Shrink and Control Critical Dimension Using Dielectric Etch Chamber for 45nm Technology and Beyond

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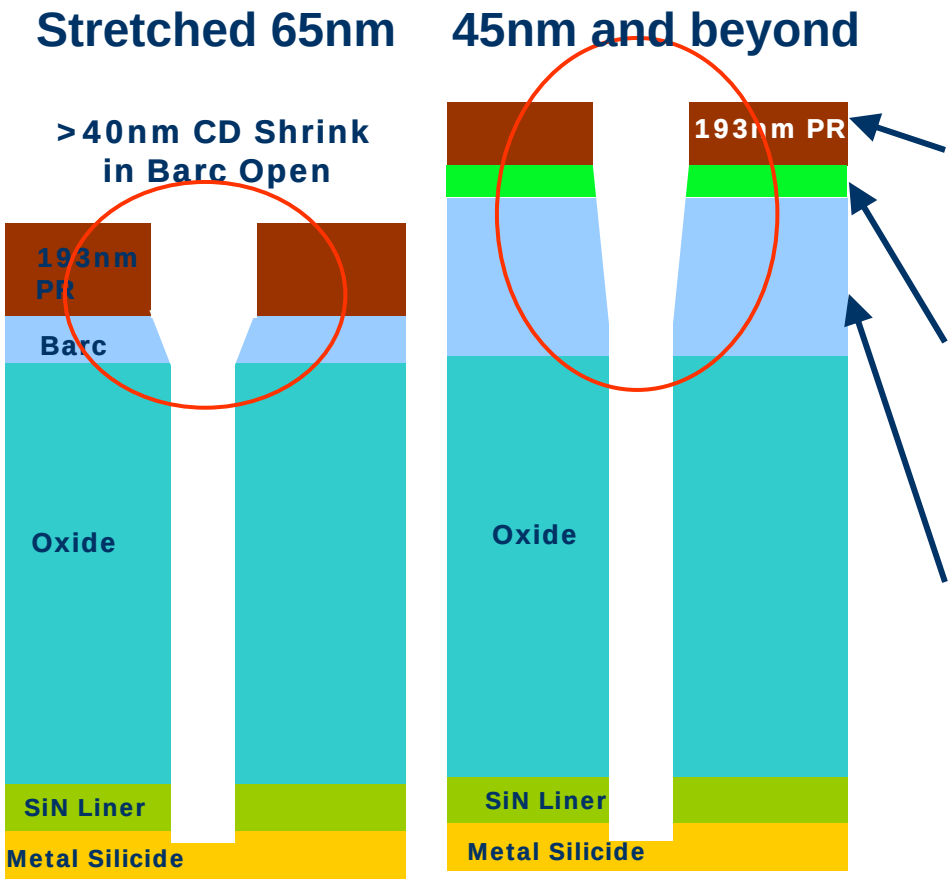
APPLIED MATERIALS®

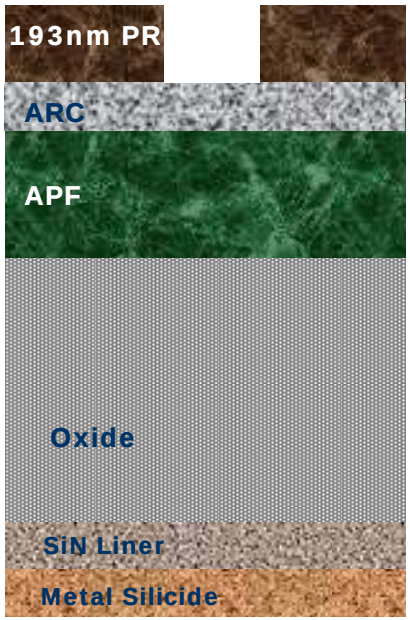
Problem Statement

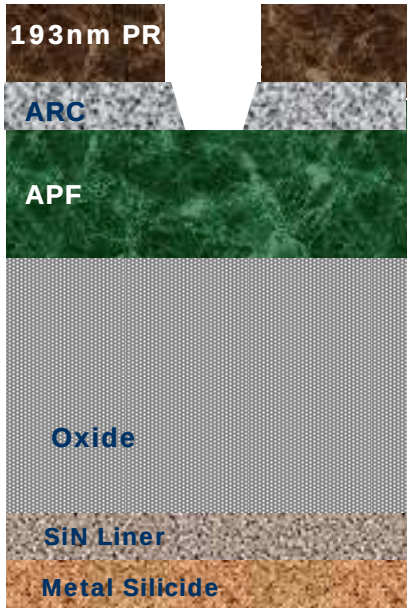


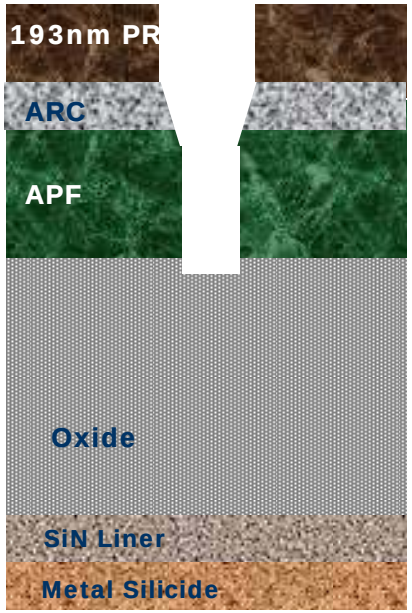
Multiple Layer resist

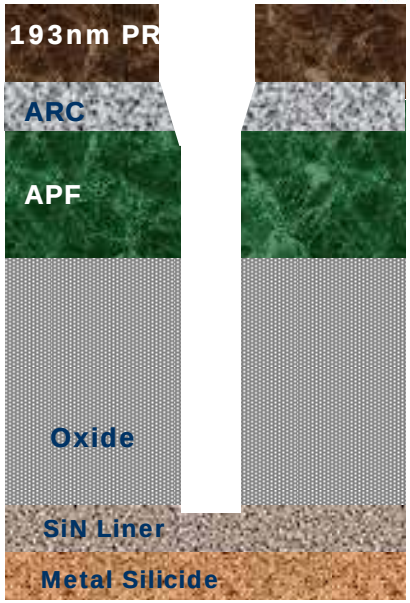
- Very thin 193nm litho resist
  - From dry or immersion litho
  - Optional BARC on scheme
- Thin hard mask
  - DARC/BARC
  - SOG
  - SiARC
- Thick image transfer layer
  - APF, amorphous carbon
  - Spin-on organic
  - I-line resist

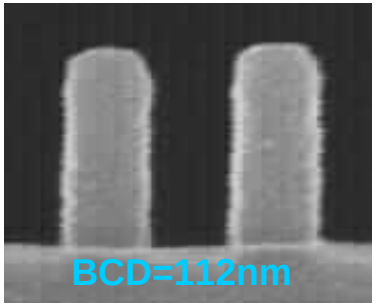
CD Shrink Process Flow – Line Open

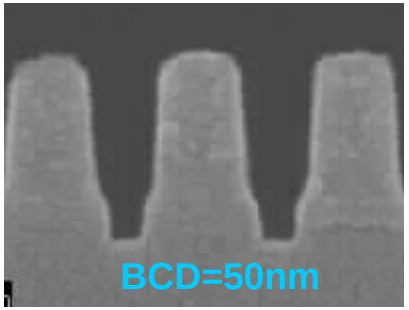


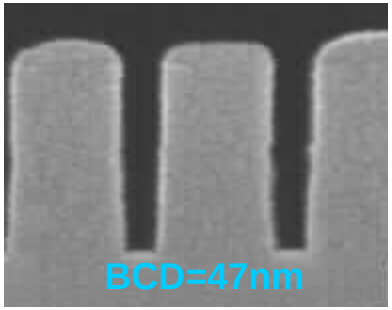


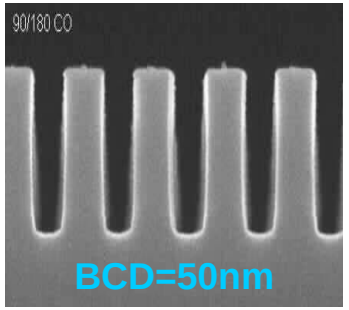


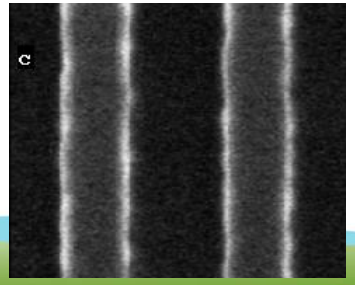


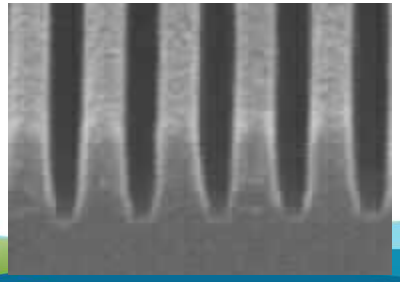


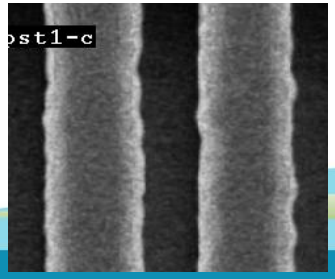


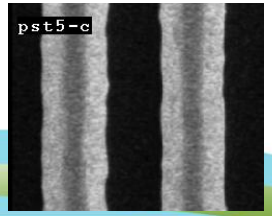




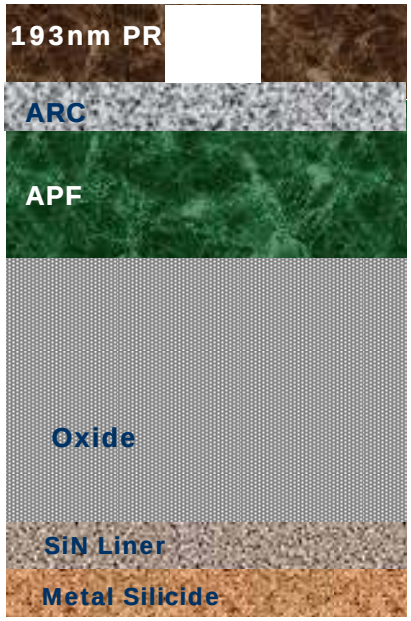


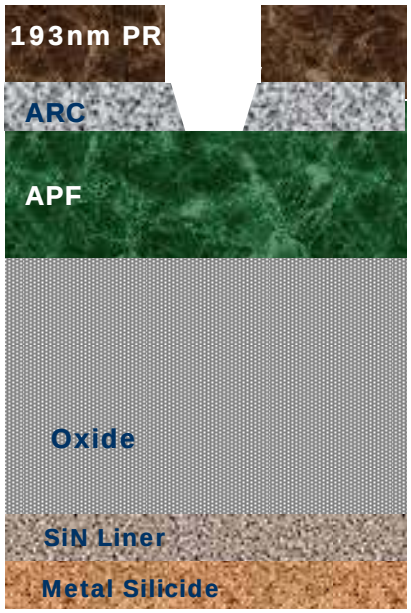


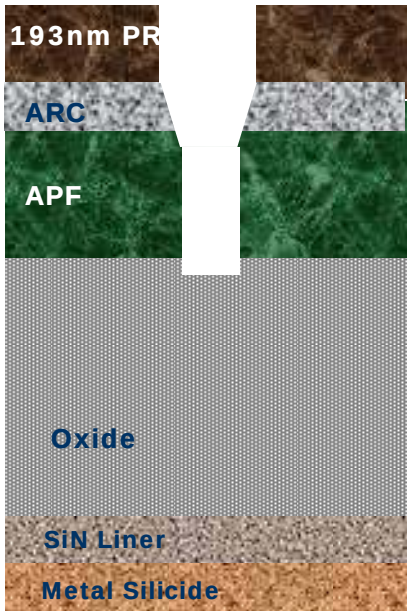


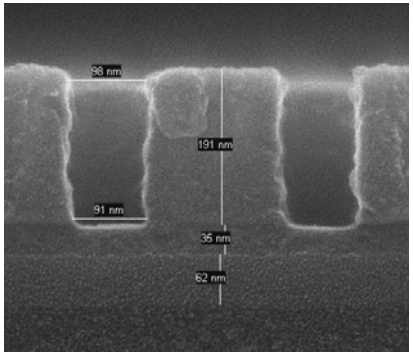


CD Shrink Process Flow – Via Etch

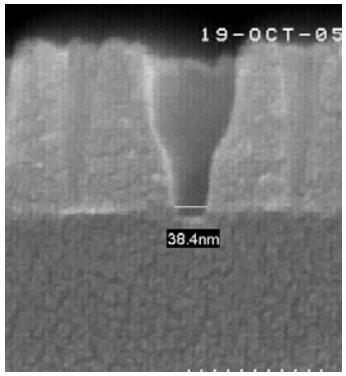






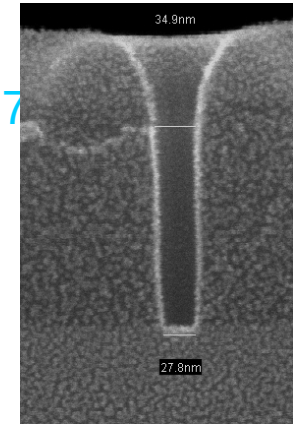


BCD=90nm



BCD=38nm

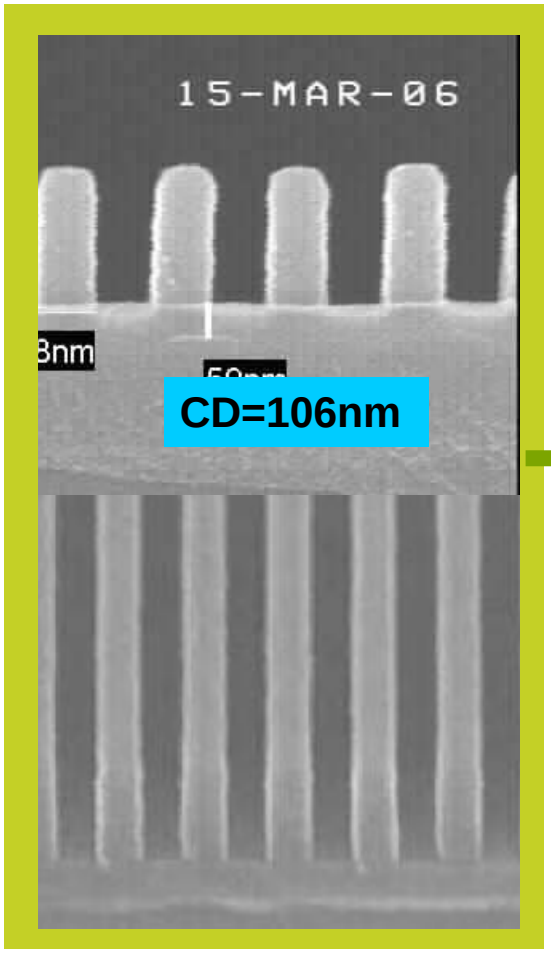
17



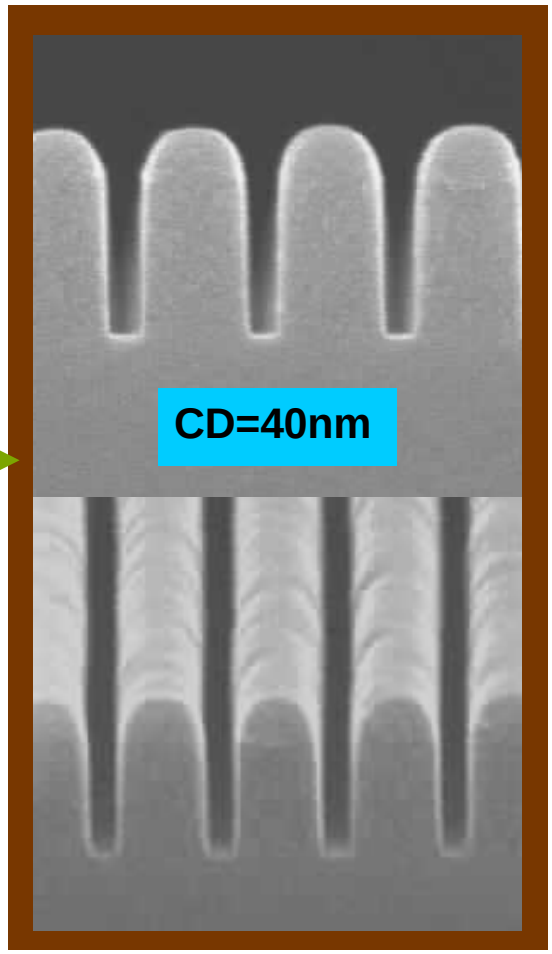
BCD=27nm

Problem Solution

CD Shrink Challenges



Our Solution



Process Knobs to Shrink CD

- Rich chemistry
- High MHz source power
- Low pressure

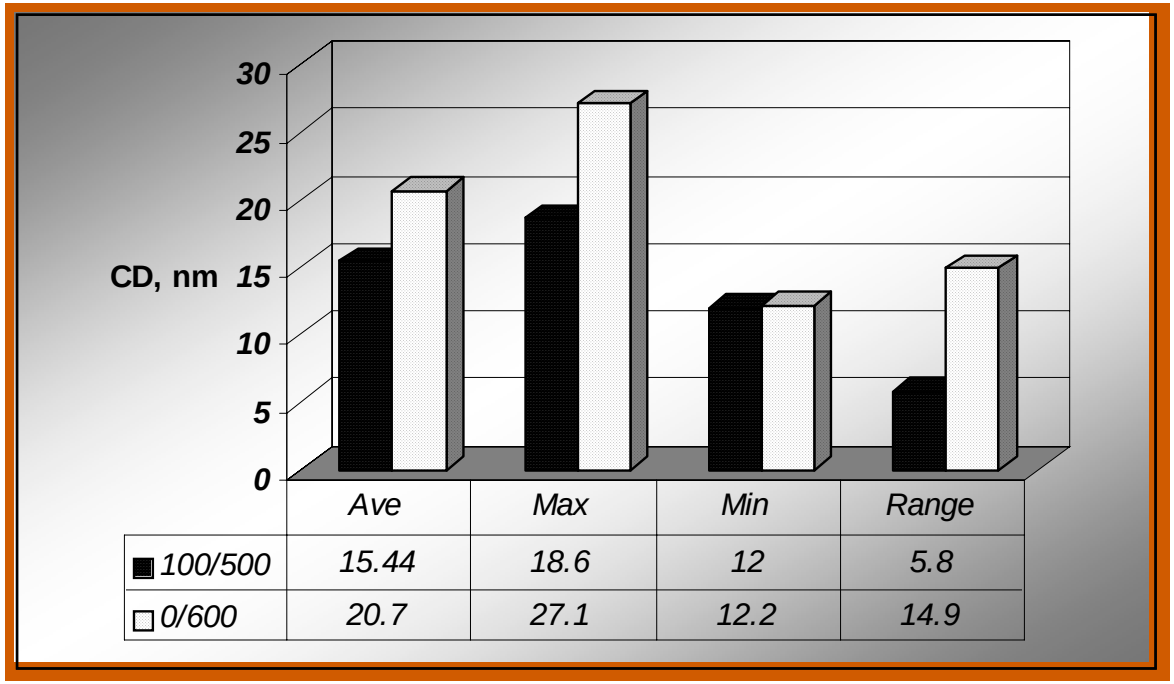
CD Shrink Range

- >60nm shrink
- <6nm CD range

High Frequency

- <100 MHz
- >100 MHz

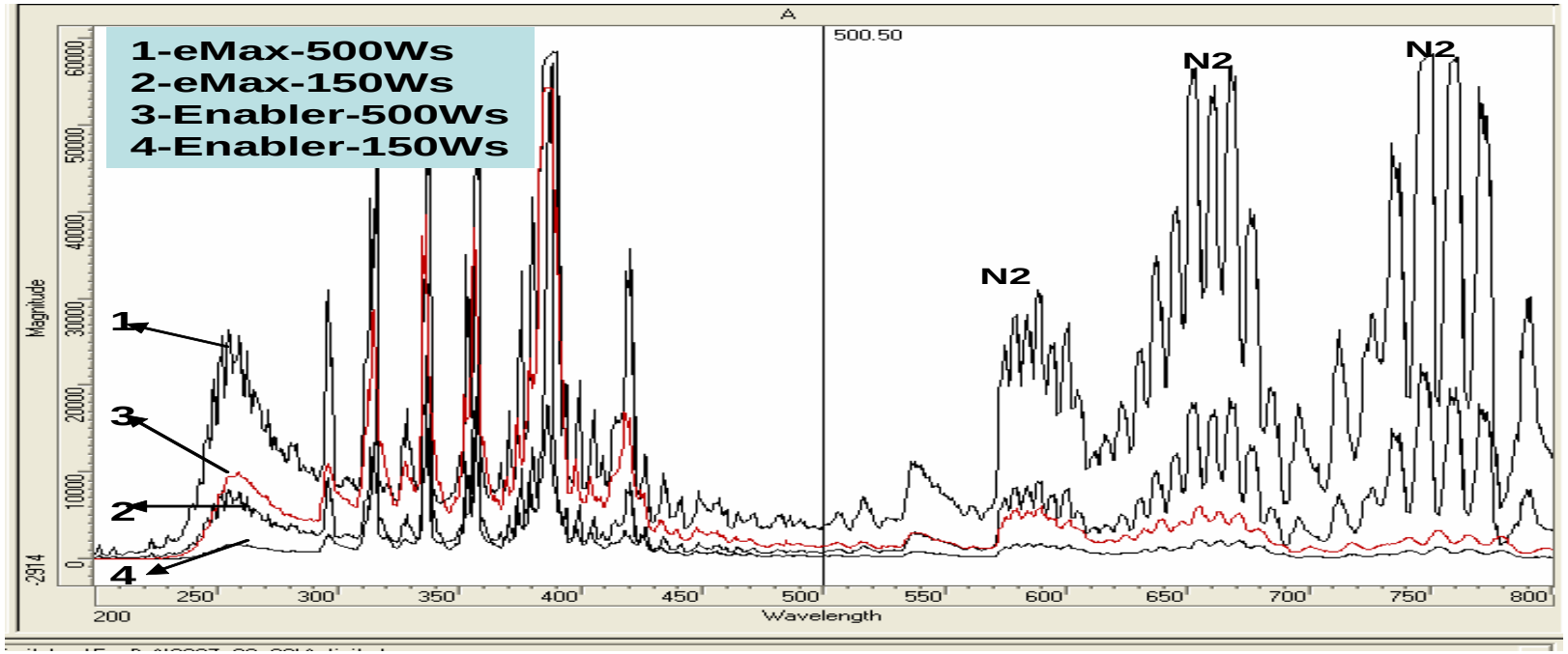
CD Shrink with and without Source Power

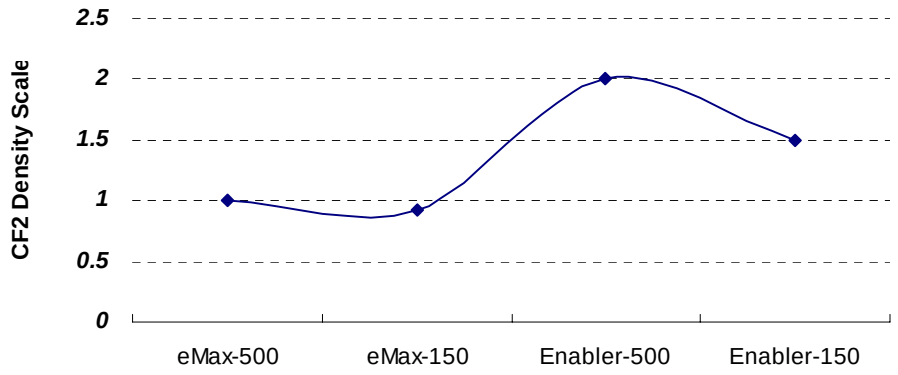


	Ave	Max	Min	Range
100/500	15.44	18.6	12	5.8
0/600	20.7	27.1	12.2	14.9

With 100 W source power, bottom CD shrink was more than zero source power

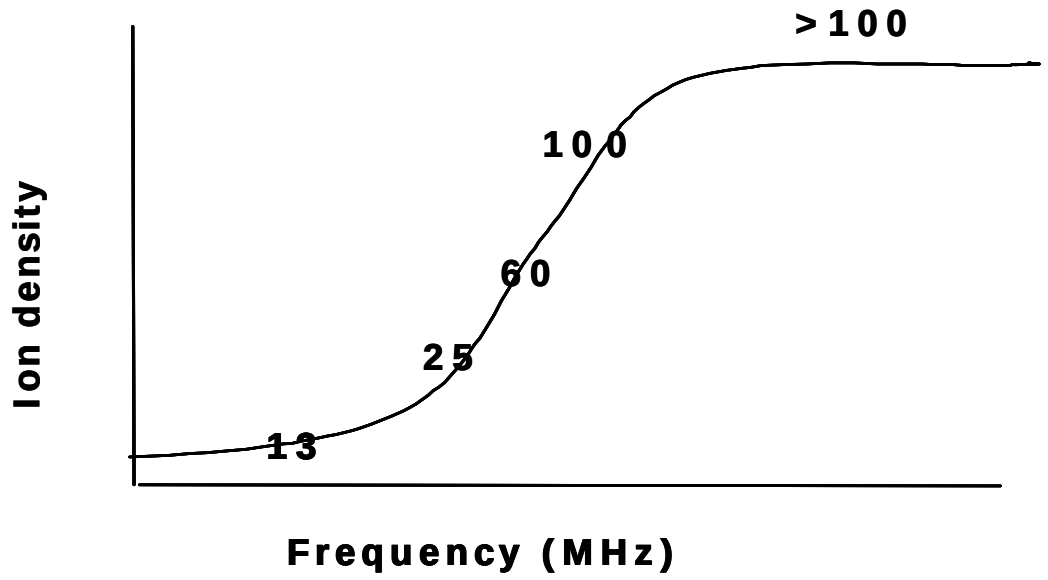
CF2 Emission with Different Frequency and Source Power





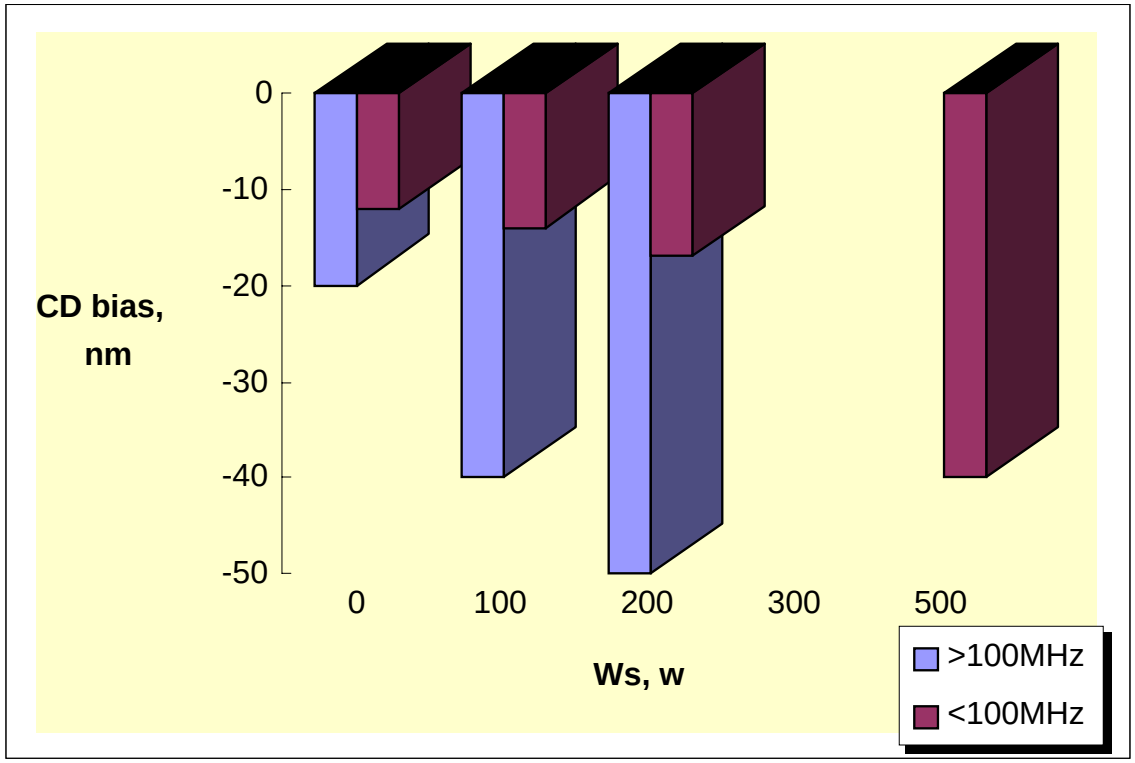
- Higher source power showed the strong CF2 species density
- Higher frequency showed the strong CF2 species density

Ion Density with Source Frequency



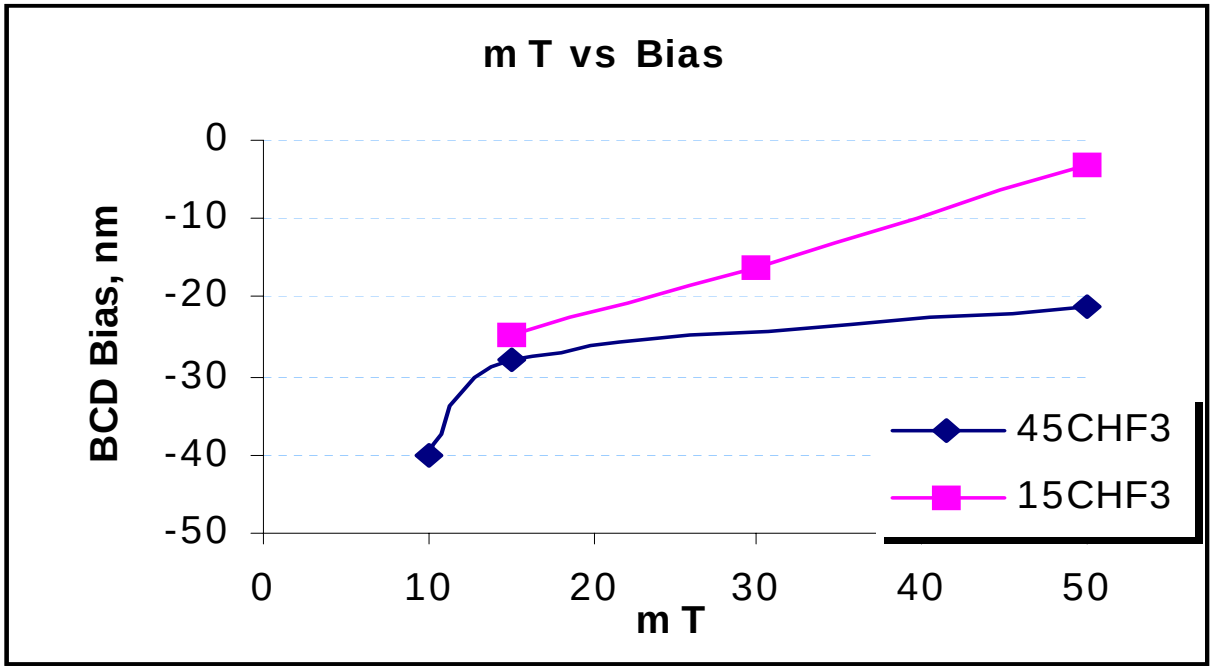
- Higher frequency, higher ion density
- Ion density flat with >100MHz

Two Frequencies Comparison on CD Shrink



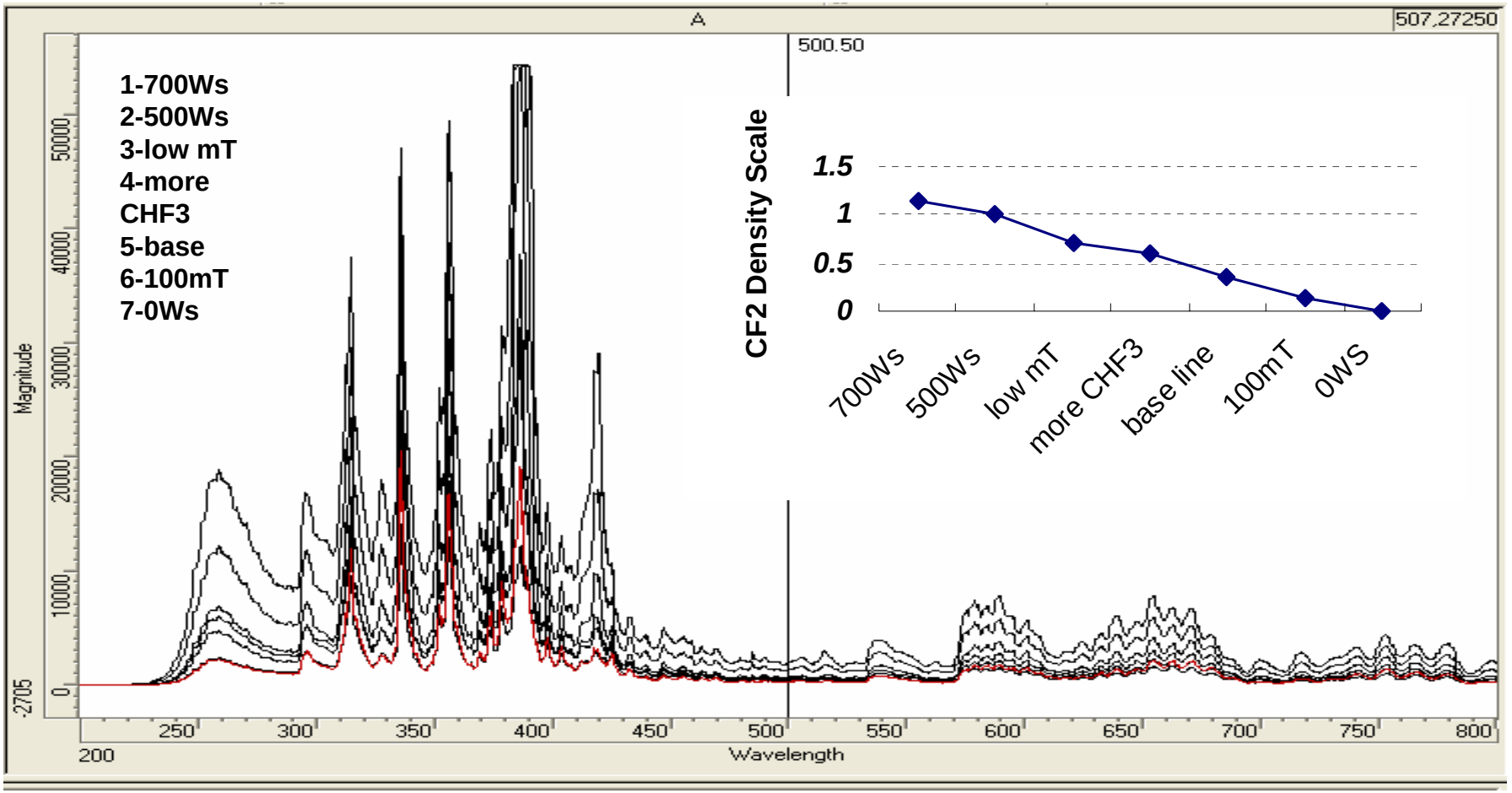
- High frequency showed big CD shrink
- High source power indicated more CD shrink

CD Shrink with CHF3 Flow and Pressure



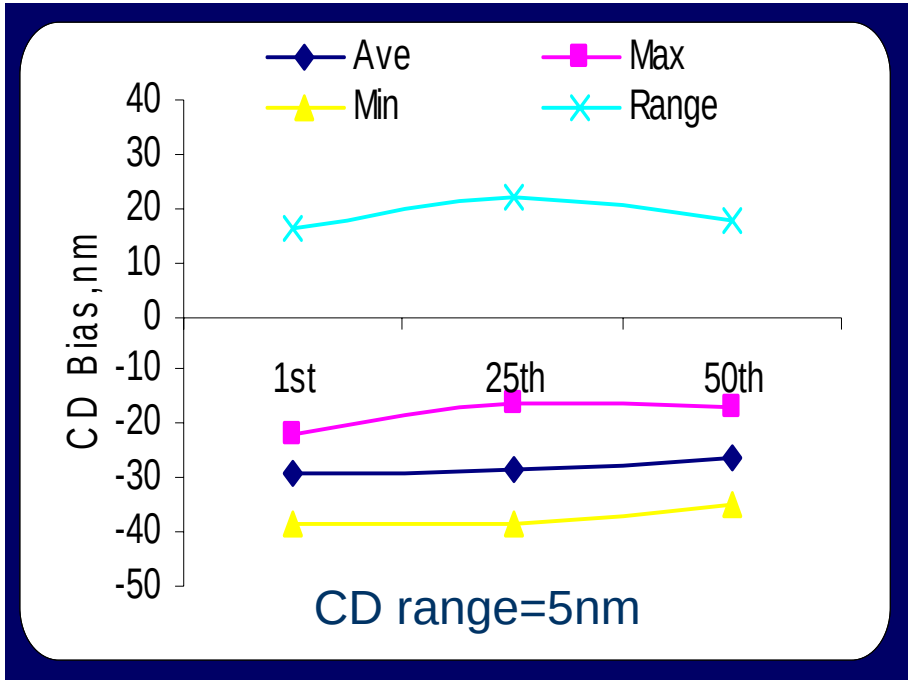
- Lower pressure, more BCD shrink
- High CFH3 flow brought more BCD shrink

CF2 Emission with Source Power, Pressure, and CHF3 Gas Flow Rate

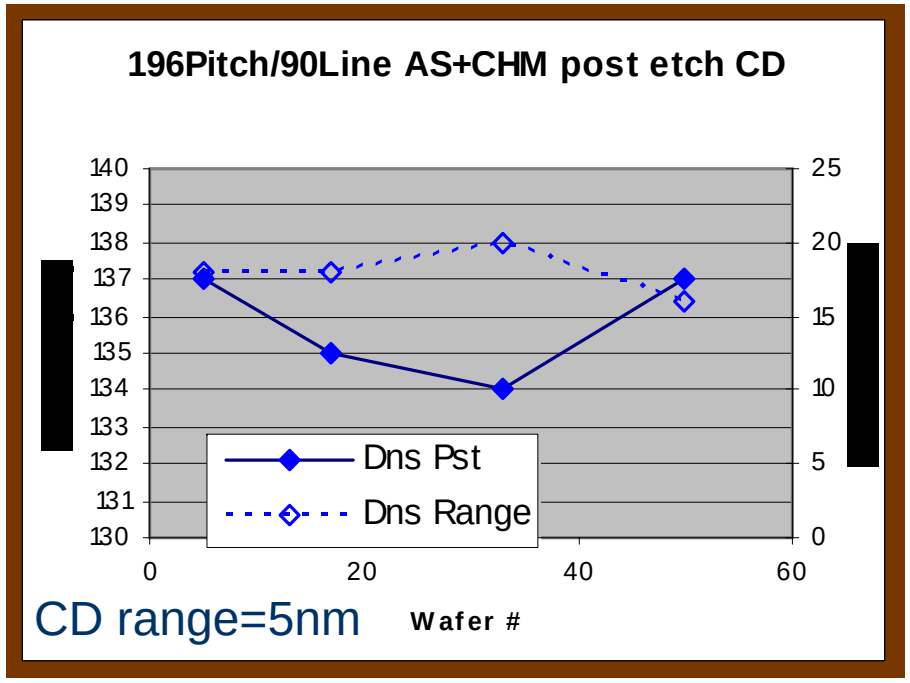


- A clear trend showed the high source power, more CHF3, and low pressure the strong emission signals

Customer's Wafer Repeatability Results with Two Different Frequency Source Powers



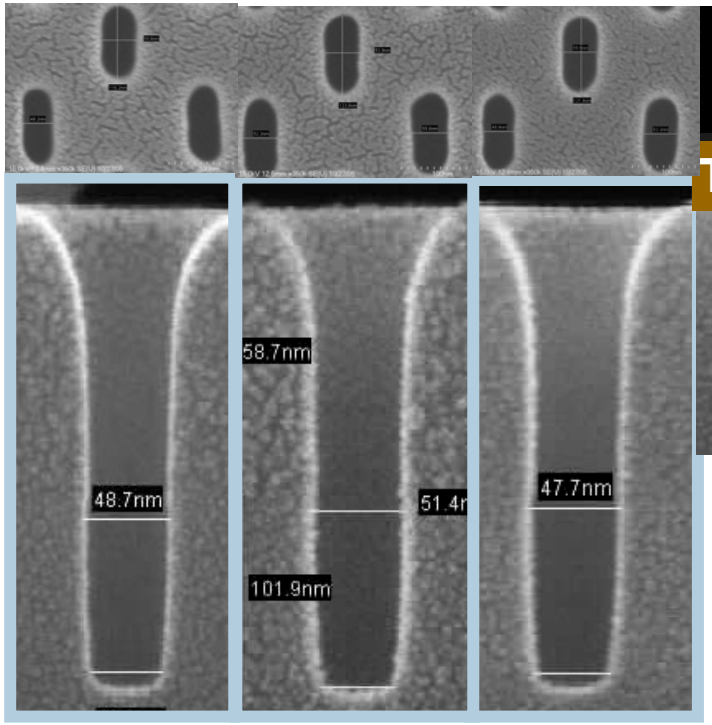
>100MHz Ws

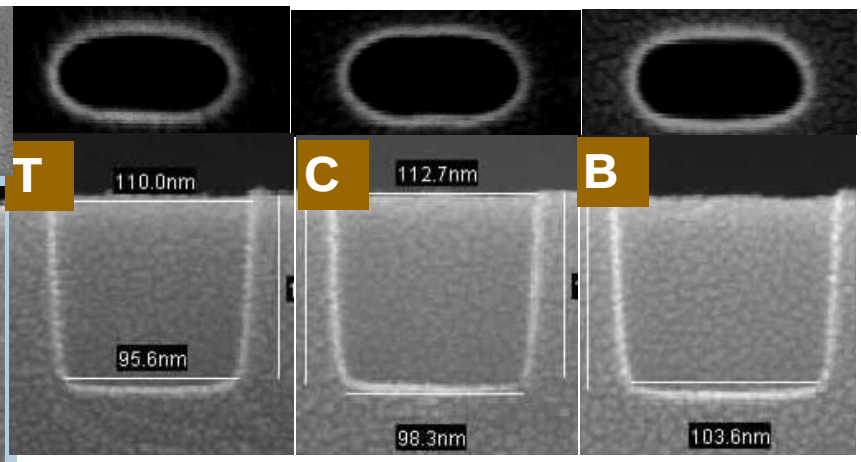


<100MHz Ws

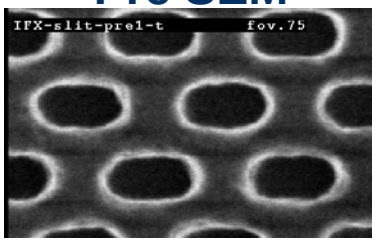
- Both >100 and <100 MHz source powers showed a pretty repeat results on CD range

Customer's Wafer Results with >100 MHz Source Power

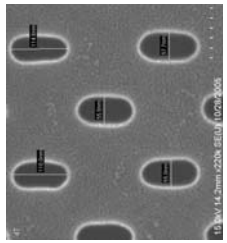




Pre SEM



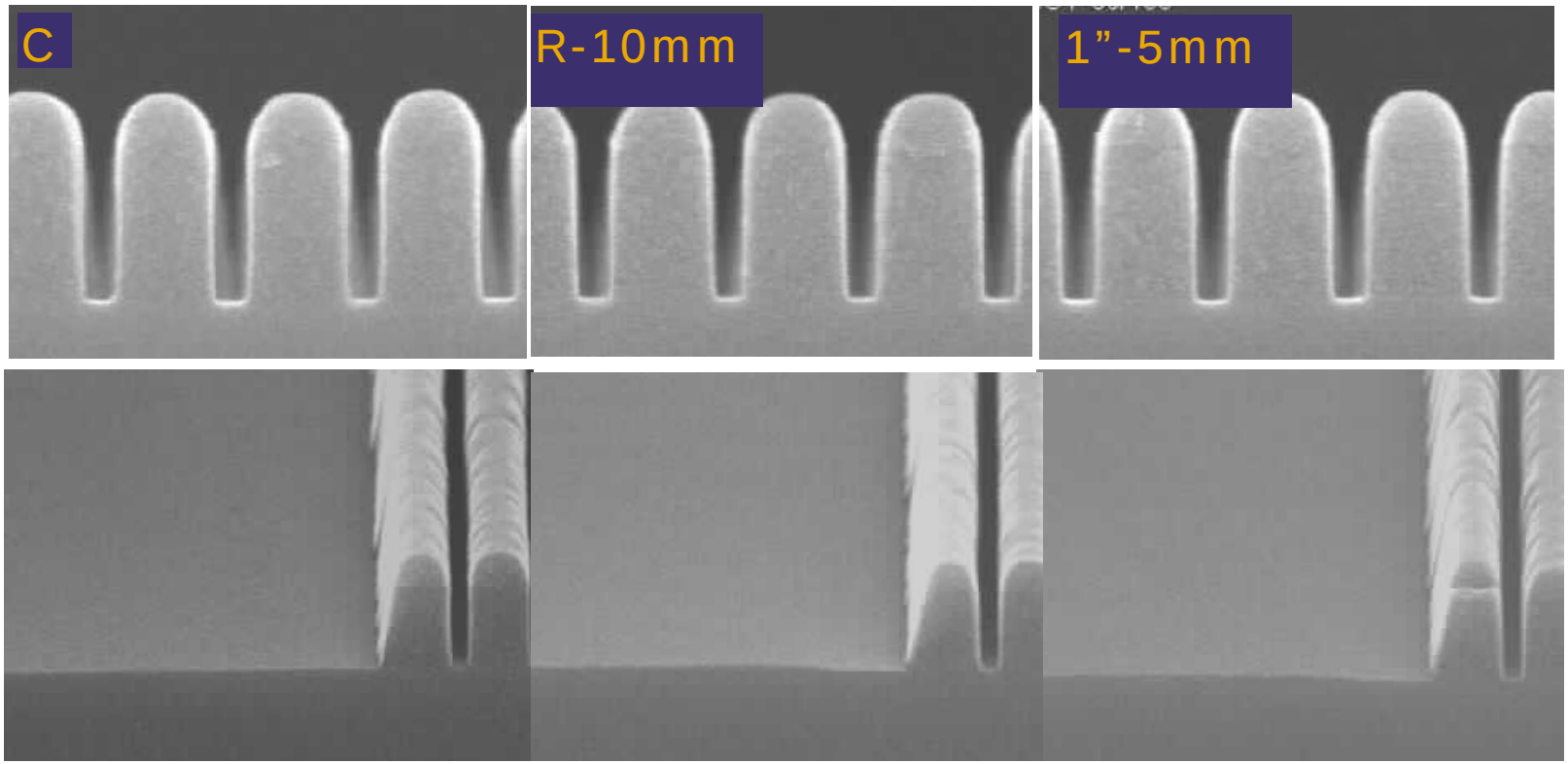
Post



- A -40nm BCD shrink with a vertical profile through wafer
- No distortion on the top view

Pre CD=80nm
Pos CD=40nm
Bias CD=40nm

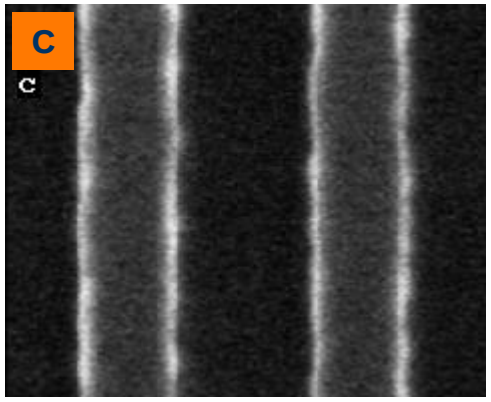
Customer's Wafer Results with <100 MHz Source Power

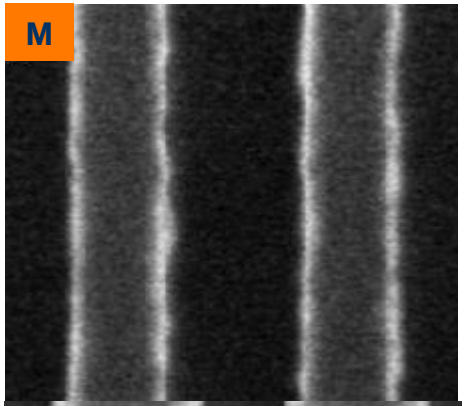


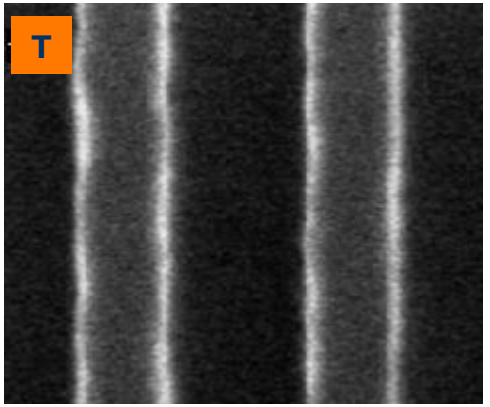
- Descent profile from center to edge with a -60nm BCD shrink
- Post CD range < 7nm

CD Shrink Top View on APF Open

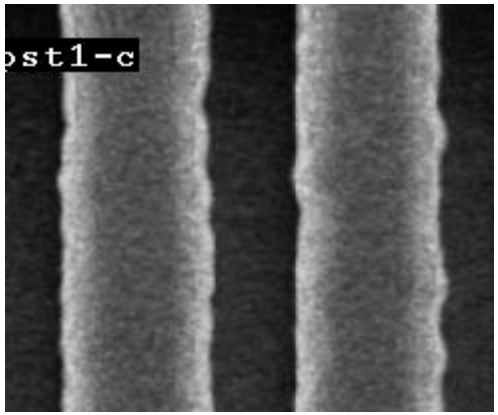
Pre
CD=110nm

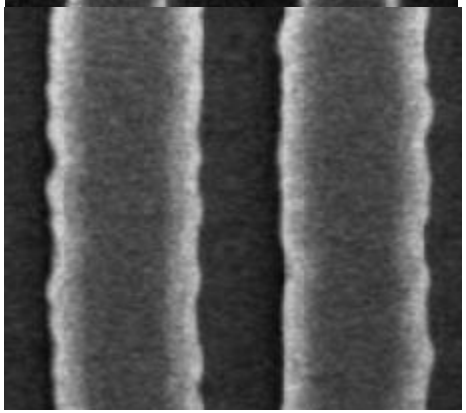


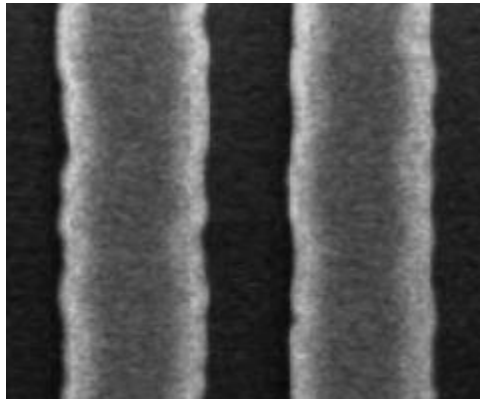




APF
CD=179nm







Bias
CD=69nm with <7nm CD range

Potential Concern and Possible Solution

- The CD shrink methodology has been used in several of demo works and has been proved as the useful solution for small CD requirement in 65nm or beyond technology. So far, there are no any data showed the productivity runs beyond <60nm CD shrink and need more production data for qualifying for 45nm or even 32 nm node technology in the future

- More repeatability work needed to be done to check the CD control window

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