

65, 45 Design rule Minimum Pitch

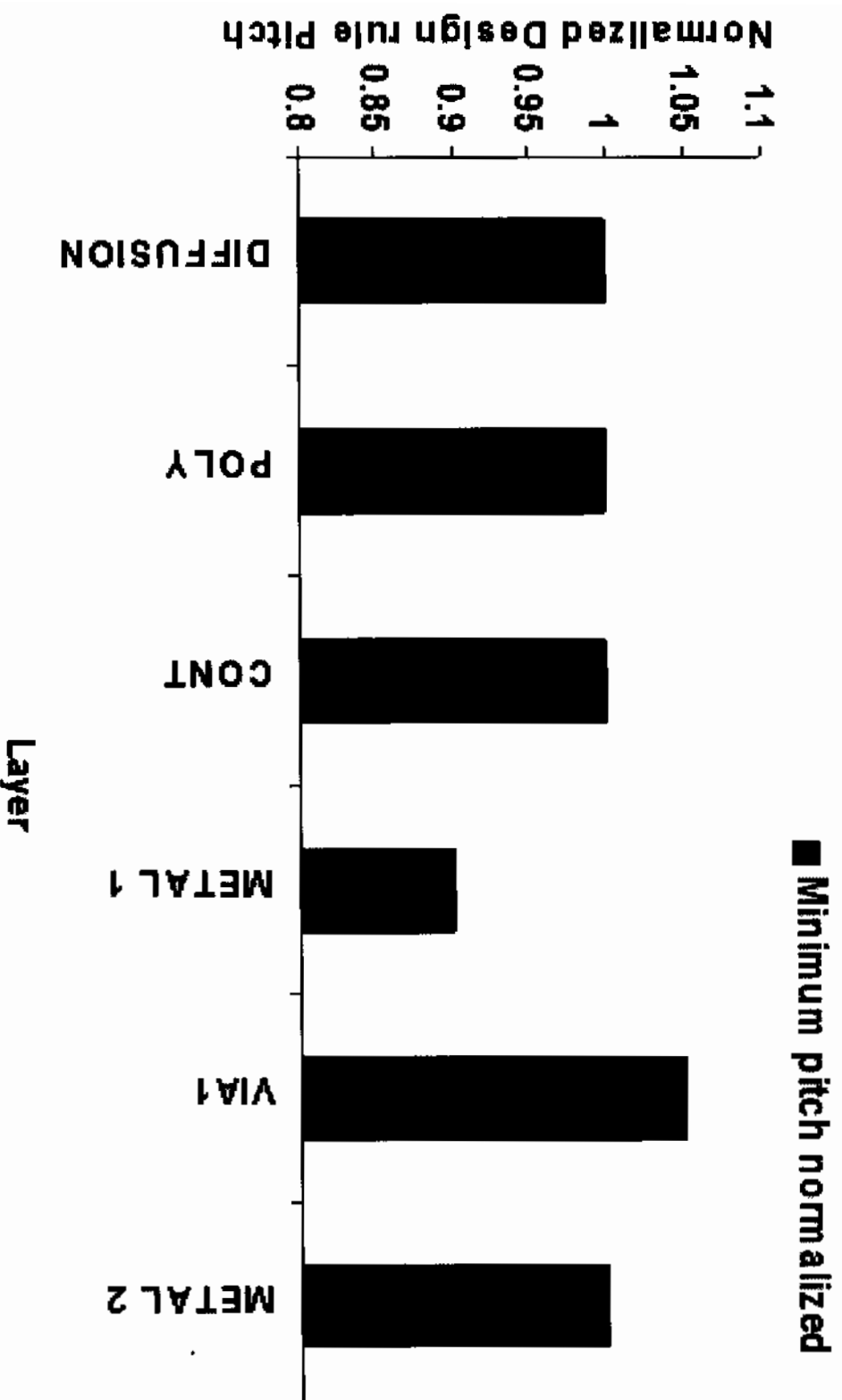


FIG. 1a

45nm node

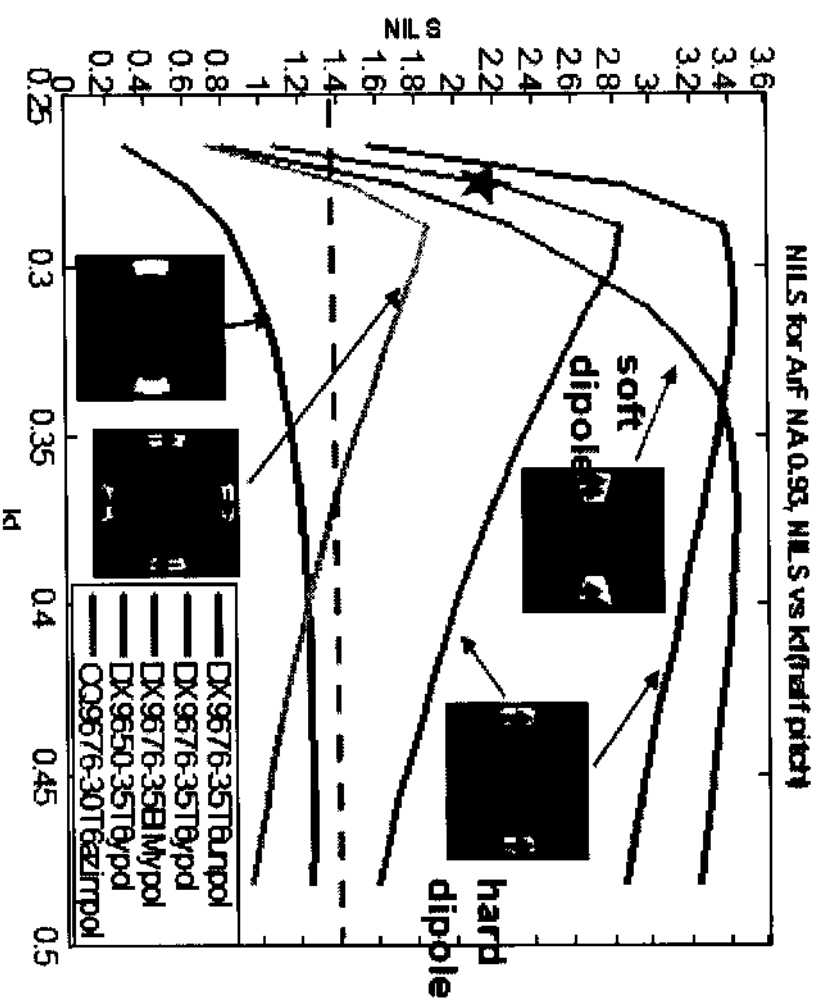


FIG 1b: Mask CD 45 to 100nm 1:1, simulated NILS for different k_1 with same duty ratio. For 45nm node, NILS is too low even using the most aggressive hard dipole does not have enough NILS; only dipole with linear y polarization provides enough contrast. The DX9676-35T6unpol is x-dipole $\sigma_{out}=0.96$, $\sigma_{in}=0.76$, pole angle 35 degree with 6% attPSM mask un-polarized. DX9676-35T6ypol has the same setting as the first case but with y-polarization. DX9676-35BIMypol. DX9650-35T6ypol is x-dipole $\sigma_{out}=0.96$, $\sigma_{in}=0.50$, pole angle 35 degree with 6% attPSM mask with y-polarization. CQ9676-30T6azimpol is the cross-pole $\sigma_{out}=0.96$, $\sigma_{in}=0.76$, pole angle 30 degree with azimuthally polarization.



FIG. 2a

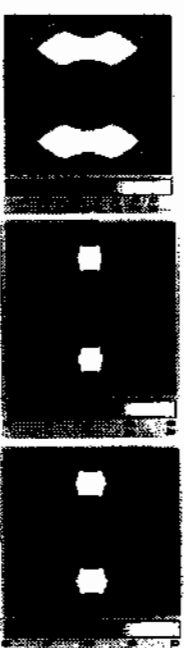


FIG. 2b

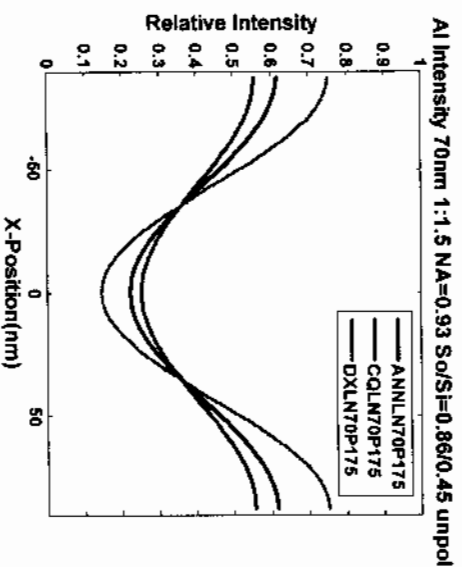


FIG. 2c

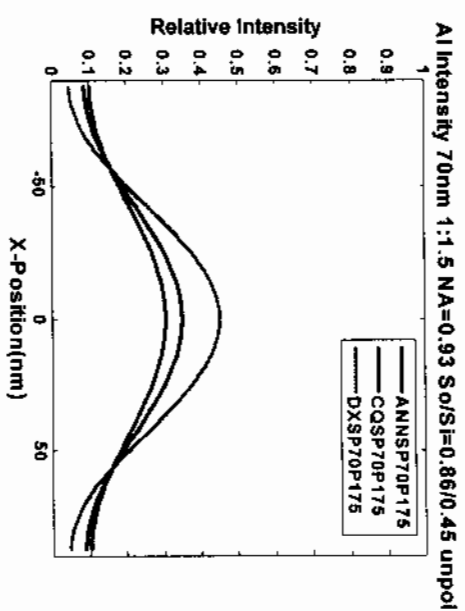


FIG. 2d

CD 70nm	Annular	Cquad	Dipole X
NILS	1.31	1.02	2.03
lmin	0.223	0.253	0.145
Line Thd	0.36	0.36	0.35

FIG. 2e

CD 70nm	Annular	Cquad	Dipole X
NILS	1.2	1.03	1.56
lmax	0.35	0.305	0.45
Space Thd	0.26	0.23	0.31

FIG. 2f

FIG. 2: (a) Diffraction pattern in the pupil for clear field (70nm chrome line, 105nm space) and (b) dark field (70nm clear, 105nm chrome). (c) Aerial image intensity of the clear field mask and (d) aerial image intensity of the dark field mask. (e) NILS (normalized image log slope), minimum intensity (lmin), and the intensity threshold to print to 70nm line and (f) for 70nm space.

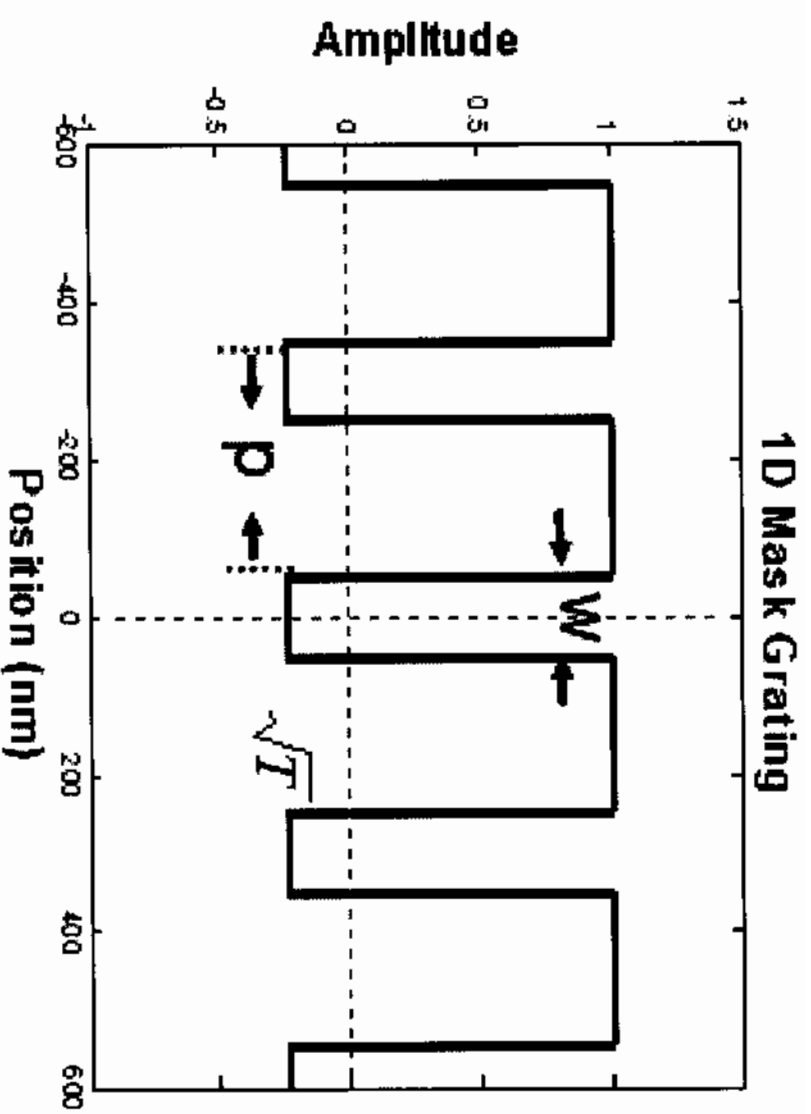
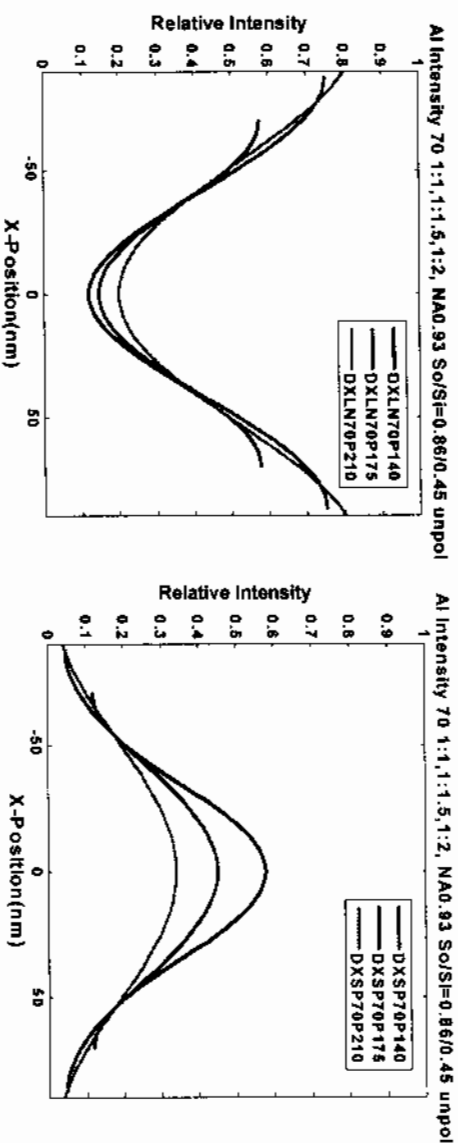


FIG 3: 1D mask grating, the width equals w , the pitch is p and the intensity transmission of the mask is T .



FIG. 4a

FIG. 4b



70nm	L 1:1	S 1:1	L 1:2	S 1:2	L 1:3	S 1:3
NILS	2.08	2.08	2.03	1.56	1.63	1.12
$I_{\text{max or min}}$	0.118	0.577	0.145	0.450	0.198	0.339
thres	0.35	0.35	0.35	0.31	0.36	0.26

FIG. 4e

FIG. 4: The diffraction patterns for (a) 70nm line and (b) 70nm space at 1:1, 1:1.5, and 1:2 ratios, (c) and (d) are the aerial images for clear field mask and dark field mask respectively. (e) The corresponding NILS (normalized image log slope), minimum or maximum intensity ($I_{\text{min}}/I_{\text{max}}$) and the intensity threshold to print to 70nm line for line.

Normalized Energy Captured line vs. space

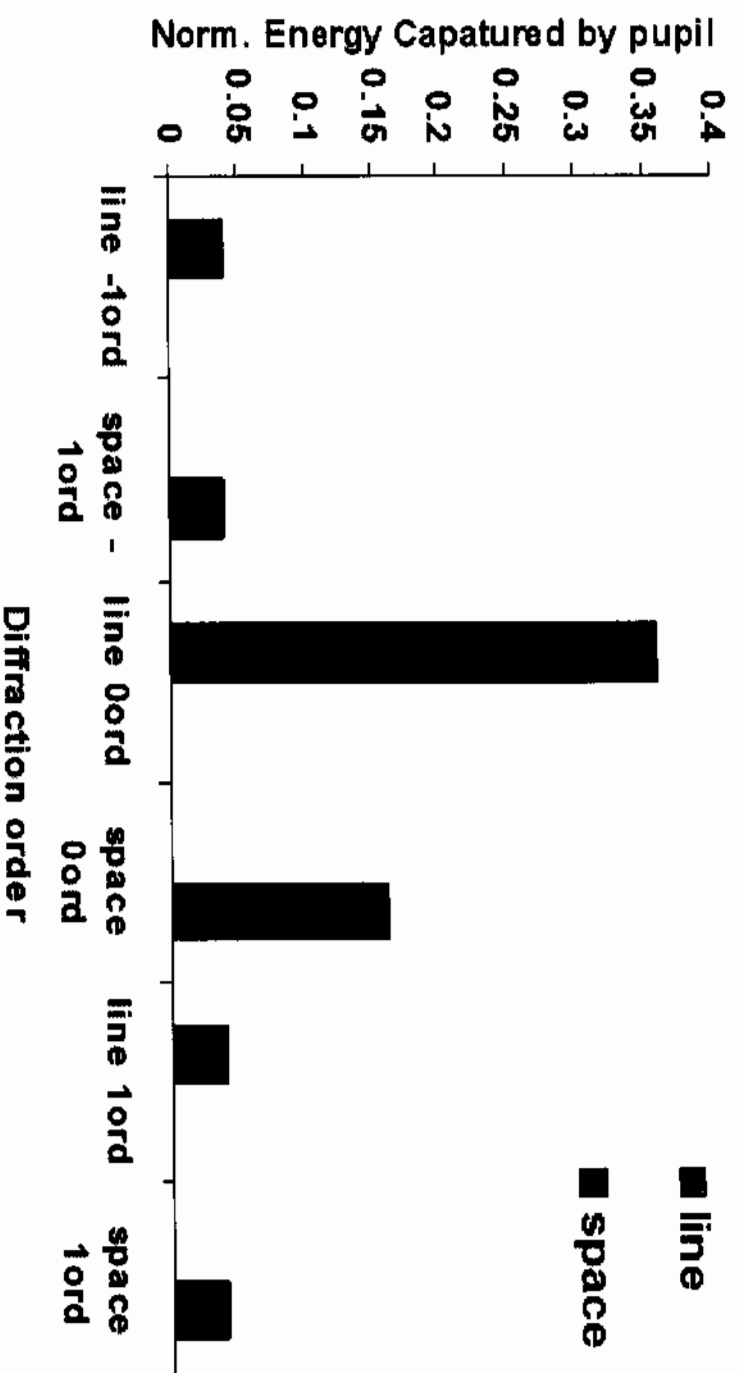


FIG 5: CD 70nm pitch 175nm, comparing the normalized energy captured by the lens pupil for line and space. It shows that the energy that comes from the +/- first order for line and trench are identical, but there is a 2X difference in 0th order energy.

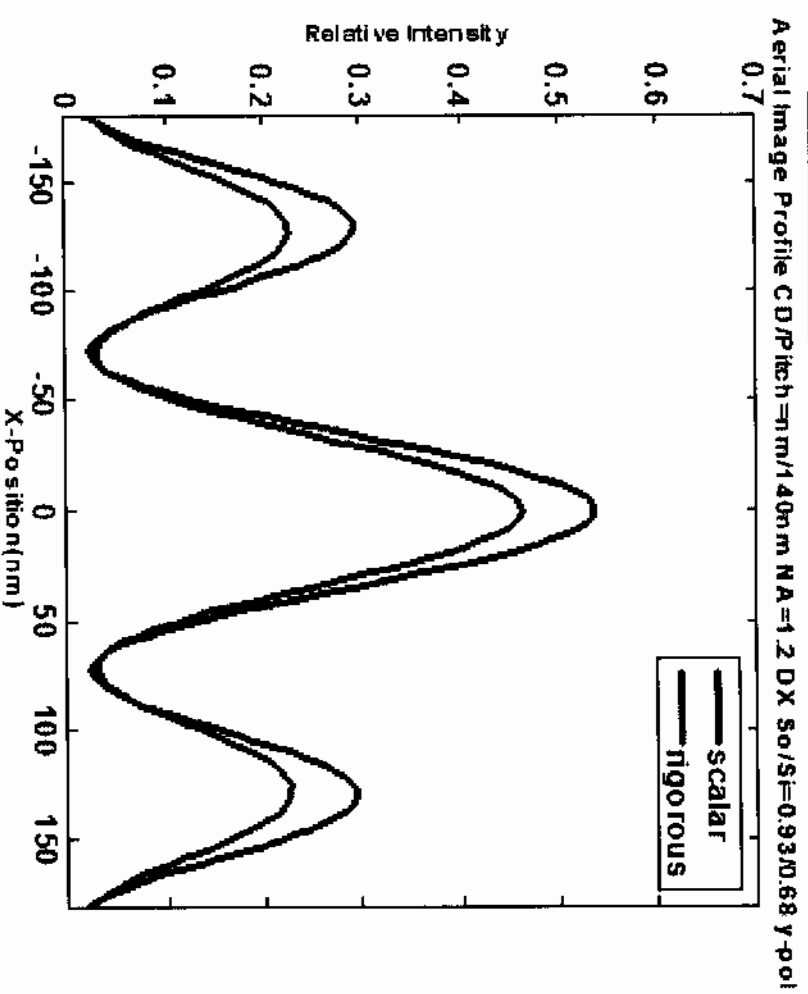


FIG 6: Comparison of the aerial image intensity profile for an isolated trench with a single sided dark field SB slot. The scalar imaging model over-predicts the trench and SB slot intensity.

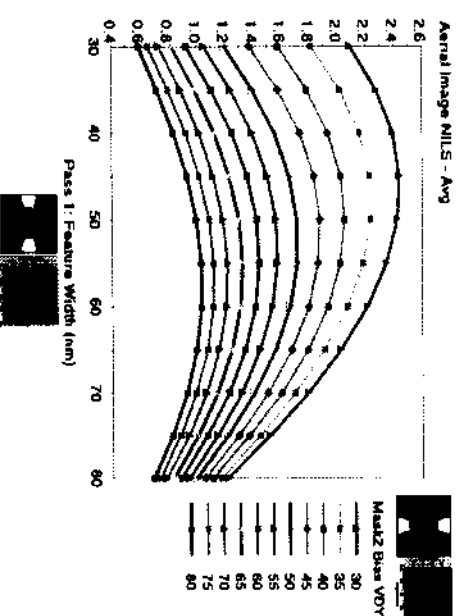
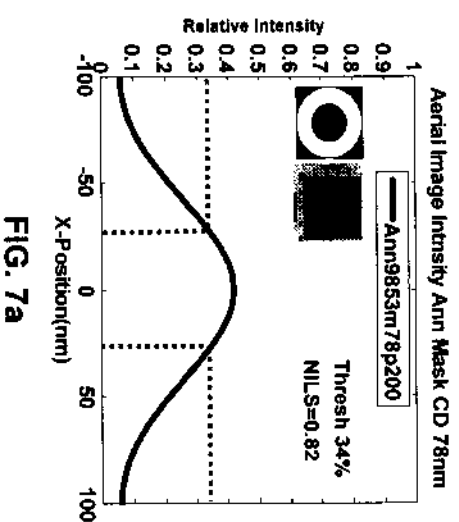


FIG. 7b

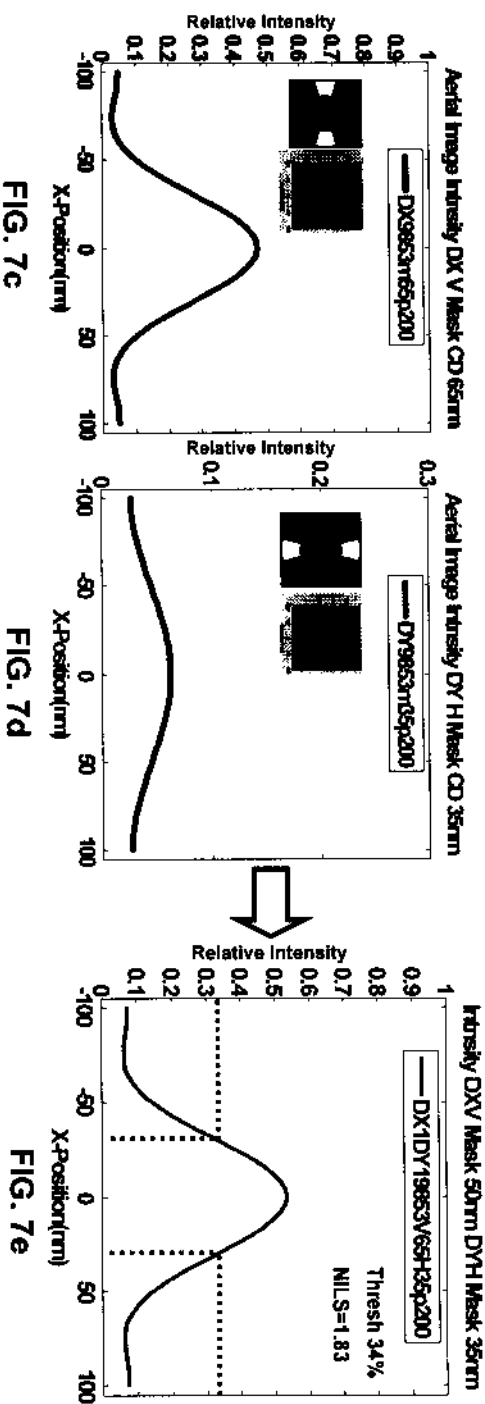


FIG. 7c

FIG. 7d

FIG. 7e

FIG 7: (a) Simulated aerial image for annular illumination with 1.2 NA, $\sigma_{out}=0.98$, $\sigma_{in}=0.53$, (b) The double exposure simulation result shows that the NILS is not only a function of vertical trench size, but also as a function of mask2 bias, the combination of the mask bias can be used to optimized the overall NILS, (c) the x-dipole is used to image the trench in the vertical mask (biased to 65nm), (d) the y-dipole expose the horizontal (mask biased to 35nm), (e) NILS from “composite intensity” is 1.83.

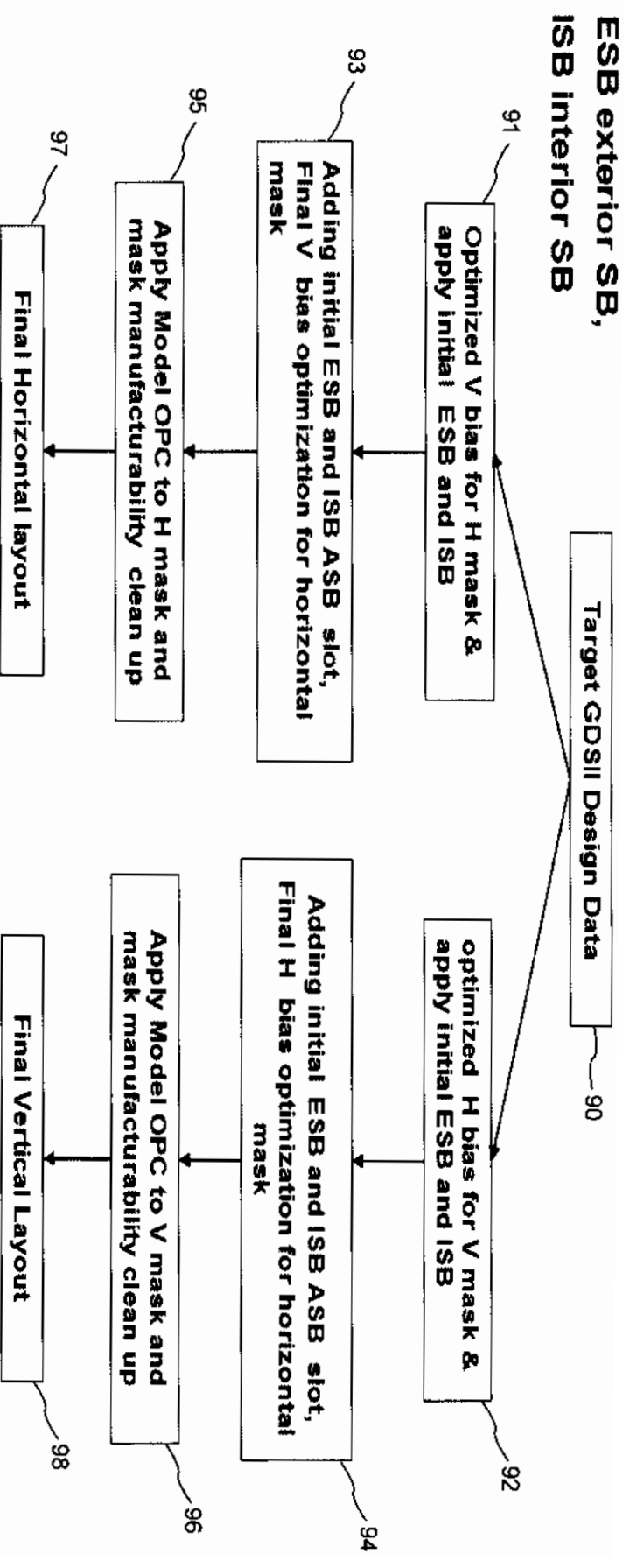
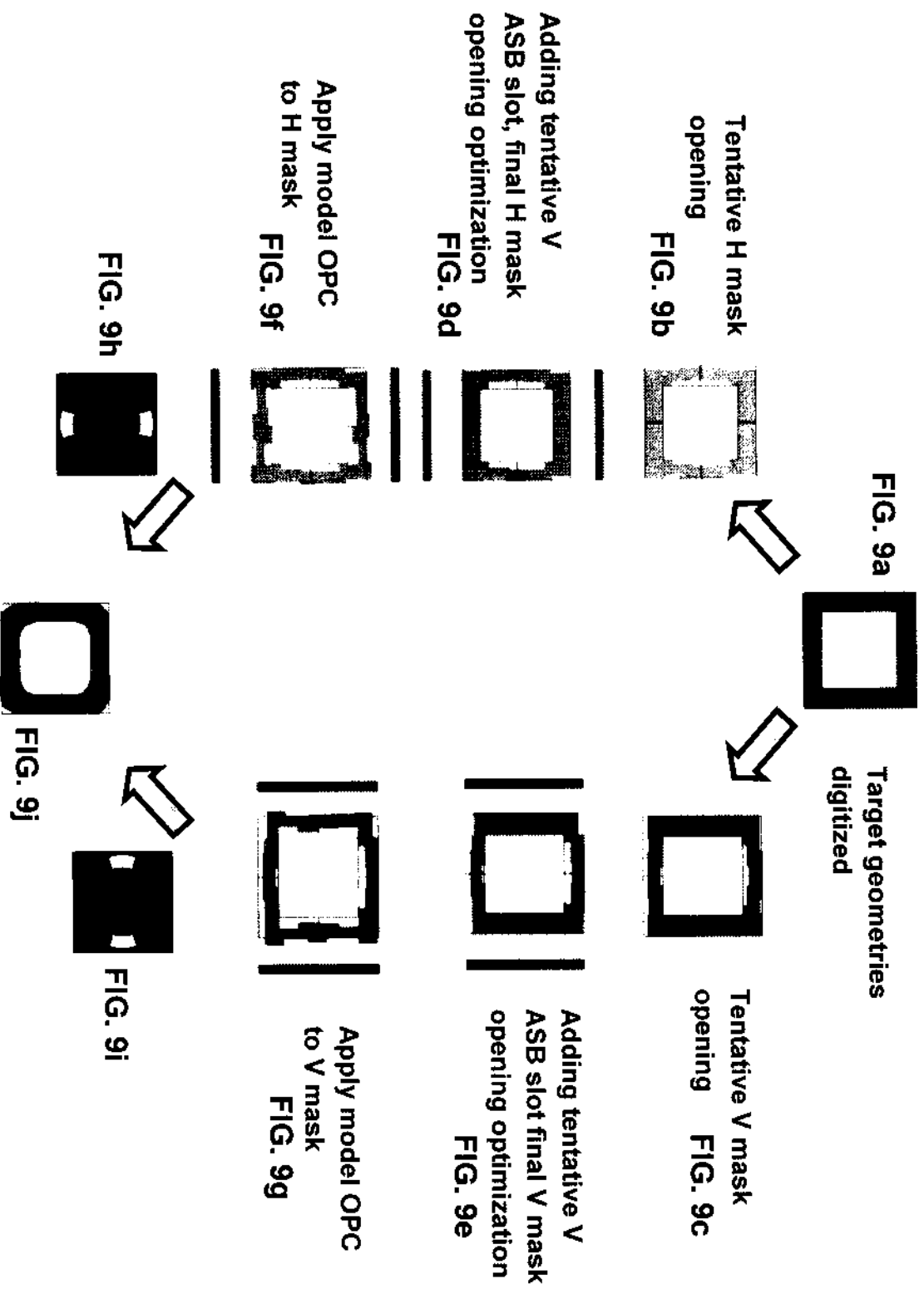


FIG. 8



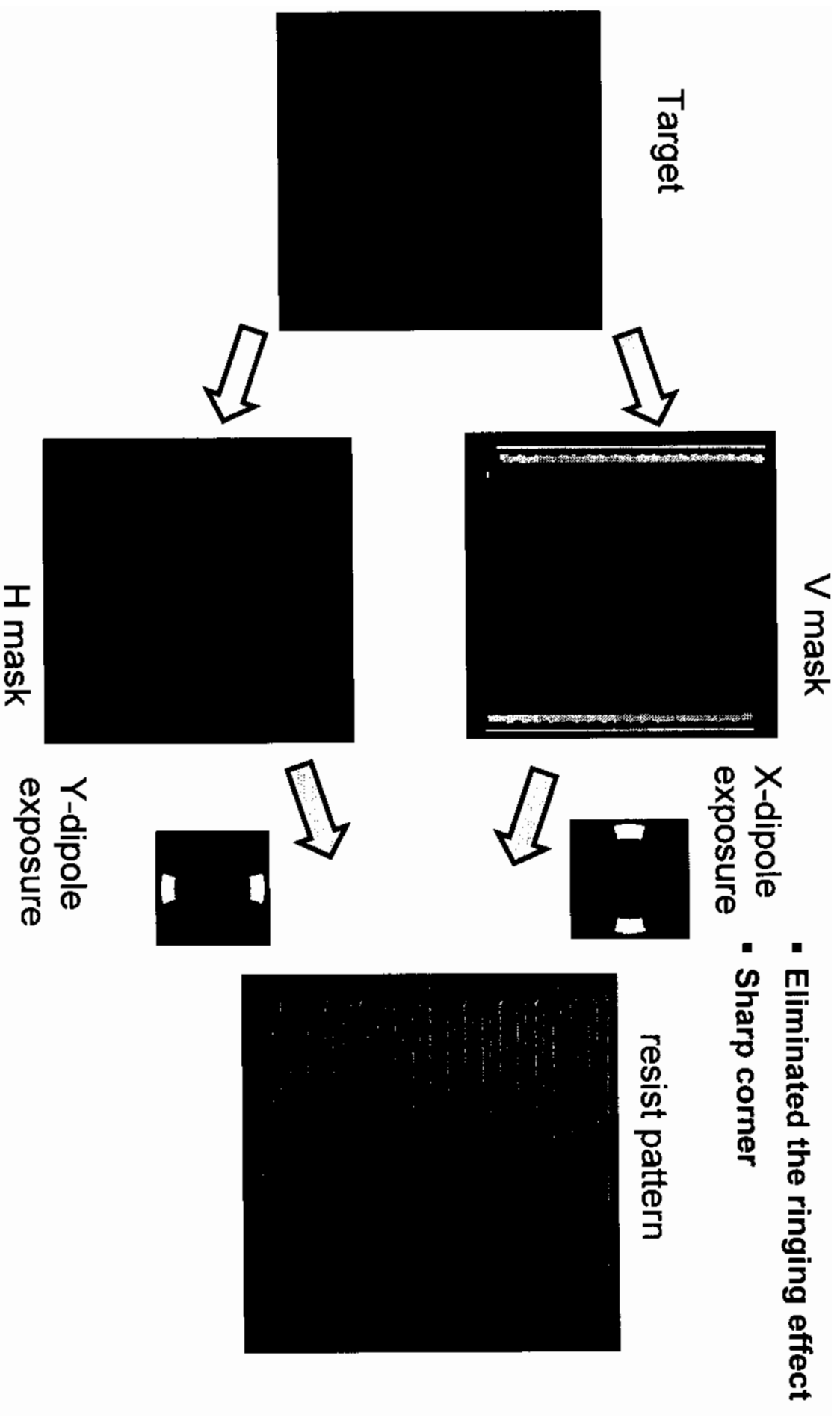


FIG. 10

Fig. 11

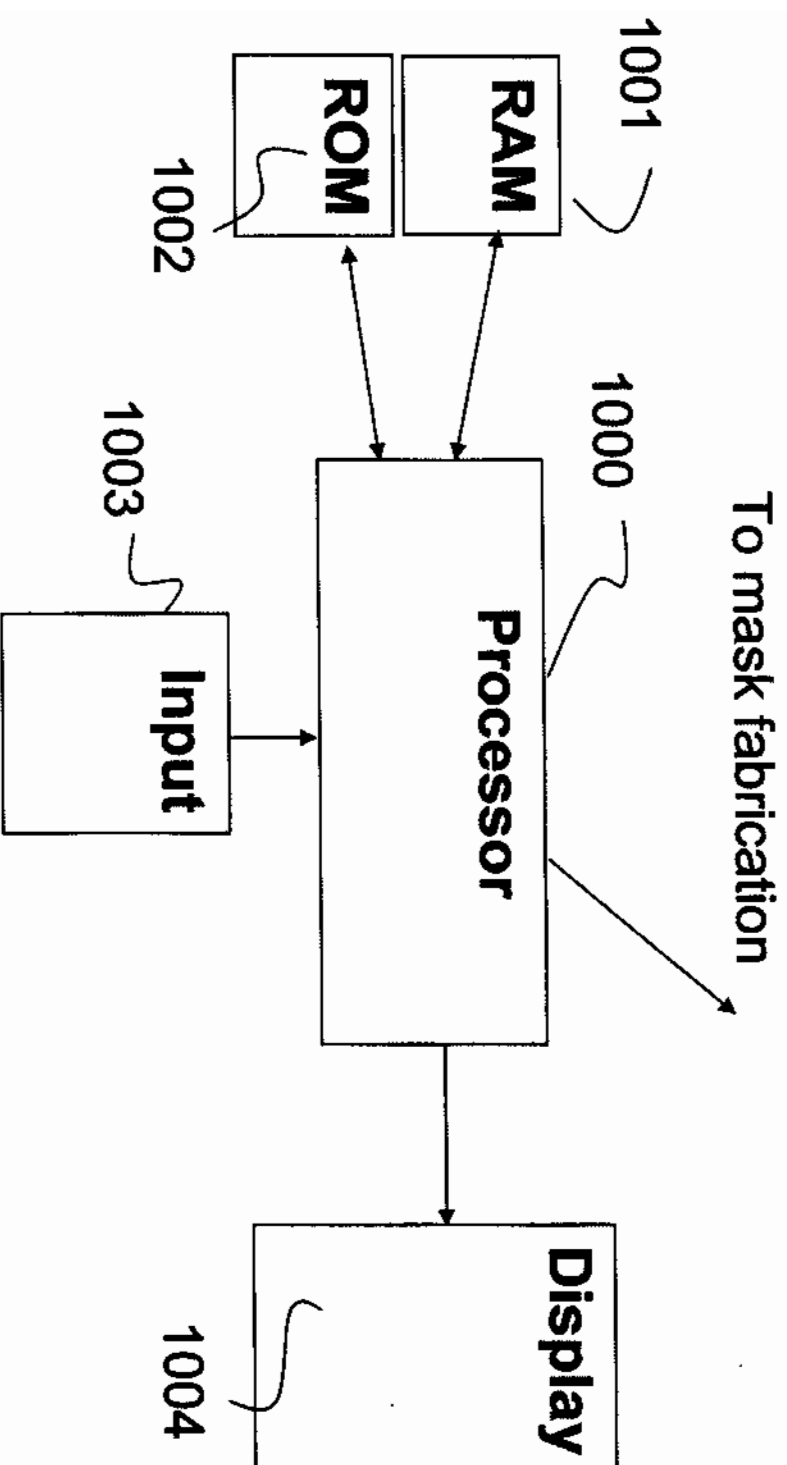


Fig. 12

