


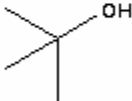
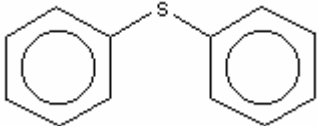
## What outgasses from photoresist?

From Kim Dean, “How much is too much”

Compound	Frequency	Comments
Benzene	72	PAG by-product
2-Methyl-1-propene (Isobutene)	41	Polymer protection product (ester)
Ethyl adamantane	14	Polymer protection product
Tert-butyl-benzene	13	PAG by-product
Acetaldehyde	10	Polymer protection product (acetal)
Alpha-methylstyrene	9	PAG by-product?
Cyclohexanone	6	Polymer protection product
2-Methyl-2-propanol	6	Polymer protection product

Plus CO, CO<sub>2</sub> and some sulfur compounds

## Chosen species for injection and exposure of mirrors to measure contamination

Contaminants	Formula	Structure	Molecular weight (amu)	Boiling point (°C)
Benzene	$C_6H_6$		78	80.1
Tert-butanol	$C_4H_{10}O$		74	82
Diphenyl Sulfide	$C_{12}H_{10}S$		186	296.2

Intended to represent known or similar structures that may outgas from resists

## Reflectivity results due to contamination from these species

Chamber Conditions	Chamber Pressure (Torr)	Exposure time (hours)	Total Dose (J/cm <sup>2</sup> )	Number of pulses (millions)	Reflectivity drop ( $\Delta R/R\%$ )
Clean (background)	$2.5 \times 10^{-8}$	8	29	36	0.35
Benzene	$1 \times 10^{-6}$	8	29	36	0.35
Tert-Butanol	$3 \times 10^{-6}$	8	11.5	36	-0.09
Diphenyl Sulfide	$1 \times 10^{-6}$	4.2	15	19	0.1
Diphenyl Sulfide	$1 \times 10^{-6}$	3.6	13	16	-0.23
Diphenyl Sulfide	$1 \times 10^{-6}$	2.9	42	13	0.1

No significant reflectivity loss for these species at these pressures and doses



## Comparison to outgassing from a full wafer

- Benzene is one of the common resist outgassing components
- From our outgassing measurements, a typical resist outgasses  $5 \times 10^{13}$  molecules/cm<sup>2</sup> of benzene
- In our 8 hour, 36 million pulse, 29 J/cm<sup>2</sup> exposure, we require  $2.8 \times 10^{20}$  molecules of benzene in a chamber with a pumping speed of 300 liters/second to keep the pressure at  $1 \times 10^{-6}$  Torr
- That is the equivalent amount of benzene outgassed by approximately 8000 wafers of typical resist
  - And we didn't see measurable reflectivity changes in this exposure
- However, it is difficult to extrapolate to much higher power and longer exposures such as in future high volume EUV tools