Uniformity Characterization of Technics-c

By Carolyn Kooi

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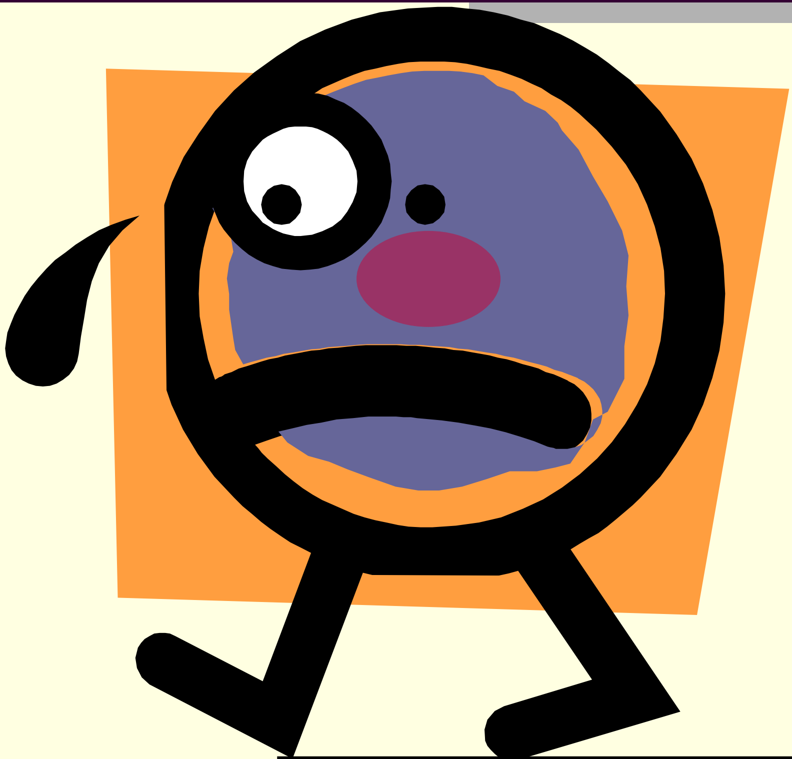
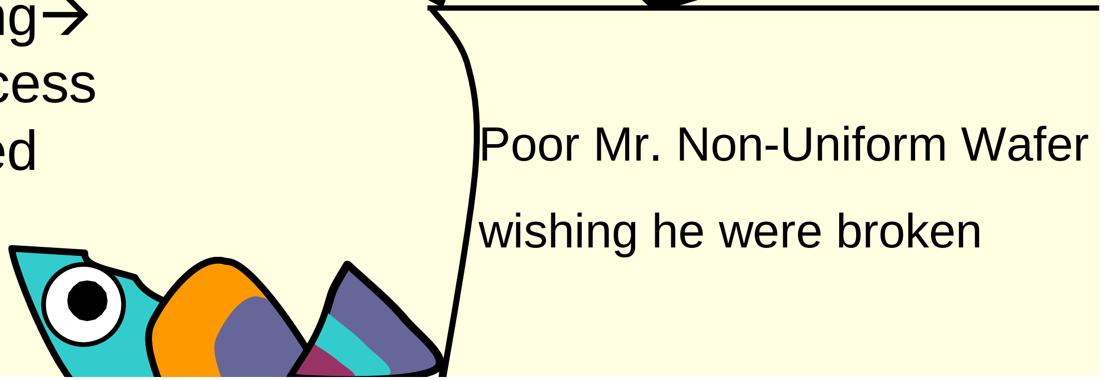
My Project

- Uniformity is key
  - →Higher yield
  - Keeps process costs down
  - Non-uniformity can be destructive
    - Too much etching→ damage to previous work on die
    - Too little etching→ necessary process is not completed



Poor Mr. Non-Uniform Wafer

wishing he were broken



My Project

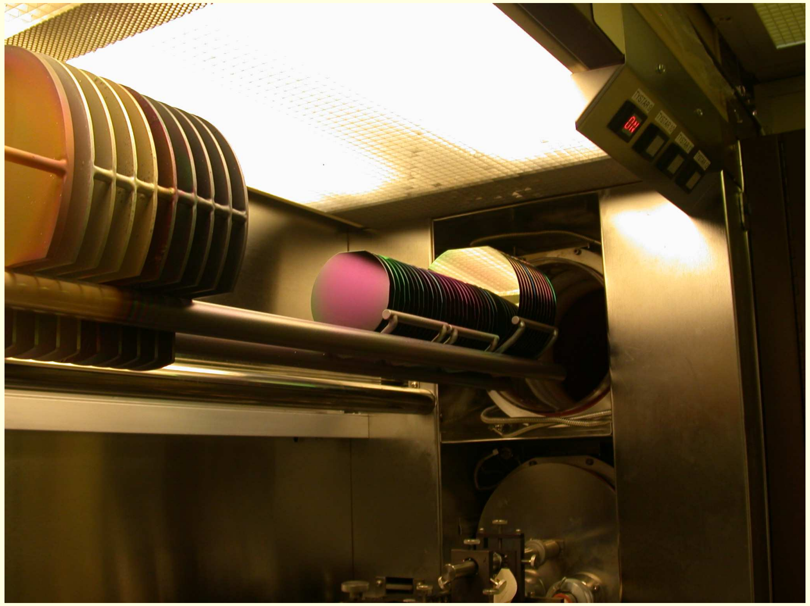
- Goal
  - To characterize the current uniformity in Technics-c
  - To pick a combination of upper and lower gas ring flows that maximizes uniformity

Process

- Grow silicon nitride (Si_3N_4) on silicon wafers
- Measure preliminary thickness of nitride with Nanospec
- Etch wafers in Technics-c
- Perform nine point measurement with Nanospec
- Calculate % non-uniformity
  - Defined by us as $\frac{\text{Max-Min}}{\text{Average}}$

Process

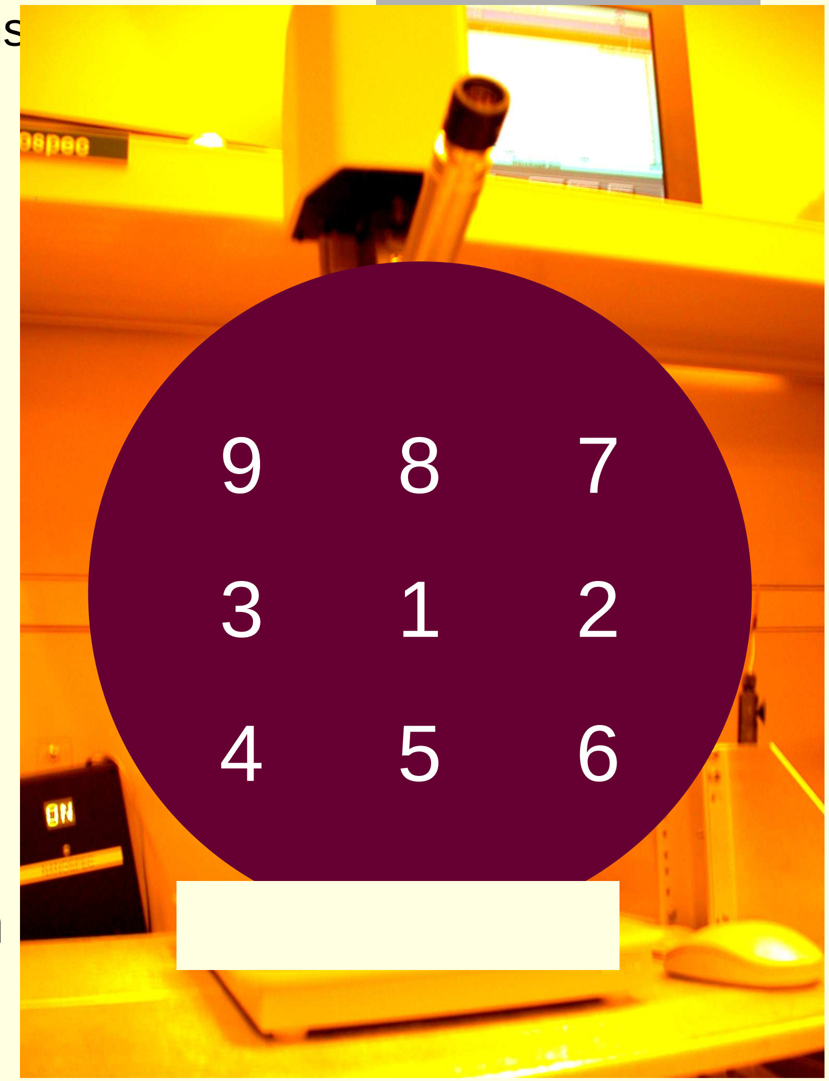
- Tystar 9
  - Deposition of nitride on silicon to create silicon nitride (Si_3N_4)
  - Low Pressure Chemical Vapor Deposition
    - $3SiCl_2H_2 + 4NH_3 \rightarrow$
      $Si_3N_4 + 6HCl + 6H_2$



Process

- Nanospec
  - Measures thickness of deposited nitride
  - Nine-point measurement
  - Reflectometry
    - Sends down white light
    - Constant wavelength in air, when meets the nitride, there is thin film interference
    - Depending on substance on wafer, there is a constant rate of refraction
  - Based on what is intensified and what is canceled out, it can detect the thickness of the deposited layer

Cons

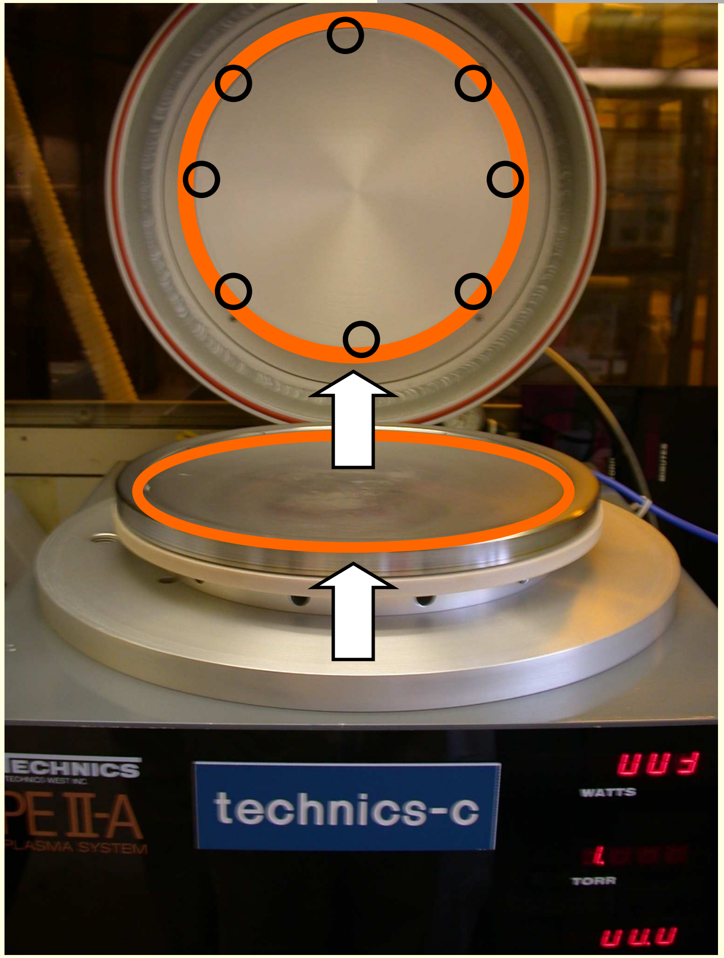


Process

- Technics-c
  - Etches silicon nitride using SF_6 and He
- Method
  - Wafers placed on platen
  - Lid is closed and vacuum is turned on
  - Once pressure is ~40mT, SF_6 and He gas are let into the chamber

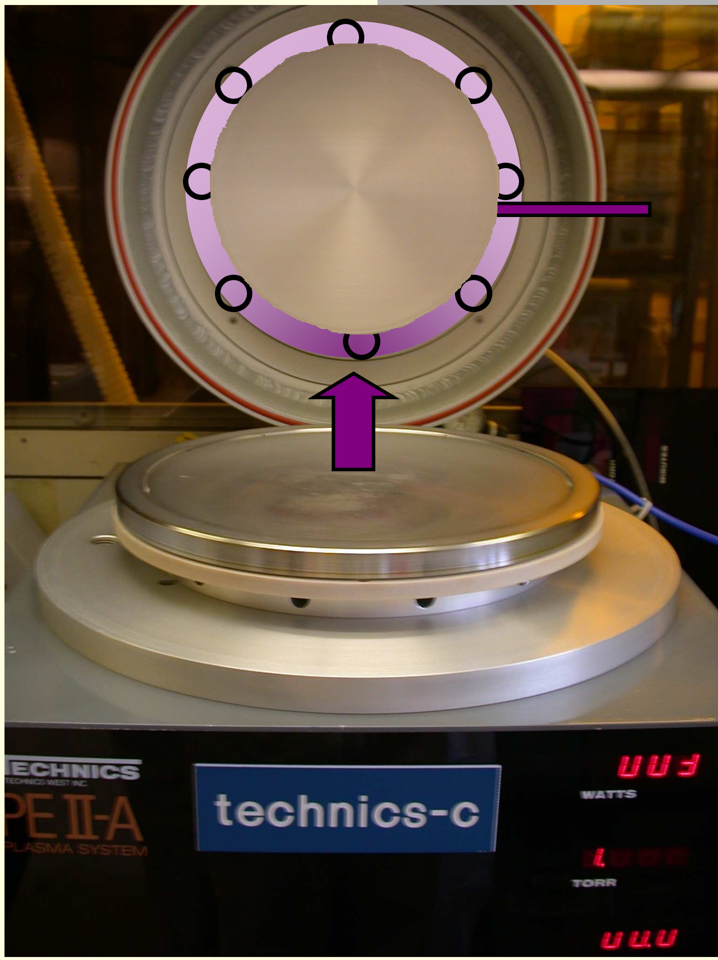
Process

- Gas feed
  - Back of upper electrode
  - Front of lower electrode
- Gas flows into chamber between platen and metal plate then enters through holes



Process

- Potential Problem
  - Gas distribution
    - Gas might not evenly disperse before entrance into chamber
    - Might cause non-uniform flow of gas in chamber
    - Center gas feed is optimal



Process

- Use 100W plasma
- The Process of Etching
  1) Dissociation

     $SF_6 + e^- \rightarrow SF_5 + F + e^-$
  2) F and He interact with surface of wafers

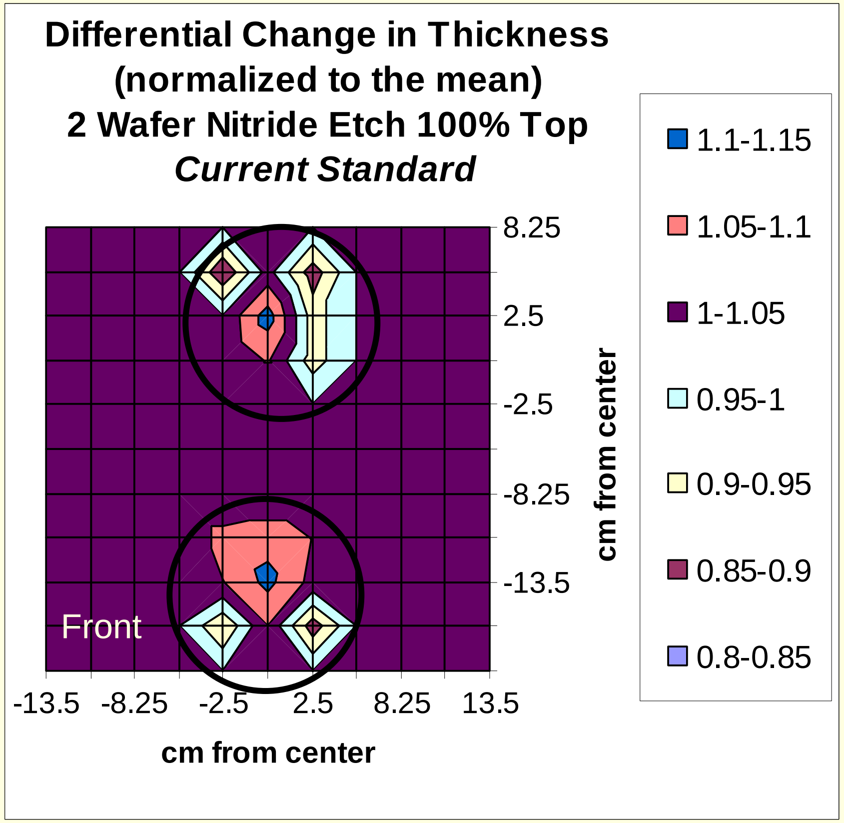
	F	He
3)	Absorbed by nitride	Bombards wafer
4)	Fluorine binds to Silicon to form SiF_3 (Silicon tetraflouride)	Knocks off Silicon Nitride

5) Volatile byproducts are removed with vacuum pump

Riley, P.E.; Hanson, D.A., "Study of etch rate characteristics of SF_6/He plasmas by response-surface methodology: effects of interelectrode spacing," IEEE Transactions on semiconductor manufacturing, Vol. 2, No. 4, pg, 178-182, Nov. 1989.

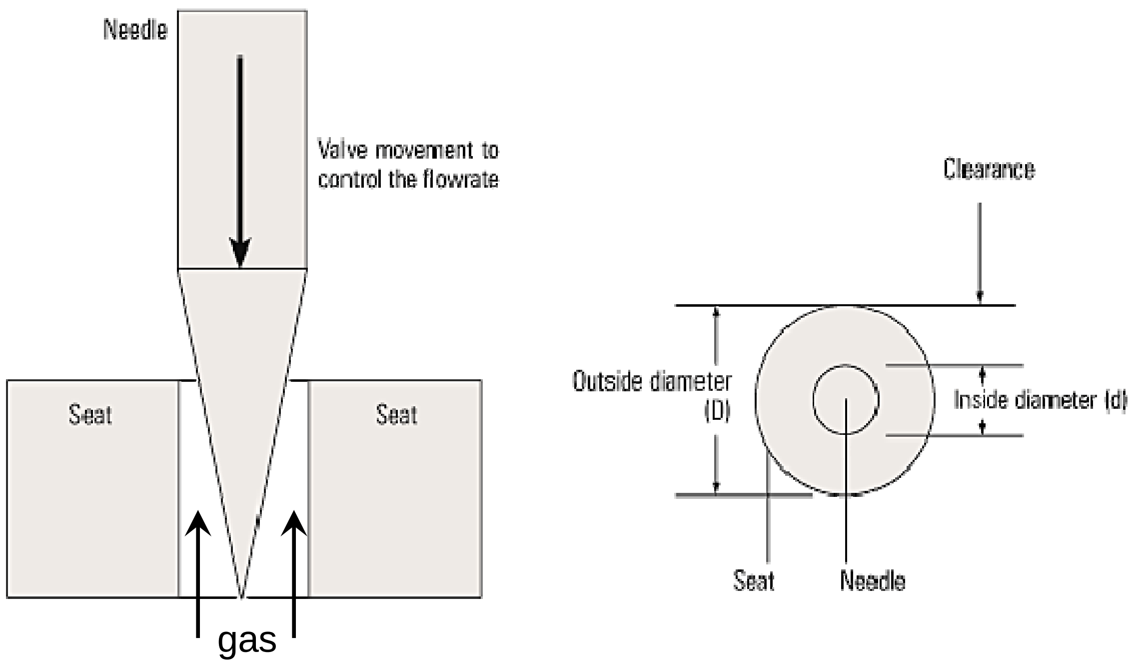
My Project

- Characterization of Technics-c
  - Current Recipe for Nitride Etch
    - 100% gas on top
    - Flow rates
      - SF_6 13.0 sccm
      - He 21.0 sccm
    - 100W
- Problem
  - When etched with current recipe wafers are not uniform
  - % Non-uniformity
    - Front 23.6%
    - Back 27.6%



$$\text{Differential Change in Thickness} = \frac{\frac{\text{Final}}{\text{Initial}}}{\text{Mean}}$$

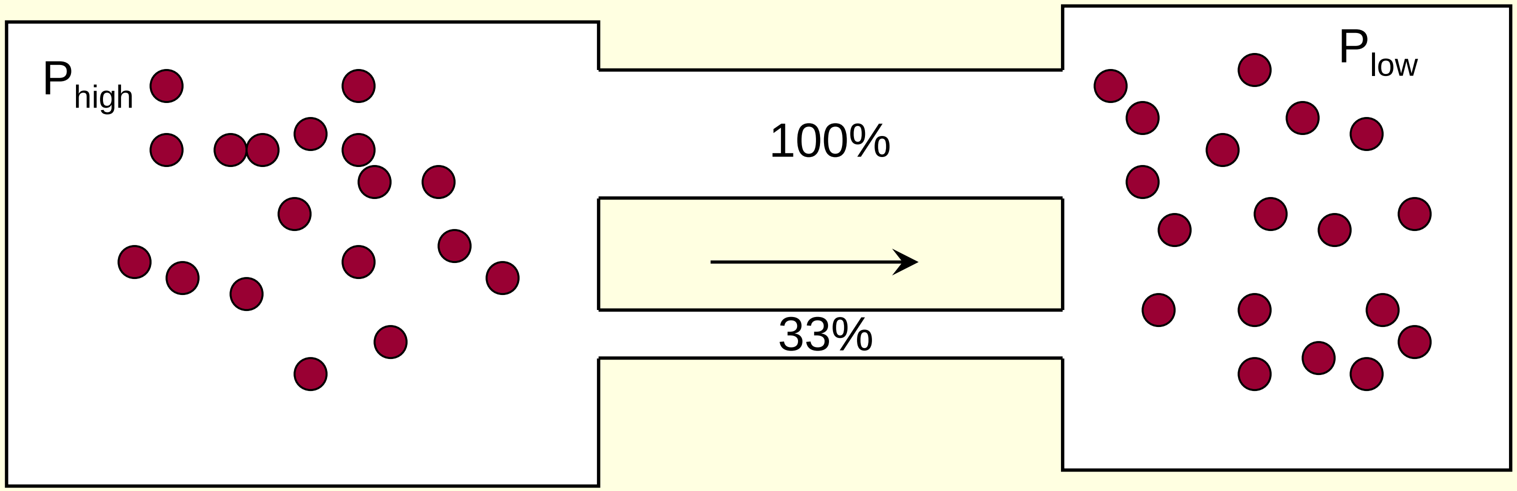
Method



http://www.spiraxsarco.com/resources/steam-engineering-tutorials/the-boiler-house/controlling-tds-in-the-boiler-water.asp

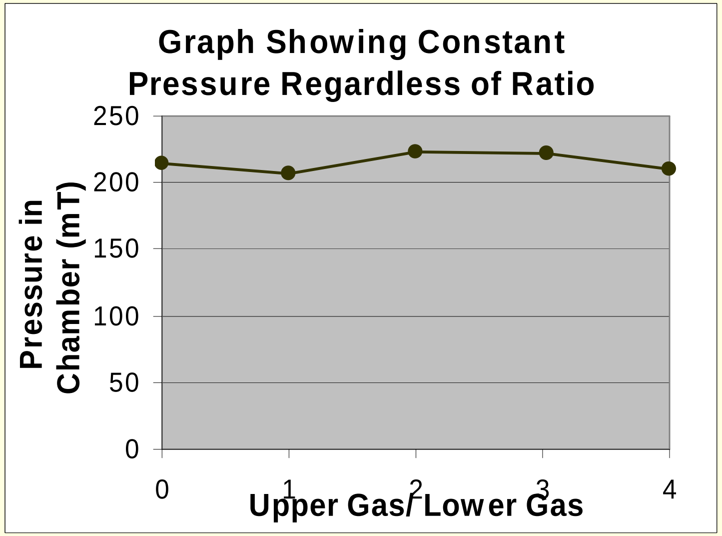
Method

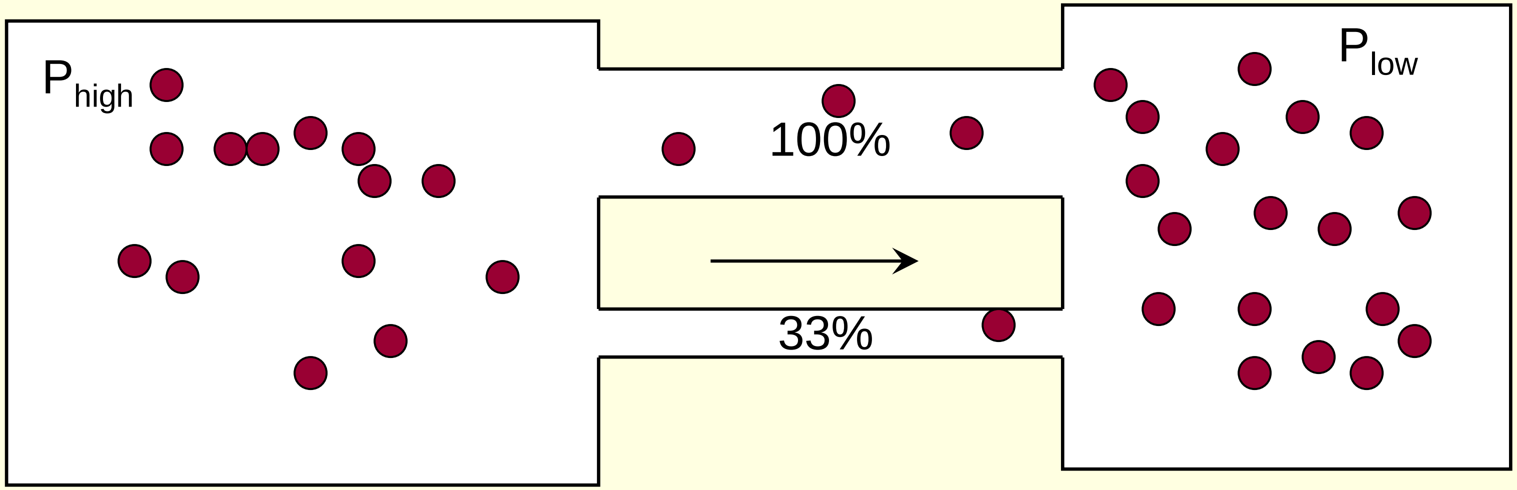
- Two Needle Valves
  - With micrometers we can precisely set our openings
    - 20 tick marks
    - Highest tick mark defined as 100%
  - Varied ratio flow between upper and lower gas



Method

- Constant pressure differential → constant total flow rate
- Constant total flow rate → gas is divided up by the ratio of upper to lower
  - In 100-33 division (3:1 ratio), flow rate in each tube is proportional to the ratio of the openings



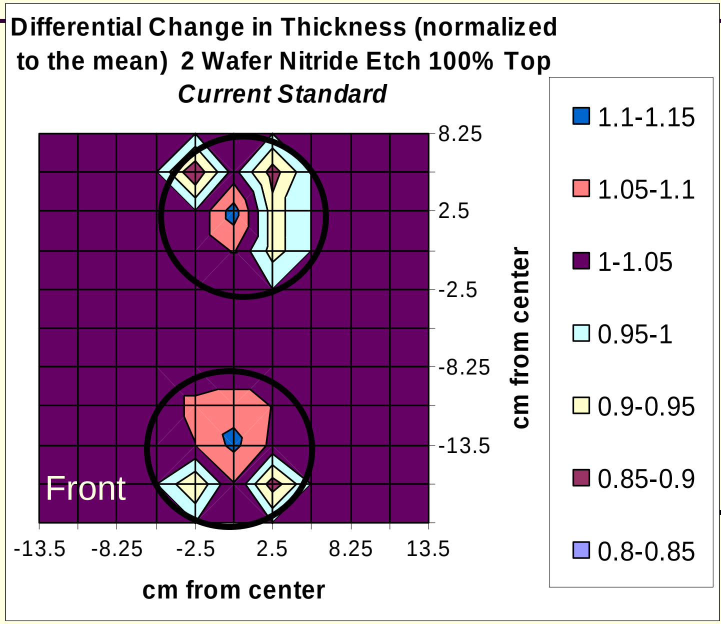


Method- Non-Uniformity

		Upper Gas				
		0	25	33	50	100
Lower Gas	0					F 23.58% B 27.62%
	25					
	33					F 2.54% B 2.53%
	50				F 2.04% B 3.66%	F 1.61% B 3.82%
	100	F 33.96% B 47.65%				F 5.26% B 9.38%

Results

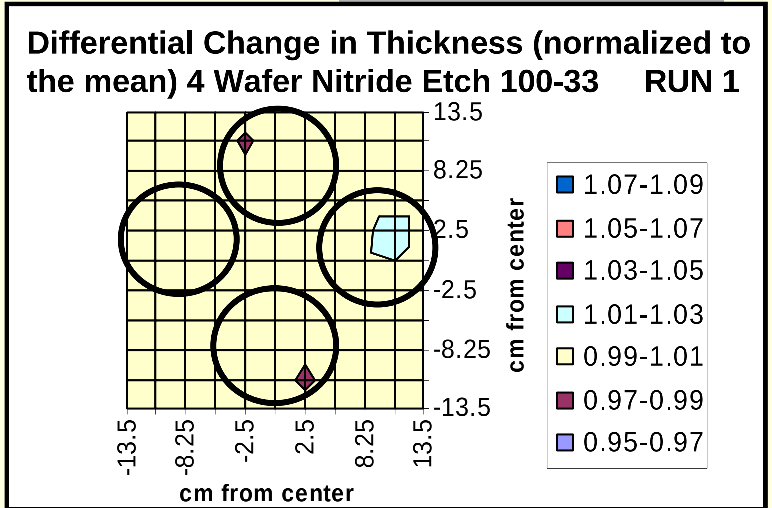
$$\text{Differential Change in Thickness} = \frac{\frac{\text{Final}}{\text{Initial}}}{\text{Mean}}$$

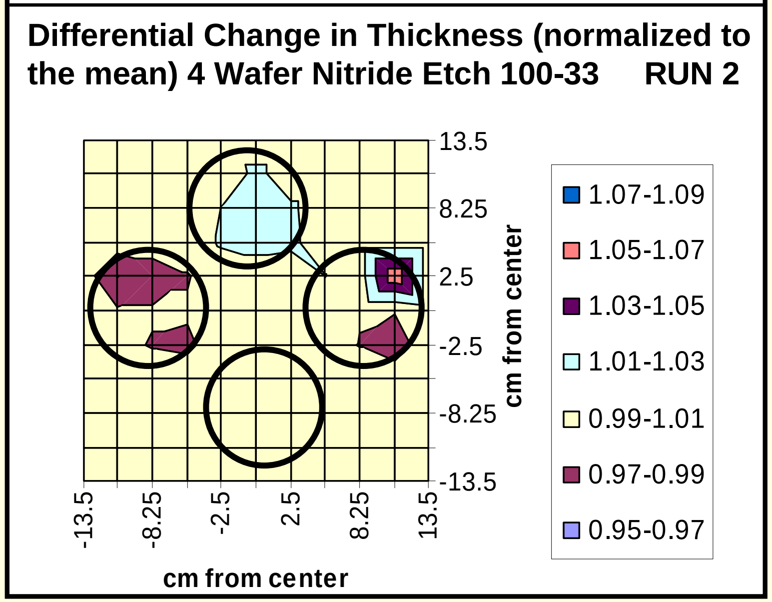


-33

%non-uniformity

	Run 1	Run 2
Front	1.8%	1.4%
Back	1.3%	2.0%
Right	1.3%	2.9%
Left	1.2%	2.7%



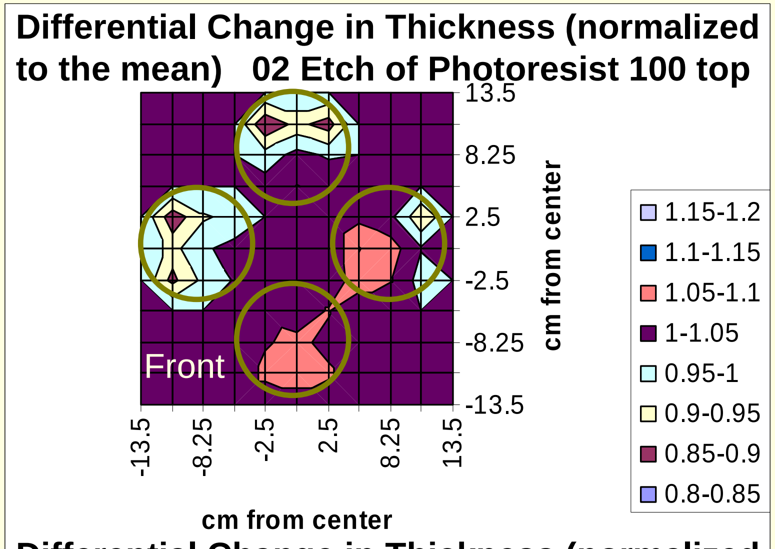


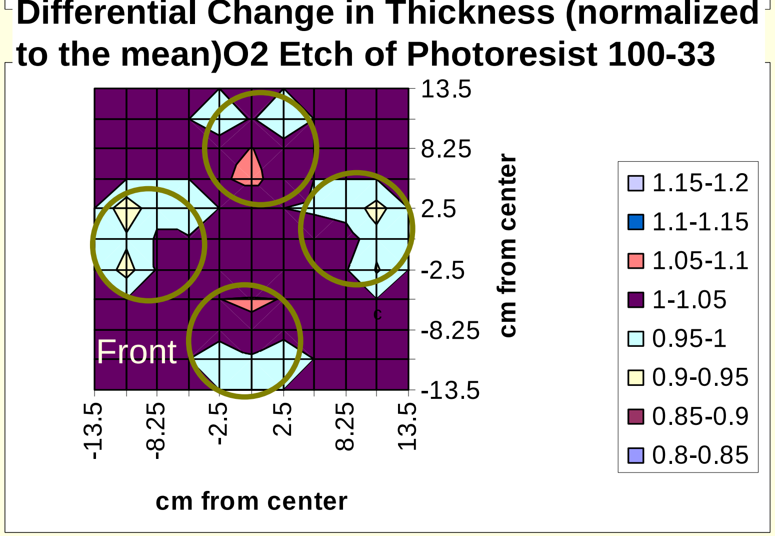
Results

Differential Change in Thickness = $\dfrac{\frac{\text{Final}}{\text{Initial}}}{\text{Mean}}$

- Success in Nitride Etch
- Technics-c is also used for ashing and etching of Photoresist
- Tested 100 top (current recipe) and 100-33
  - O_2, 300W,1 minute
  - Percentage of non-uniformity

    from 100-0 to 100-33 etch
    - F 8.4% → 9.7%
    - B 20.5% → 10.7%
    - R 15.7% → 11.4%
    - L 15.7% → 11.2%

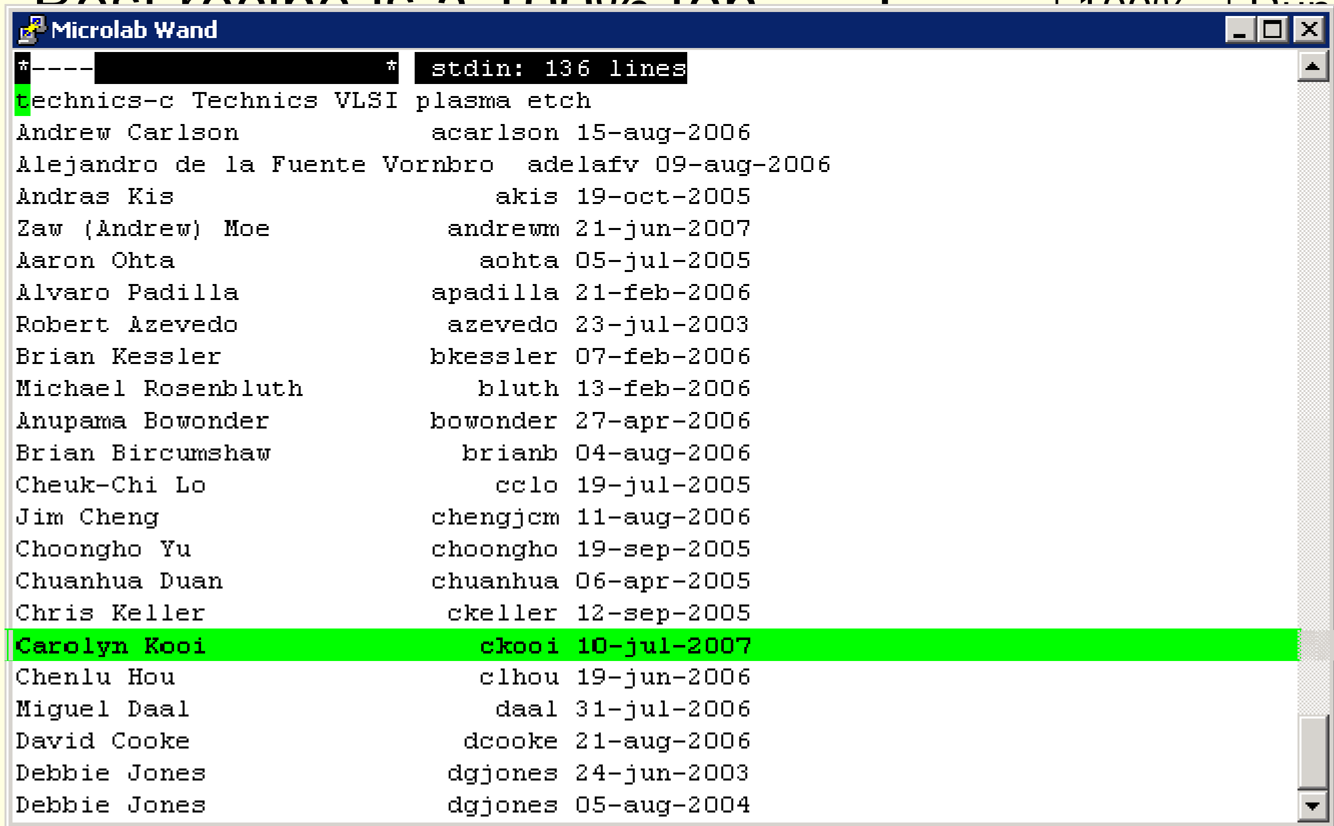




Summary

- Best recipe is a 100% top

	100%	Run 1	Run 2
			1.4%
			2.0%
			2.9%
			2.7%



Acknowledgements

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