



creating solutions

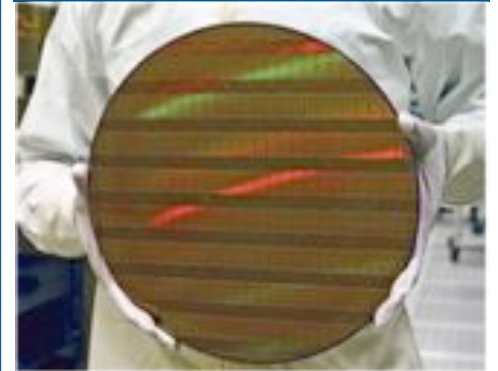
Imageable Oxides: New Solutions for Resist

Jason Stowers, Alan Telecky,
Andrew Grenville
October 20, 2010

Display Backplane TFT Materials



Lithography Resist

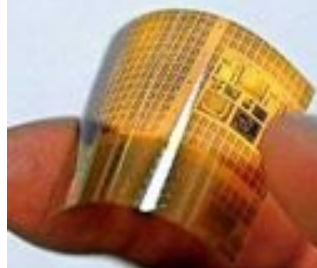


Thin Film PV



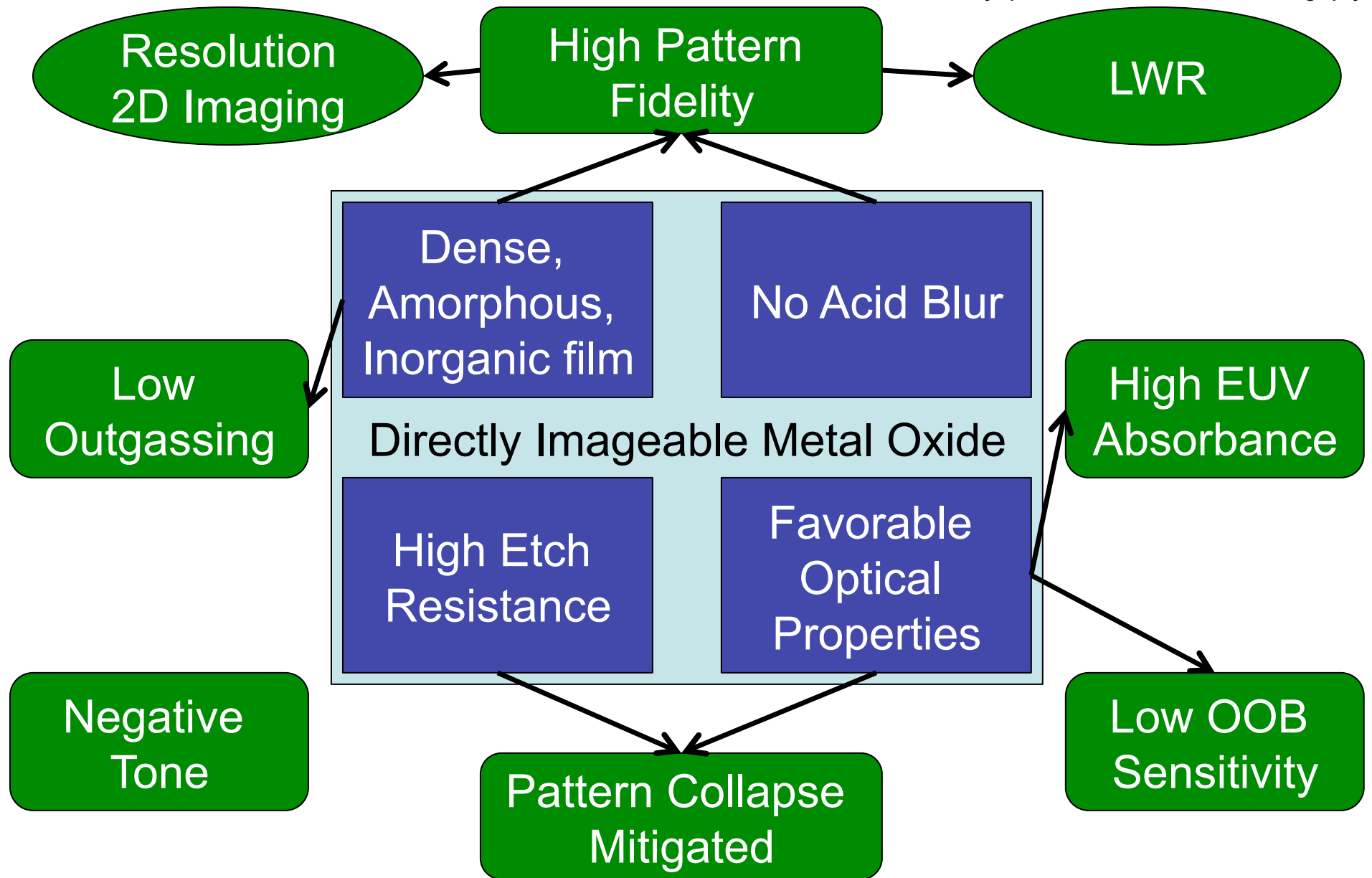
Materials And Processes

Printed Electronics

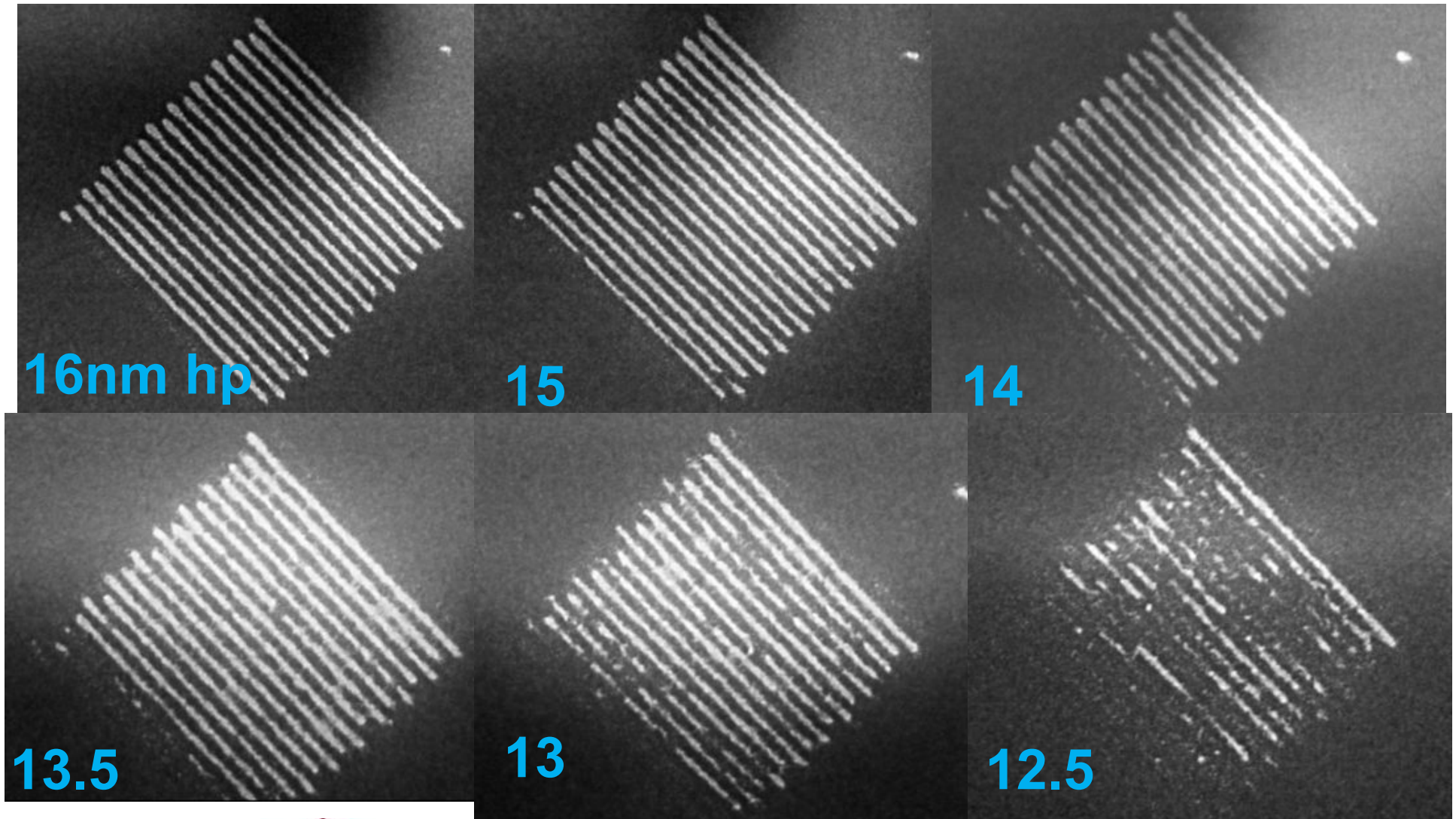


Window Coatings





Pushing LBNL MET Resolution



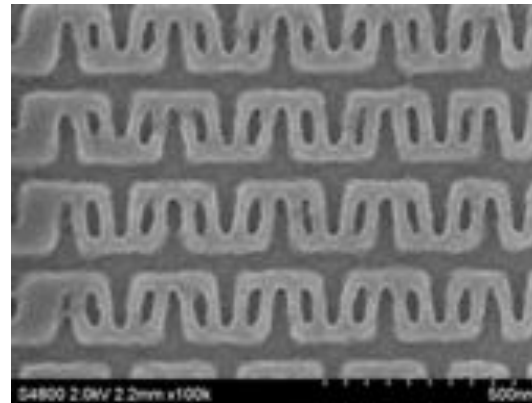
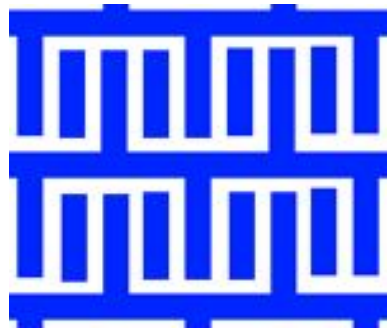
LBNL F2X imaging, $\sim 70 \text{ mJ/cm}^2$

Data courtesy Patrick Naulleau, Chris Anderson LBNL 4

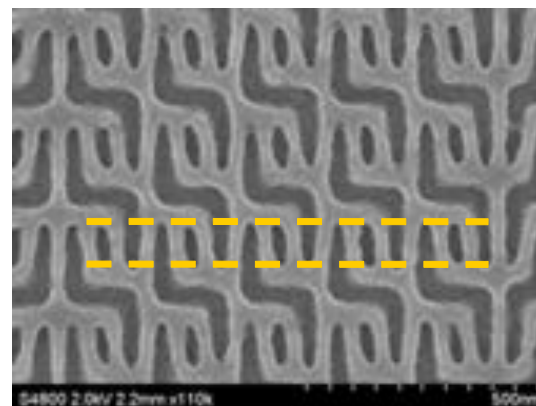
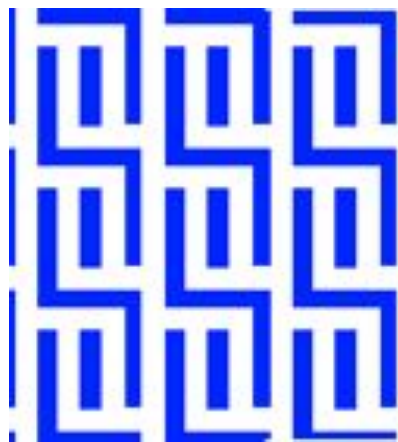
2D Pattern Fidelity



Mask Representation



32 nm HP
'Ts'
(2 pitch)



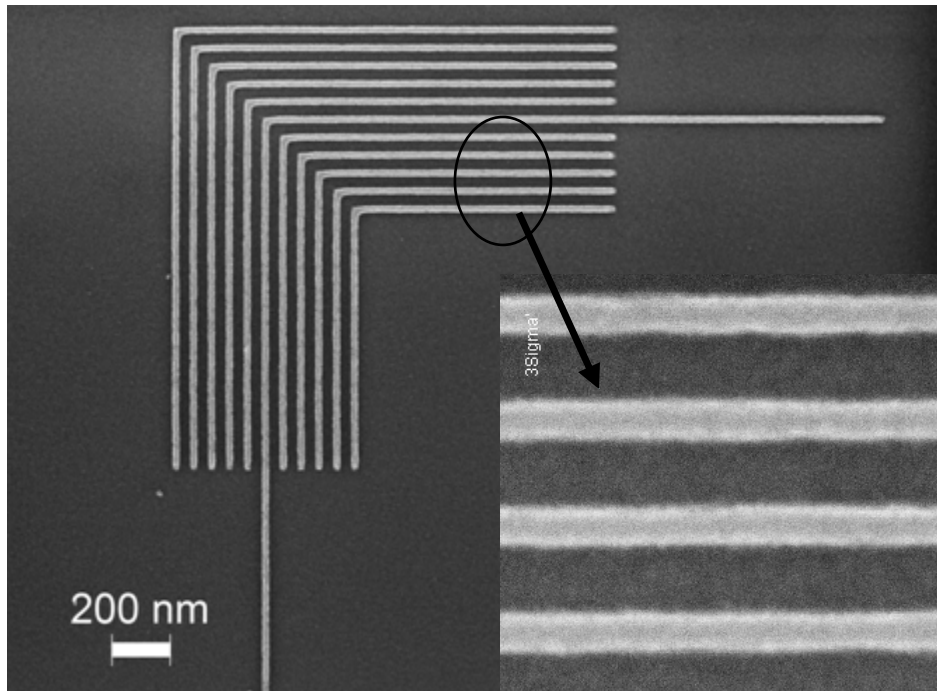
32 nm HP
jogs
(2 pitch)

Conventional
Resist (pCAR)

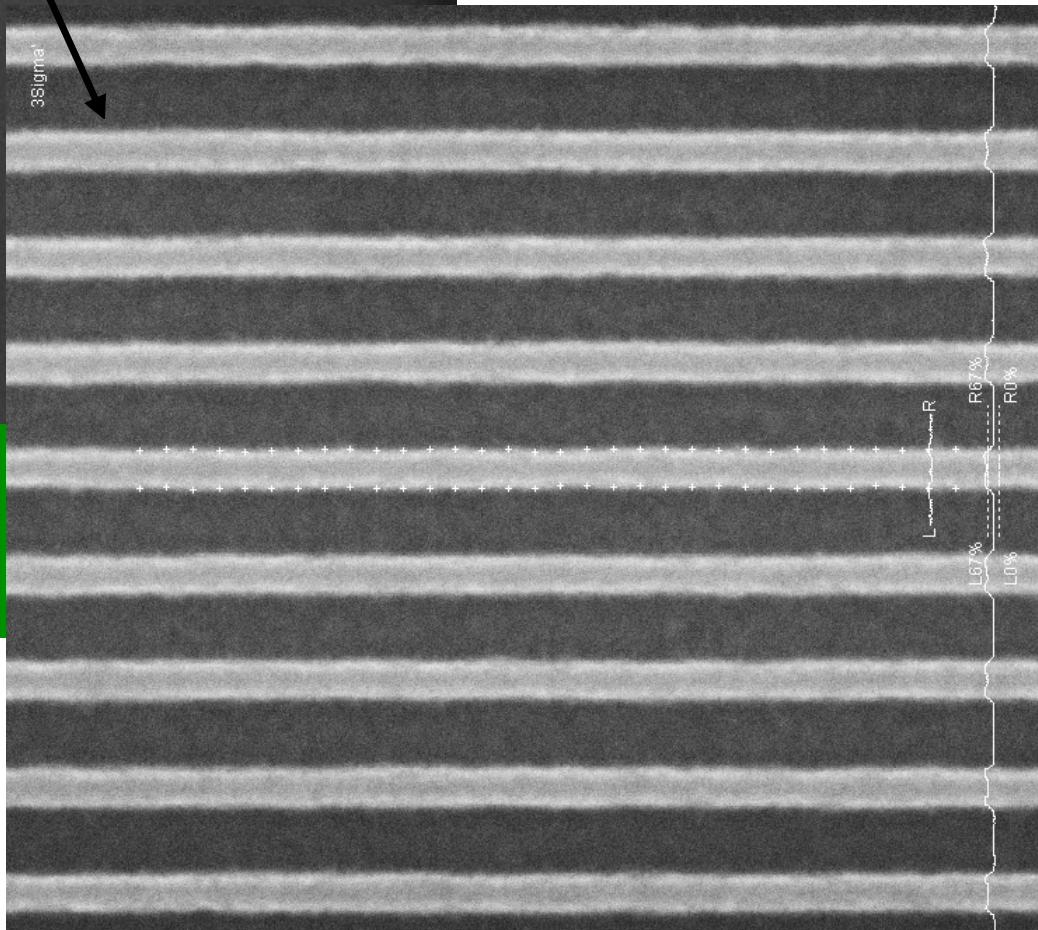


Data from SEMATECH Berkeley eMET, courtesy Tom Wallow, Global Foundries

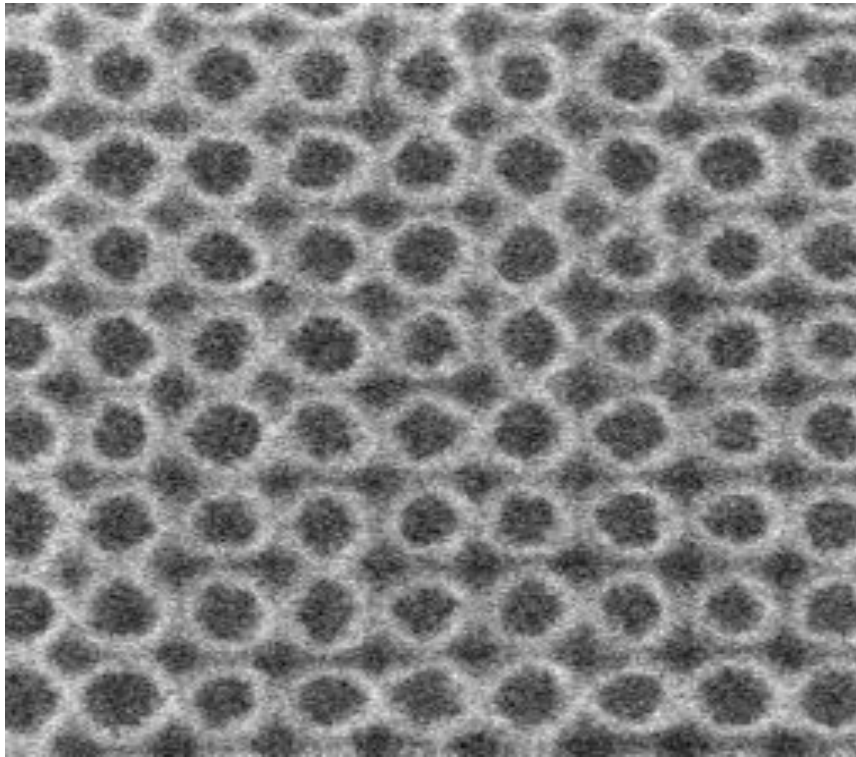
Low LWR (by e-beam)



LWR 1.6-1.8 nm
CD 21 nm, 60 nm pitch
30keV EB, 436 $\mu\text{C}/\text{cm}^2$

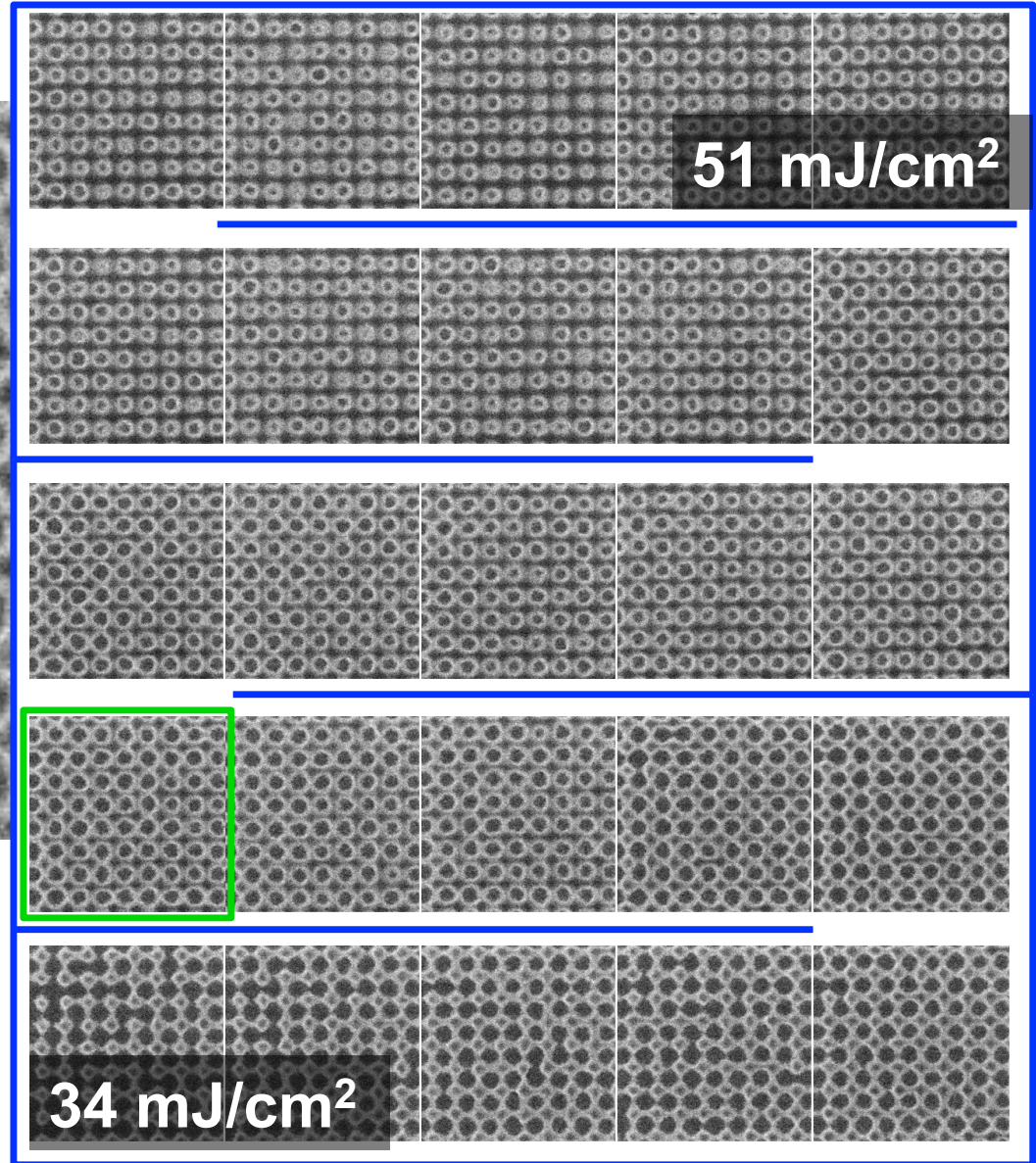


32 HP Contact Holes on IMEC ADT



32nm half-pitch, 40 mJ/cm²

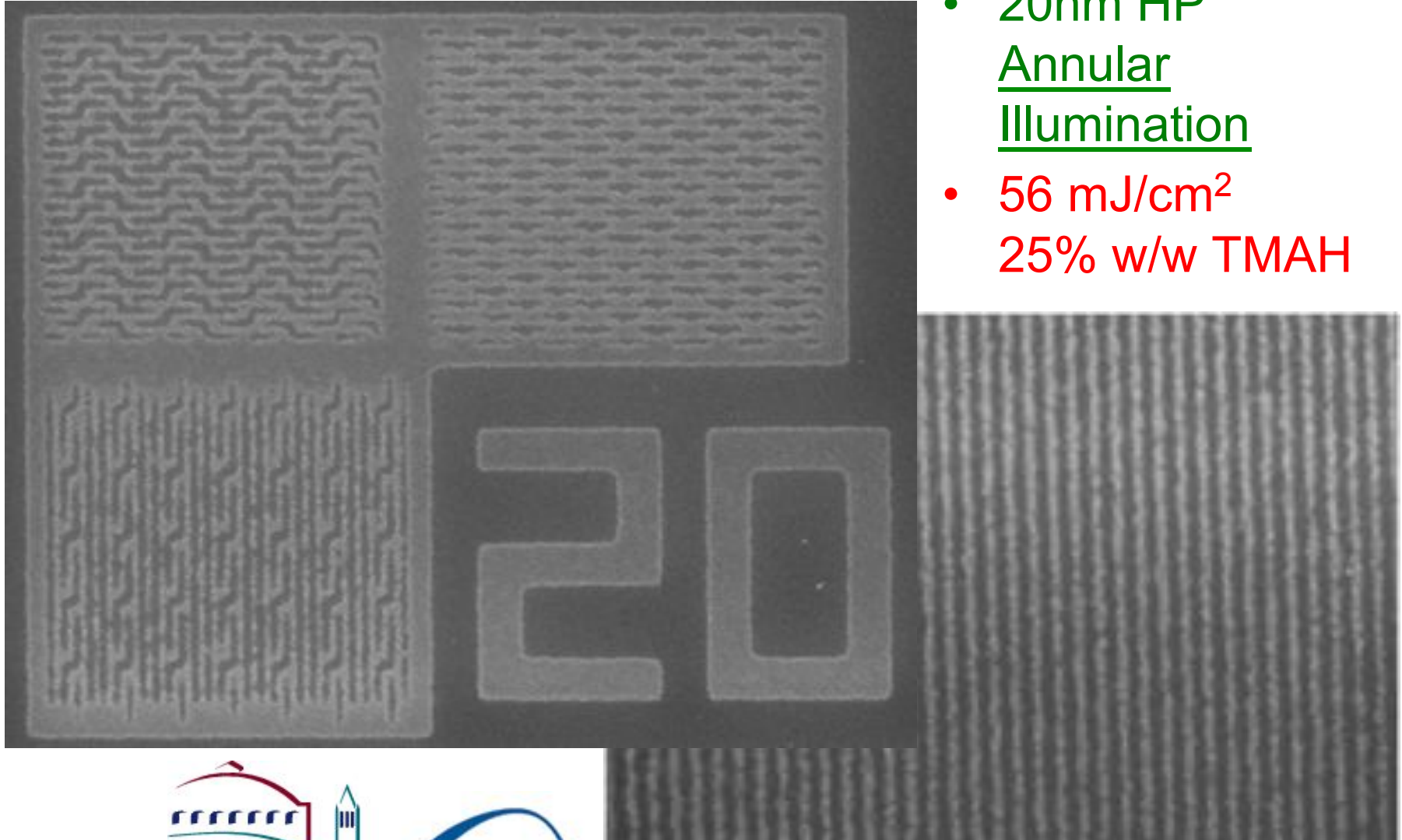
Note: *dose meander only*, 25% TMAH



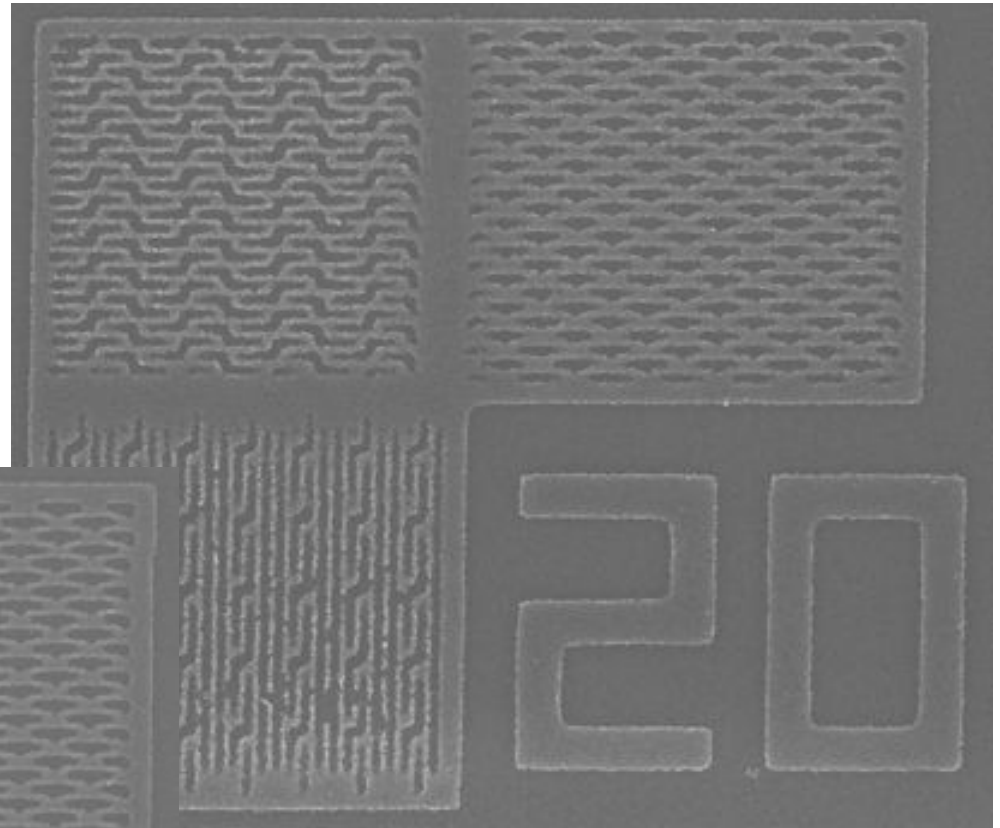
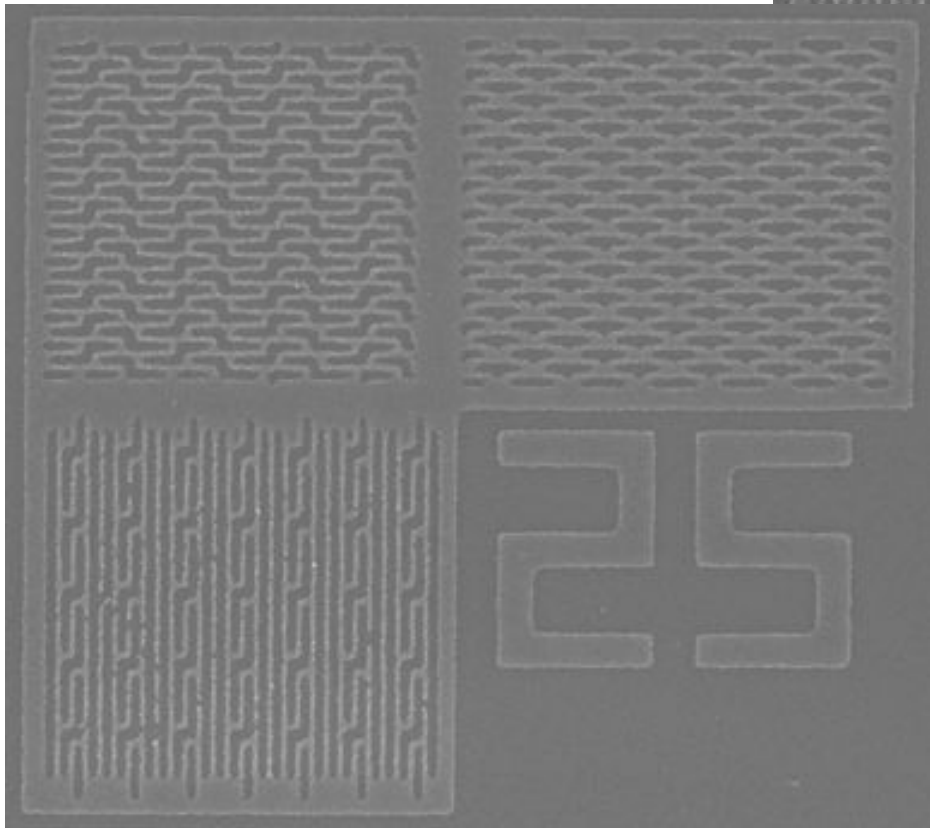
Courtesy Roel Gronheid, IMEC

Resolution

- 20nm HP
Annular
Illumination
- 56 mJ/cm²
25% w/w TMAH



Alternate Developer



Annular Illumination

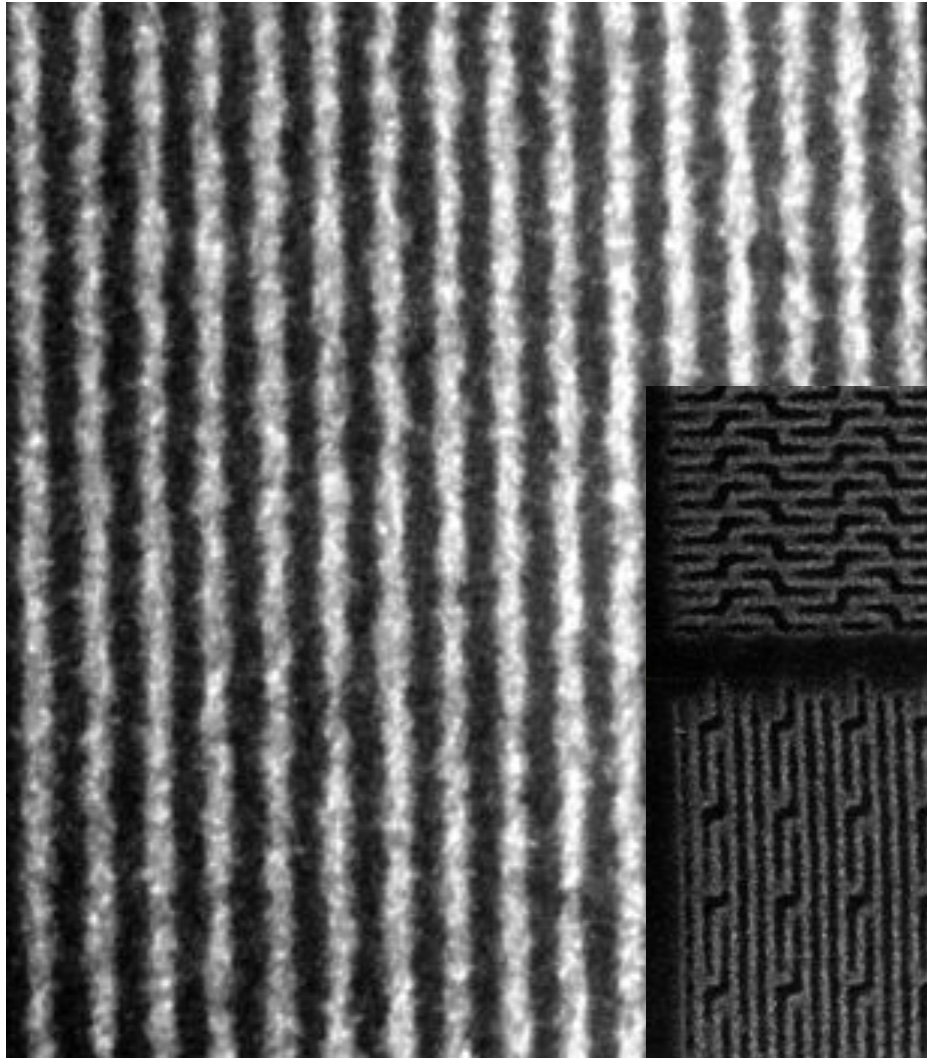
65 mJ/cm²

35% w/w TEAH

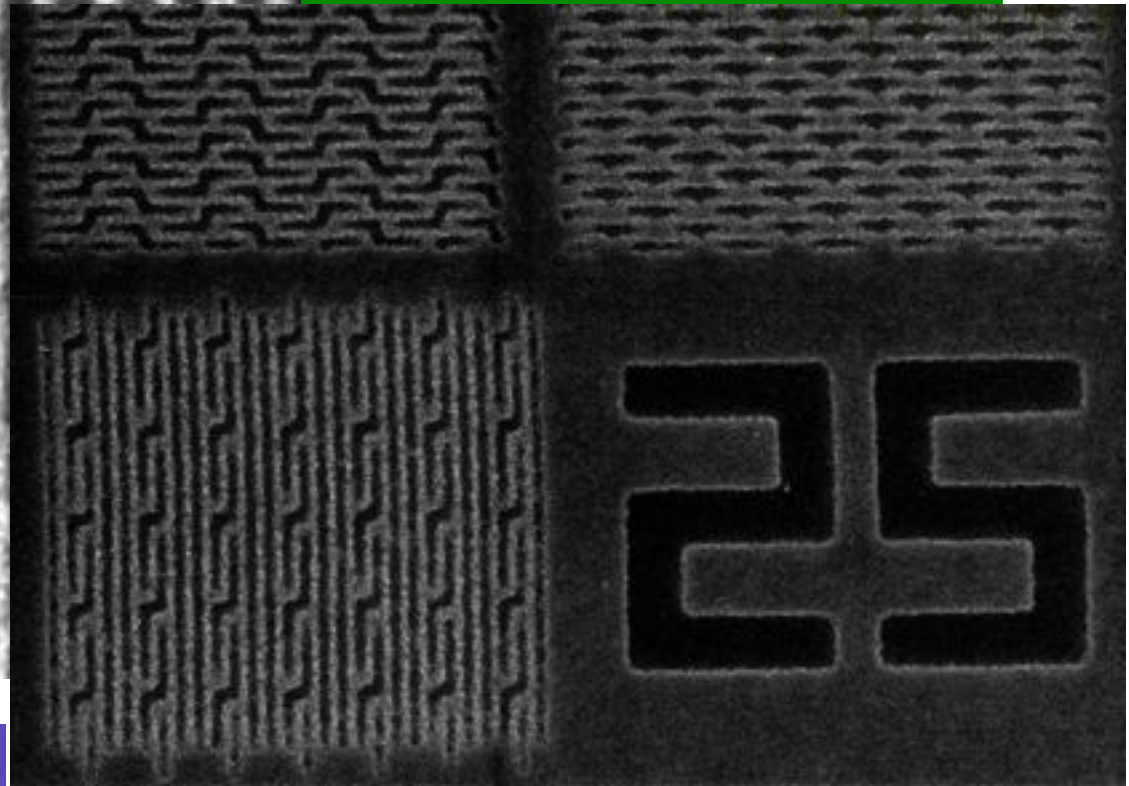
(Tetraethyl ammonium hydroxide)



Process Development for Increased Sensitivity



- 24 hp lines and 25 hp SRAM cell
- 35% TEAH
- 24 mJ/cm²



Courtesy Hiroki Nakagawa, Mark Slezak, JSR Micro

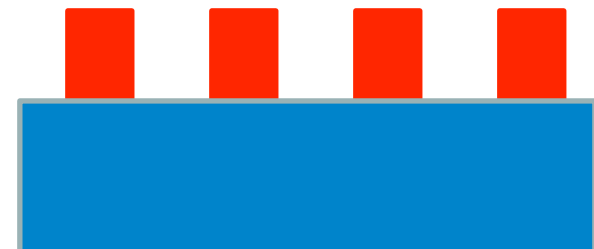
Pattern Collapse Mitigated

Resist Film Thickness Driven by EUV Absorbance and Etch

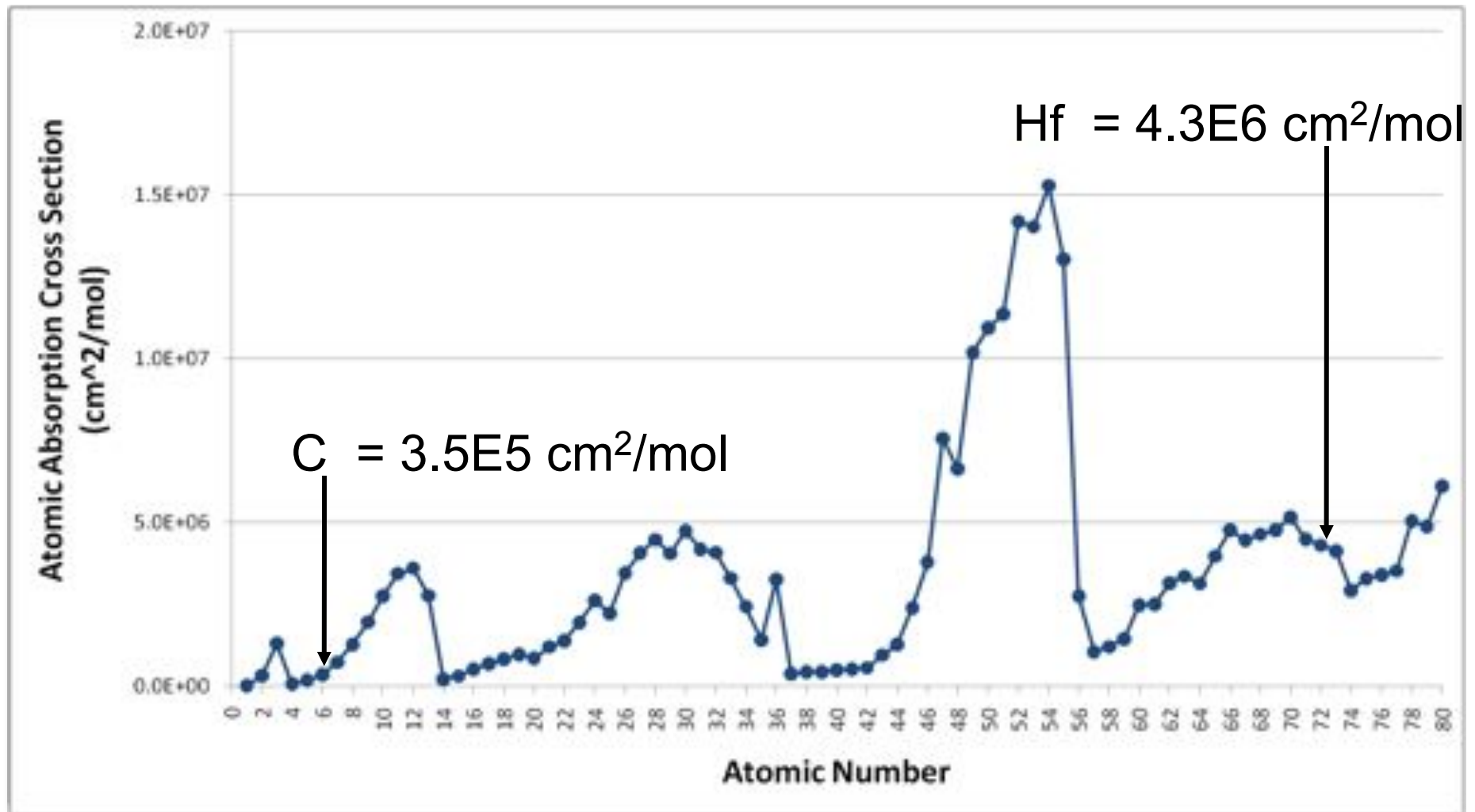
p-CAR



Metal
Oxide
Resist



EUV Photoabsorption Cross Section



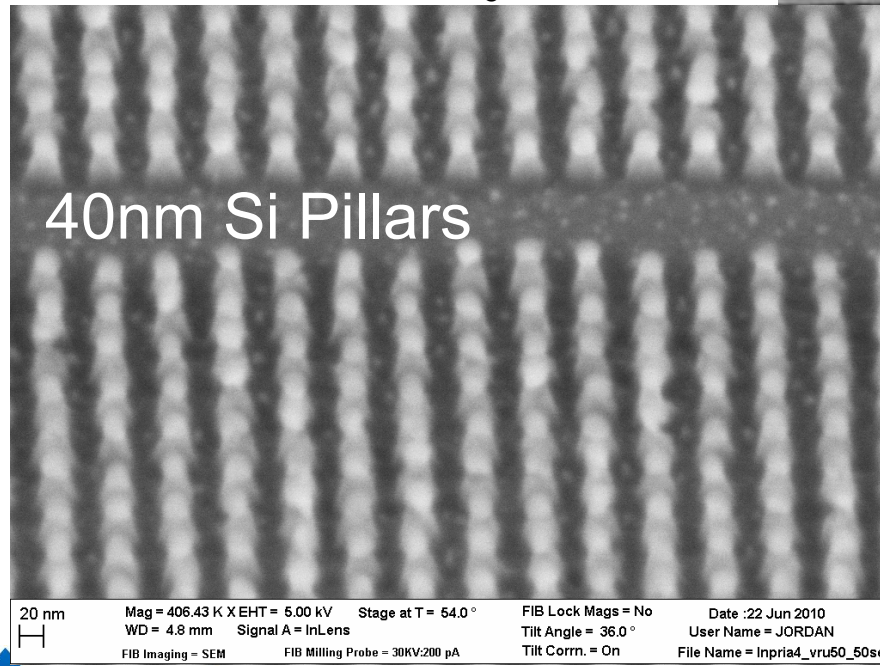
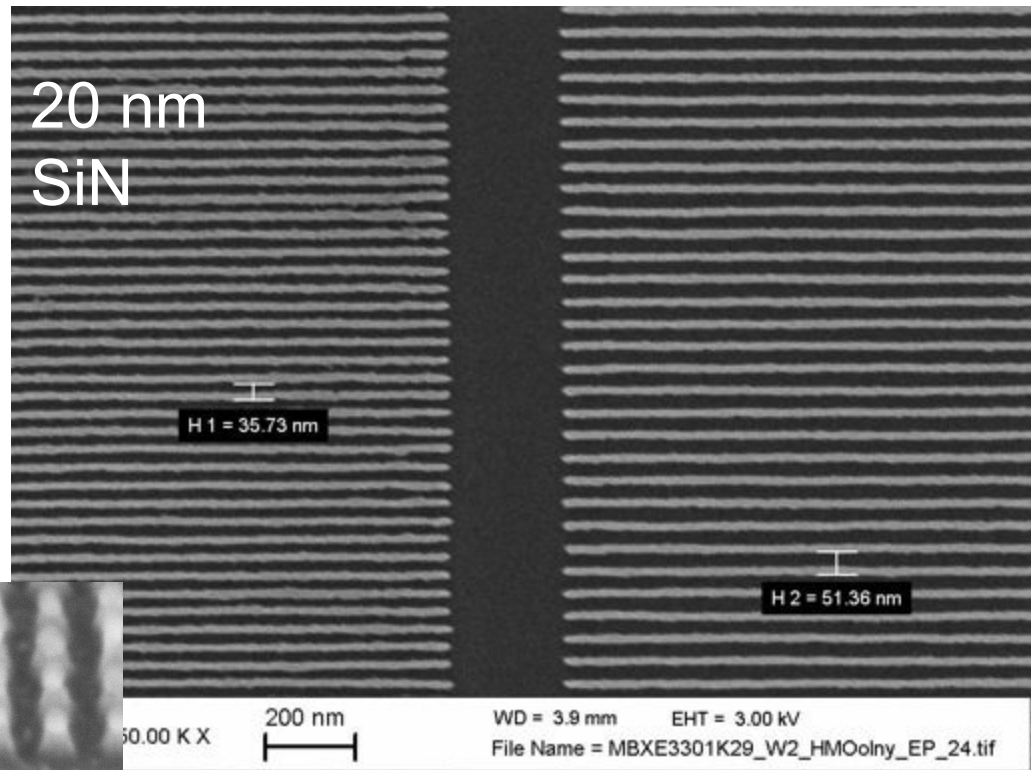
Pattern Transfer

**Direct transfer
using resist as
mask**

SF₆ based RIE

18 HP

25 HP



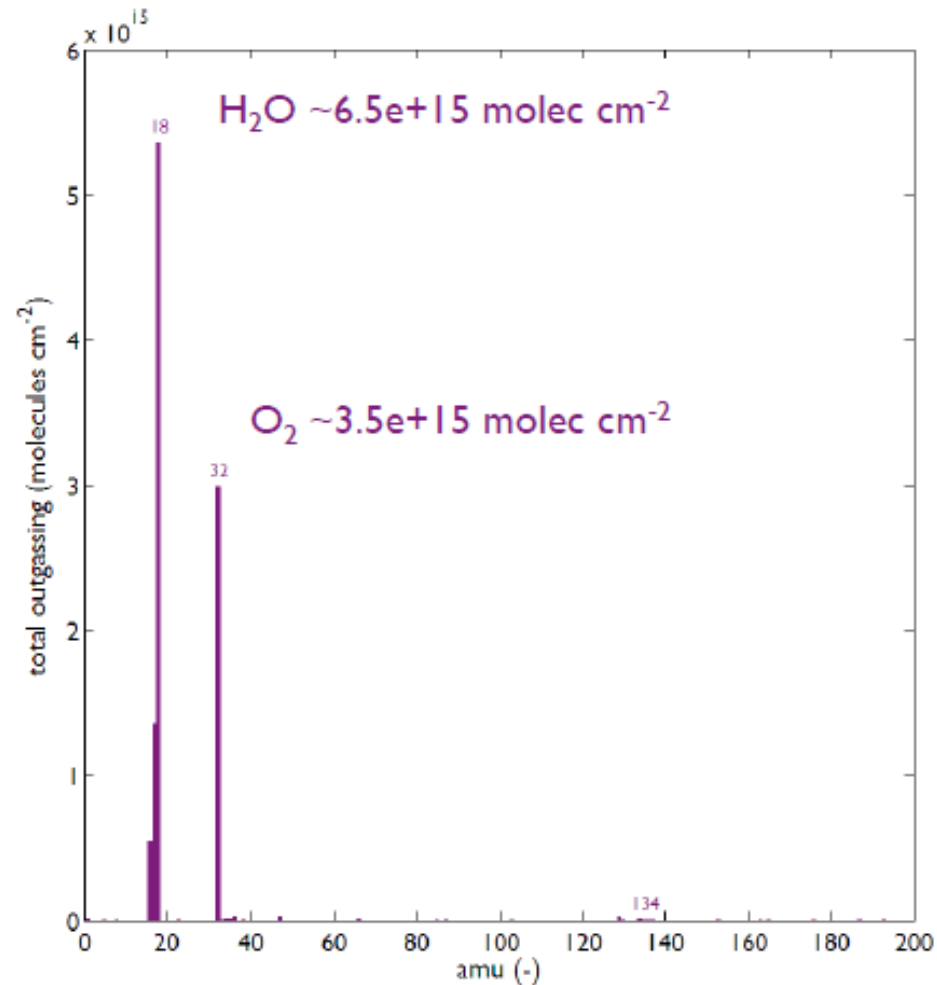
Courtesy;
Markus Brink
Ernst Kratschmer
Sebastian Engelmann
Michael Guillorn
IBM

25 HP

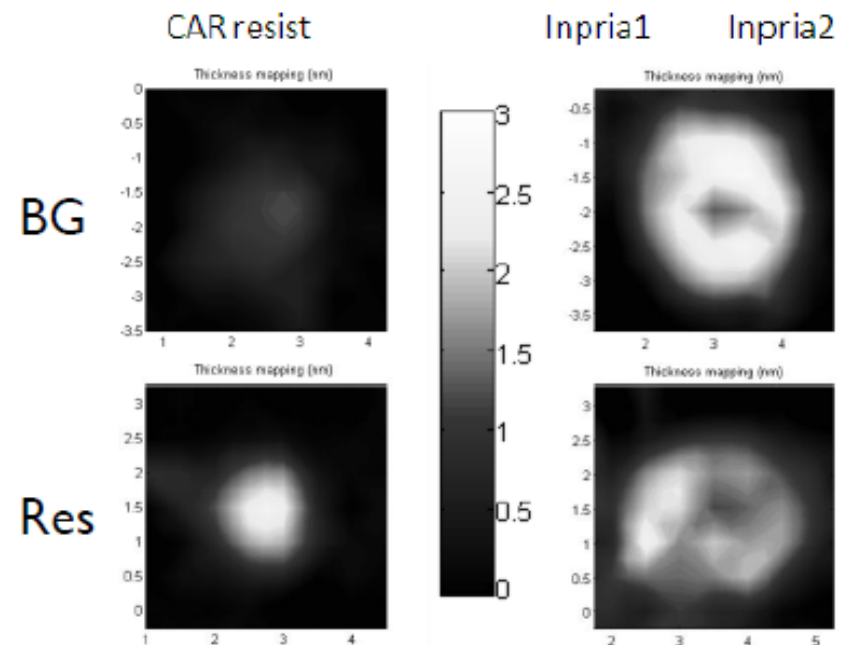
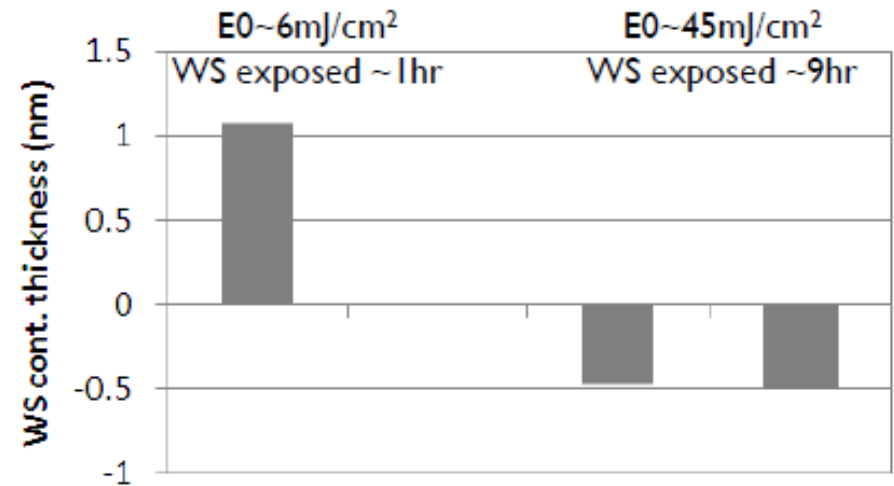
Courtesy; Jordan Katine,
Hitachi Global Storage Technologies



Outgassing Tests



H_2O and O_2 outgassing result in (carbon) contamination removal !



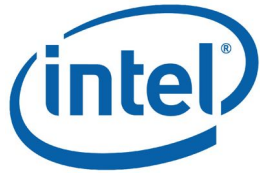
Courtesy Roel Gronheid, Ivan Pollentier, IMEC

Conclusions

- Inpria's metal oxide resist yields unprecedented EUV pattern fidelity with no acid blur
 - <16nm hp demonstrated
 - 2D imaging: 20nm SRAM cell printed on 0.3NA MET
 - Capable of very low LWR
- Ultrathin imaging mitigates pattern collapse
- Completely inorganic
 - Demonstrated very low outgassing relative to scanner specs
- Development underway for improved sensitivity, alternate developer and underlayer integration



Acknowledgments



- This work was supported by SBIR grants from the National Science Foundation