SURFACE AND LINE-EDGE ROUGHNESS (SR & LER) IN PLASMA-DEVELOPED RESISTS

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**PURPOSE of the work**

- Evaluation of model Si-containing polymers (siloxanes) as resists for 157 nm lithography (co-polymers of siloxanes can be aqueous-base developed)
- Study of SR and LER in plasma- and solution-developed resists
- Investigation of whether plasma-developed resists can have small LER, comparable to solution-developed resists
- Simulation of SR & LER (see paper R-10P)

**EXPERIMENTAL**

- Bilayer siloxane-based resists (polydimethylsiloxane, PDMS)
  - Commercial PDMS (Alkdrich, M$_{\text{w}}$=2
  - Synthesized PDMS (University of Athens) M$_{\text{w}}$=1
- Single layer resists (epoxy chemically amplified negative-tone resist, EPR)
- Siloxane-segmented PDMS (positive-tone)
- Solution-developed EPR (negative-tone)

Preparation for bilayer resist:
- Exposure: E-beam Vector scan Leica EBPG3, 50 kV, beam-diam 50nm
- Development: Solution development for PDMS, and Plasma development for the bottom layer (AZ2214): BRI, 30 s for O$_3$, plasma null or without BTS etch
- BTS: F-containing mixture for 5-6% of etch time

Measurements: SEM, AFM

Why Siloxanes?

- 157 nm transparency
- Resolution capabilities
- PDMS with narrow MW distribution
- PDMS with broad MW distribution

**RESULTS: Role of BTS**

LER of PDMS

- LER of PDMS with/without BTS
- Effect of BTS on LER

**DISCUSSION: Comparison with EPR**

LER of EPR

- LER of EPR with/without BTS
- Effect of BTS on LER

**DISCUSSION: Explanation of effect of BTS on LER**

- Schematic indicating the relation between SR and LER: LER corresponds to SR at smaller dose due to actual image. Thus, the closer the mass of SR is to clearing doses, the higher is LER.

For a positive-tone resist: more drastic BTS moves the max in SR towards smaller doses (farther away from clearing doses), thus reducing LER

For a negative-tone resist: more drastic BTS moves the max in SR towards higher doses (farther away from clearing doses), thus reducing LER

**WHY SILOXANES?**

- 157 nm transparency
- Resolution capabilities

PDMS with narrow MW distribution

PDMS with broad MW distribution

**CONCLUSIONS**

- Plasma and solution-developed resists can have similarly low values of SR at useful doses, provided appropriate BTS etch is performed
- Minimization of LER can happen by shifting the max of SR further away from clearing doses
- Siloxanes exhibit good resolution, small SR at useful doses, small LER (with BTS), and are thus good candidates as copolymers of 157 nm resists

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