Correlating Resist Photospeed using Various Exposure Platforms

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Abstract: Resist and materials manufactures typically determine lithographic performance of productions batches at wavelength. Specifically, e-beam resist are tested using e-beam exposure and 248nm resist are tested using DUV exposure. EUV has posed a dilemma as there are no resist companies that have EUV exposure tools residing in there facility. In an effort to determine if it is reasonable to use e-beam and or DUV imaging to certify resist performance as they leave a photoresist manufacturers' facility.

Introduction

After a photoresist formulation has been decided upon, and the company starts to work on scaling up the photoresist formulation, the next step is to assure the formulation can be made reproducibly raw material batch control, shelf life, and engineering curves need to be developed in order to guarantee lot to lot reproducibility.

There are a number of photospeed measures employed for the characterization, quality control, and quality assurance of photoresist in both their manufacture and by the ultimate customer. In this paper we investigate from an experimental stand point, the precision and reliability of these measures for EUV photoresists (tested using DUV and e-beam photospeed tests. It has been demonstrated that for a given photoresist formulation a 'single point' measure of photospeed may not be indicative of the observed lithographic 'sizing' behavior. As a result, we are looking at process window (exposure latitude, focus latitude and linearity) (1).

Questions that need to be answered

1. Can E-beam or DUV be used for testing production batches, at Resist Manufacturer, locations in order to deliver production batches?
   - No impact on the key process parameters
     - Exposure latitude
     - Focus latitude
     - Linearity
     - Imaging performance
2. Is it possible to extrapolate performance of EUV lithographic features using CD control at 180-200nm?

Experimental Conditions

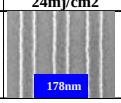
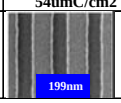
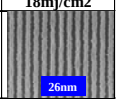
248nm
- Substrate: AR3 66nm
- BARC
- Thickness: 80nm
- PAB: 120C-60s
- Exposure: S203 NA0.68/ 2/3Ann.
- PEB: 100C-60s
- Dev.: TMAH 2.38%, 60s
- Target: 180nm L/S

E-beam
- Substrate: Bare silicon with HMDS
- Thickness: 80nm
- PAB: 120C-60s
- Exposure: HL-800D
- PEB: 100C-60s
- Dev.: TMAH 2.38%, 60s
- Target: 200nm L/S

EUV
- Substrate: AR3 66nm BARC
- Thickness: 40nm
- PAB: 120C-60s
- Exposure: Albany MET Albany E-MET 0.3NA Quad
- PEB: 100C-60s
- Dev.: TMAH 2.38%, 60s
- Target: 26nm L/S

** A special Resist Formulation was used in the study

Optimum Conditions

	248nm exposure	E-beam exposure	EUV exposure
Exp. Lat.	38	23	16
Foc. lat.	NA	NA	0.2um
dose	24mj/cm2	54umC/cm2	18mj/cm2
Nominal	 178nm	 199nm	 26nm

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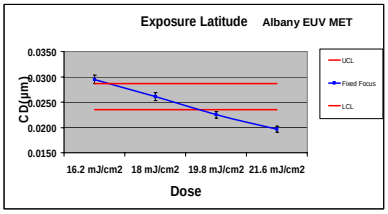
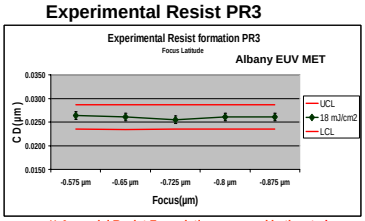
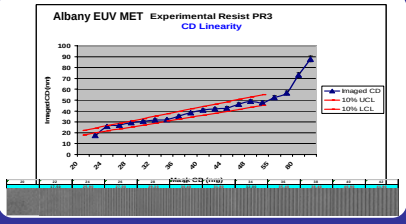
Experimental Resist PR3



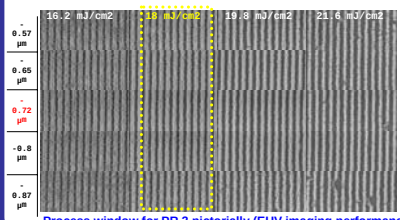
Experimental Resist PR3



** A special Resist Formulation was used in the study



Expo/ Focus - Experimental Resist PR3

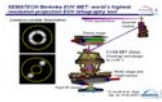


Process window for PR 3 pictorially (EUV imaging performance)

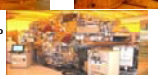
(All EUV imaging was conducted at the RMDC)

Resist Materials Development Center
World class imaging capability

Albany MET & TEL ACT12



Alpha Demo @ CNSE



Summary of Findings and Future Work

The objective of this work was to determine if it is possible to use exposure wavelengths, other than EUV, to assure lot to lot performance of preproduction resist batches. The early work done here serves a baseline of the performance seen currently with a fixed batch of a model resist formulation. The resist batches looked at, so far, seem to indicate that it is reasonable to use this testing method. More studies will be needed to see if there are any issues with process window characterization (batch to batch).

Shelf life will need to be studied in detail, and more resist lots will need to be tested.

The work here is starting at a very good time as EUV lithography seems to be gaining steam, and it will be very important to have an approach to lock in resist performance to assure the easy transition from research and development to high volume manufacturing resist infrastructural operation.

Future work will involve accelerated aging studies, adjusted resist formulations and more extensive studies of process latitude variability as resist lots change.

1) Liability of photospeed and related measures of resist performances

Schlicht, Karin R., Proc. SPIE Vol. 2195, p. 624-639, Advances in Resist Technology and Processing XI, Omkaram Nalamasu; Ed.

2) " The SEMATECH Berkeley microfield exposure tool: learning a the 22-nm node and beyond," Patrick Naulleau (June 2, 2009). *Lawrence Berkeley National Laboratory*. Paper LBNL-882E (LBNL MET image).

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