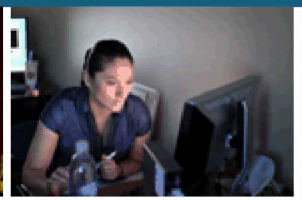
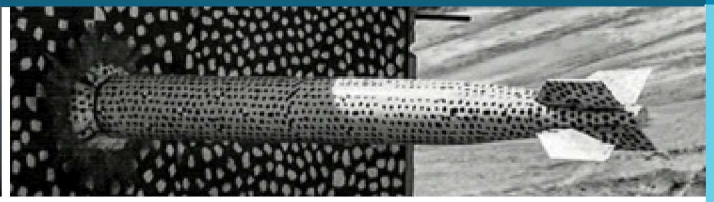
SAND2020-5223PE

VTO/MOSFET Process Updates





PRESENTED BY

Caleb E Glaser – NSME PhD Student

NANOSCIENCE & MICROSYSTEMS ENGINEERING

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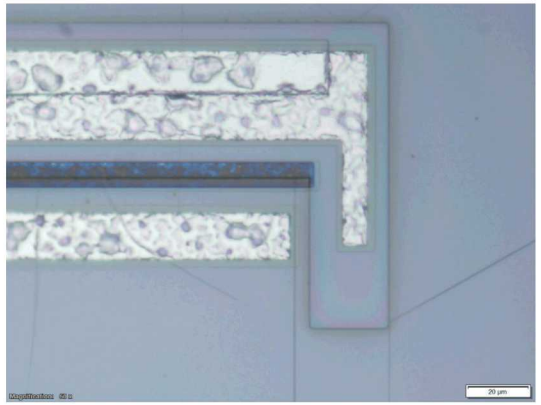
Outline

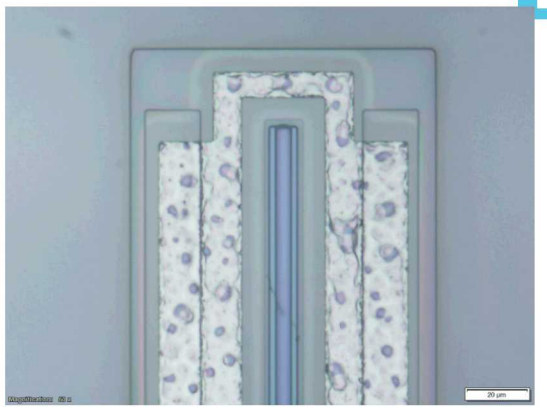
- Gate dielectric wet etch issues
- Gate metal sidewall coverage and liftoff
- GaICP microdots
- Next steps

Gate dielectric etch

- Problems with etch
  - Massive undercut of PR mask when in BOE 6:1
  - Difficult to determine when etch is complete
- Solutions
  - Find HF concentration to give 30-70 nm/min etch for SiO_2
  - Determine etch rate of other dielectrics in process



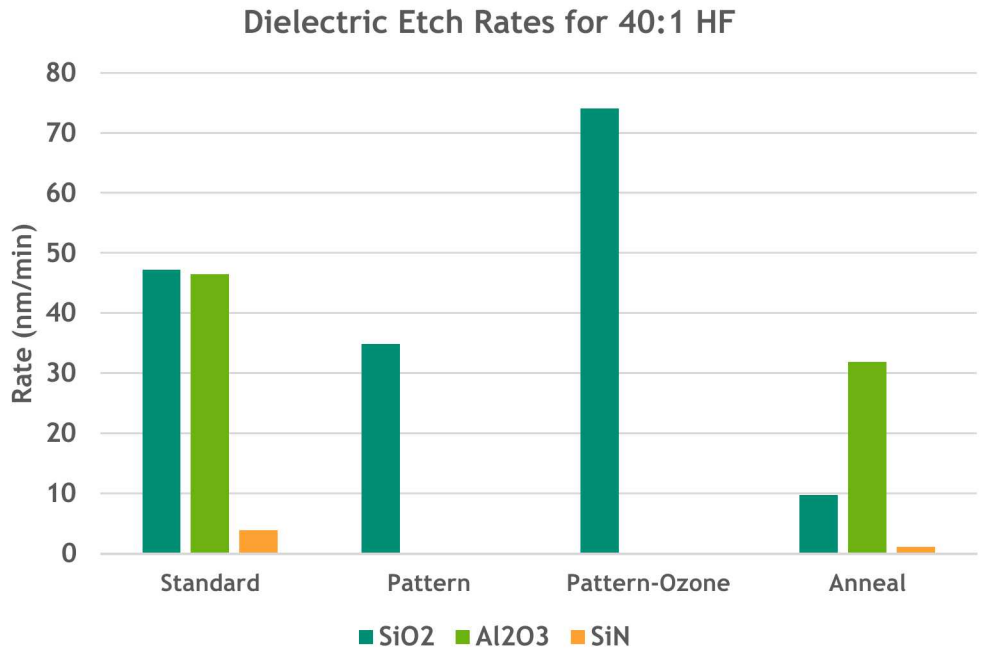
Incomplete etch



Completed etch with severe undercut

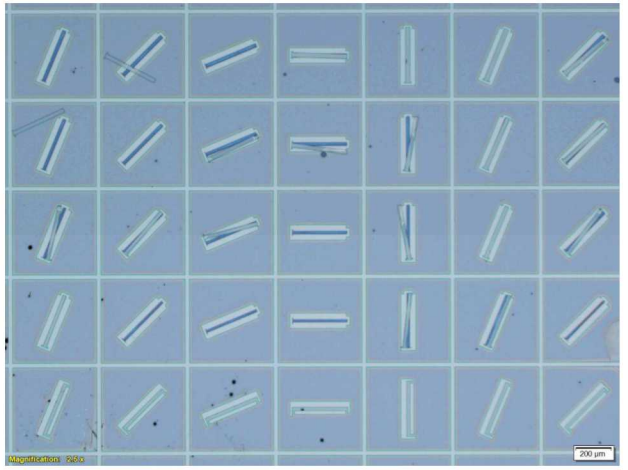
40:1 HF Raw Data (nm/min)

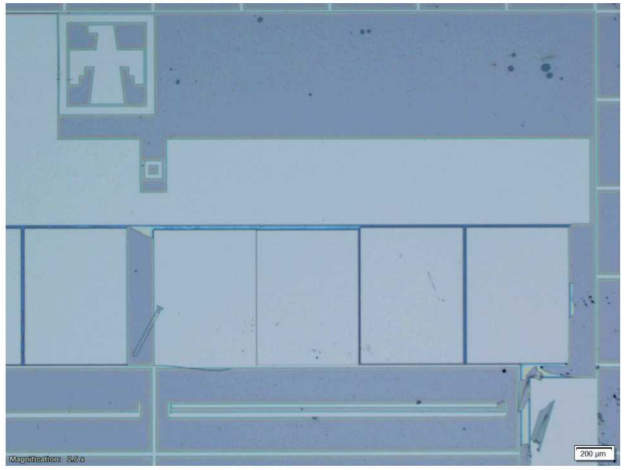
	SiO_2	Al_2O_3	SiN
Standard	47.2	46.5	3.9
Pattern	34.9	-	-
Pattern-Ozone	74.1	-	-
Anneal	9.8	31.9	1.1

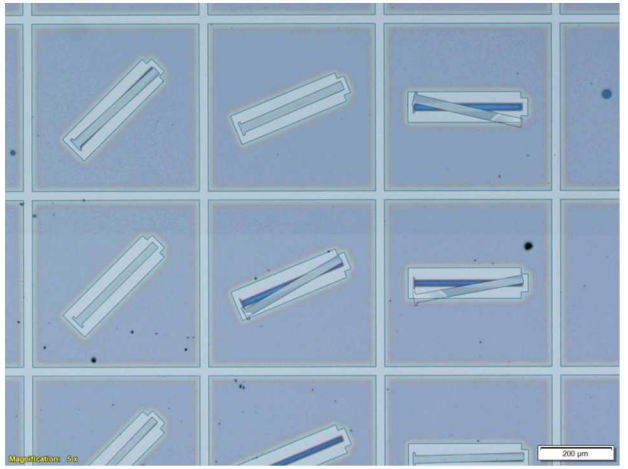


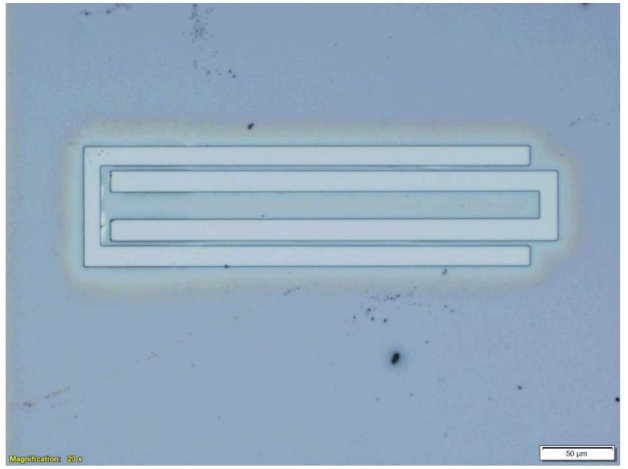
Patterned SiO_2 etch

- 200 nm of SiO_2 removed with 40:1 HF
- Liftoff and loss of mask to fully etch
- Undercut when SiO_2 is fully etched



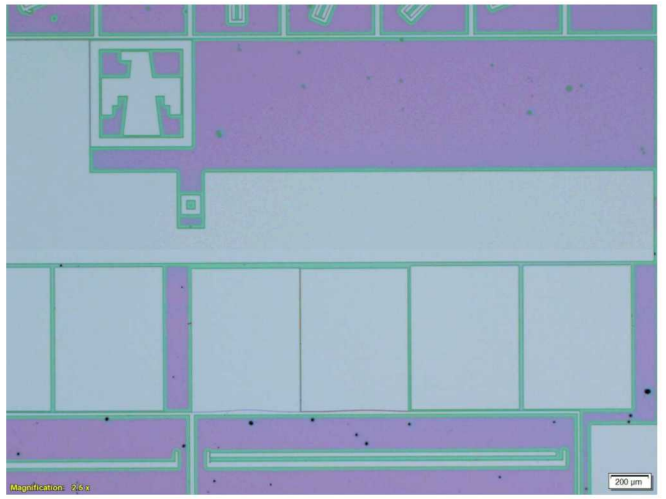


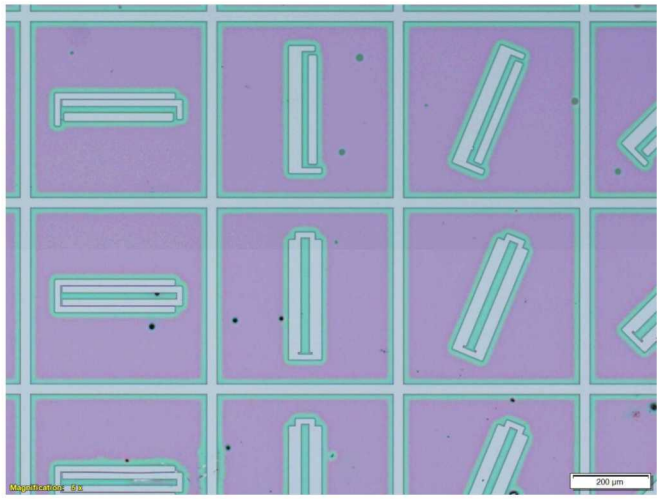


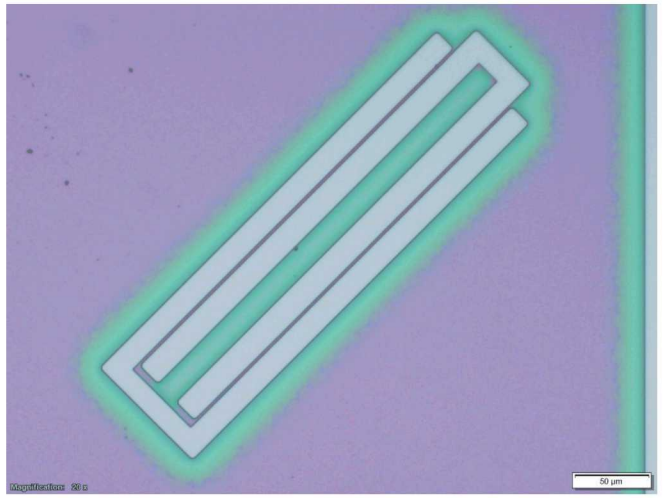


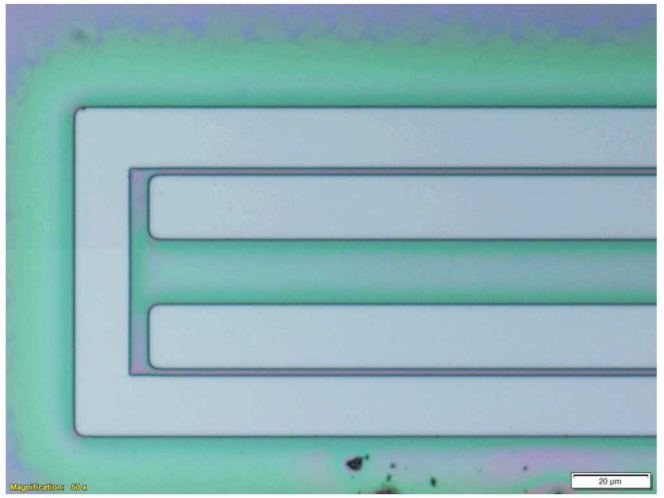
Patterned SiO_2 – 1 min O_2 Ash

- 200 nm of SiO_2 removed with 40:1 HF
- Add 1 min O_2 plasma Ash before etch
- Significant undercut
  - No pattern loss from etch



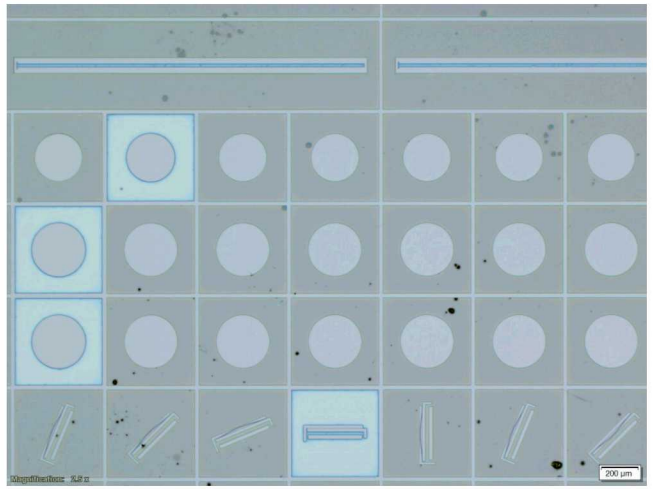


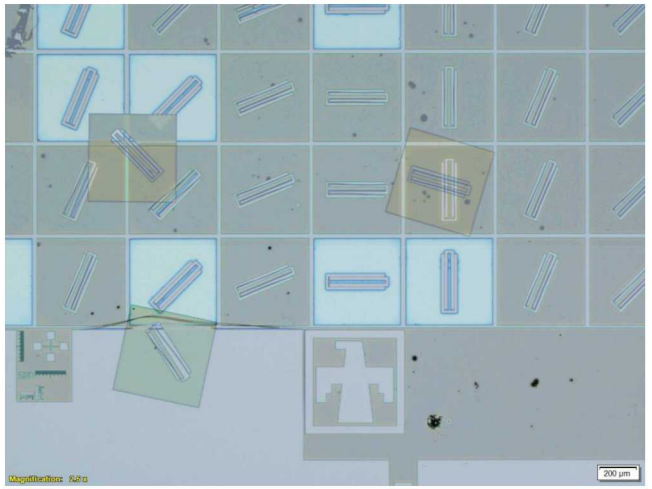


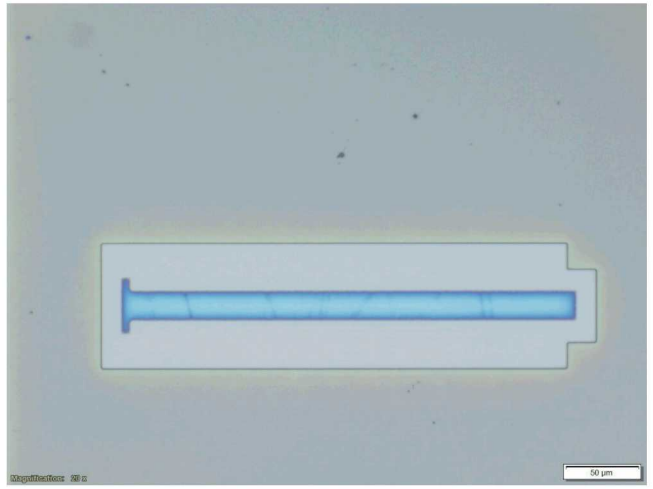


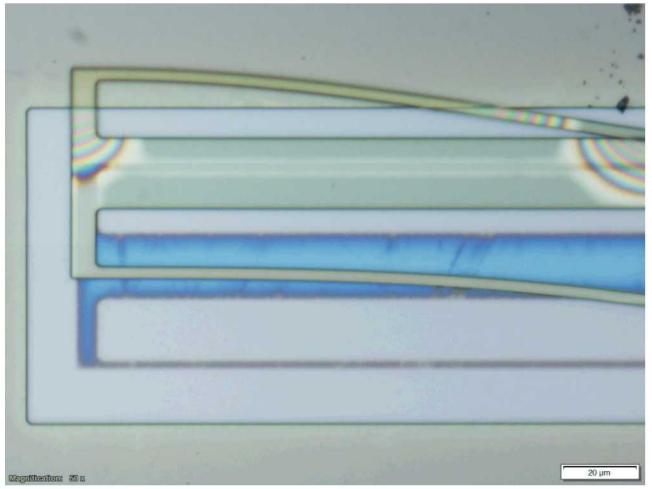
Patterned SiO2 – 30 min Ozone

- 200 nm of SiO_2 removed with 40:1 HF
- 30 min chamber condition followed by 30 min ozone
  - Ozone after PR pattern
  - 1 min ASH after ozone treatment
- Sample cleared at 2.5 min
  - Undercut and total pattern loss
  - 30 min ozone appears too long
  - Vapor HF tool or ozone prior to patterning



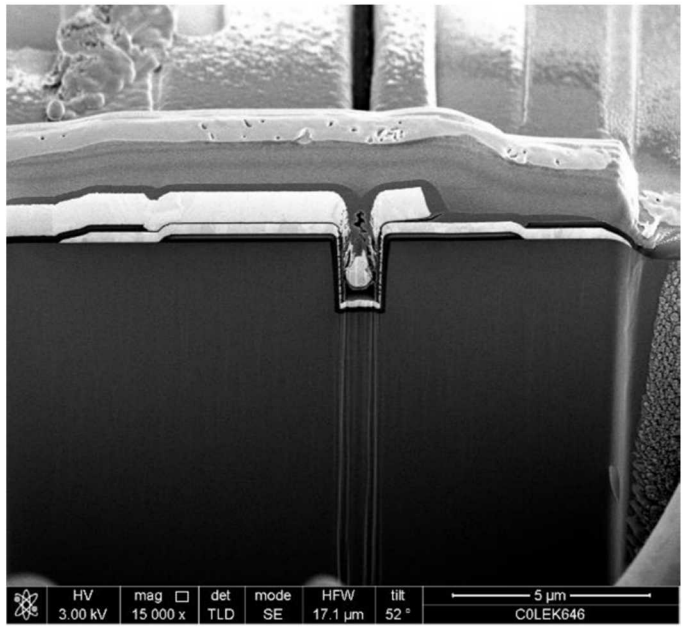




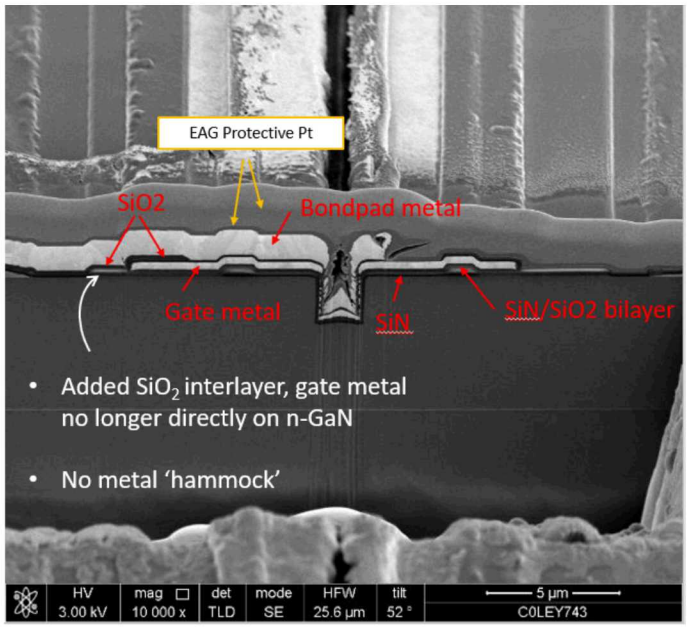


Gate metal sidewall coverage

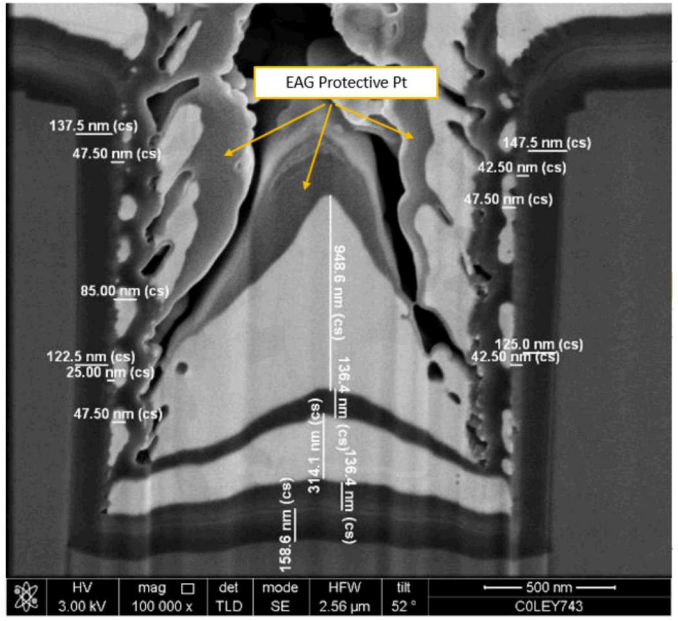
- Gate metal in trench
  - Increased Ti adhesion layer (10-100 nm) to improve sidewall coverage
  - Variable angle evaporation at 14°
- Previous process used high speed planetary and suffered from hammock effect
- Voids in sidewalls with poor Au adhesion
  - Gate metal – Ti-100 nm / Au-250 nm
  - Bondpad metal - Ti-100 nm / Au-1000 nm



Previous lot with hammock effect



Increased Ti to eliminate hammock

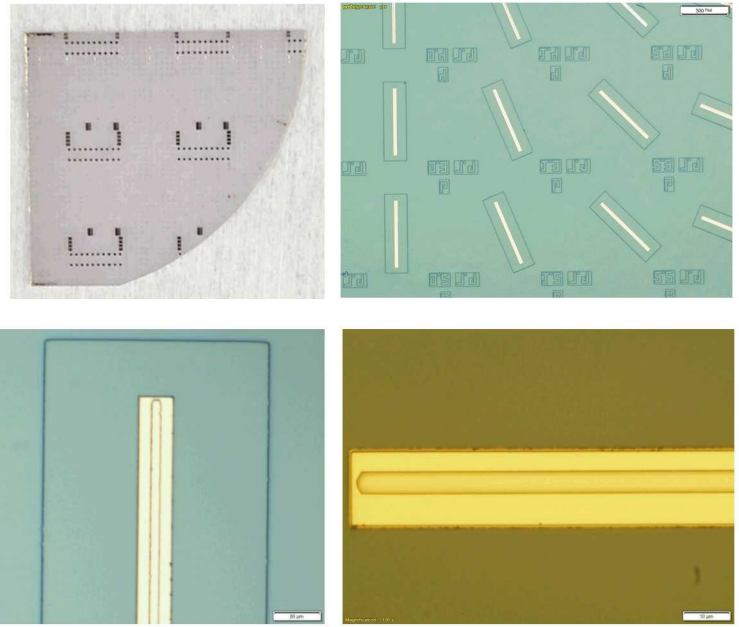


Voids in metal from Au adhesion

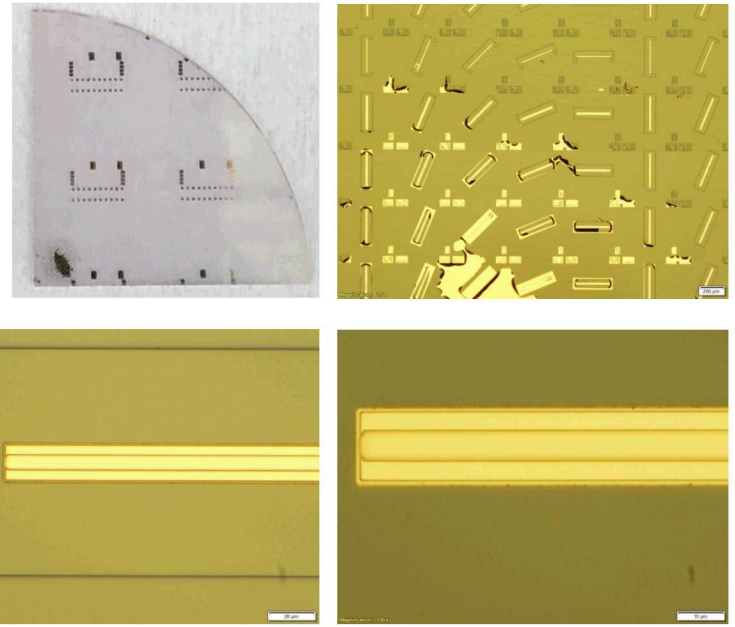
Gate metal PR mask selection

- Determine best resist for gate metal
  - 2020 – negative resist ~ 2.2 um thick
  - 2035 - negative resist ~ 3.5 um thick
  - 5214 - image reversal ~ 1.5 um thick

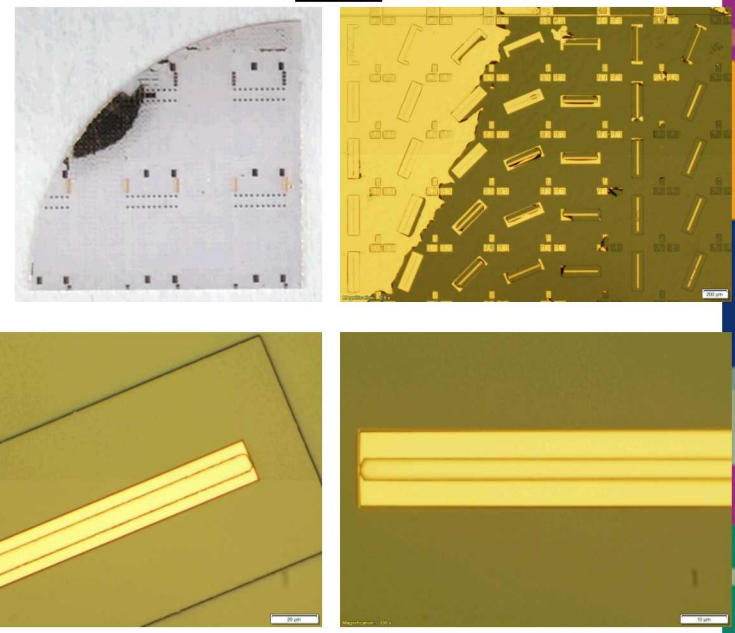
2020



2035

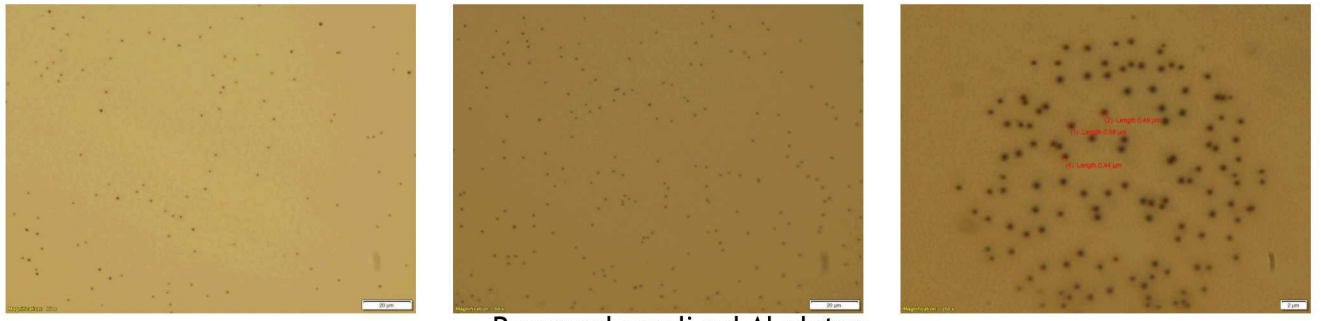


5214

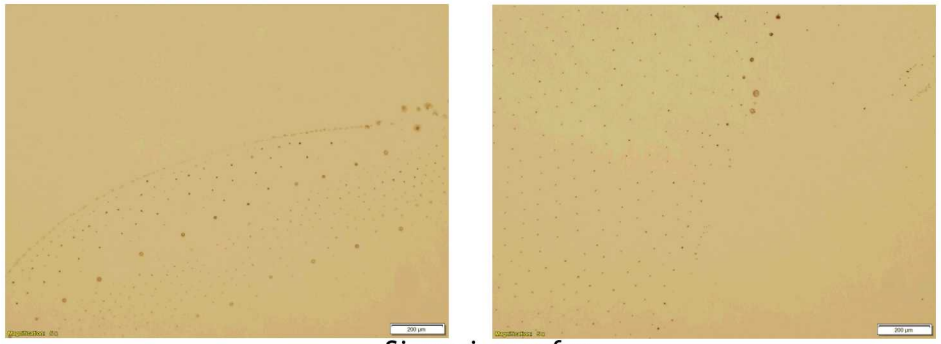


Microdots after GaICP trench etch

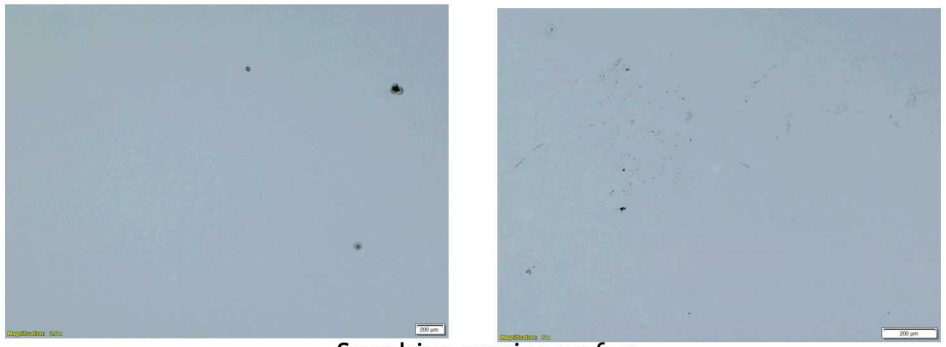
- Microdots appear on sample after 2 um trench etch
- Compare loading conditions to eliminate
  - Recessed anodized Al platen
  - Sample mounted on Si wafer
  - Sample mounted on sapphire



Recessed anodized Al platen



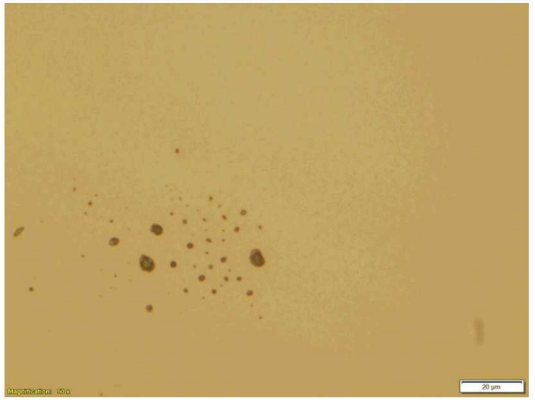
Si carrier wafer



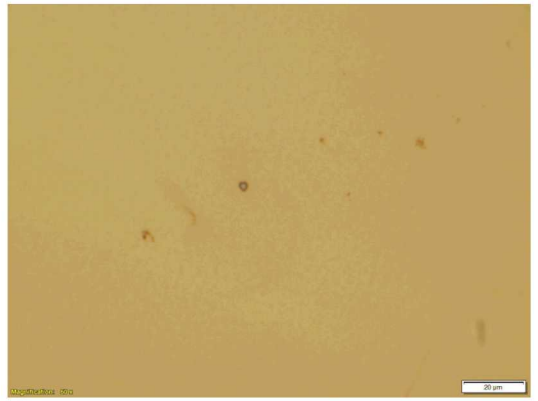
Sapphire carrier wafer

Microdots cont.

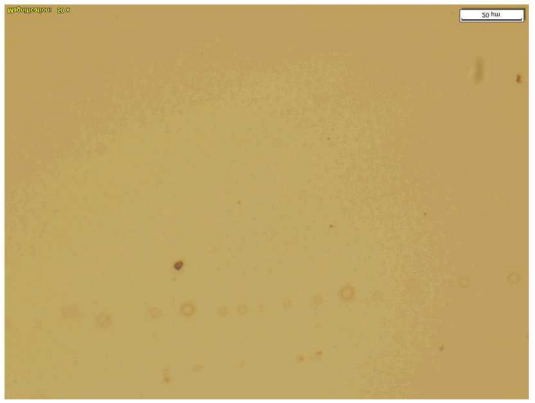
- Wet methods to remove microdots post etch
  - H_3PO_4
  - Acetone, Methanol, IPA
  - IPA with swab



Recessed post 5 min H_3PO_4



Recessed post 15 min H_3PO_4



Recessed post AMI clean

Sapphire mounted post IPA swab

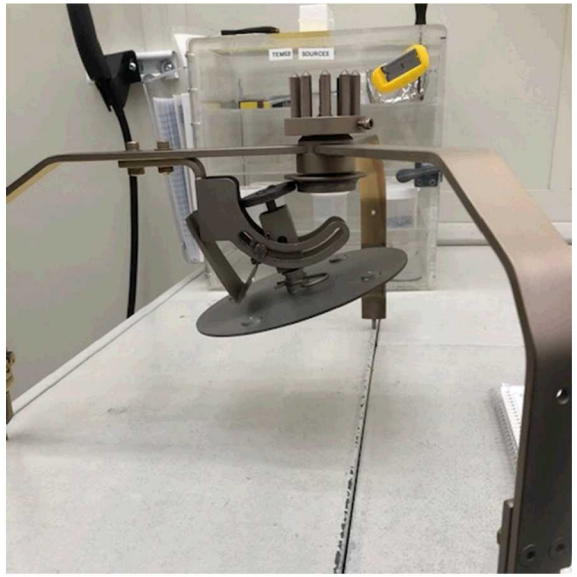
Summary of semester work

- Determined 40:1 (DI:HF) best dilution for SiO_2 gate etch
  - Still need to find best method for ozone surface treatment
- Variable angle metal evaporation fixture at 14° best for conformal trench coverage
  - Voids from Au adhesion still an issue
- Evaluated several resists for gate metal pattern liftoff
  - Time for liftoff needs addressed
  - Thicker resists require longer soak time for liftoff
- Trench etch microdots and contamination
  - Cleaning methods including IPA swabs slightly improve

Next Steps

- Determine selectivity of PR mask
  - Calibrate other resists
- Find best way to determine when dielectric fully removed
  - Measured with Nanospec Reflectometer
- Understand trench microdot issue and how to mitigate
  - IPA swab
- Gate metal quick lot
  - Compare VAP, HSP, and sputtering
  - VAP with slower deposition rate
- Literature review for buried p-GaN activation
- Begin training for probe testing of completed devices

HSP fixture for metal evaporation



VAP fixture for metal evaporation