Outgassing studies on EUV underlayers containing PAGs

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Background and Goals:

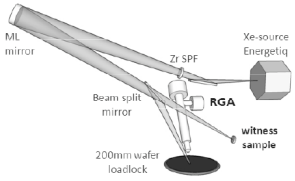
While prior studies have been carried out on resist outgassing properties, in this study, we focused on crosslinked systems. Spin-on hardmasks were formulated to contain photoacid generators (PAGs) to lower the exposure dose required for an EUV resist. Under EUV exposure, it is expected that the acid formed in the underlayer can act as an acid feed layer, thus lowering the photoresist dose to size. While this might be a way to improve photoresist performance, there are concerns about outgassing contamination from PAG by-products originating in the hardmask or other layers beneath the resist.

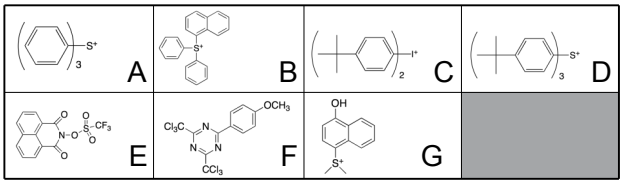
In this study, we quantified the amount of outgassing from underlayers containing various types of PAGs. The main contaminants were identified, and the efficiency of PAG activity to affect dose to size was assessed using Eo measurements and lithographic evaluation.

Experimental Details and PAGs Studied:

PAGs were added to a spin-on hardmask matrix in equimolar amounts. Hardmasks were coated on top of a spin-on carbon (SOC) layer and baked at 175˚C. A sample with no PAG was tested as a control.

An Energetiq Xe source was used for EUV exposure during RGA analysis.

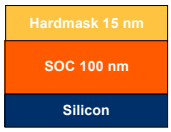




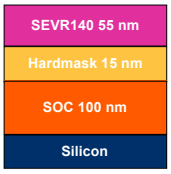
- PAGs used are commercially available. Ionic and non-ionic PAGs were tested.
- The cations, the main contributors to outgassing, are shown above.

Evaluation Stack:

For outgassing

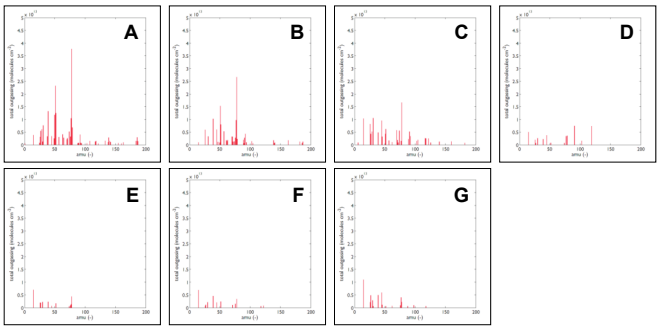


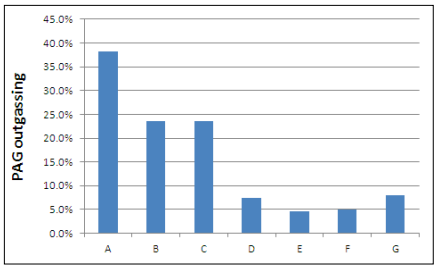
For contrast curves and lithography



RGA Outgassing Results:

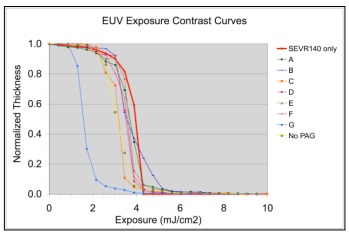
An RGA of a sample without PAG has been subtracted from the samples with PAG. The RGA traces below show that PAGs A-C outgas at higher levels than PAGs D-G.





- The main contributors to outgassing were benzene (78 amu) and diphenyl sulfide (186 amu).
- For samples A-C, 20-40% of total outgassing was generated by the PAG cation.

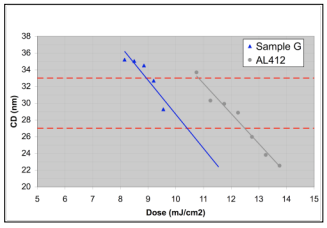
PAG Efficiency Using EUV Eo Testing:

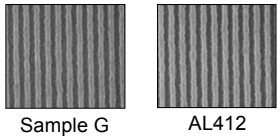


Sample	Eo (mJ/cm2)
SEVR140	4.3
No PAG	4.3
A	4.8
B	5.2
C	3.9
D	4.3
E	4.8
F	4.3
G	3.0

- Spin-on hardmask containing PAG “G” is very effective at lowering Eo on SEVR140 EUV resist.

EUV Lithographic Evaluation:





- A dose shift was observed when patterning 30-nm lines on Sample G.
- An organic underlayer, Brewer Science® E²Stack® AL412 coating, is shown for comparison.

Summary / Conclusions:

The results show that:

1. Spin-on hardmasks do not contribute significantly to underlayer outgassing.
2. PAGs can be used to reduce dose on EUV resists, but these must be carefully chosen to reduce outgassing.
3. Further investigation on the effect of adding PAGs to underlayers is needed as dose to size is not the only parameter of importance in lithographic evaluations.

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