

Thrust B

Ozonated Water Research Directions

Sangwoo Lim

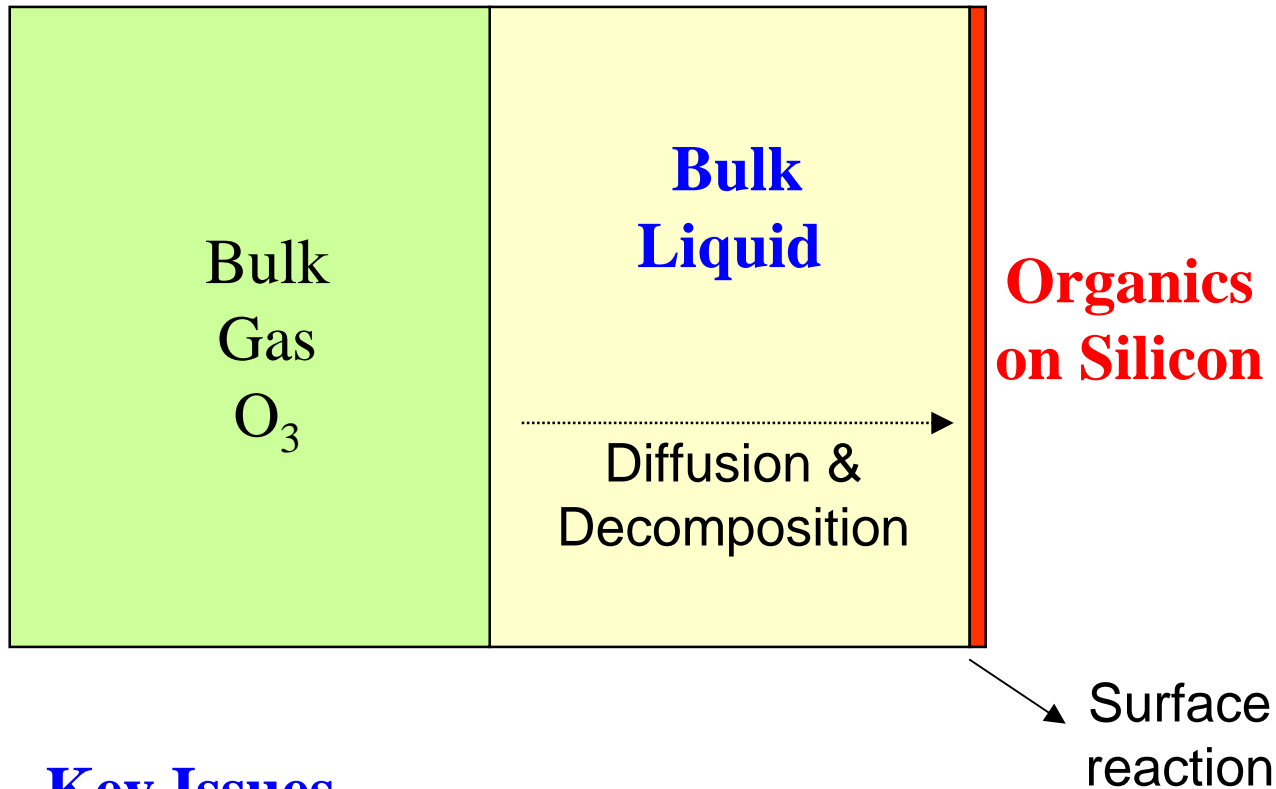
Dept. of Electrical Engineering
Stanford University

Ozonated Water Cleaning Impact

Resist striping & replacement for Piranha cleaning

- CoO; 29% reduction compared to piranha.
- Environmental Gain
 - Eliminates most H_2SO_4 use and waste.
 - Less UPW use, due to elimination of H_2SO_4 rinse.
- Safety
 - Eliminates exposure to hot piranha
 - Need to learn how to handle O_3 safely.

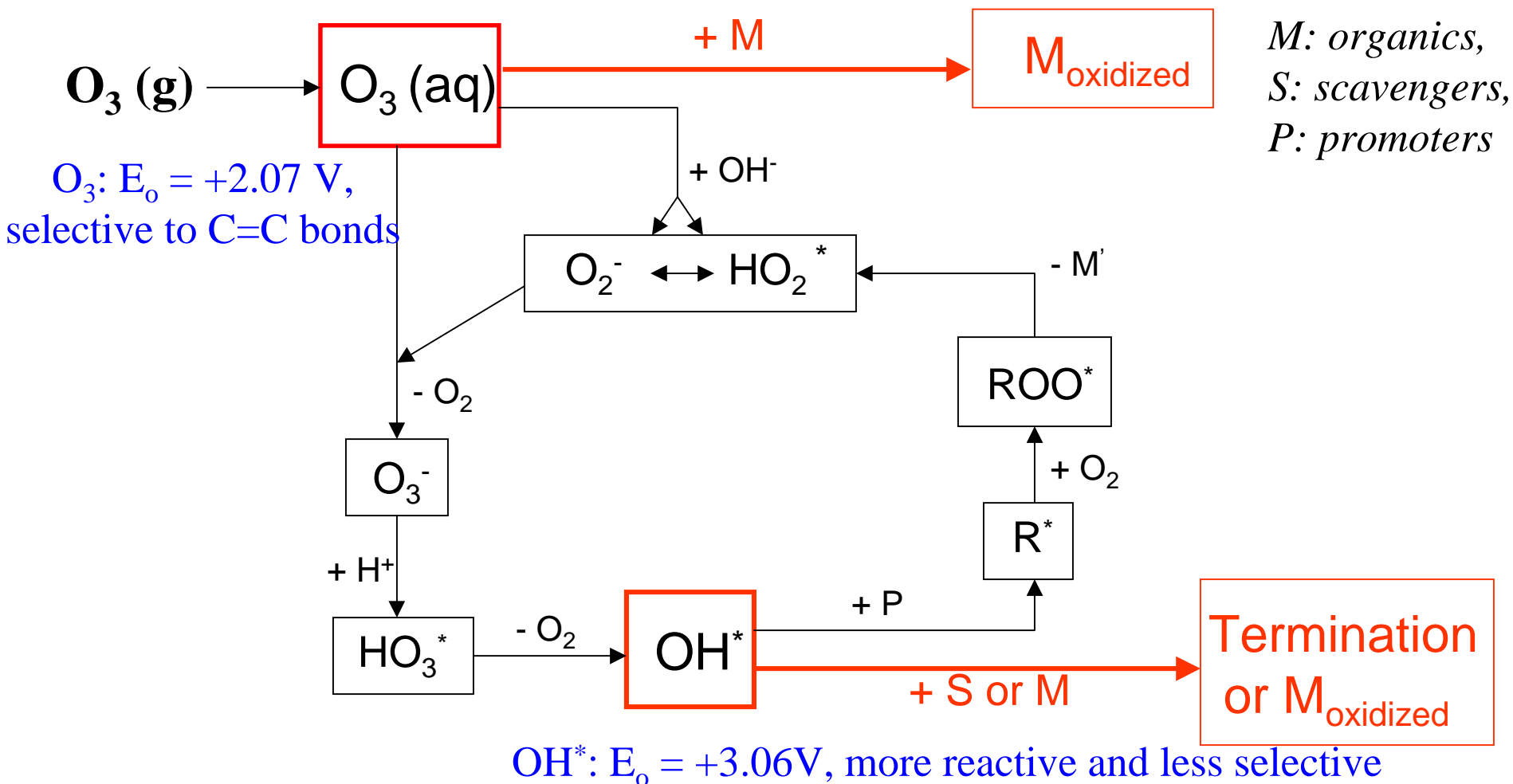
Process



Key Issues

- **Boundary Layer Control**
- **O_3 Decomposition**

O₃ Decomposition Model



Chain Reaction Chemistry

1. Direct consumption of O_3 , e.g., phenol
2. Initiation of O_3 decomposition, e.g., OH^- , glyoxylic acid
3. Propagation, e.g., formic acid, methanol
(OH^* scavenged, but O_2^{*-} reformed.)
4. Termination, e.g., tert-butanol, HCO_3^- , CO_3^{2-}
(OH^* scavenged, and no O_2^{*-} or H_2O_2 formed.)

Cleaning Parameters

S. De Gendt et al., *Symp. on VLSI Technol.* p.168, 1998.

- pH \uparrow : $[O_3]$ \downarrow
- promoter addition $[H_2O_2]$ \uparrow : $[OH^*]$ \uparrow , $[O_3]$ \downarrow ,
resist removal \downarrow
- inhibitor addition $[CH_3COOH]$ \uparrow : $[OH^*]$ \downarrow , $[O_3]$ \nearrow ,
resist removal \nearrow
- Temperature \uparrow : $[O_3]$ \downarrow , but removal efficiency/ $[O_3]$ \uparrow

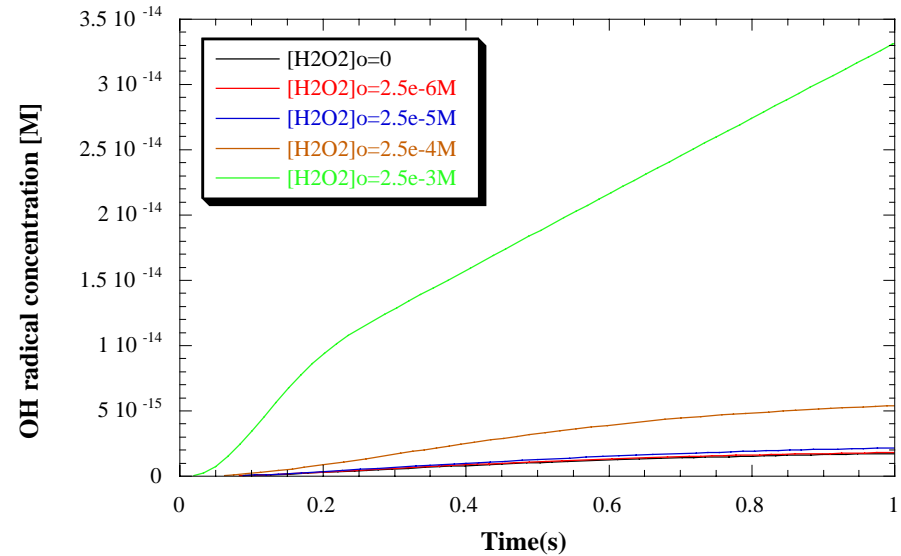
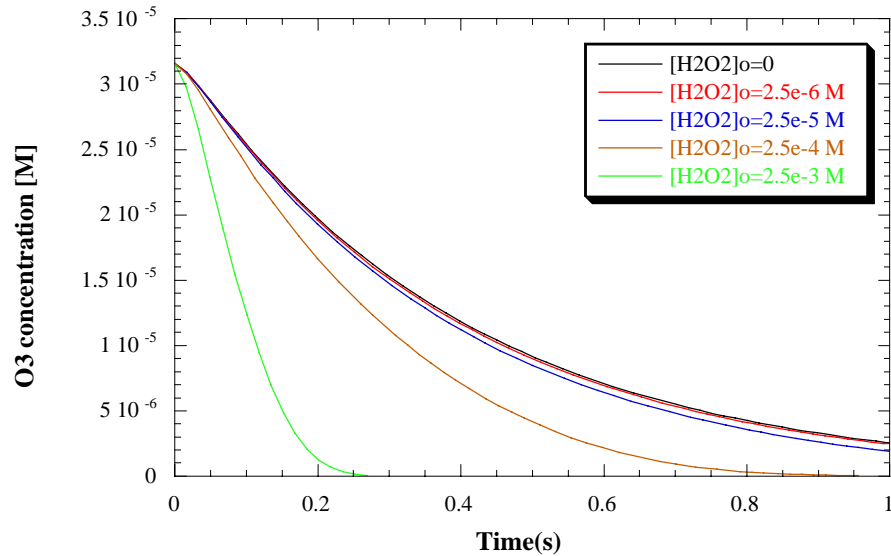
What is the chemical structure of various resists?
What are the water-soluble etch products?

Numerical Simulation

- Simulates direct and indirect oxidant concentrations.
- Predict the distribution of intermediate species.
- Examines the kinetic roles of scavengers and promoters on O_3 and OH^* concentrations

Simulation Results

$[O_3]_o = 3.16 \times 10^{-5} \text{ M}$, $[OH^-]_o = 7.17 \times 10^{-3} \text{ M}$, $[CO_3^{2-}]_o = 3.0 \times 10^{-3}$



Some Questions

- Which oxidation is preferred, direct or indirect?
 - What is the oxidation mechanism of resist?
 - What is the main etch species, O_3 or OH^* ?
- Is the decomposition model realistic?

Future Work

- Gathering all kinetic data and Remodeling.
- Combining of simulation and experimental data.
- Elucidating O₃ decomposition and cleaning efficiency.
 - pH,
 - scavengers,
 - promoters.....