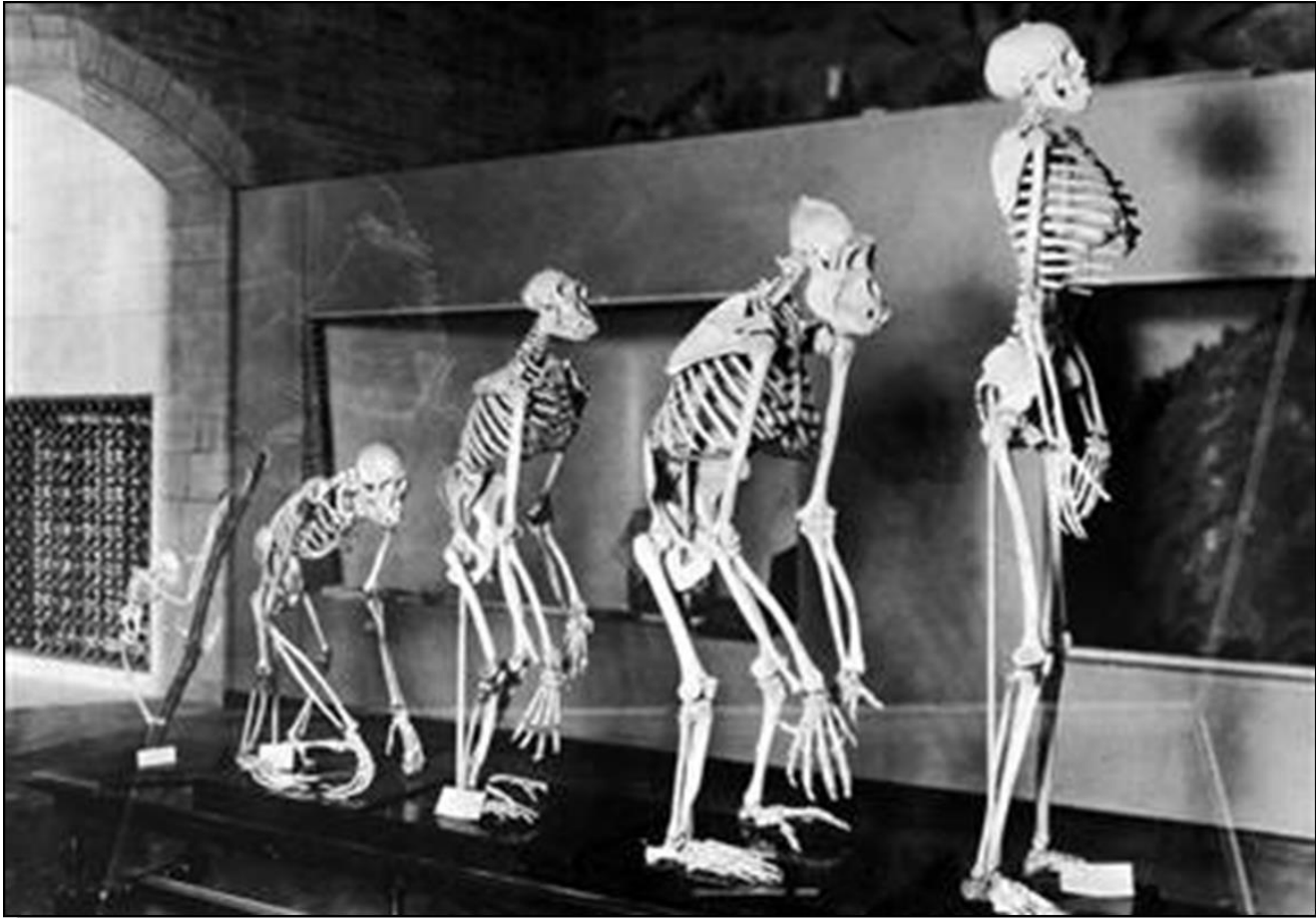
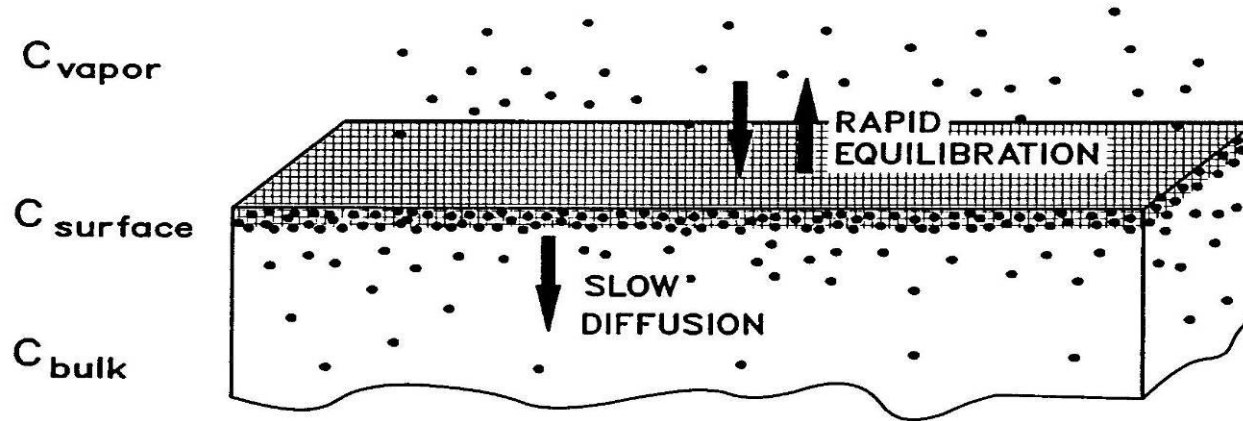


Lecture 15

Chemical Engineering for Micro/Nano Fabrication



Polymer Permeability



$$C_{\text{surface}} = S \times C_{\text{vapor}} \quad (\text{Henry's Law})$$

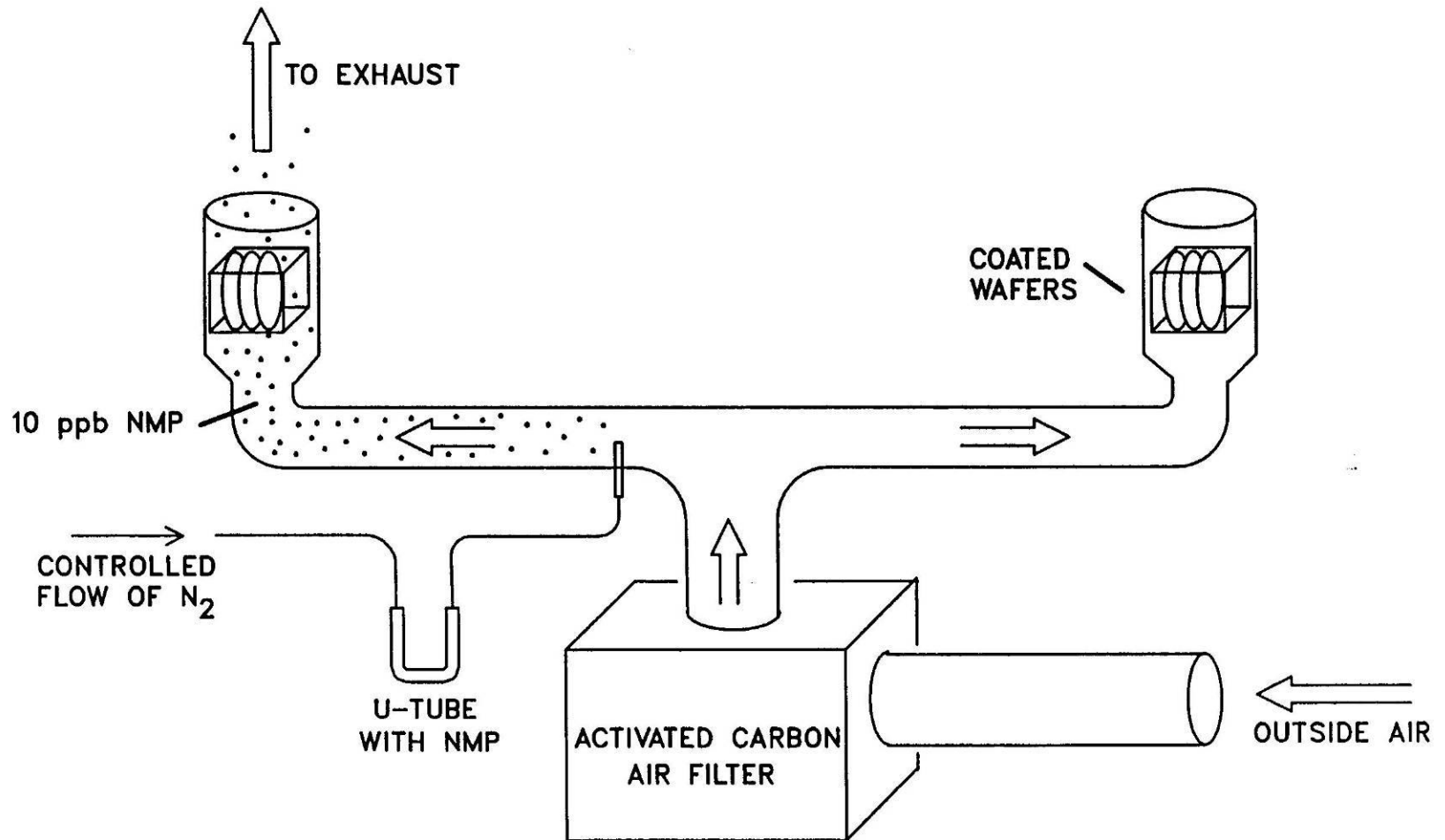
$$\text{Diffusion Rate} = -D \frac{dC}{dx} \quad (\text{Fick's Law})$$

$$\frac{dC}{dx} = f(C_{\text{surface}}) \text{ so}$$

$$\text{Sorption Rate} = f(\text{Solubility, Diffusivity})$$

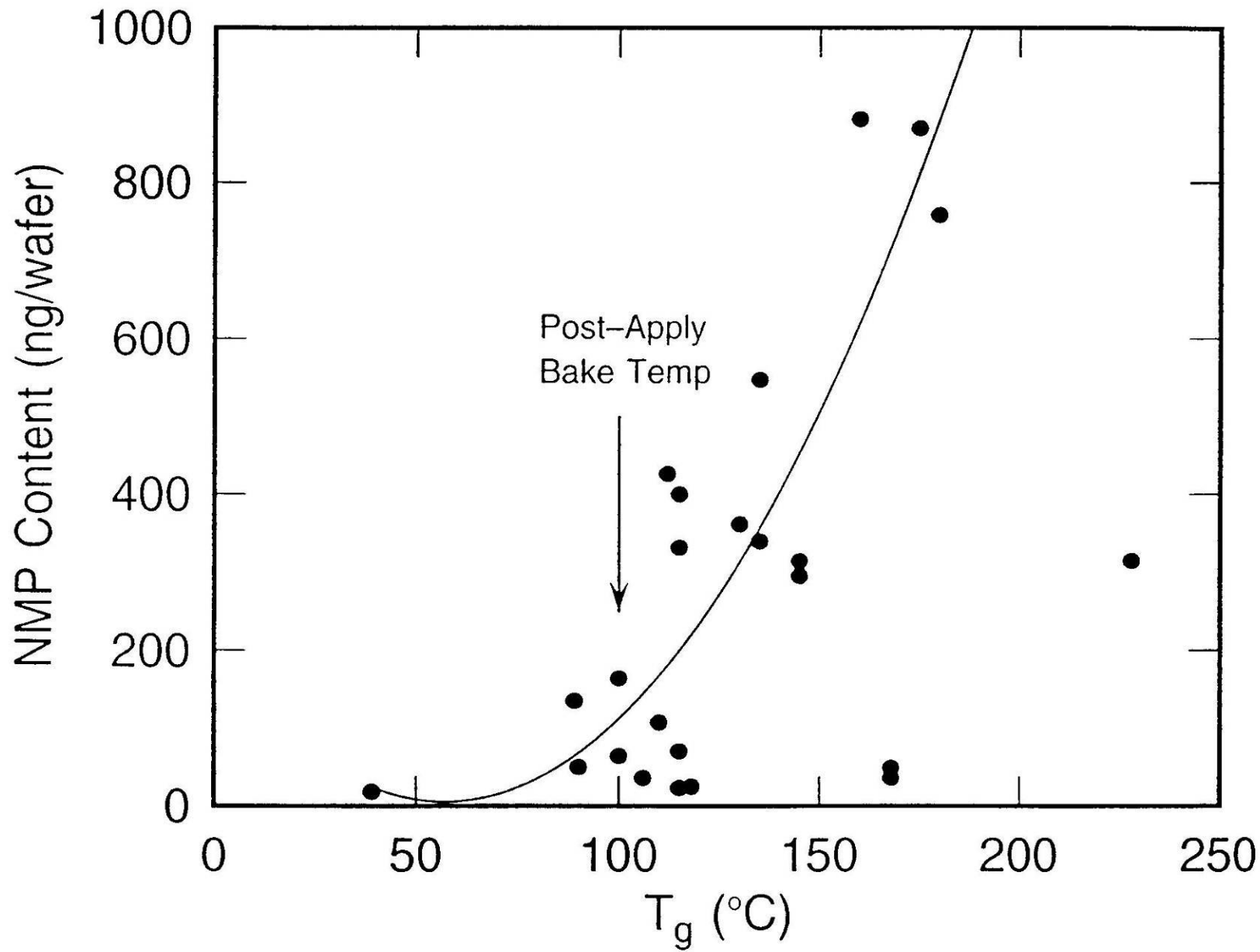


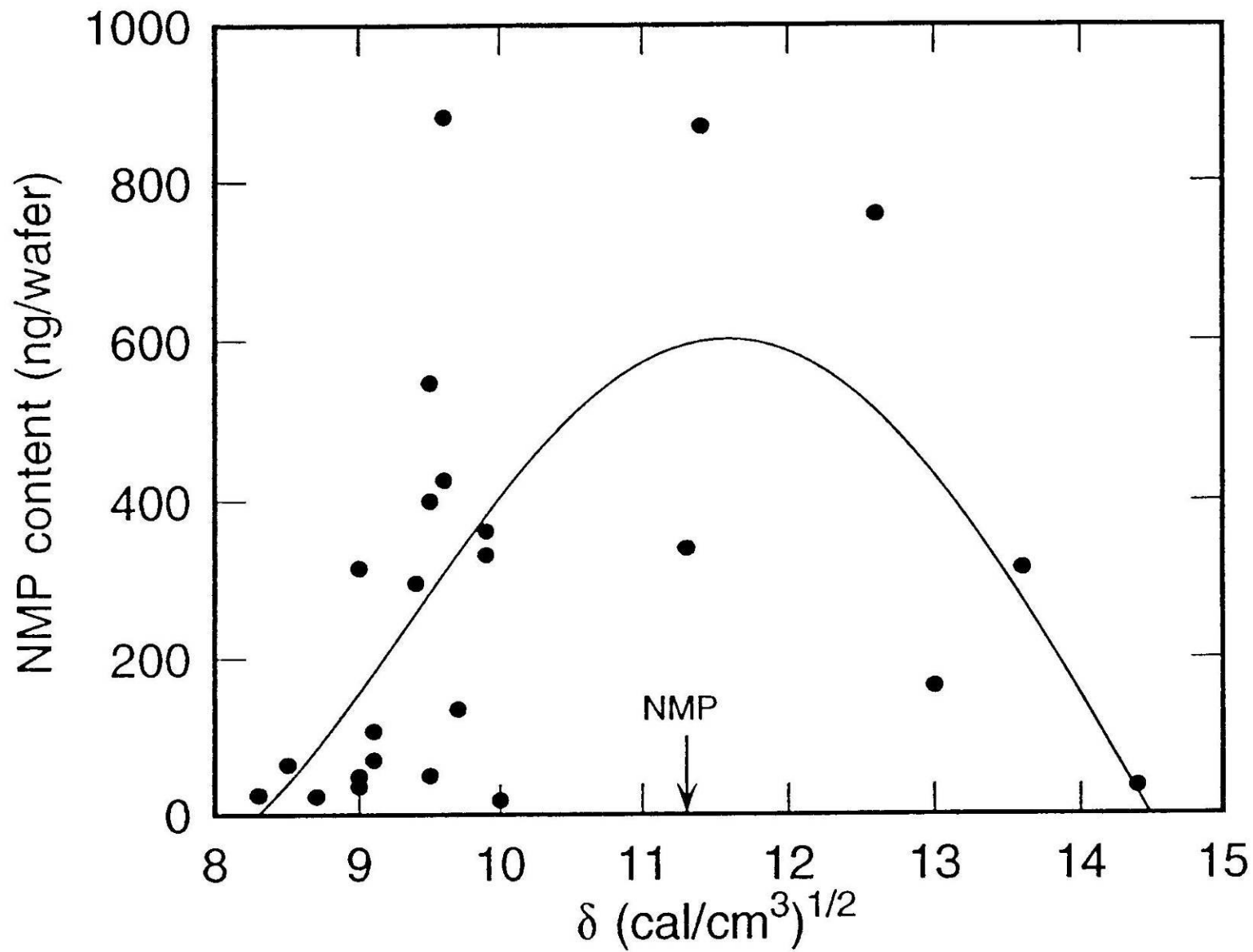
Experimental Apparatus



Polymer	NMP Content (ng/wafer)	Solubility Param. (cal/cm ³) ^{1/2}	T _g (°C)
poly(methylmethacrylate)	70	9.1	115
poly(4-t-BOC-styrene)	547	9.5	135
poly(4-t-BOC-styrene) from Maruzen PHOST	400	9.5	115
m-cresol novolac	164	13.0	100
poly(4-hydroxystyrene)	758	12.6	180
poly(styrene)	64	8.5	100
epoxy cresol novolac	18	10.0	39
poly(MMA-TBMA-MAA)	296	9.4	145
poly(α -Me-styrene-co-Bz-MA)	107	9.1	110
poly(t-Bu-vinylbenzoate)	882	9.6	160
poly(3,5-Me ₂ -4-t-BOC-styrene)	362	9.9	130
poly(t-butyl methacrylate)	25	8.3	118
poly(TBMA-MMA)	23	8.7	115
poly(3,5-Me ₂ -4-hydroxystyrene)	870	11.4	175
poly(α -Me-styrene) (low MW)	49	9.0	168
poly(α -Me-styrene) (high MW)	36	9.0	168
poly(acrylic acid)	36	14.4	106
poly(4-t-butylstyrene)	315	9.0	145
poly(4-acetoxystyrene)	332	9.9	115
poly(methacrylic acid)	315	13.6	228
poly(4-MeO-styrene)	135	9.7	89
poly(4-MeO-styrene-co-4-t-BOC-styrene)	426	9.6	112
poly(3-t-BOC-styrene)	50	9.5	90
p(3-Me-4-hydroxystyrene)	340	11.3	135



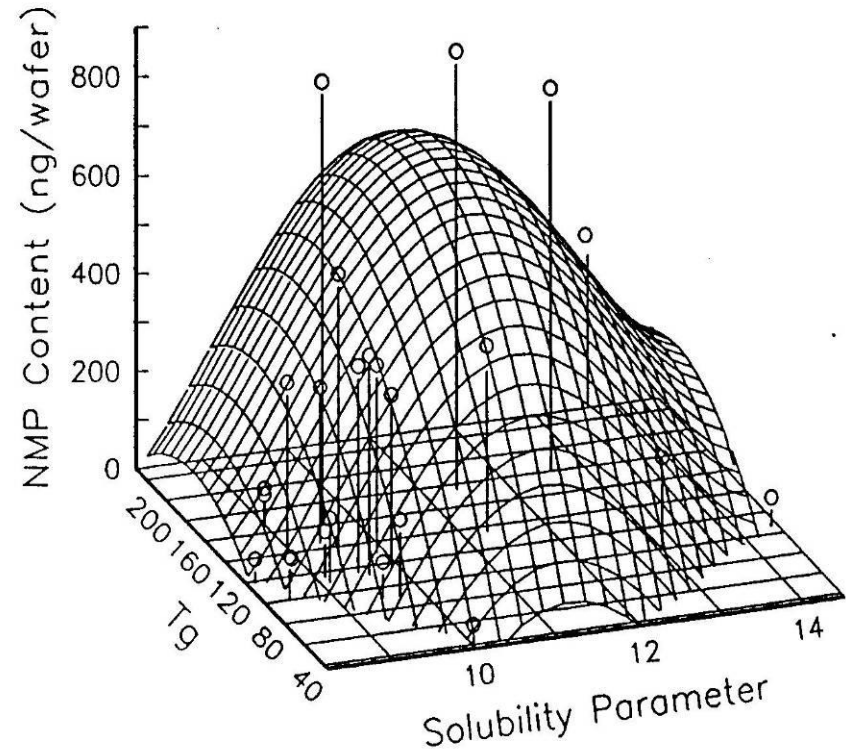
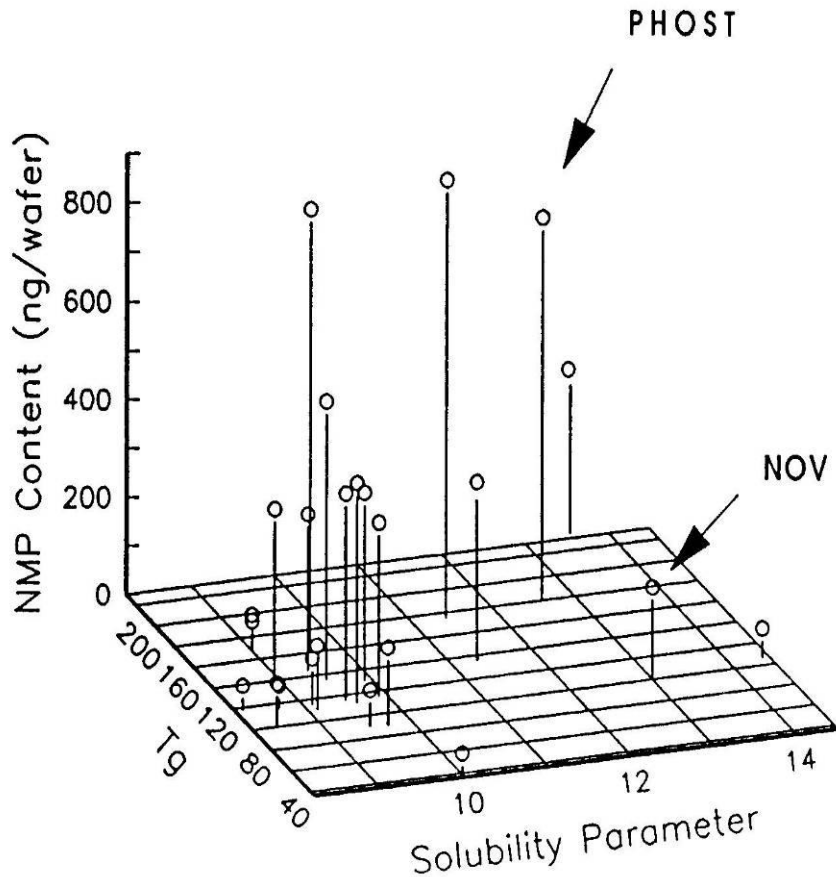




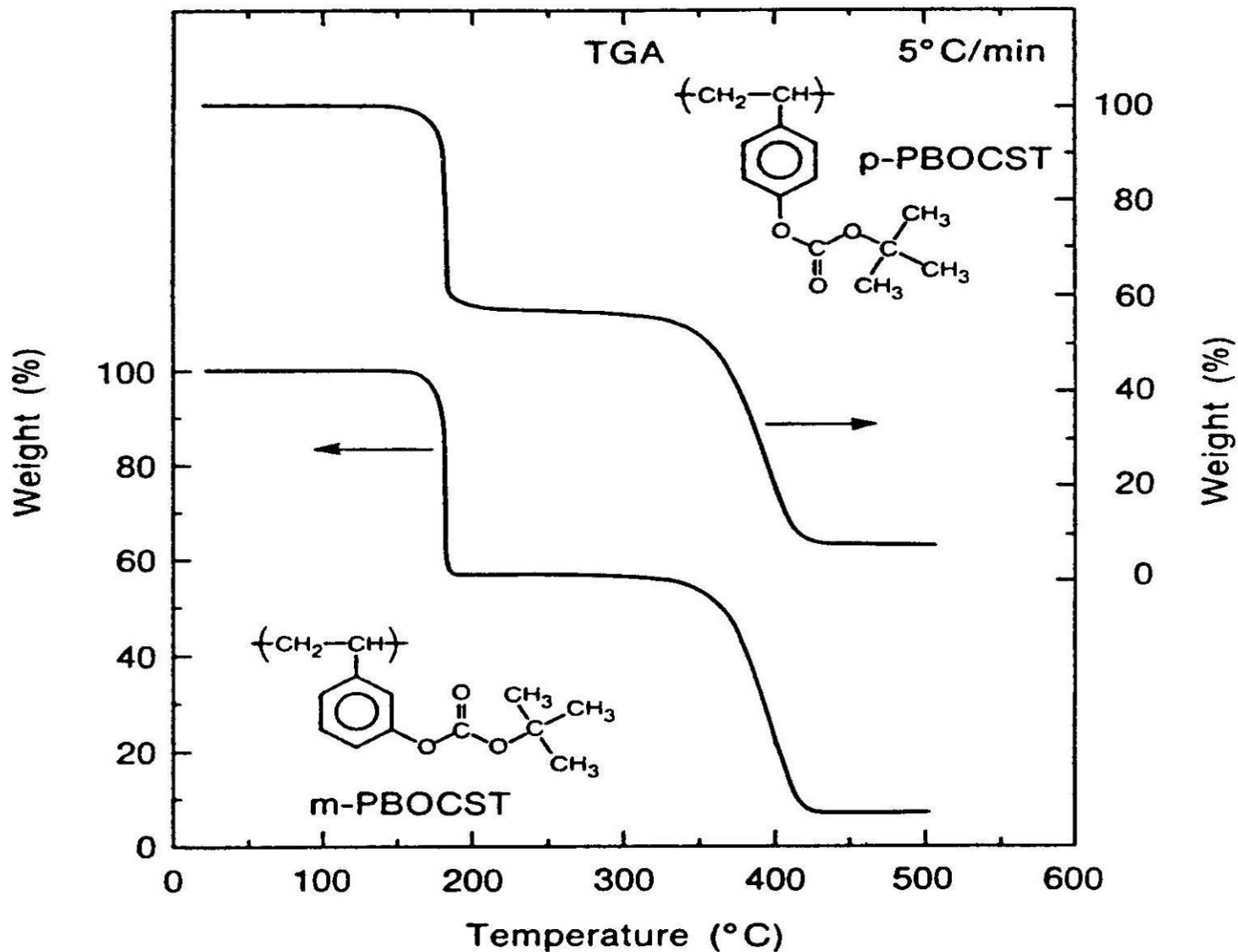
NMP Absorption versus Solubility Parameter

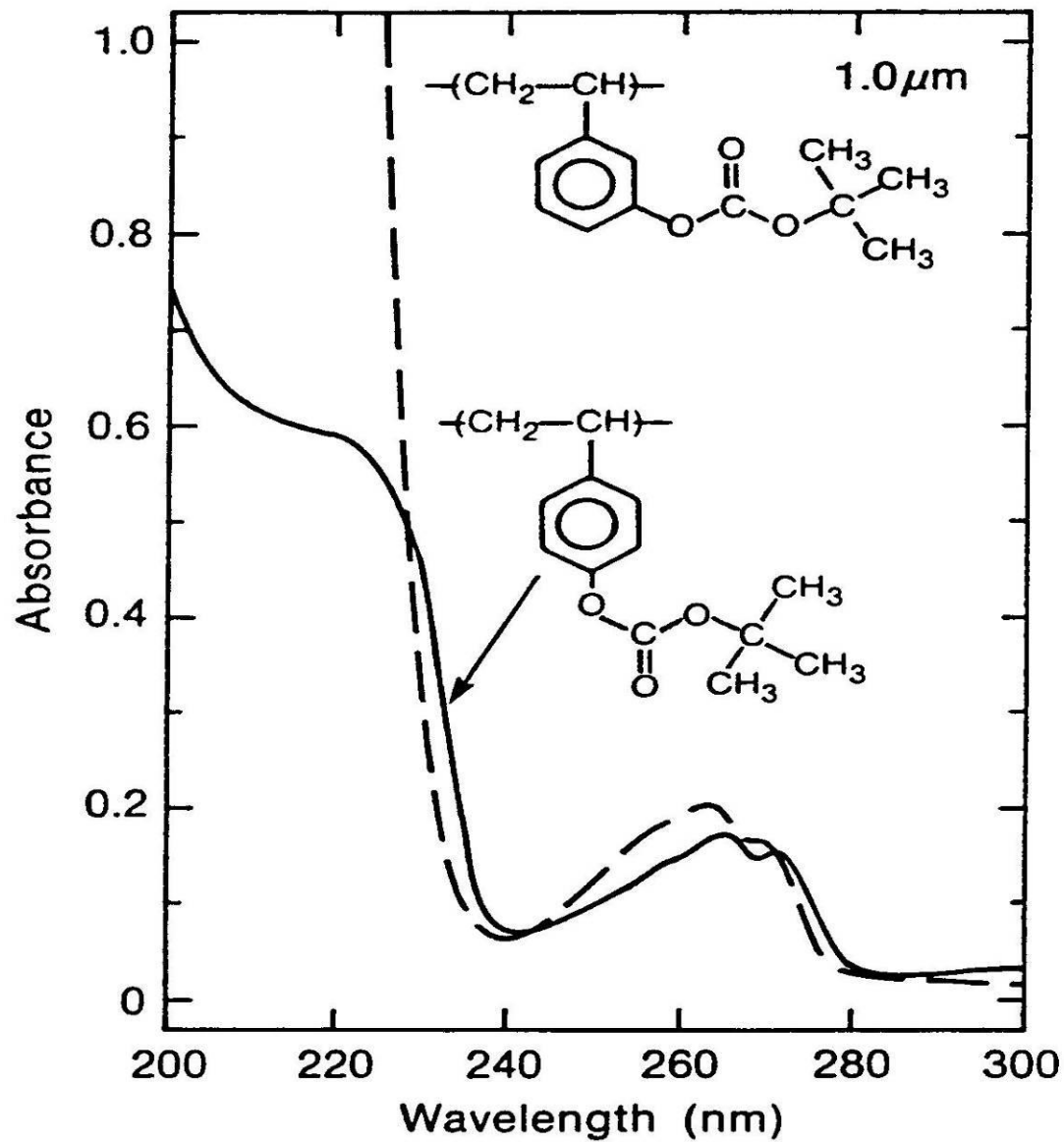


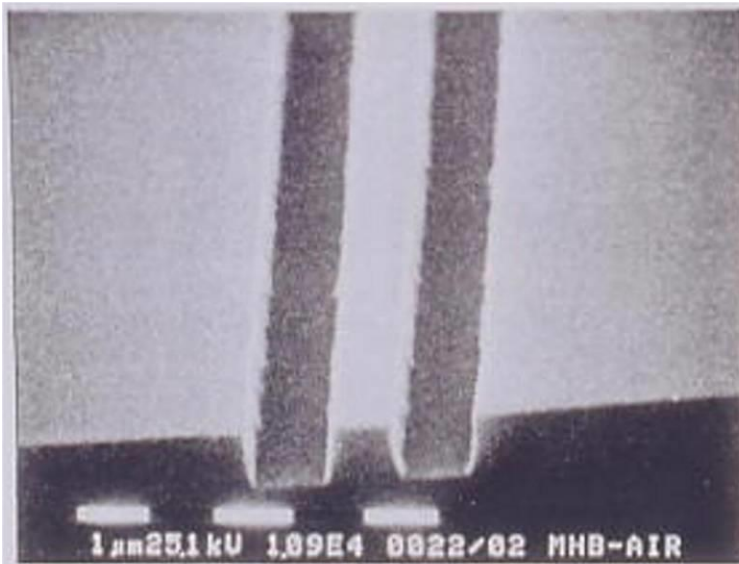
NMP Uptake vs T_g and Solubility Parameter



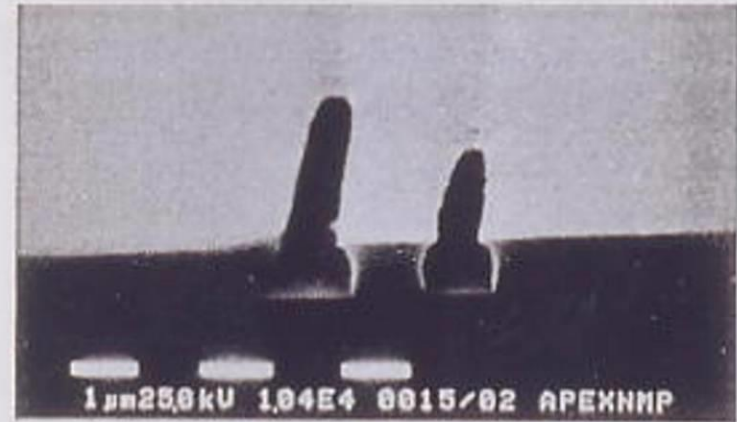
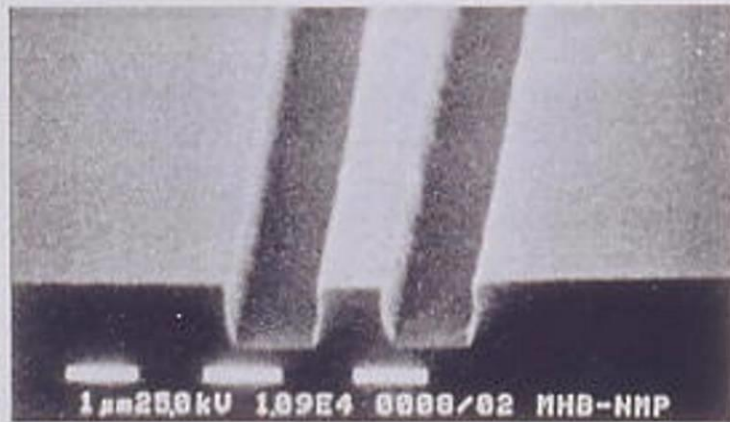
Thermogravimetric analysis





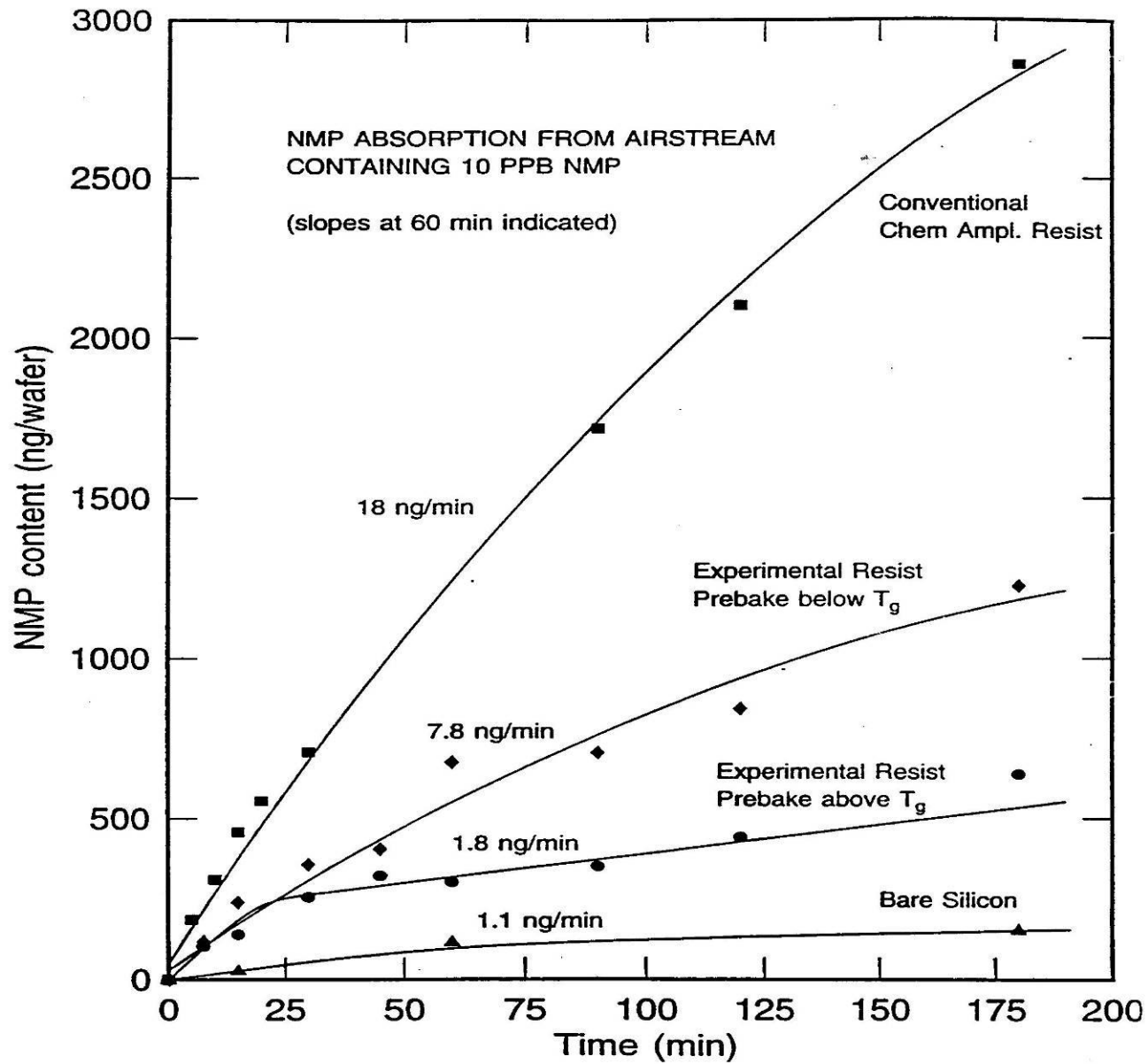


Filtered Air (15 min)

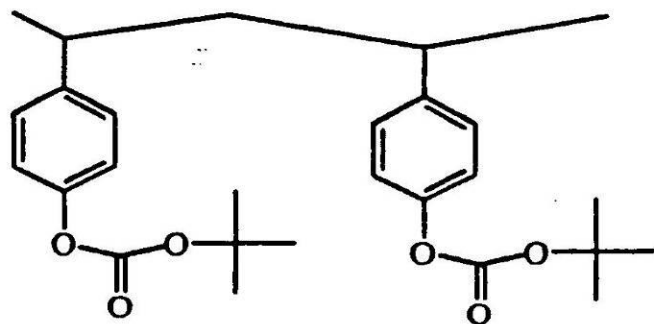


10 ppb NMP (15 min) before exposure

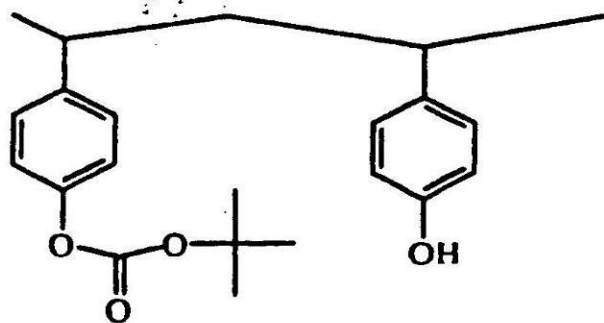
Effects of filtered air (top) and 10ppb NMP (bottom) on positive images printed in the meta- (left) and para- (right) P(HOST-co-BOCST) resists.



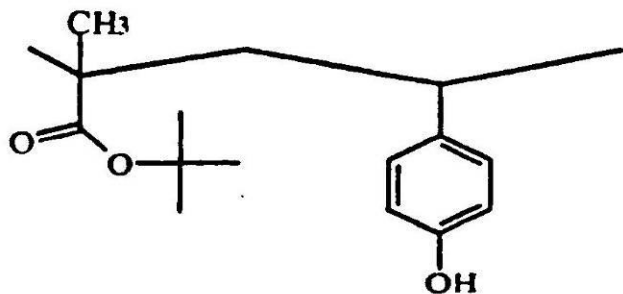
The "Family"



t-BOC



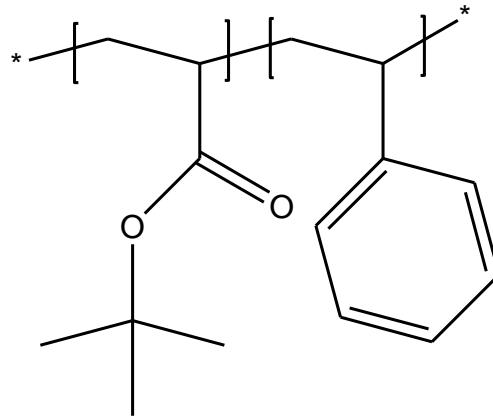
APEX



ESCAP



ESCAP

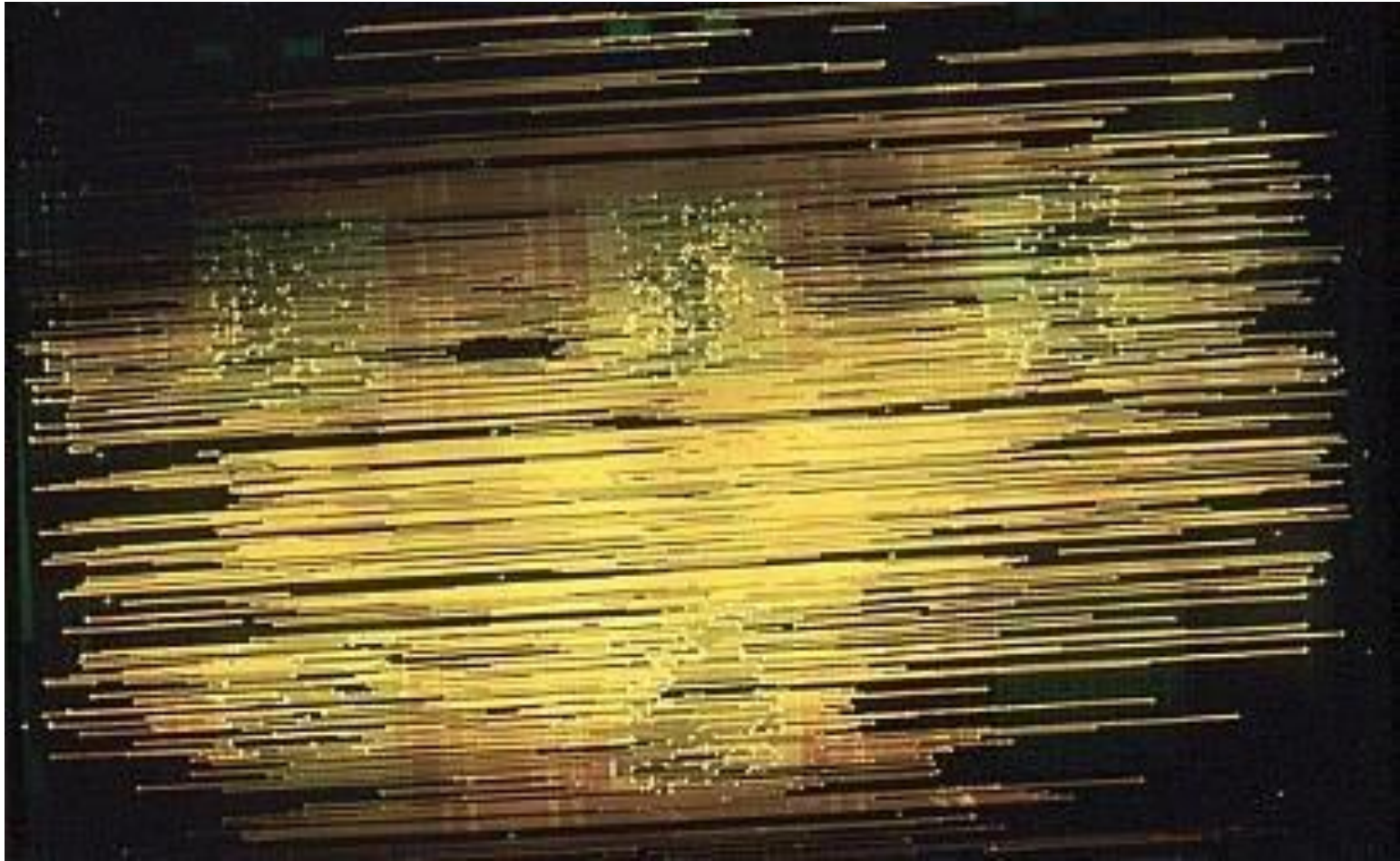


- Acrylic reduces solubility of NMP
- Acrylic ester more thermally stable than the t-butyl carbonate
- Enables post apply bake Temp > T_g
- Bake > T_g decreases permeance

Hiroshi Ito



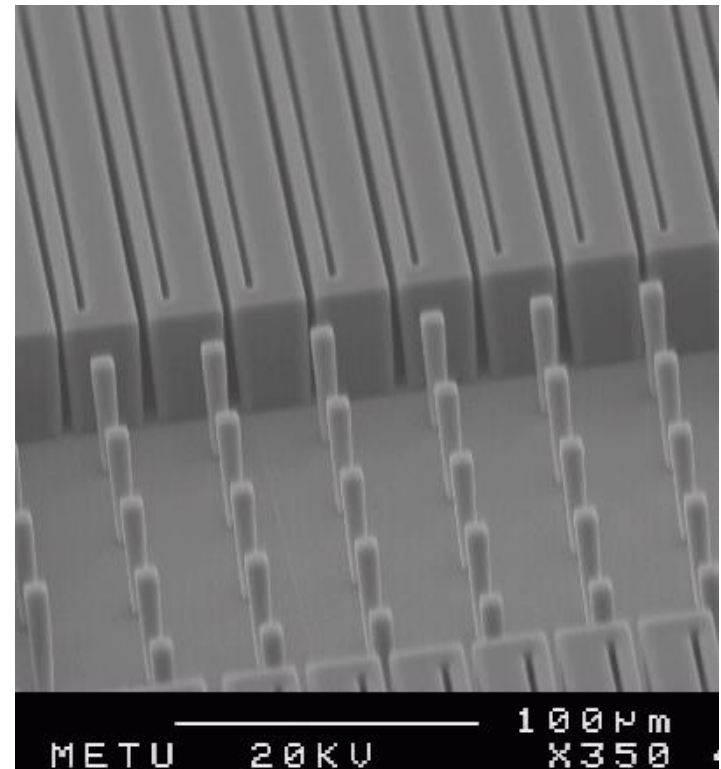
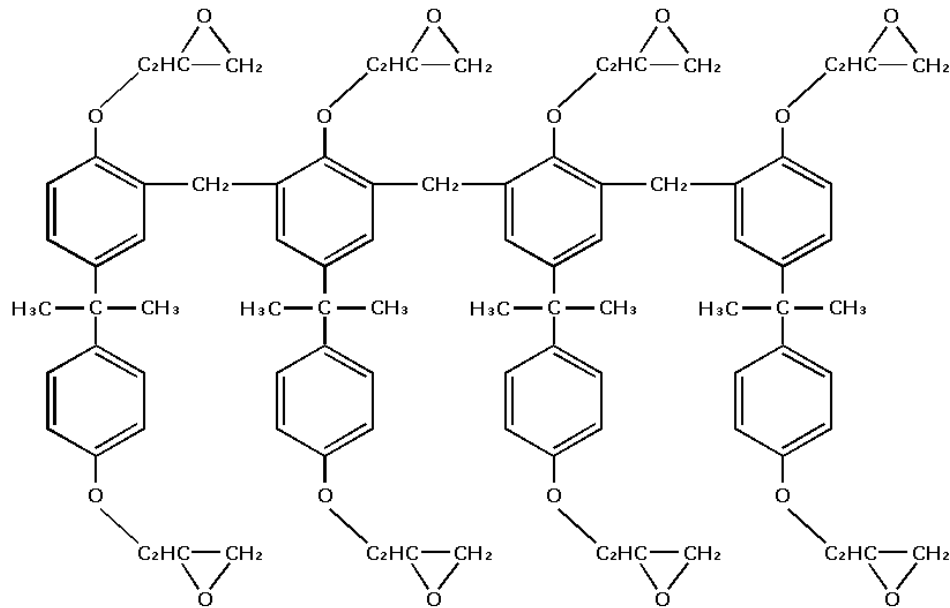
IBM Mainframe Circuit Board



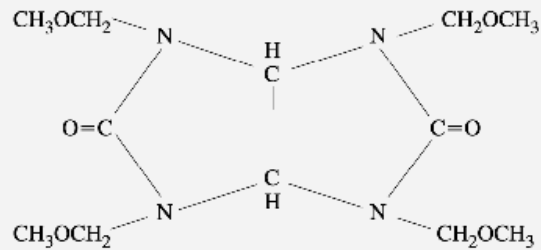
one of 20 layers printed circuit board that contained nearly a mile of wire interconnections used in IBM Mainframes.



SU-8 Negative Resist

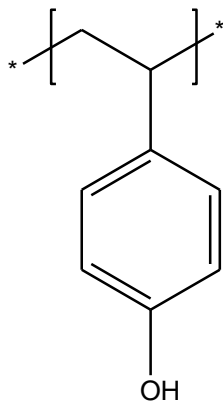


IBM CGR Negative Resist



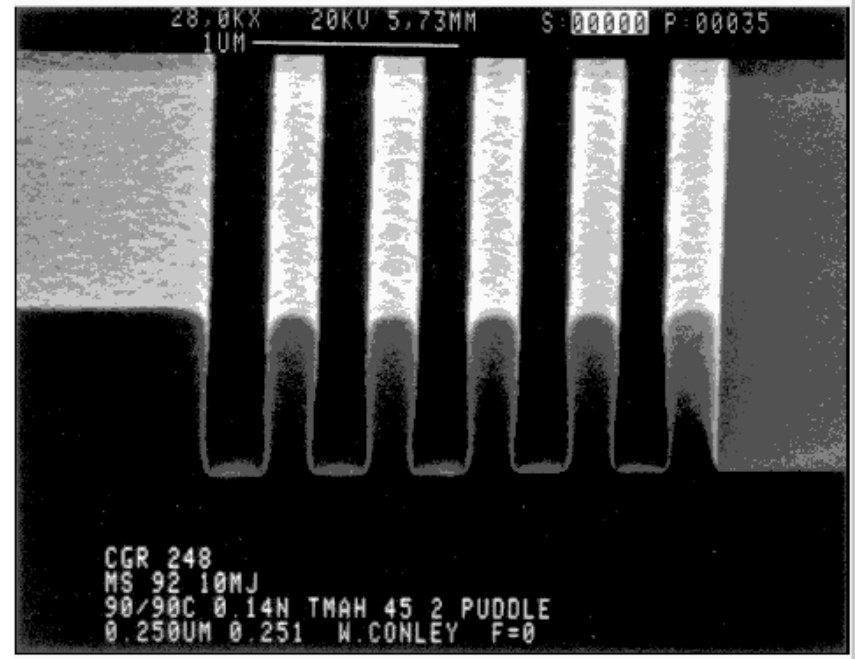
Formula IX

Powderlink 1174 cross-linker.



PAG

ChE 384T / 323

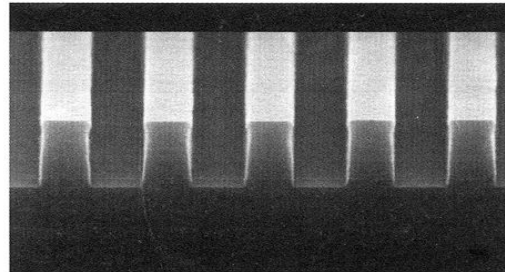


Eliminate Contamination of DUV Resist

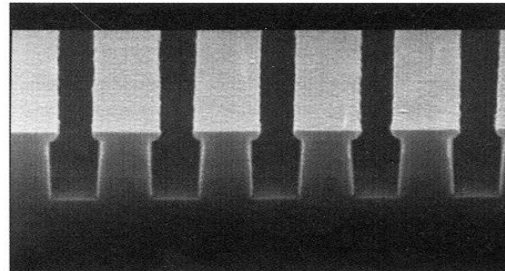
Chemical Air Filter System

Superior contamination control for deep ultraviolet microlithography applications

The Problem:
DUV photoresist patterns degrade after exposure



0.44 micron profile with no delay in alkaline contaminated environment.

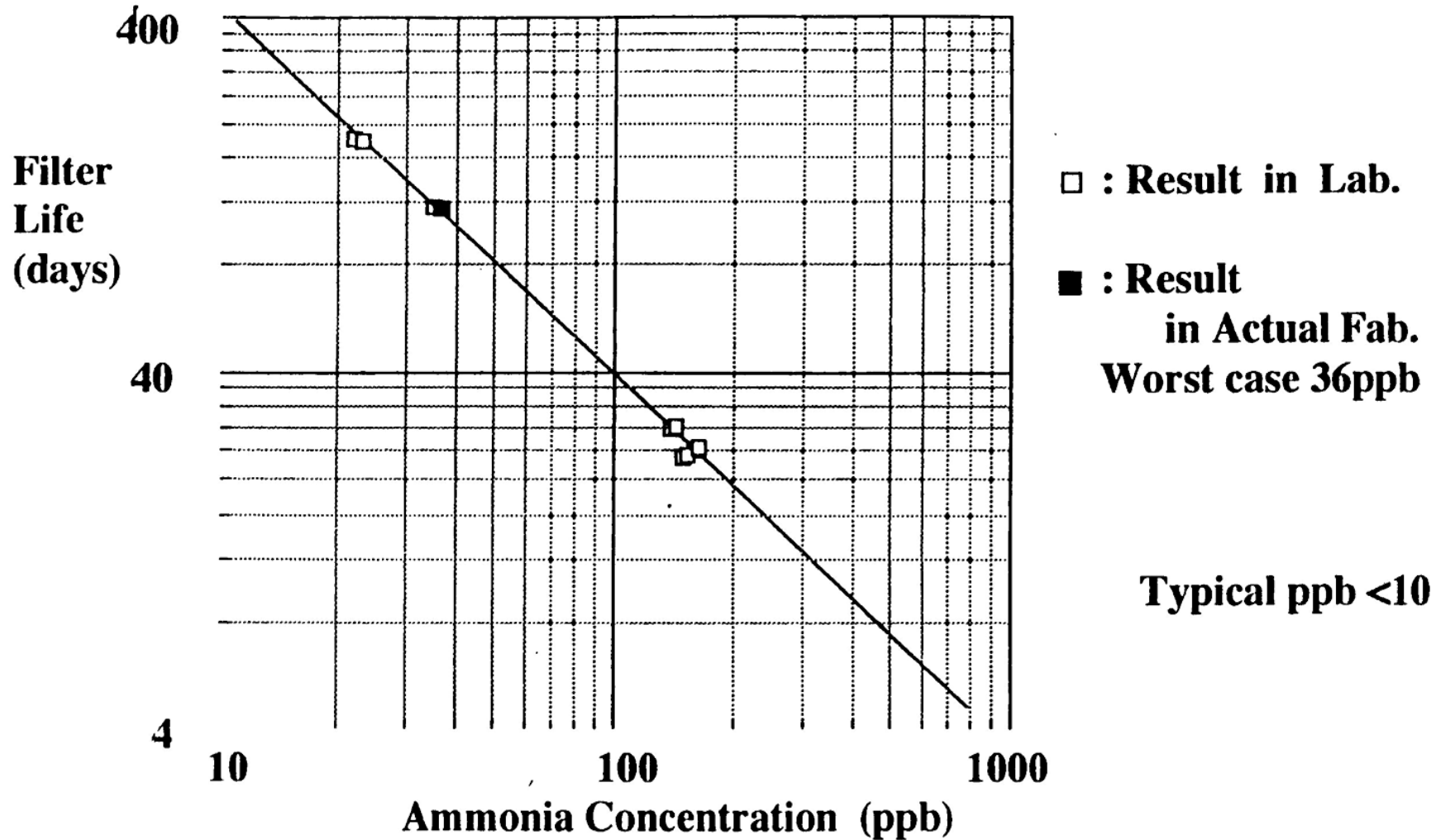


0.44 micron profile after delay in alkaline contaminated environment.

The Solution:
Remove gaseous alkaline contaminants with VaporSorb



Actual Data - Filter Life vs NH₃ Concentration



Entergris, Inc



Air purification system

