CD Reduction through Annular Illumination and Sidewall Spacers

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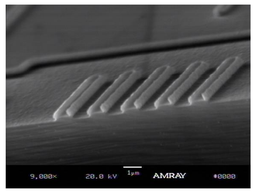
I. Project Objectives

Goal: A method of using a hard-mask to achieve sub 350 nm patterning of mask features with i – Line lithography. The outlined procedure can be used to manufacture features well below the resolution limit for i-line lithography.

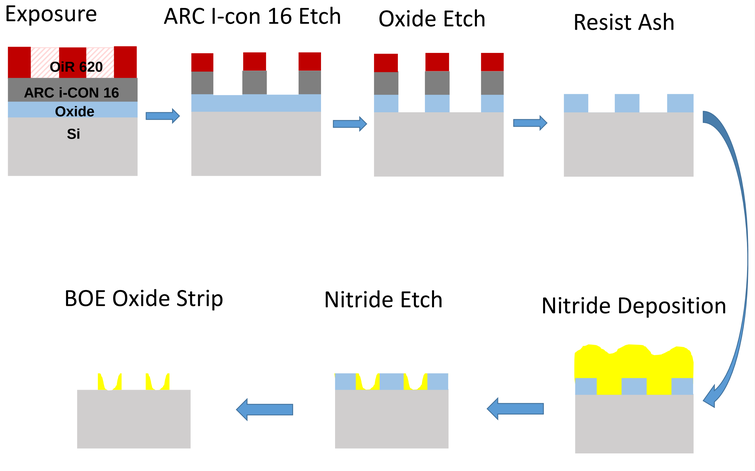
II. Motivation

- The capabilities of ASML's PAS 5500 5X reduction stepper to image dense critical dimensions below 300nm is of interest. Off-Axis Illumination is one method used in industry today to extend current lithography capabilities. Annular is one form of OAI used to influence the Depth of Focus.
- The purpose of this project is to pattern mask features below 350nm into a hard mask of thermal oxide. The hard mask will act as a pitch defining feature for sidewall spacer formation.
- Nitride is chosen for a sidewall spacer material because of its selectivity and end point detection.



Sidewall Spacers formed around 1um Hard Mask Features.

III. Procedure



IV. Lithography

- OiR 620 resist is diluted with PGMEA to coat a film thickness below production capabilities.

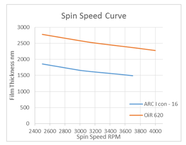


Figure 1

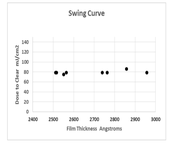


Figure 2

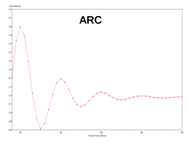


Figure 3

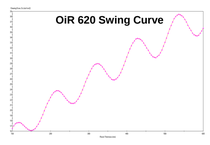
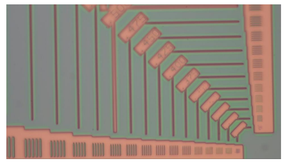


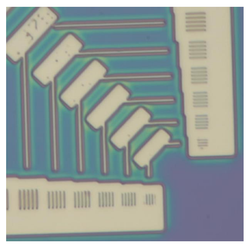
Figure 4.

- Figure 1 is the Spin Speed curves generated to find film thickness for OiR 620 and ARC i-Con 16.
- The benefits of using a ARC layer are shown in figure 2 to minimize dose to clear swing curve.
- Prolith simulation are used as a reference for material thickness.
- Figure 3 highlights a minimal reflectance for a ARC at 1600A.
- Figure 4 shows and optimal resist thickness at 2600A.
- Annular Illumination with σi = 0.45, and σo = 0.86 to successfully transfer a pattern to Resist on BARC on Oxide at 325nm.

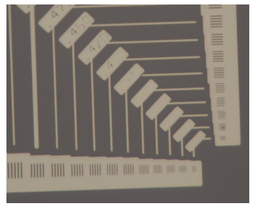


Etch

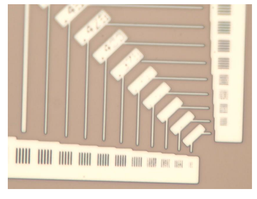
- ARC i-Con 16 etch recipe:
  - Power: 200W
  - Pressure: 70mT
  - O2: 5 sccm
  - Etch Rate: 2500 A/min



- Oxide Etch Recipe:
  - Power: 250W
  - Pressure: 70mT
  - O2: 5 sccm
  - CHF3: 30 sccm
  - Ar: 100 sccm
  - Etch Rate: 638 A/min

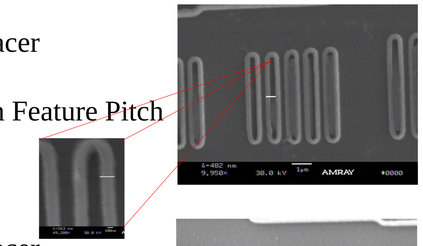


- Nitride Etch Recipe:
  - Power: 250W
  - Pressure: 70mT
  - CHF3: 30 sccm
  - SF6: 30 sccm
  - Ar: 100 sccm
  - Etch Rate: 757 A/min

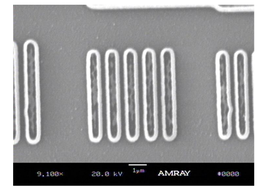


Results (con't)

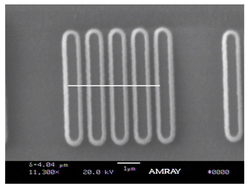
- 2000A nitride Sidewall Spacer
- 263nm line width
- 500nm Mask Pitch, 482 nm Feature Pitch



- 1500A nitride Sidewall Spacer
- 192nm line width
- 500nm Mask Pitch, 529nm Feature Pitch



- 1200A nitride Sidewall Spacer
- 205 nm line width
- 500nm Mask Pitch, 600nm Feature Pitch



V. Conclusions

Further analysis of Sidewall Spacer material thickness is needed to determine minimum CD.

Future Work

- Transfer Sidewall Spacer pattern to a polysilicon gate.
- Second litho – etch step to remove the ends of each Sidewall Spacer.

References

[1] Plasma Etching , L. Fuller
[2] E. Bowser, "Double patterning isolated and dense features with an ASML PAS 5500 i-line stepper, Senior Design, Rochester Institute of Technology, 2013.
[3] B. Curanovi**, "Development of a fully-depleted thin-body FinFET process," M.s., Rochester Institute of Technology, 2004.

Acknowledgements

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