EUV process sensitivities and optimizations for wafer track processing

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Introduction

As Extreme ultraviolet (EUV) lithography technology shows promising results below 40nm feature sizes, TOKYO ELECTRON LTD.(TEL) is committed to understanding the fundamentals needed to improve our technology, thereby enabling customers to meet roadmap expectations. TEL continues collaboration with imec for evaluation of Coater/Developer processing sensitivities using the ASML Alpha Demo Tool for EUV exposures. The results from the collaboration help develop the necessary hardware for EUV Coater/Developer processing. In this work, new promising resist materials have been studied and information pertaining to EUV process sensitivities was obtained. Specifically, post exposure bake (PEB) impact to CD is studied in addition to dissolution characteristics for the developer process. From these data, the impact track hardware parameters to the EUV resist process can be known. Additionally, potential process improvements from novel applications are investigated. Resolution improvement possibility is explored with tetra butyl ammonium hydroxide (TBAH) in place of the standard tetra methyl ammonium hydroxide (TMAH) and FIRM™ Extreme001 rinse material is evaluated for the reduction of pattern collapse.

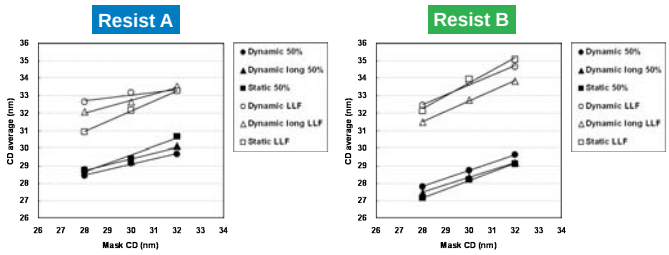
Experiment

- **Track**
  - Machine : CLEAN TRACK ACT™ 12
  - Under layer : FT20nm
  - Resist : EUV resist material
  - Developer : TMAH, TBAH
  - Rinse solution : FIRM™ Extreme001
- **Exposure**
  - Machine : ADT (ASML)
  - Illumination : NA=0.25, σ=0.5
  - Reticle : imec TM07
- **Measurement**
  - Machine : CG4000, KLA2800
  - Target : HP27-32nm

Sensitivity characteristic of track process

1.Mask Linearity

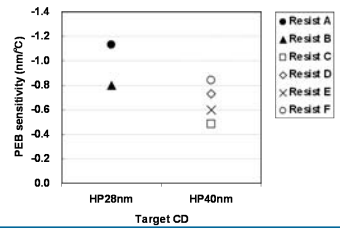
- Mask linearity of developer and mask condition.
- Mask tiling 50% has ~7-8%flare.
- Mask tiling LLF has ~3-4%flare.



Mask linearity is impacted by flare percent and developer process differently for each resist platform

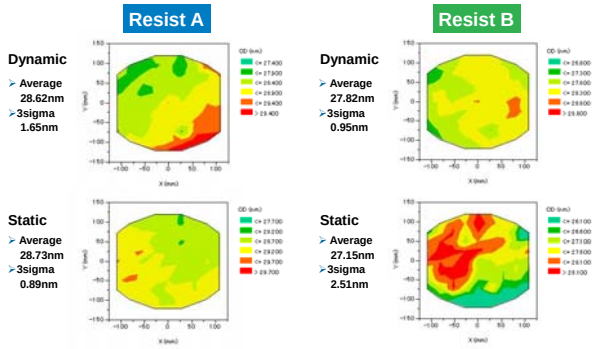
2.PEB Sensitivity

- Comparison with PEB sensitivity for different resist platforms.



Increased PEB sensitivity at HP28nm will be more critical for CDU Budget

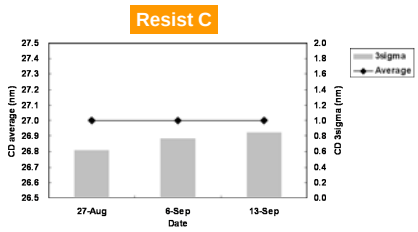
3.CD Uniformity at HP28nm



CDU performance is impacted by resist platform
Optimization for each platform is necessary

4.Stability for CD uniformity at HP27nm

- Stability of CD uniformity for day to day.

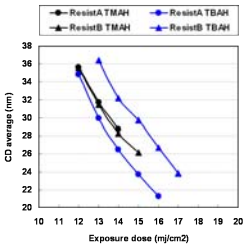


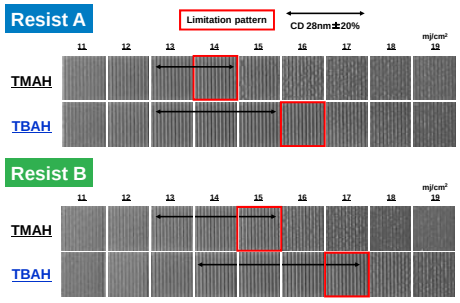
In track process, CD 3sigma of intrawafer is stable over time

TBAH performance

1.TBAH Resolution at HP28nm

- Comparison of TMAH and TBAH for resolution limit.

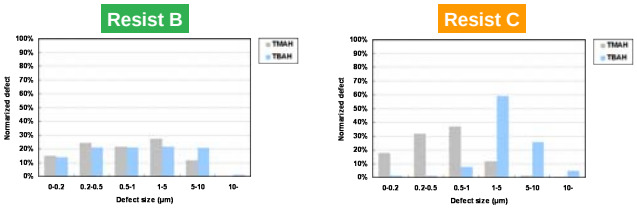




TBAH performance is dependant on resist type. Resolution can be improved

2.TBAH defect size trend

- Comparison of TMAH and TBAH for size distribution.

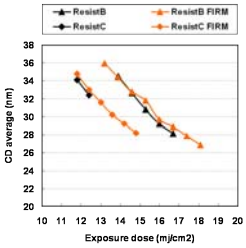


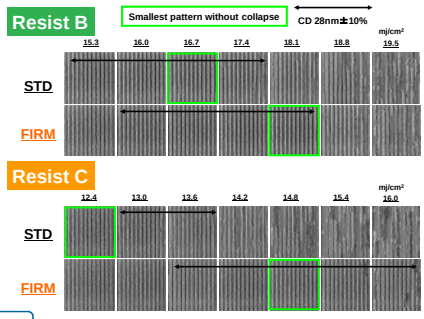
The defect count of bigger defect size (blob) on TBAH is higher than that of TMAH

FIRM™ Extreme001 performance

1.FIRM Pattern collapse at HP28nm

- FIRM effect for pattern collapse limit.

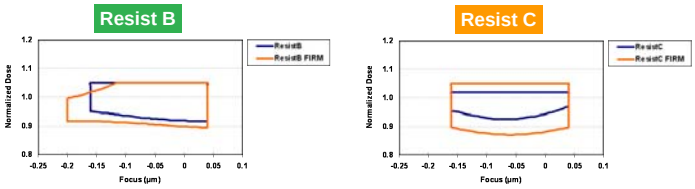




FIRM can improve pattern collapse

2.FIRM Process margin at HP28nm

- FIRM effect for process margin.



The influence on the process margin is different for each resist

Conclusion

In this work, we confirmed the track processing sensitivity for promising EUV resist materials. The developer process sensitivity varies based on the resist platform and may need to optimized differently for different platforms. It was found that the PEB sensitivity is low, but still needs to be considered for CDU budget contribution on shrinking feature sizes. TBAH can improve ultimate resolution, but the magnitude of the enhancement is platform dependant. Further work is needed on defectivity with the TBAH process, but preliminary indications are that special consideration must be made for blob type defects with this developer material. Finally, FIRM™ Extreme001 rinse material can increase the process window for pattern collapse, enabling higher aspect ratio patterning.

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