Fabrication of Sub-300nm Fins by Self-Aligned Double Patterning at RIT

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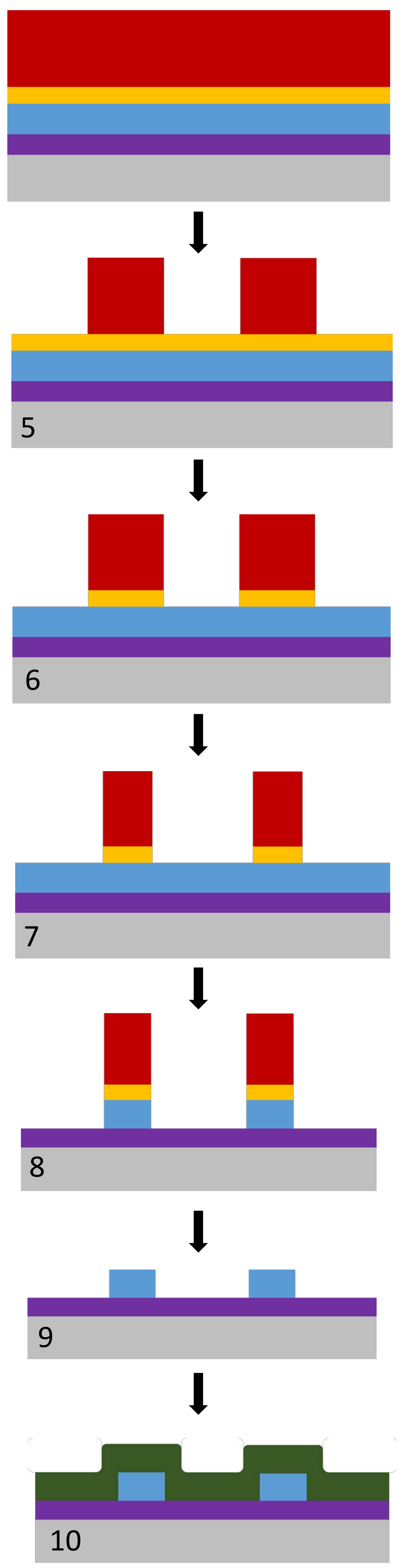
Project Objectives

Goal: Fabricate sub-300nm silicon fins at RIT's SFML by self-aligned double patterning (SADP).

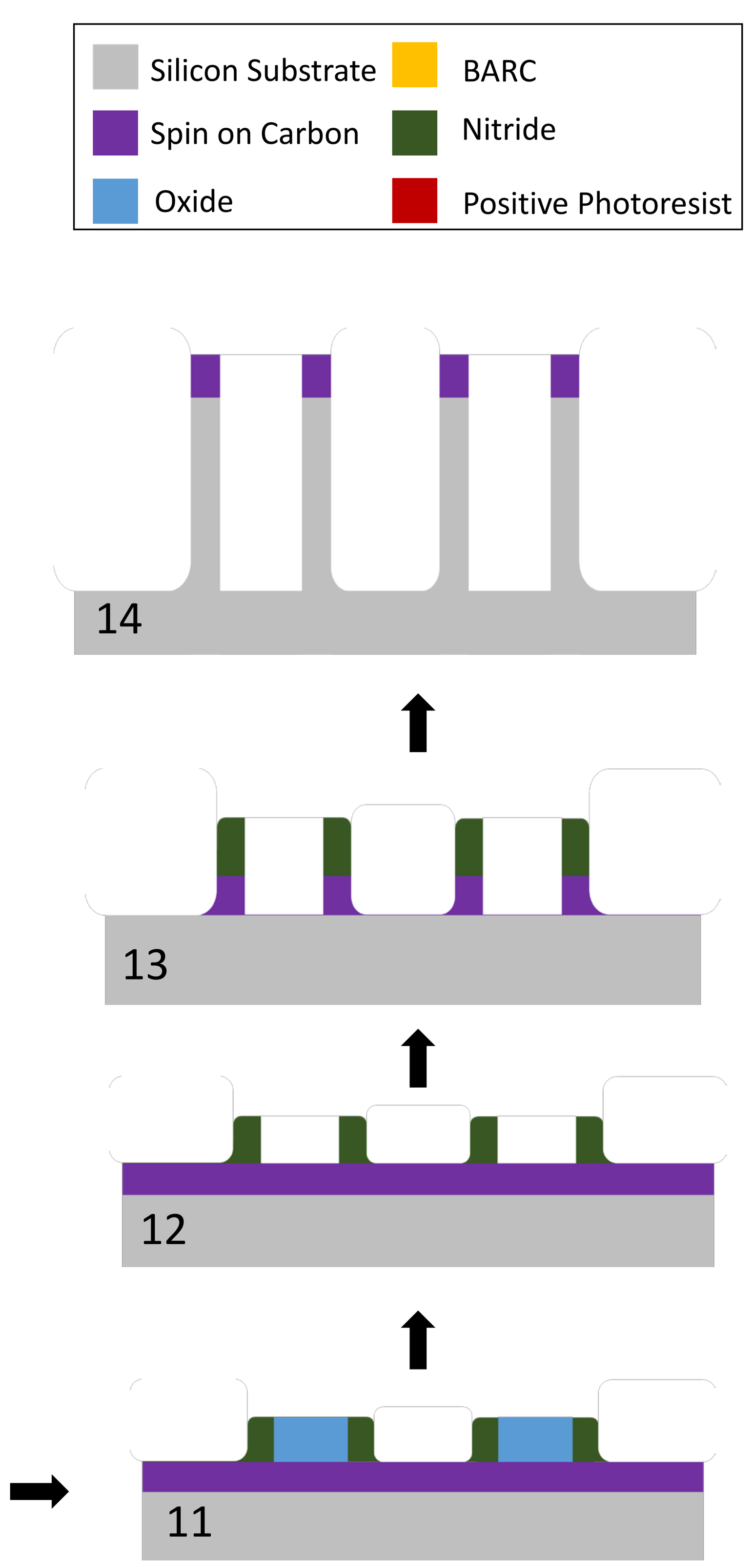
Motivation:

- Patterning advancements necessary to uphold Moore's Law
- SADP → FinFETS
- RIT currently only has a planar CMOS process

Theory



- SADP allows for the lithography pattern to be transferred to a mandrel, which in turn will be used as an etch mask.
- Smaller features may be realized without the implementation of more expensive lithography equipment.

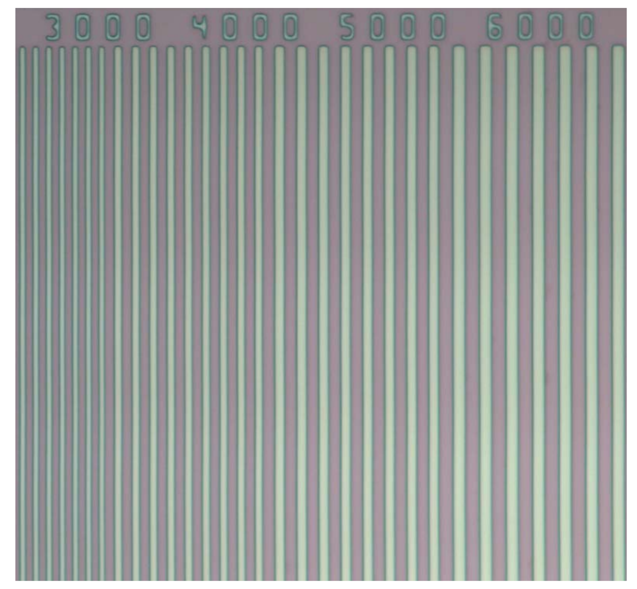


Process Flow [1]

1. RCA Clean
2. SOC Hardmask
3. Deposition
4. Oxide Mandrel Deposition
5. BARC Deposition
6. Photolithography
7. Etch BARC
8. Trim Etch for Mandrel
9. Mandrel Etch
10. Solvent Strip
11. Silicon Nitride Deposition
12. Silicon Nitride Spacer
13. Etch
14. Strip Oxide Mandrel

    Etch SOC

    Etch Silicon Fins

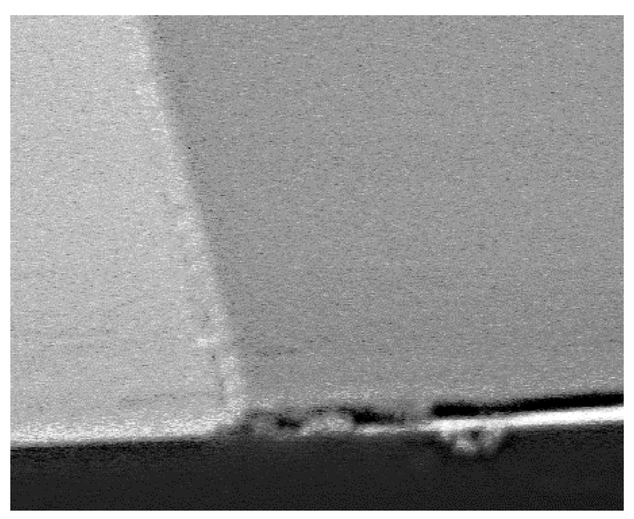


Patterning of multi-width lines and spaces.

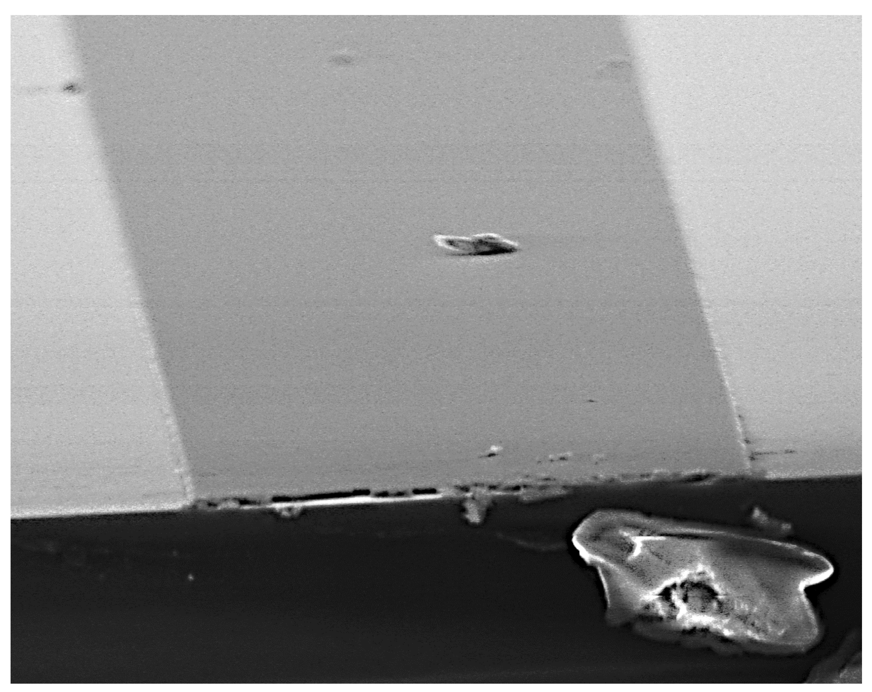
Laboratory Results

- Lithography:
  - Qualified AZ MiR 701 PR for use with process
  - Thinned resist 2:1, 701 PR:PGMEA for 300nm coat
  - FEM performed → Conventional illumination, NA = 0.48, Sigma = 0.625 → dose = 148 $^{mJ}/_{cm^2}$
- Determined spin speeds and times for SOC, BARC, and PR depositions
- Deposition rates determined:
  - Nitride = ~64 Å/s with 20 min. deposition in LPCVD
  - Oxide = ~88 Å/s in Applied Materials P5000 TEOS chamber
- Produced the following standard deviations in film uniformity:
  - SOC: 1.56%
  - Oxide: 3.45%
  - BARC: 0.47%
  - Photoresist: 1.27%
  - Nitride: 1.49%
- Etch rates determined:
  - Oxide: ~32 Å/s
  - BARC: ~8 Å/s
  - Nitride: ~3 Å/s

Oxide Mandrel Etch:
60 second etch
30 scc CHF3
60 scc CF4
100 scc Ar



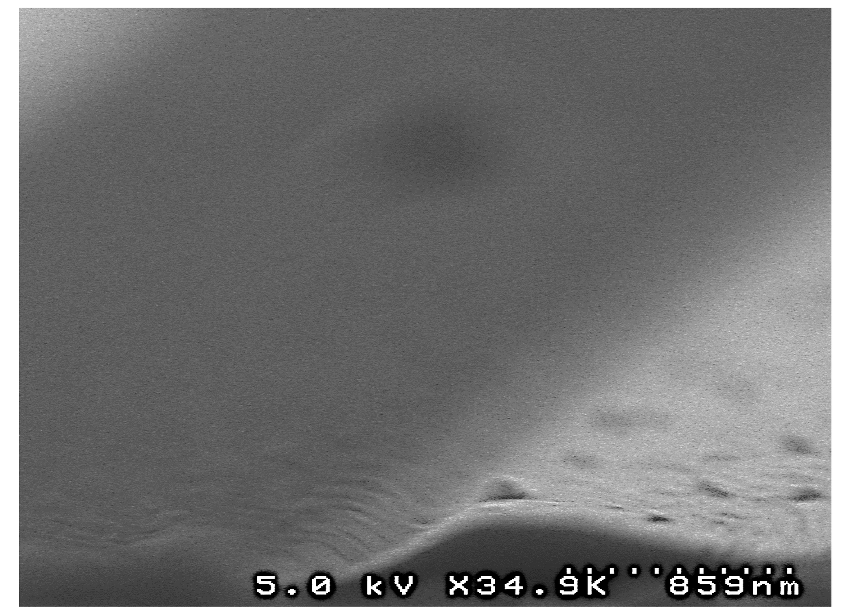
Zoomed-in view of oxide mandrel sidewall.



Wide oxide mandrel on silicon substrate.

Laboratory Results (continued)

Nitride completely removed post nitride spacer etch. Absence of hardmask over oxide mandrel layer resulted in angled mandrel sidewalls. PR/BARC on top of the oxide must have eroded during the vertical reactive ion etch, compromising the pattern.



Post nitride spacer etch; no nitride spacers present.

Conclusions

- Hard mask layer needed on top of oxide mandrel layer
- In addition, oxide mandrel etch may not be anisotropic enough, resulting in undesirable removal of silicon nitride spacers
- Further testing and development necessary
- Undergraduate course – implementation of fin fabrication in labs

Future Work:

- Development of RIE/hardmask plasma etch process improvements
- Develop complete implementation of P5000 tool cluster
- Undergraduate course – implementation of fin fabrication in labs
- PhD candidate – development of finFET process

References:

[1] O'Connell, Christopher, "An Etching Study for Self-Aligned Double Patterning" (2018). Thesis. Rochester Institute of Technology. Accessed from https://scholarworks.rit.edu/theses/9906

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