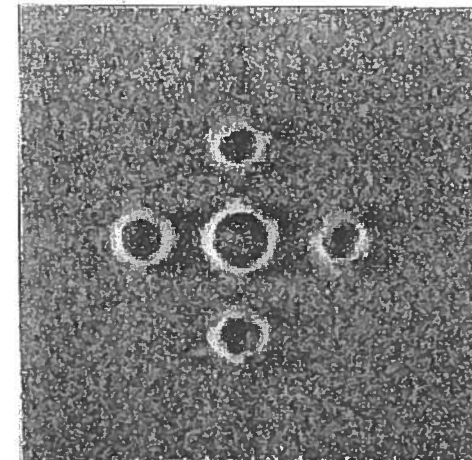
SEM Images of Printed 160 nm Isolated Contact Windows with Assist Slots



Isolated 160 nm Contact Window with 320/100/160 Assist Features



Isolated 160 nm Contact Window with 320/120/160 Assist Features



Isolated 160 nm Contact Window with 320/120/200 Assist Features

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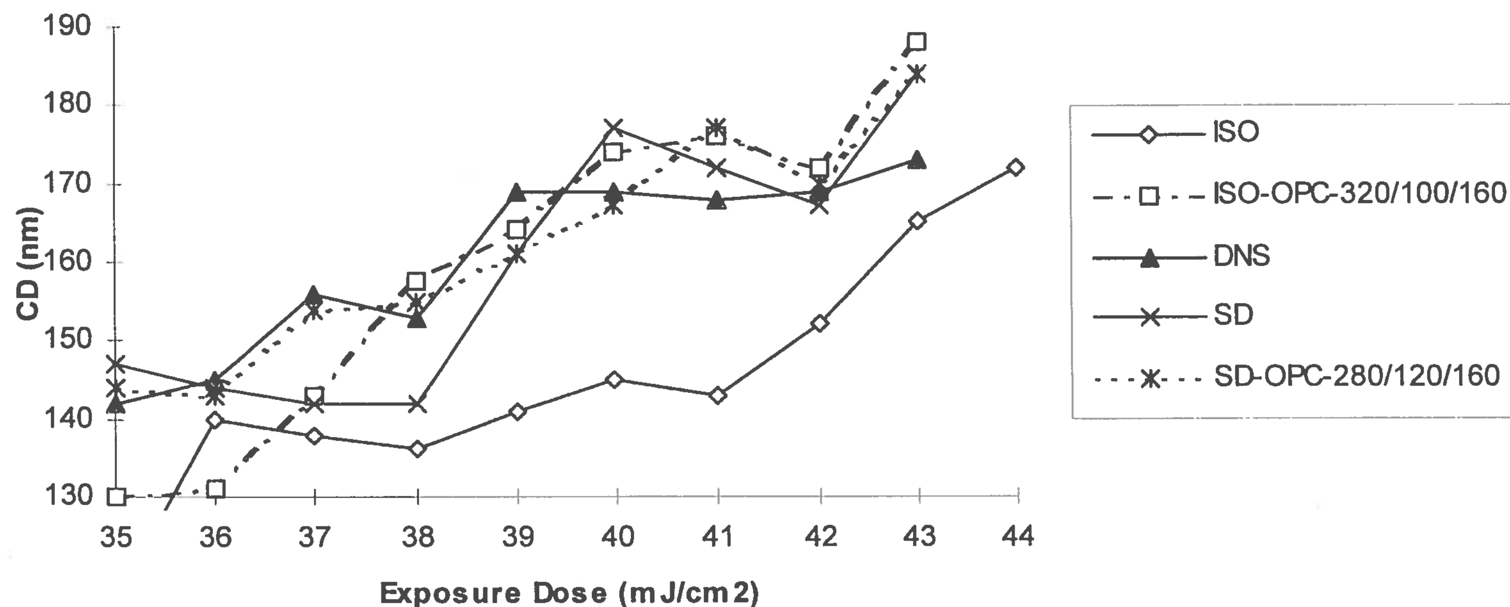
160 nm Contact Window CDs Through Exposure Dose at Best Focus (Conventional Illumination, $\sigma = 0.7$)



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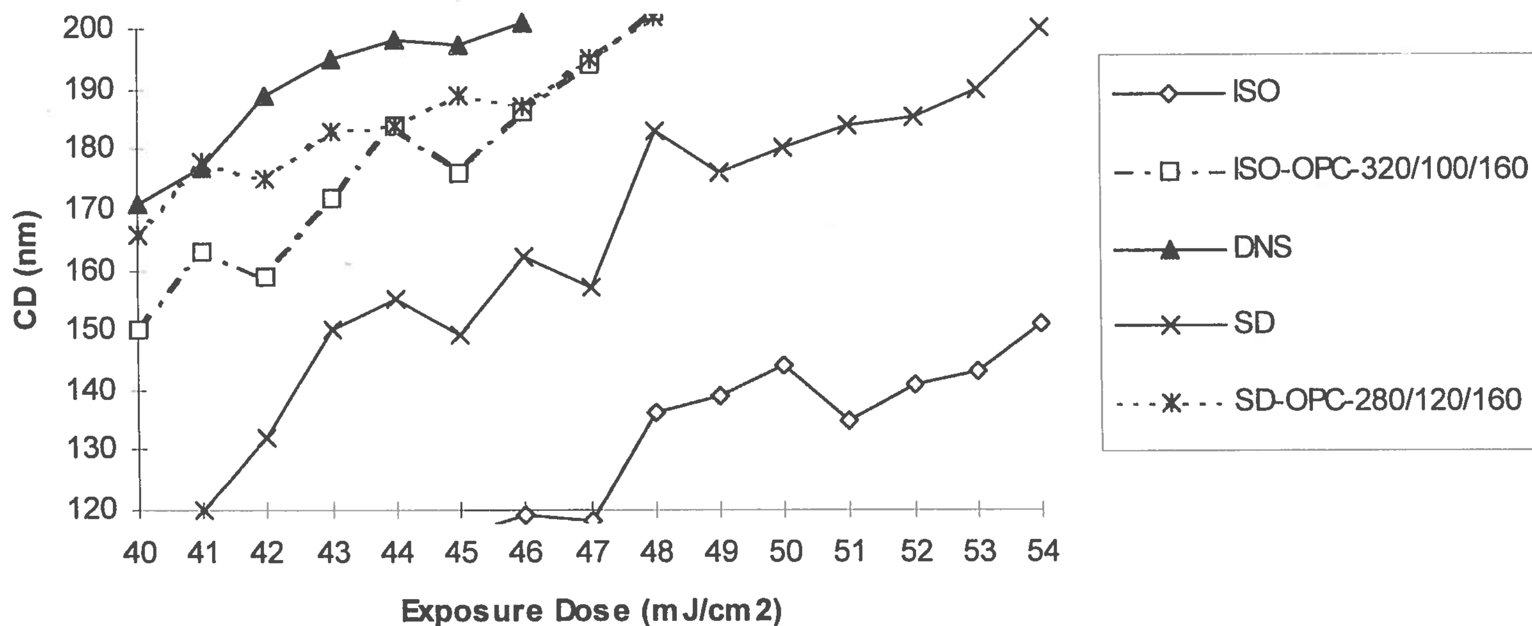
160 nm Contact Window CDs Through Exposure Dose at Best Focus (Quadrupole Illumination)



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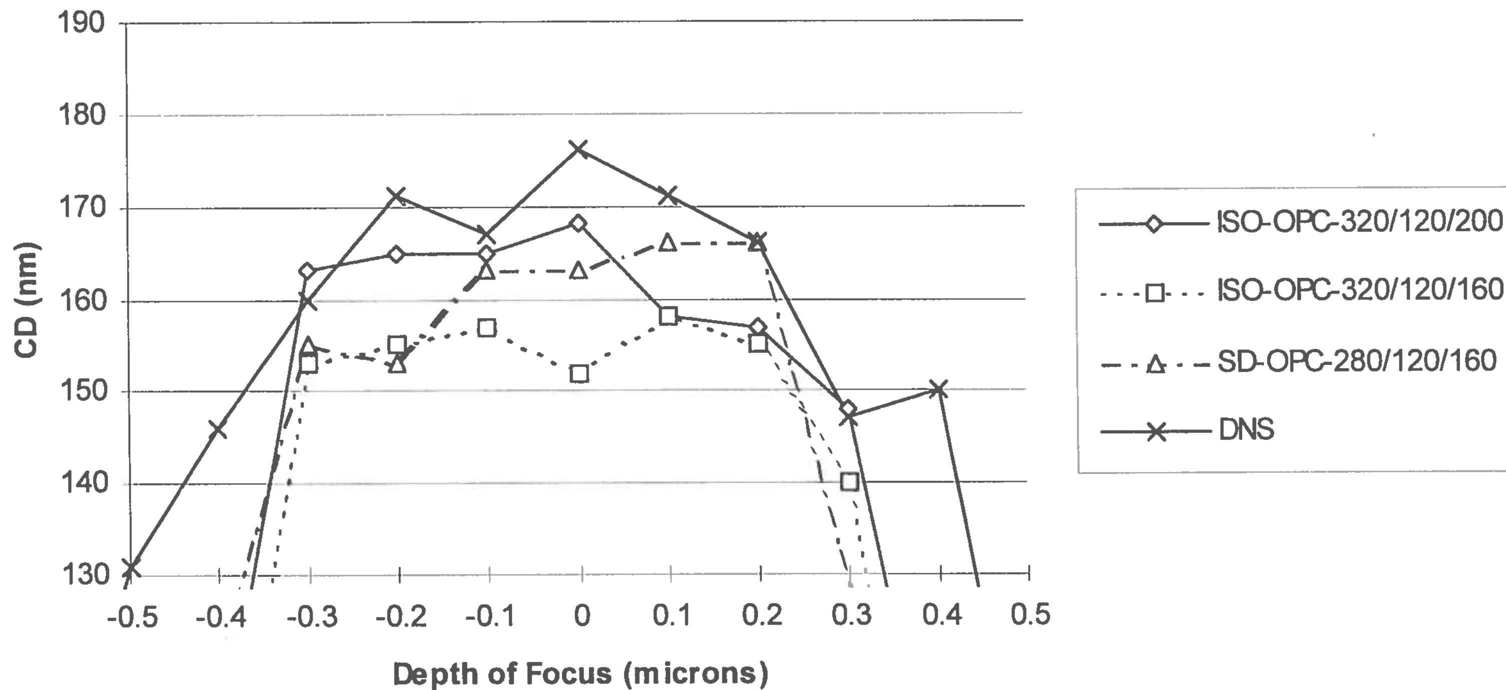
160 nm Contact Windows at 40 mJ/cm² Exposure Dose Using Quadrupole Illumination



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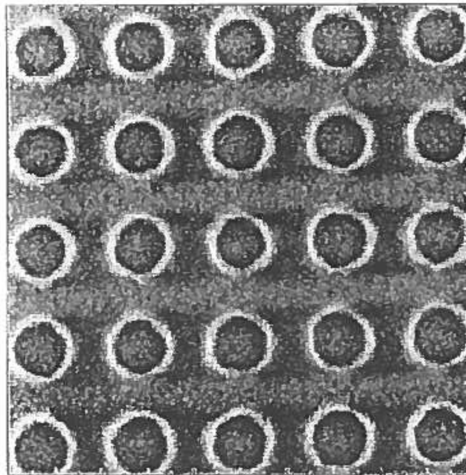
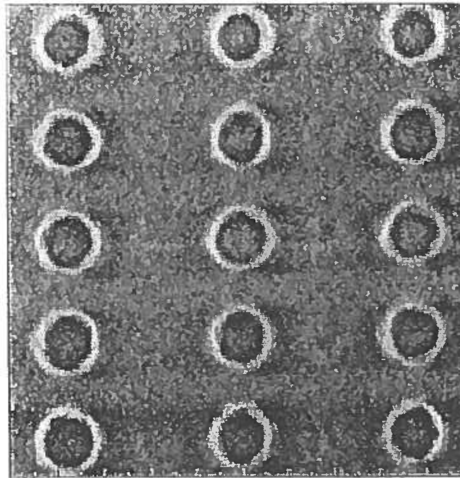
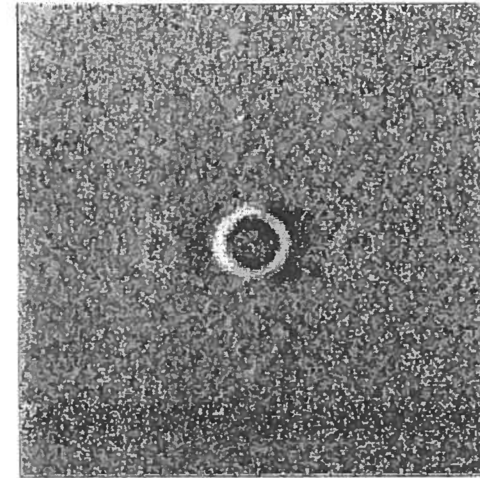
160 nm Contact Windows Printed at 40 mJ/cm^2 Exposure Dose



Dense 160 nm Contact Windows



Semi-Dense 160 nm Contact Windows with 280/100/160 Assist Features



Isolated 160 nm Contact Window with 320/120/160 Assist Features

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Conclusions

- Sub-resolution assist feature technique improves the overall CD uniformity of contact windows especially when combined with quadrupole illumination.
- The DOF of contact windows with assist features can be increased by about 0.3 μm using quadrupole illumination.
- Sub-resolution assist feature technique significantly reduces the proximity effects of printed contact windows with different pattern densities.
- Assist slots with different sizes performed quite similarly in terms of improvement of the process latitude, but it is important to determine the critical size of non-printing assist features for each new resist process and illumination condition used.

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