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# A Technique to Measure Dose and Focus Based on CD-SEM

Kyoungmo Yang, Yutaka-Hojyo,
Norio Hasegawa, Hideo Sakai,
Lorena Ferry

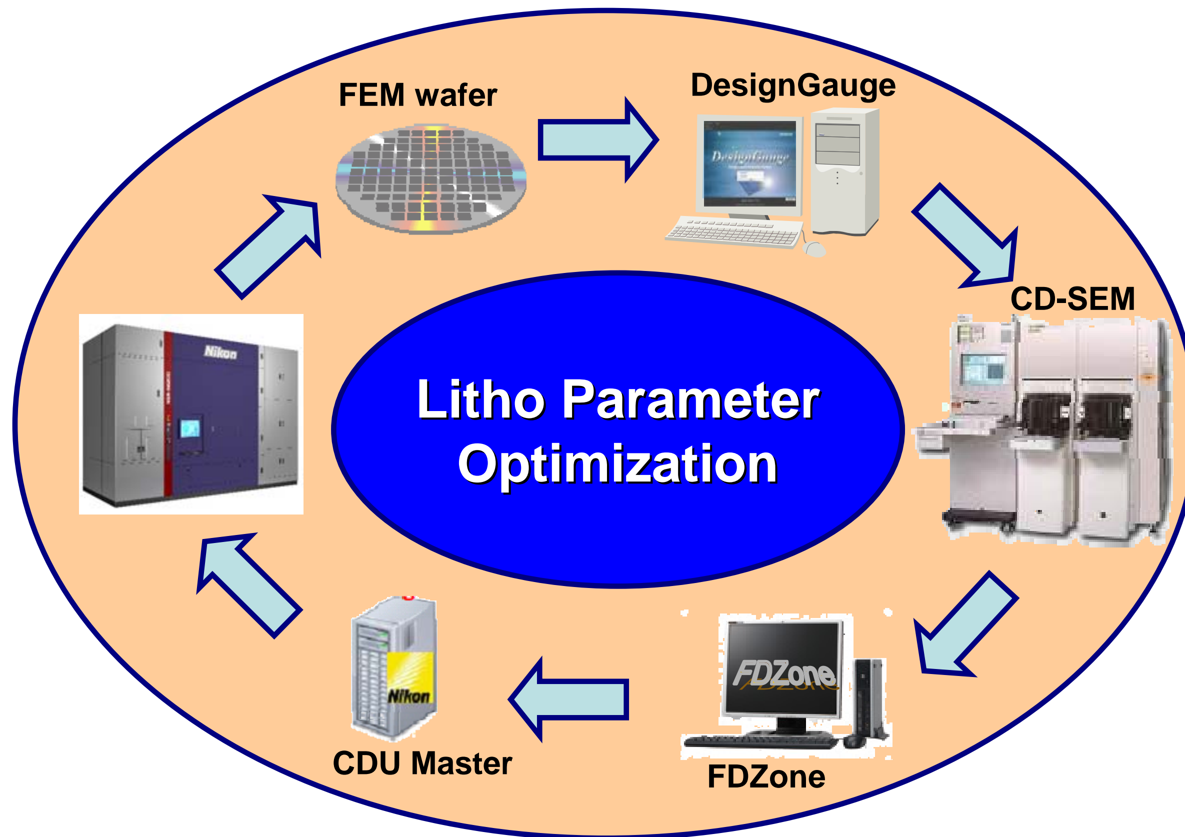
Hitachi High-Technologies

# Outline

- Motivations and objective
- Defocus･Dose measurement algorithm
  - MPPC Algorithm
  - Defocus･Dose measurement algorithm
- Experimental
- Conclusions and Acknowledgment
- More measurement solutions for Lithography

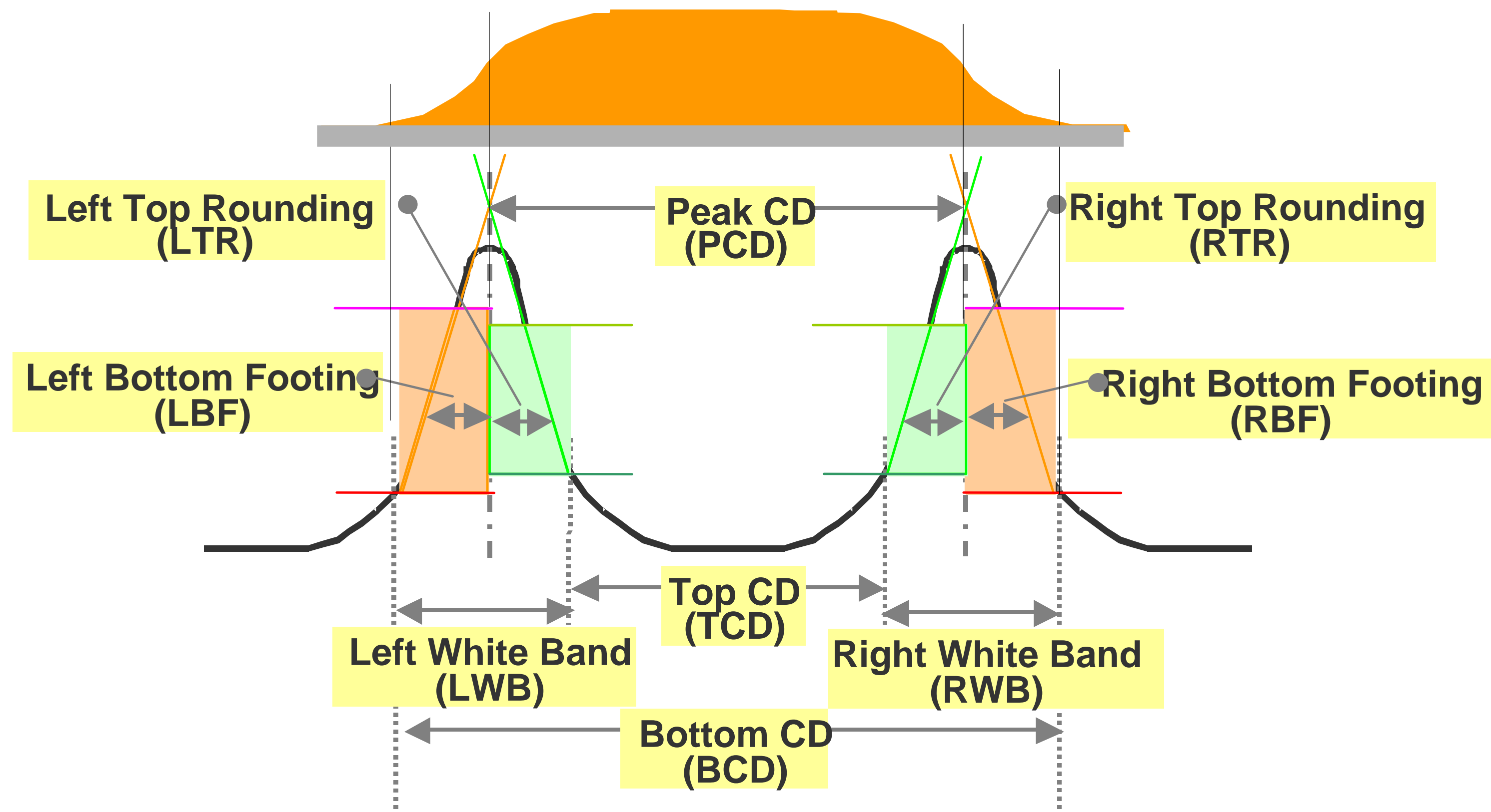
# Motivation

- Correct for systematic CD error due to processing to further improve CDU performance

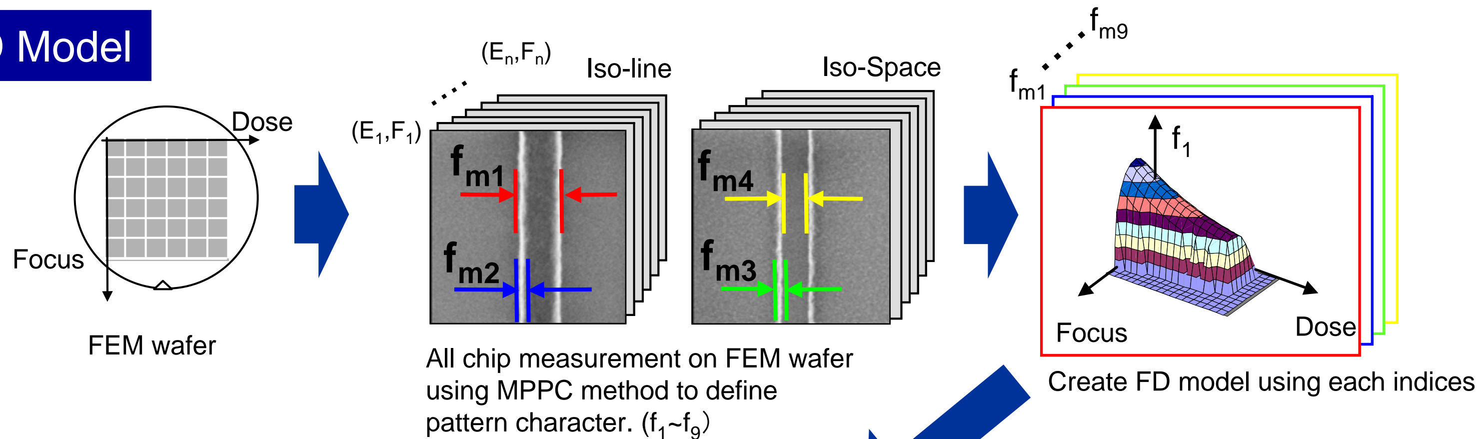


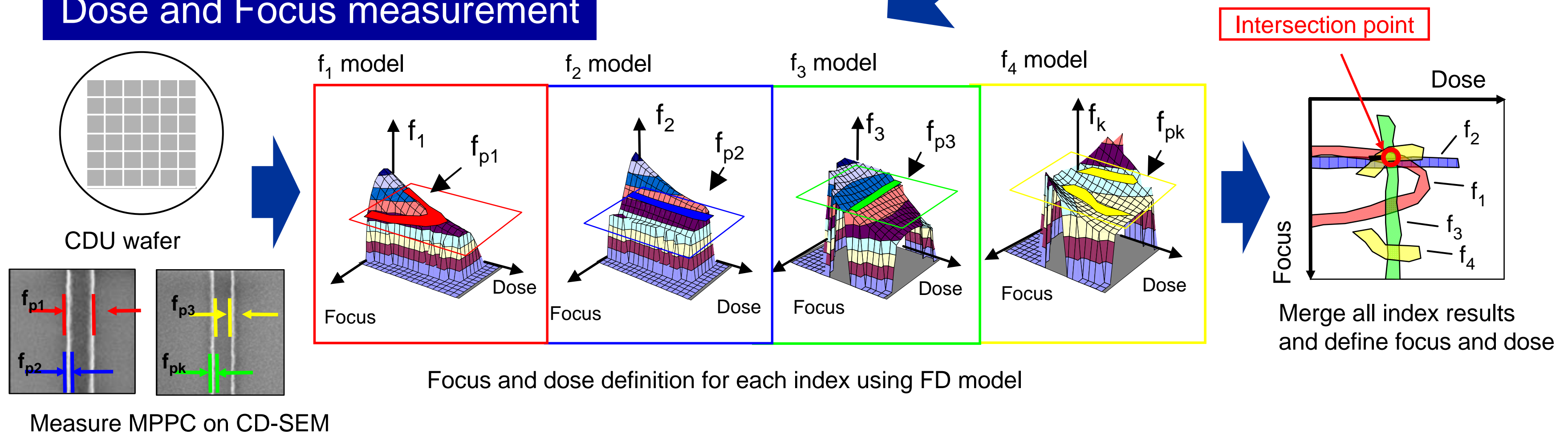
# MPPC Indices

- 9 indices form MPPC (Multiple Parameters Profile Characterization) method on CD-SEM



# Focus and Dose Measurement Algorithm



# Experimental 1

- Target and process condition
  - Nikon NSR-S620D
  - Track: Lithius ProVi
  - Target: Line 50nm Pitch 250nm
  - Metrology:

    CG4100 (HITACHI CD-SEM)
  - Wafer
    - FEM wafer:

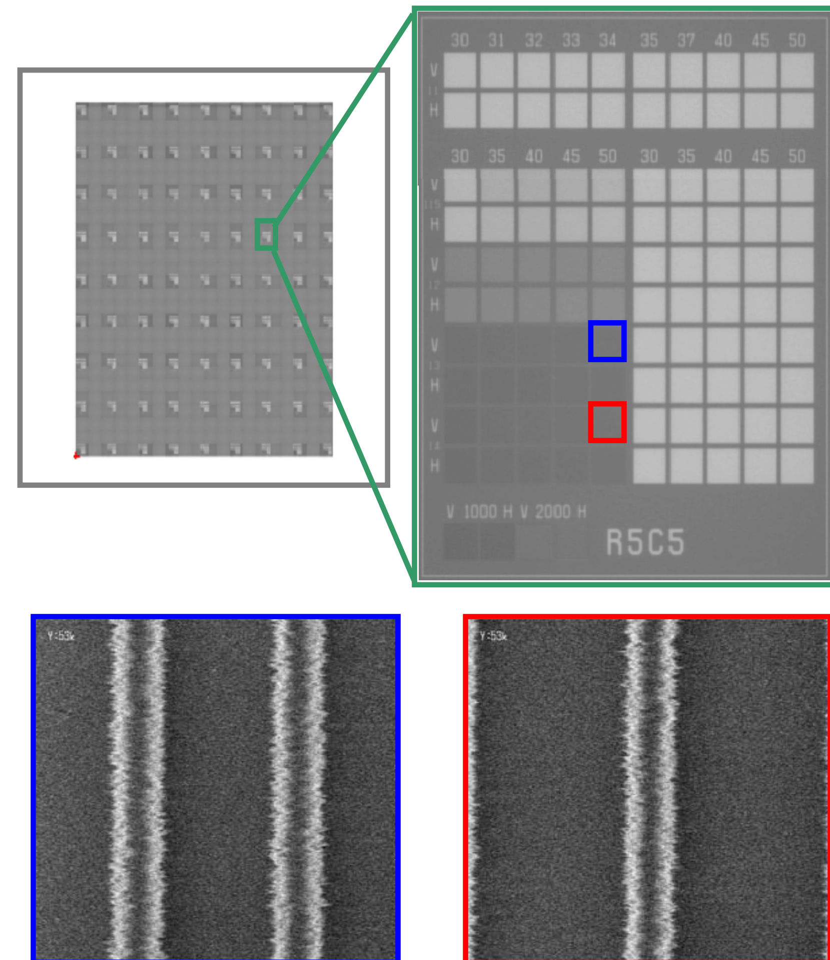
      Dose 11.1mJ/cm² (0.5mJ/cm² step)

      Focus 60nm (20nm step)
    - CDU wafer:

      Dose split wafer 5wafers

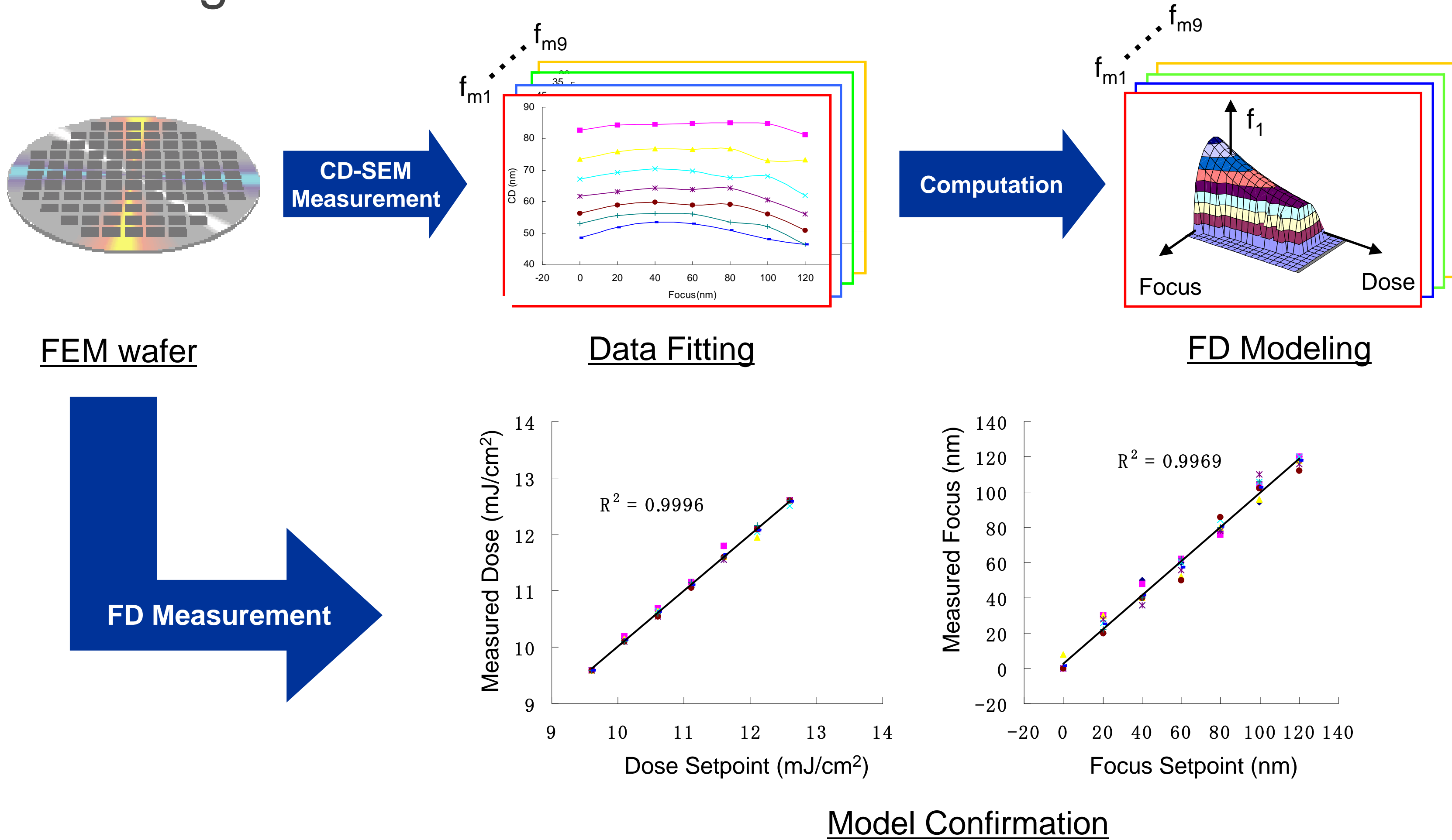
      (Best, ±0.5mJ/cm², ±0.25mJ/cm²)
  - Sampling
    - 25 points per chip and full chip in wafer including wafer edge area.

Reticle information

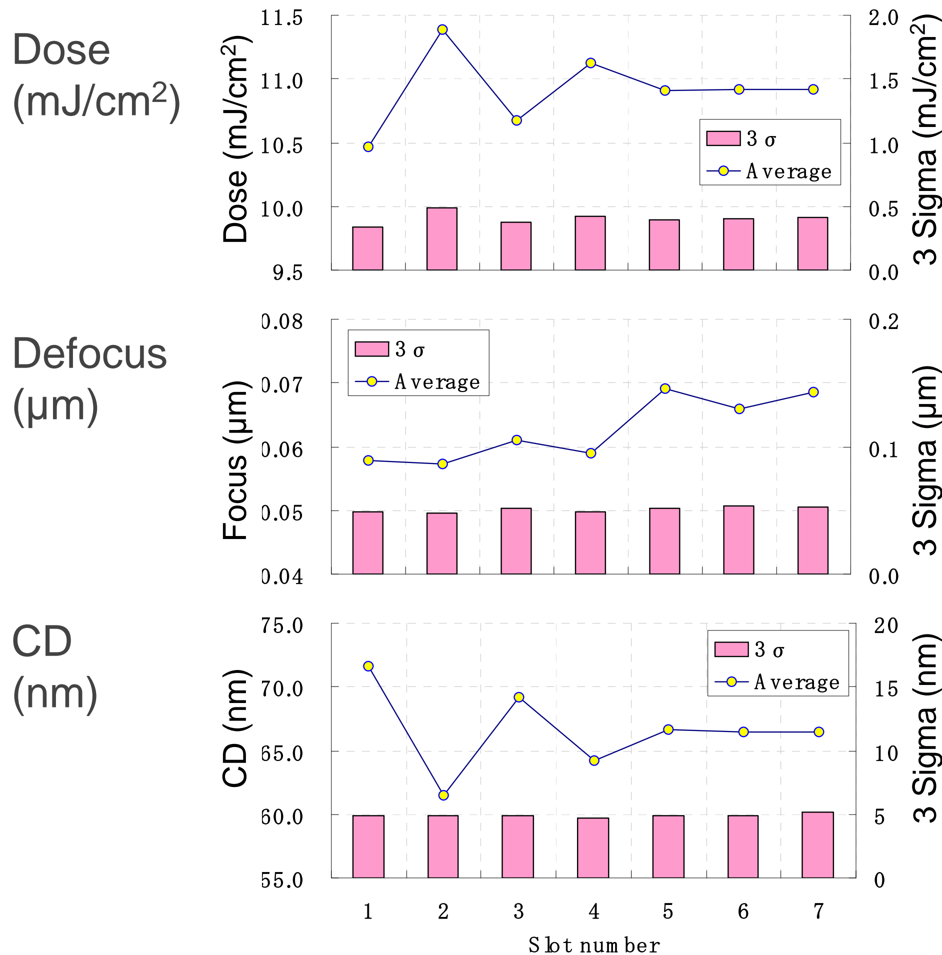


# Experimental 1

- Model generation and validation



# Experimental 1: Results




**Measurement Result (Average)**

| Slot | Setpoint | | Measuremet results | | |
|---|---|---|---|---|---|
| | Dose (mJ/cm2) | Focus (um) | Dose (mJ/cm2) | Focus (um) | CD (nm) |
| 1 | 10.6 | 0.06 | 10.47 | 0.058 | 71.60 |
| 2 | 11.6 | 0.06 | 11.39 | 0.057 | 61.50 |
| 3 | 10.85 | 0.06 | 10.67 | 0.061 | 69.20 |
| 4 | 11.35 | 0.06 | 11.12 | 0.059 | 64.20 |
| 5 | 11.1 | 0.06 | 10.91 | 0.069 | 66.60 |
| 6 | 11.1 | 0.06 | 10.92 | 0.066 | 66.50 |
| 7 | 11.1 | 0.06 | 10.92 | 0.069 | 66.50 |

* Litho tool variation and offset are included on the measurement results.

**Difference between Setpoint and Measurement**

| Slot | Without offset | | With offset | |
|---|---|---|---|---|
| | 0 | 0 | 0.18 | -0.003 |
| | Dose | Focus | Dose | Focus |
| 1 | -0.13 | -0.002 | 0.05 | -0.005 |
| 2 | -0.21 | -0.003 | -0.03 | -0.005 |
| 3 | -0.18 | 0.001 | 0.00 | -0.002 |
| 4 | -0.23 | -0.001 | -0.05 | -0.004 |
| 5 | -0.19 | 0.009 | -0.01 | 0.006 |
| 6 | -0.18 | 0.006 | 0.00 | 0.003 |
| 7 | -0.18 | 0.009 | 0.00 | 0.006 |

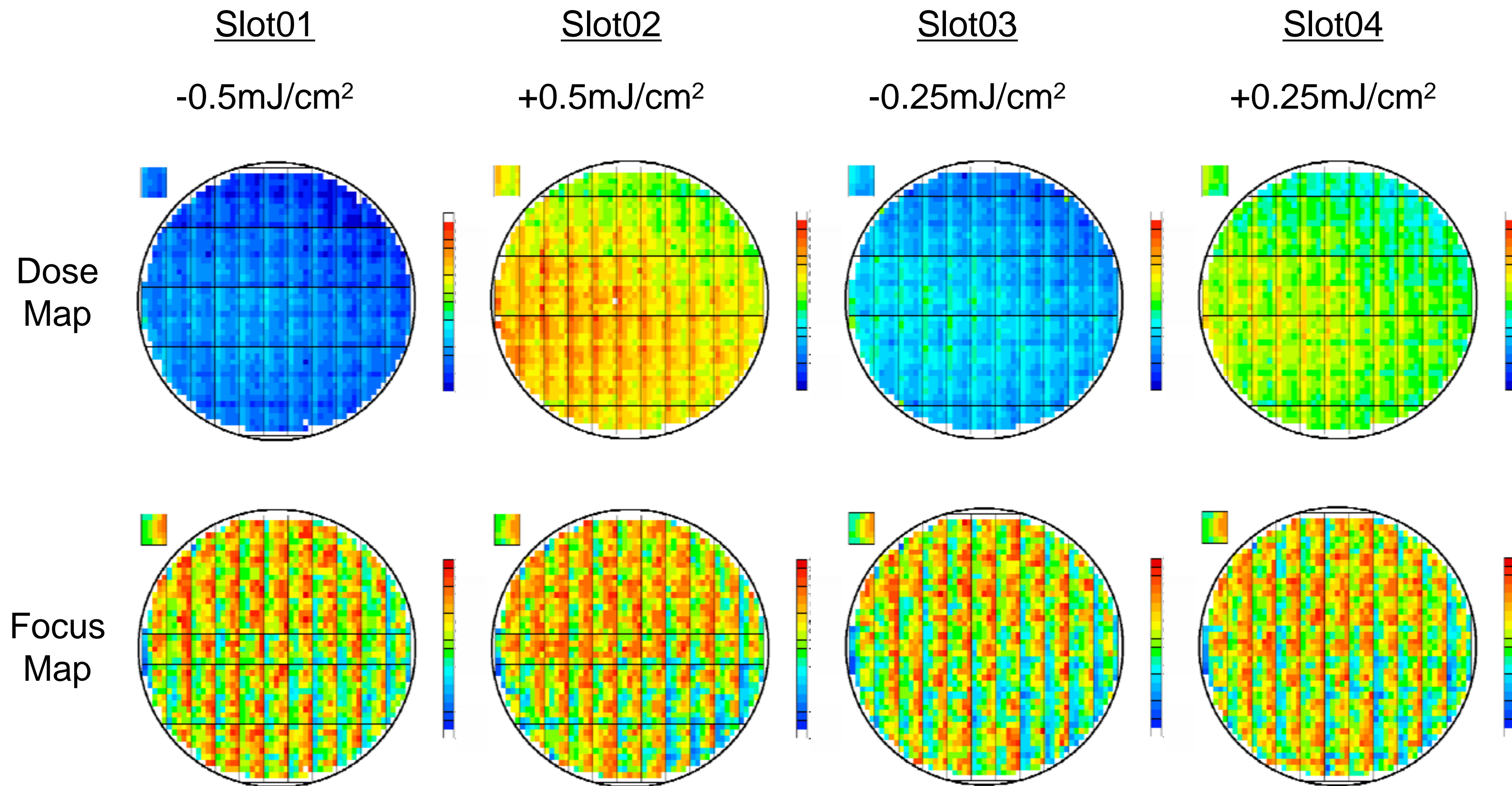
* Difference between setpoint and measurement data are less than 0.05mJ/cm²

**Remark**

Less than 1nm will be changed when dose is moving 0.1mJ/cm²

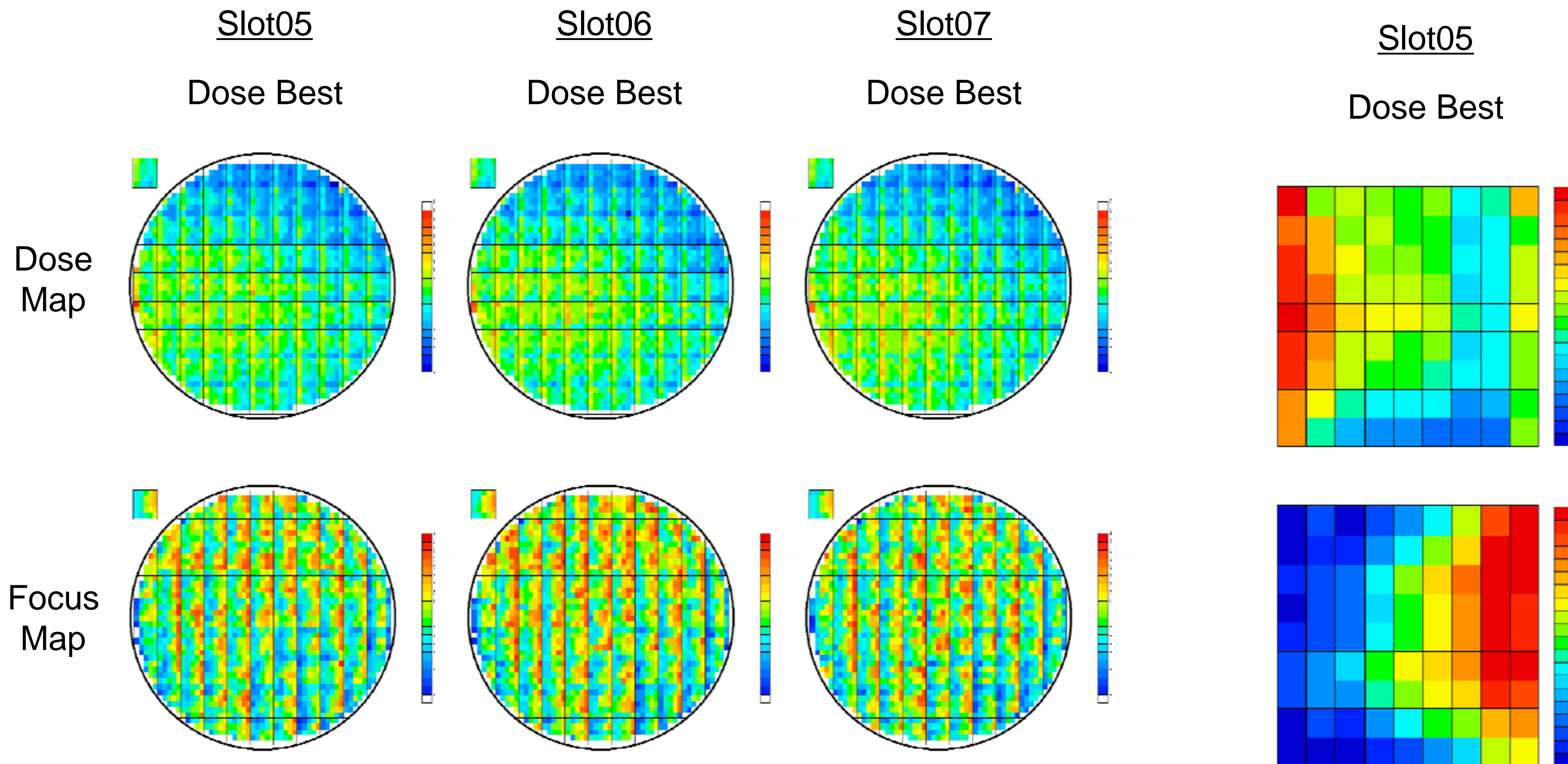
# Experimental 1: Results

- Dose and focus fingerprint (Slot 01~Slot 04)

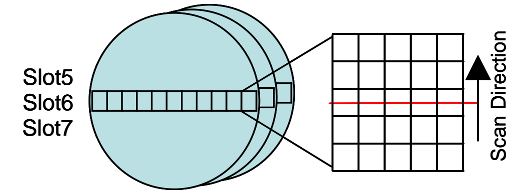


# Experimental 1: Results

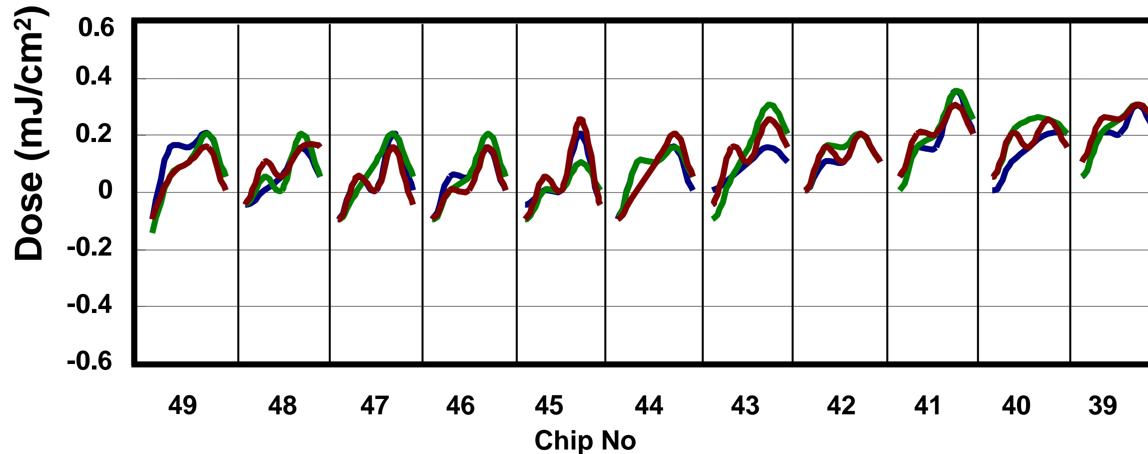
- Dose and focus fingerprint (Slot 05~Slot 07)



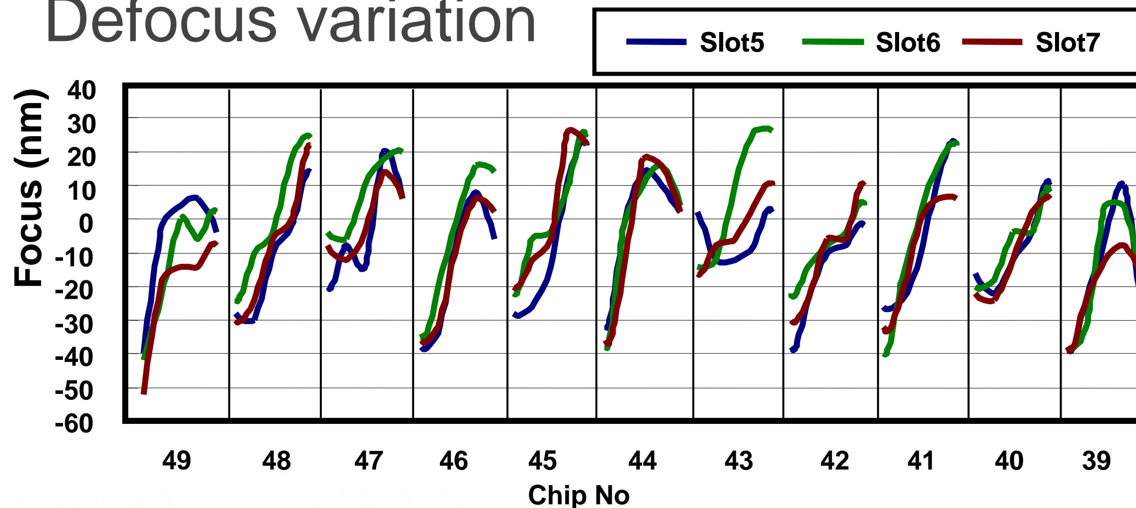
# Experimental 1: Analysis




- Dose variation




- Defocus variation




**Status**

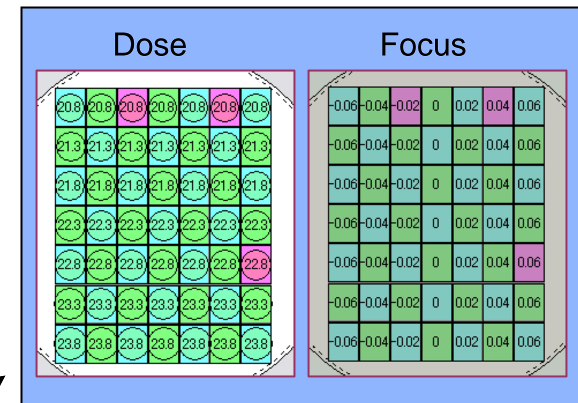
- 3 wafers were printed as same litho condition.
- Litho process variation and measurement uncertainty are included.

**Analysis**

- The variation of 3 wafers are less than 0.1mJ/cm² of dose which included litho process variation and measurement uncertainty.
- ***Dose measurement uncertainty =0.1mJ/cm² – Litho process variation***
- For the defocus result, less than 20nm (0.02um) variation between 3 wafers.
- ***Defocus measurement uncertainty = 0.02um - litho error.***

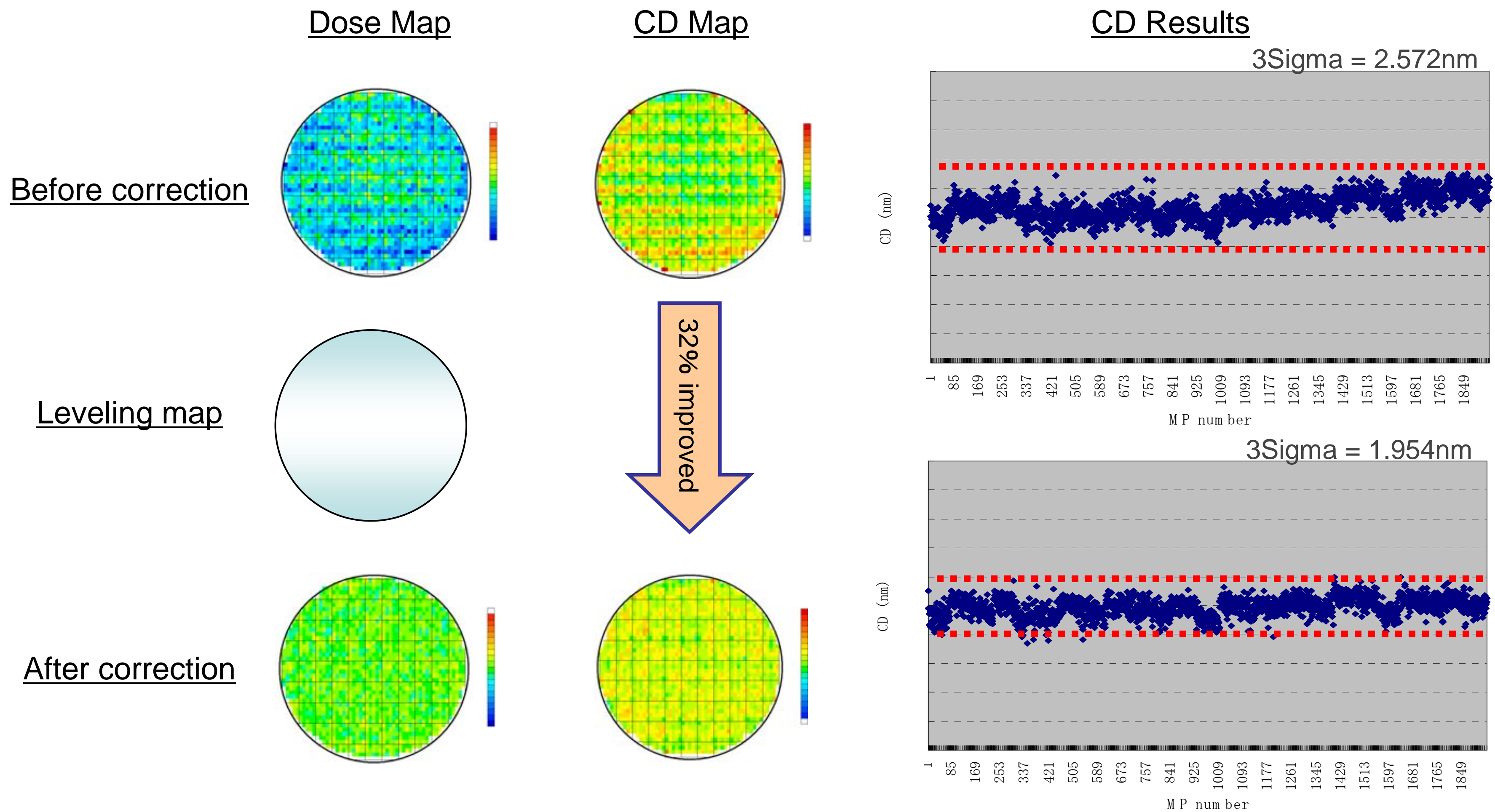
# Experimental 2

- Target and process condition
  - Nikon NSR 620
  - Track: Lithius ProVi
  - Target: Line 50nm Pitch 250nm
  - Metrology: CG4100 (HITACHI CD-SEM)
    - Rectangle scan (250kx * 35kx)
  - Wafer
    - Reference wafer: Refer right side for dose and focus condition
    - CDU wafer: after dose correction
  - Sampling
    - 25 points per chip and full chip in wafer including wafer edge area



# Experimental 2: Results

- Dose correction



# Conclusions and Acknowledgements

- Conclusions
  - A technique for dose and focus measurement has been introduced
  - Estimated accuracy of dose and focus measurement are:
    - Dose < 0.1mJ/cm$^2$
    - Focus < 20nm (0.020μm)
  - 32% improvement of CDU after dose correction
    - CDU Before/After correction: 2.572nm/1.954nm
- Future Steps
  - Dose and focus correction at the single pattern and contact.
  - Reference model correction will be necessary for more accurate measurement


- Acknowledgments
  - A special thanks to Hitachi High Technologies; Shigeru-Yonekawa to arrange focus and dose measurement tool for this project.
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