



193nm Immersion Lithography Resist Research

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Motorola Assignee

Presentation Agenda

- The Team & Activities
- Goals
- Immersion Resist Research Activities
- July Workshop
- Presentations from Immersion Team
 - University of Texas at Austin (*Bob LeSuer-Bard Research Group*)
 - University of Texas at Austin (*Chris Taylor-Willson Research Group*)
 - University of New Mexico (*Alex Raub-CHTM, S.Brueck-Director*)
 - Rochester Institute of Technology (*Bruce Smith*)
 - Intl SEMATECH (*Will Conley*)
- Future Immersion Resist Research Work

Resist Group Members

- Will Conley (Motorola-SEMATECH) chairman
- Gene Feit (SEMATECH) co-chair Emeritus
- Bob Allen, Greg Wallraff and Bill Hinsberg (IBM)
- Ralph Dammel, Andy Romano (Clariant/AZ)
- Rod Kunz (MIT-Lincoln Labs)
- Mitsuru Sato (TOK)
- Prof Bruce Smith, Research Assoc. Yongfa Fan, Lena Zavyalova, Anatoly Bourov (RIT)
- Profs Grant Willson, Allen Bard, Research Assoc. Chris Taylor, Bob LeSuer (U-Texas)
- Stewart Robertson-Shipley

Resist Immersion Project

- **Charter: Determine the feasibility of immersion lithography from the perspective of interactions between immersion fluid and resist.**
 - Determine whether there is a problem with the resist-fluid interactions and identify the causes
 - Determine the allowable contact time
 - Enumerate issues for exposure tool manufacturers
- **Scope: 193nm lithography with water as the immersion fluid**

Why did we do what we did?

- **Dec '02**
 - We did know if anything even imaged
 - Look at the surface for components leaching
 - Surface analysis for PFOS through water analysis
 - Scanning conductivity
 - Micro pH
 - Radio labeling
 - Multiple in parallel approach to learn “something”
- **Jan'03-July '03**
 - Collect data for July Immersion workshop
- **July '03-Jan'04**
 - Collect data to determine “feasibility” of immersion lithography
 - Lithographic public is still “*not sure*”

Activities of the Group

- **Professor Allen Bard- (UT)**
 - Micro pH and scanning conductivity measurements
 - Scanning Conductivity Measurements
- **Professor Grant Willson (UT)**
 - Collaboration with Prof Bard on pH and Scanning Conductivity
 - Synthesis of Radio Labeled Compounds
- **Prof Bruce Smith (RIT)**
 - Immersion Lithography Exposure System
- **Professor Steve Brueck (UNM)**
 - Imaging experiments and fluid contamination studies
- **TOK (M. Sato) & Clariant (R. Dammel)**
 - Materials

ISMT Project Direction

- **Phase 1 (Jan '03-July'03)**
 - Immersion task forces;
- **Phase 2 (Aug '03-Jan'04)**
 - Post task force follow up to further support go/no-go decision for immersion technology
 - Laser durability/contamination test bed for evaluating final optic with different coatings, water content & contaminants
- **Phase 3 (Feb'04 to Dec'04)**
- **Phase 4 (Jan'05-Dec'05)**

July Workshop

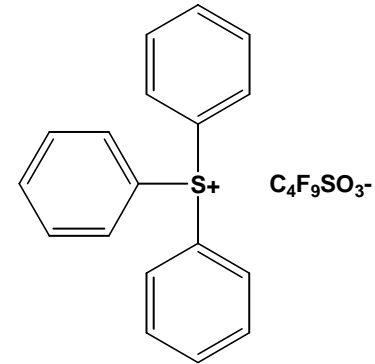
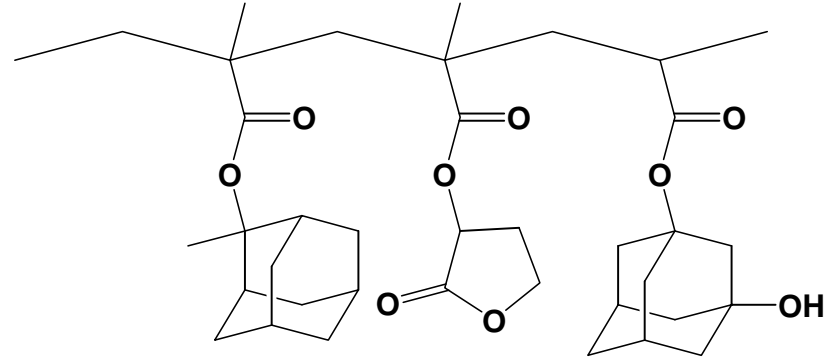
July Workshop

- **What is occurring at the surface?**
- **Do present ArF resist materials work?**
- **Do present materials absorbance water?**
- **What is leaching out of the film?**

Chemistry of TOK ILP0X EM Test Resists

FORMULATION

- 60 PGMEA/ 40 Ethyl Lactate casting solvent
- 28 MADMA- 52 BLMA-20 HAdA
- 5 parts TPS-PFBS
- 0.46 parts base
 - ILP01 : triethanolamine
 - ILP02 : tripentylamine
 - ILP03 : tri-n-dodecylamine



Baker HPLC grade water used for tests



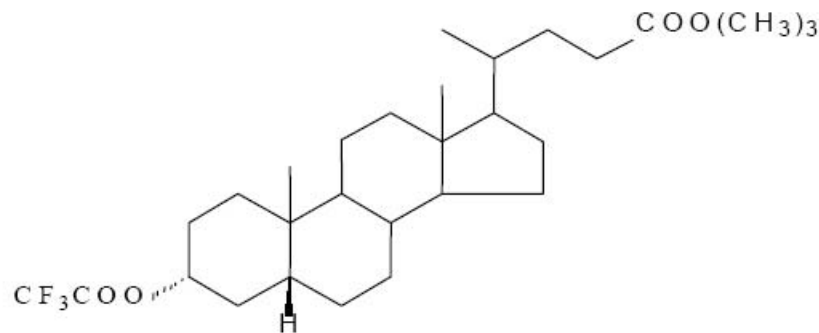
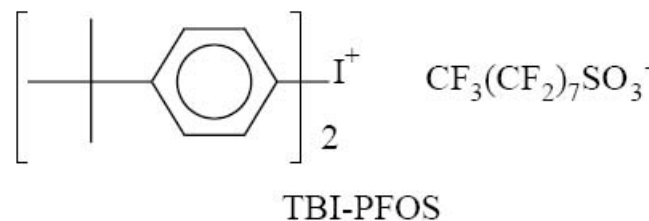
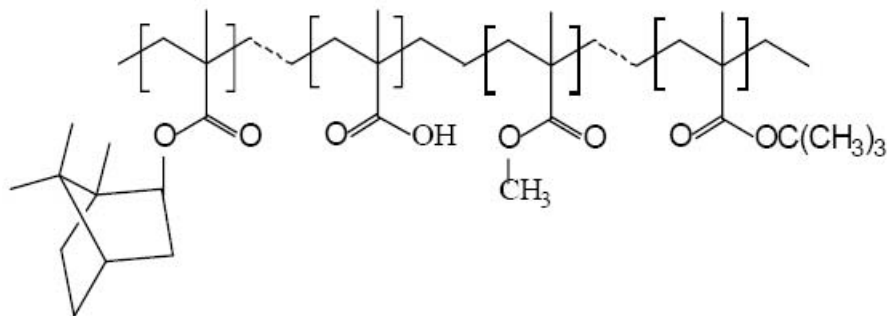
Chemistry of IBM V2 Test Resist

FORMULATION

- 10% polymer in PGMEA
- 25 IBM- 30 MMA-10 TBMA-35 MAA
- 5 parts TBI-PFOS
- 20 parts DI (lithocholate)
- 0.2 parts tetra-butyl ammonium hydroxide

(5 parts = 50 mg/g polymer)

Baker HPLC grade water used for tests



AZ Clariant Resist for LIL Studies

- **AZ Clariant EXPI Resist**

- **Polymers:**

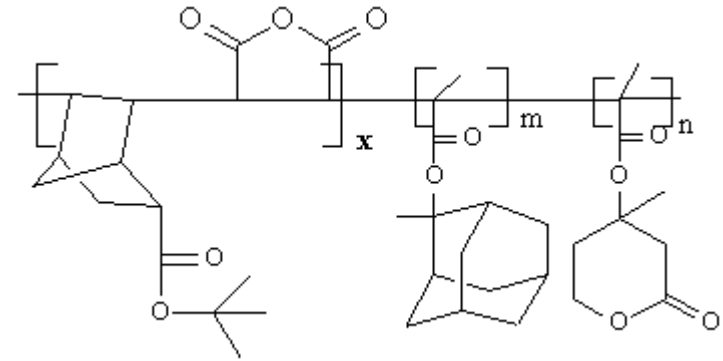
- T2030 (Hybrid)
- T518 (Acrylic)

- **PAGs:**

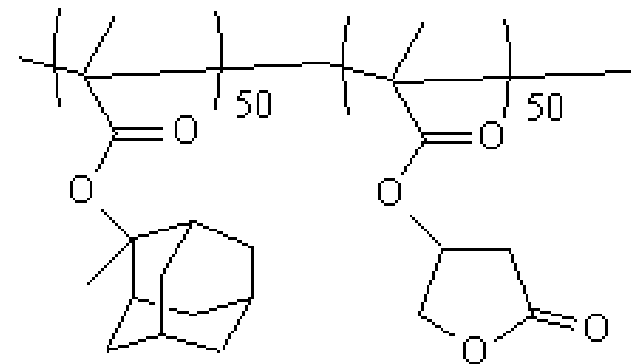
- TPSNf (Large)
- TPSTf (Small)

- **Bases:**

- Trioctylamine (Large)
- Diethanolamine (Small)



Polymer T2030



MA dMA

GBLMA

Polymer T518

July Workshop

- **Surface studies at MIT-LL to understand changes in surface energy and XPS analysis of resist surface**
 - Evidence of PAG and water soluble quenchers depleted from the surface and is dependent on PAG size. PAG segregation was detected in TOF-SIMS analysis, however, bulk profile the same for wet and dry . Water insoluble bases do not appear to leach.
 - Most leaching occurs at the surface of the film
 - Action: determine leaching rates.
- **Do present ArF resist materials work?**
 - YES!
 - Some slight modifications to achieve good imaging in 193nm & 213nm IL systems, 65nm ½ pitch demonstrated.
 - Step and repeat could be another story

July Workshop

- **Do present materials absorbance water?**
 - Depending on the polymer, water uptake rates vary
 - Material provided by TOK (IP01) ~ 1ppth per sec with ~0.5% water content absorbed over 300 seconds.
 - Yes, experiments conducted at IBM-Almaden Research Center clearly demonstrated that water is absorbed through the film using D₂O

July Workshop

- **What is leaching out of the film?**
 - Experiments on materials provided by IBM, TOK and Clariant
 - NEXAFS measurements on IBM materials demonstrated 50% loss
 - Water contact time experiments with TOK and Clariant materials and analysis of water completed
 - Resist components-products have some solubility in water
 - PAG structure influences solubility
 - PAG anion and base detectable in water

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