P-MA-18

Study of a CDMAP function for an EUV mask using NPI-7000

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Concept of NPI-7000

（background)

●Due to the delay of the Next-generation lithography EUVL, Miniaturization is progressing in the method of DPT(double patterning)/SPT(sidewall patterning) using ArF immersion exposure. Herewith number of masks required for fabrication inspection capability is increased.

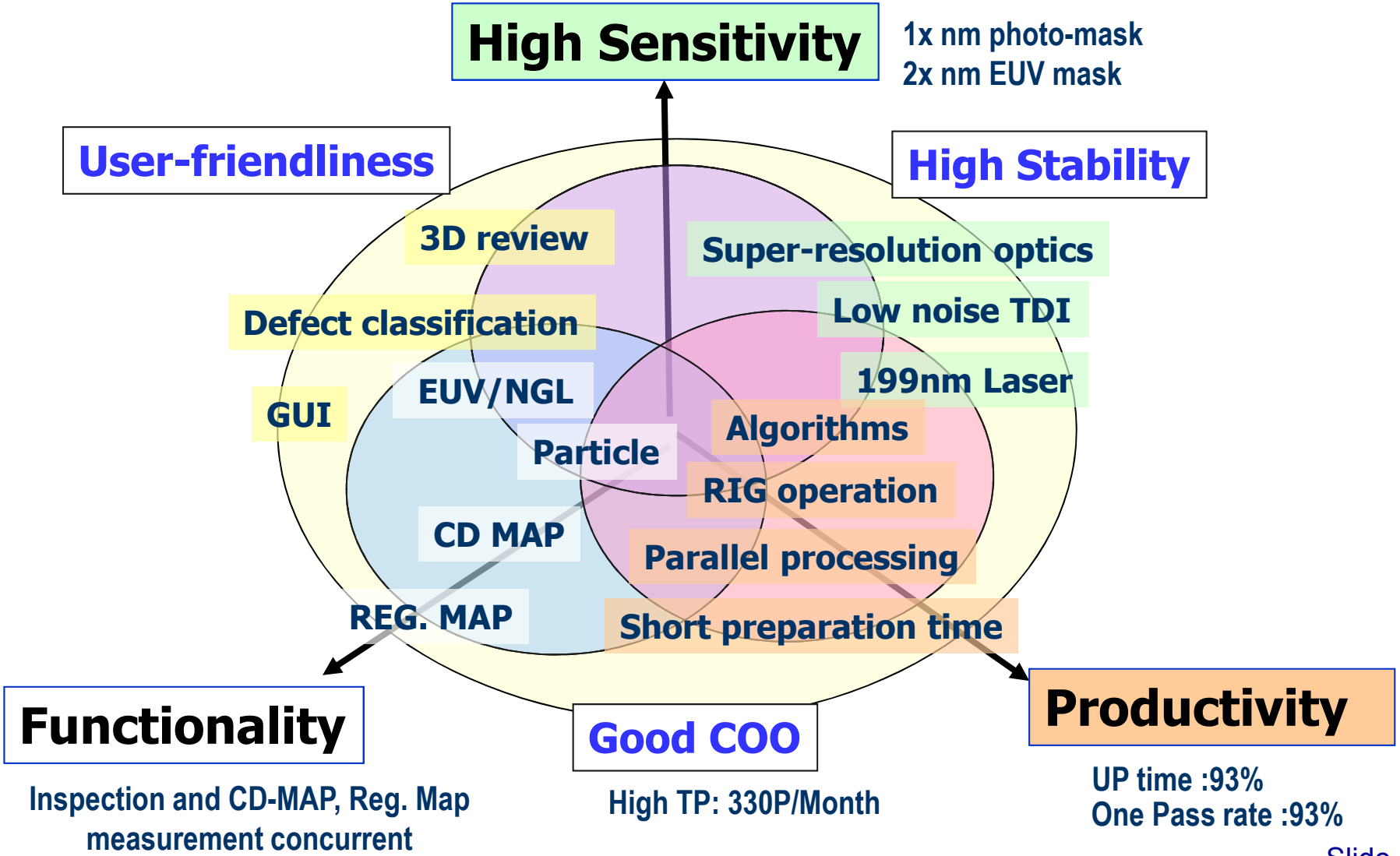
(concept)

●NPI-7000 provides a reduction in costs of inspection performance and high productivity in response to this request for hp1x generation.
It also provides

- ･the option to increase the added value of inspection tool performance, and
- ･the EUV mask inspection mode after Hp22nm which used together circular (or S polarized) and P polarized illumination.

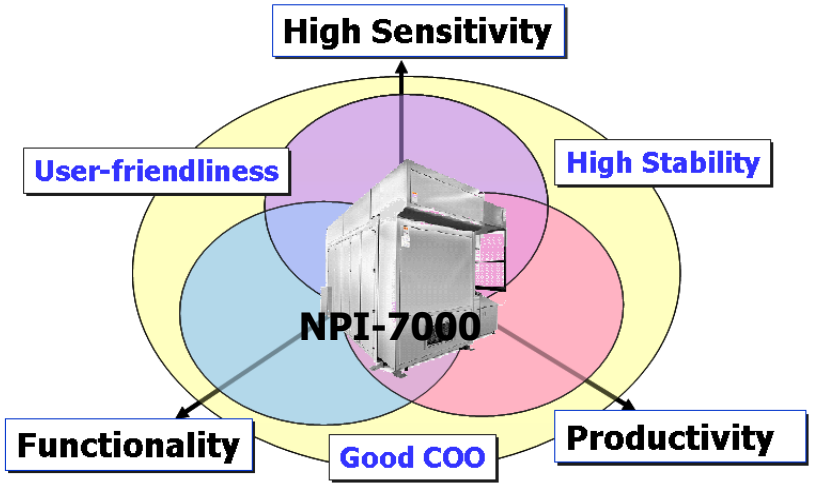
NPI-7000 Features

- Well balanced High-end Mask Inspection Tool -



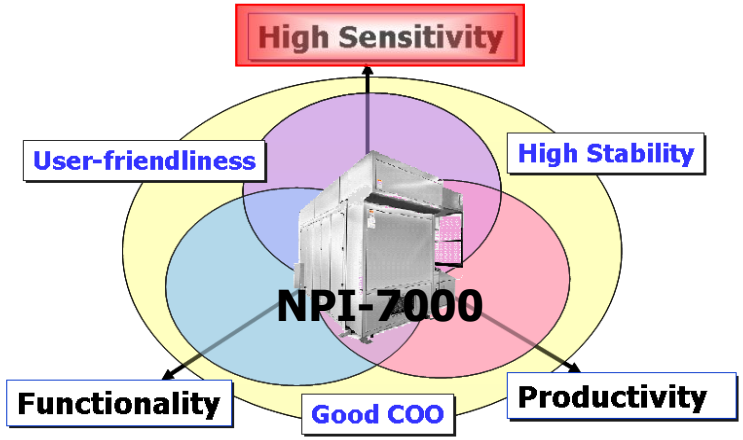
NPI-7000 Features

- **High sensitivity** for hp2x-1x photo-mask and EUV mask
  - High quality pattern image and reference image
  - Sophisticated and flexible algorithms
- **Productivity** with short inspection time & data-preparation
  - High-speed scan; 85min for hp1X@P60
  - High-speed inspection setup
- **Functionality** for process window expansion
  - Integrated Multi-Function Concept
  - Software simulated AIMS function
  - Several types of mask available
- **Factory friendly concept**
  - High stability
  - User-friendly
  - Cost efficiency (Good CoO)



◆ High sensitivity for hp2x-1x photo-mask and EUV mask

- High quality pattern image capture and reference image generation
  - Scanner system, which has consist of
    - High-resolution inspection optics with various types of illumination condition
    - Low noise TDI sensor
    - Ultra-precise mask stage system
  - RIG (Reference Image Generator) system which has
    - Model-based image generator corresponding to 100nm and beyond feature size.
- Sophisticated and flexible detector
    - To achieve high capture rate of the killer defects, NFT provides for not only traditional detectors, but also provides software-based flexible detectors for DOI.



NPI-7000 Sensitivity Specifications

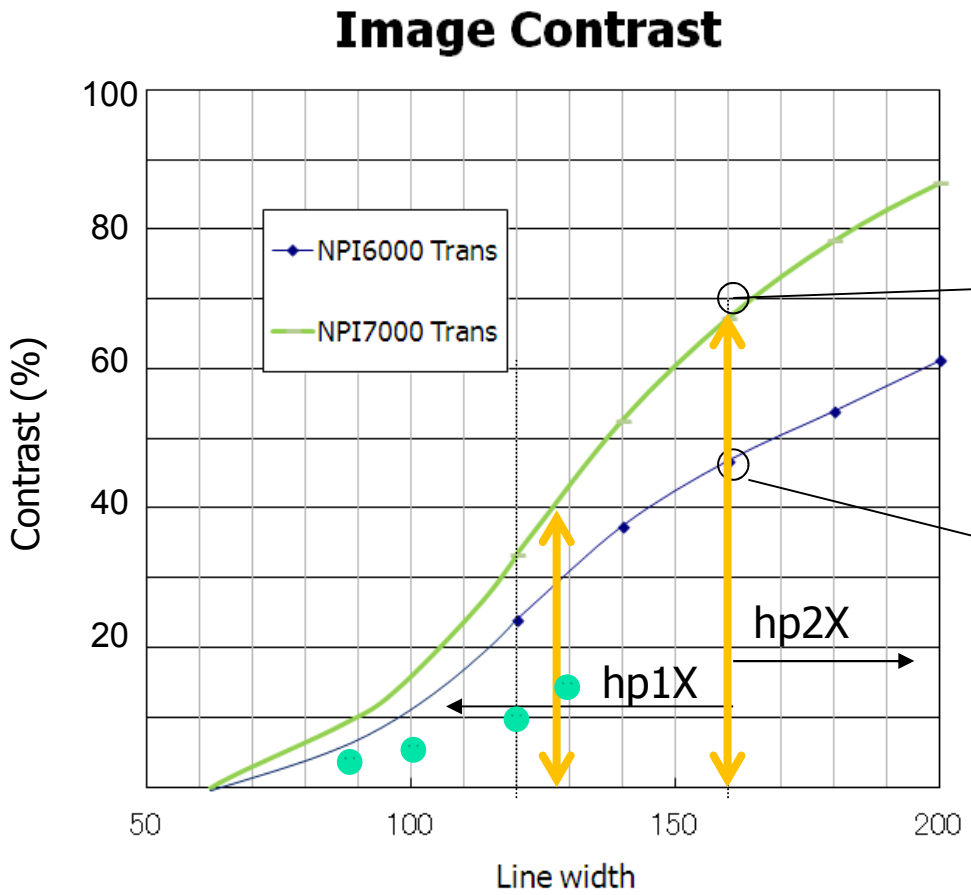
			NPI-6000		NPI-7000	
Photomask inspection						
	Inspection mode		T &R Concurrent		T & R Concurrent	
	Inspection time (Max TP for 100×100mm)		120min@P70nm 300min@P50nm		85min@P60nm 120min@P50nm	
	Sensitivity ArF-HT		hp32-2X (DP)		hp2X-1X (DP)	
			DD	DB	DD	DB
		Pin dot	35	35	25	25
		Pin hole	35	35	25	25
		CD error	15	15	10	10
EUVL Pattern inspection						
	Reflection illumination type		C polarization		C polarization P & S Pol. Concurrent	
	Inspection time (100×100mm)		300-360min@P50nm		<150min@P50nm	
	Sensitivity EUVL mask		hp45-32		hp32-22	
			DD	DB	DD	DB
		Pin dot	40	—	30	35
		Pin hole	40	—	30	35

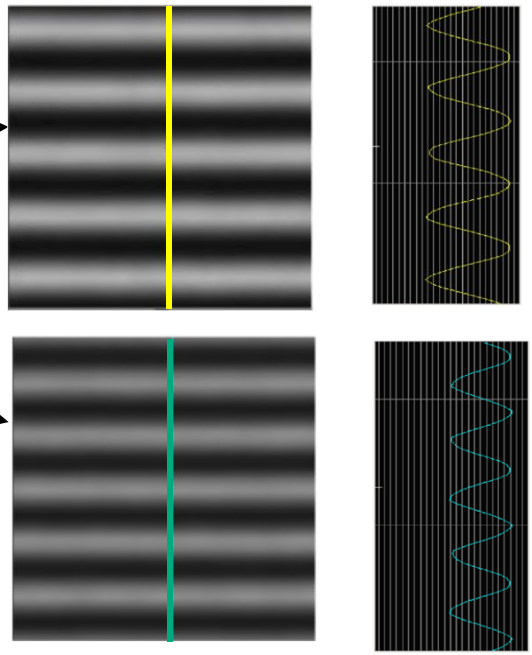
NPI-7000 image contrast advantage

High sensitivity

- **Image contrast / resolution enhancement technology**
- **More than image contrast 70%@hp20 nm**
  - **20% higher than NPI-6000**

Offer contrast to be inspected 1x





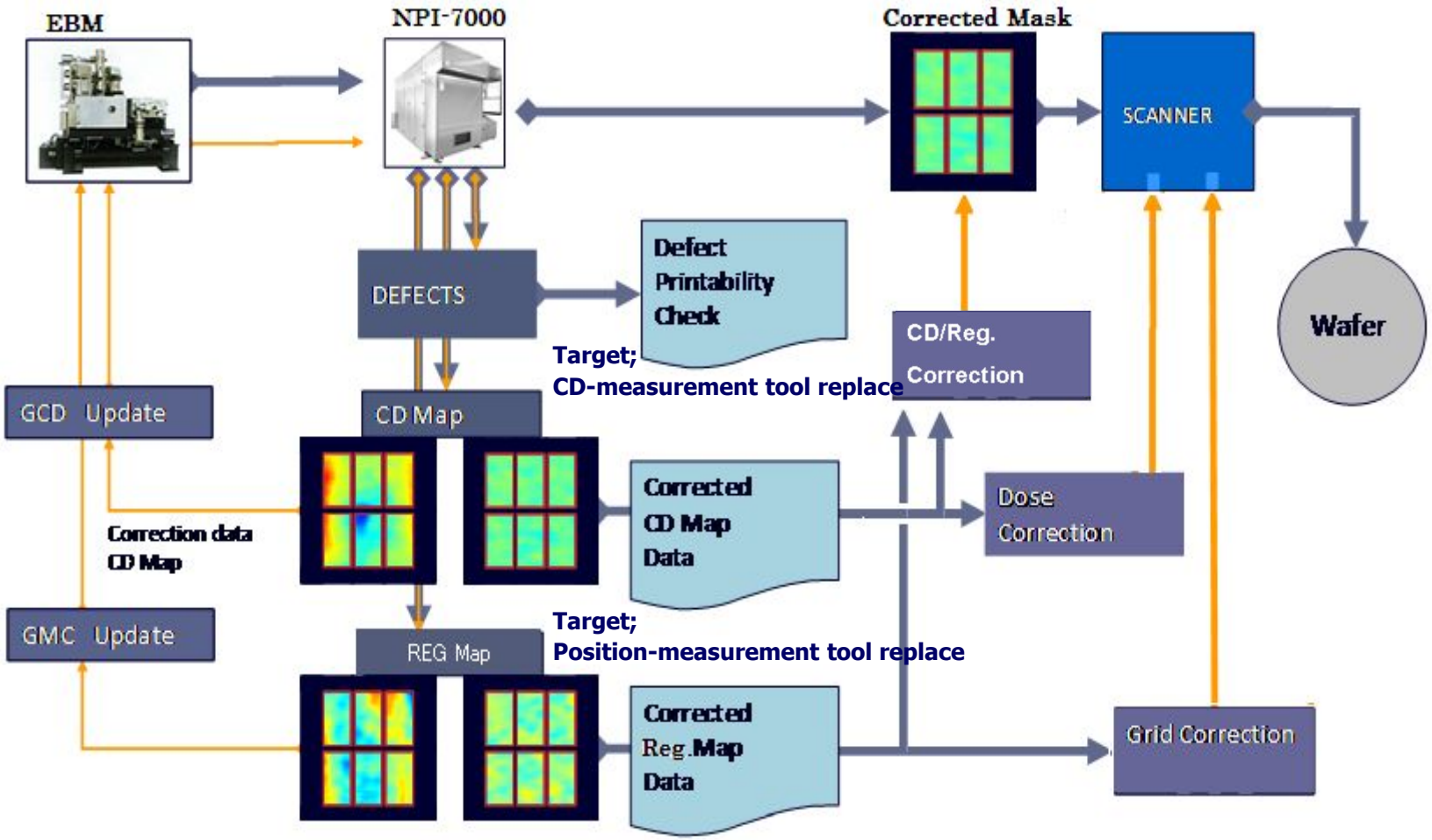
P-polarized image of EUV mask

Integrated Multi-Function Concept

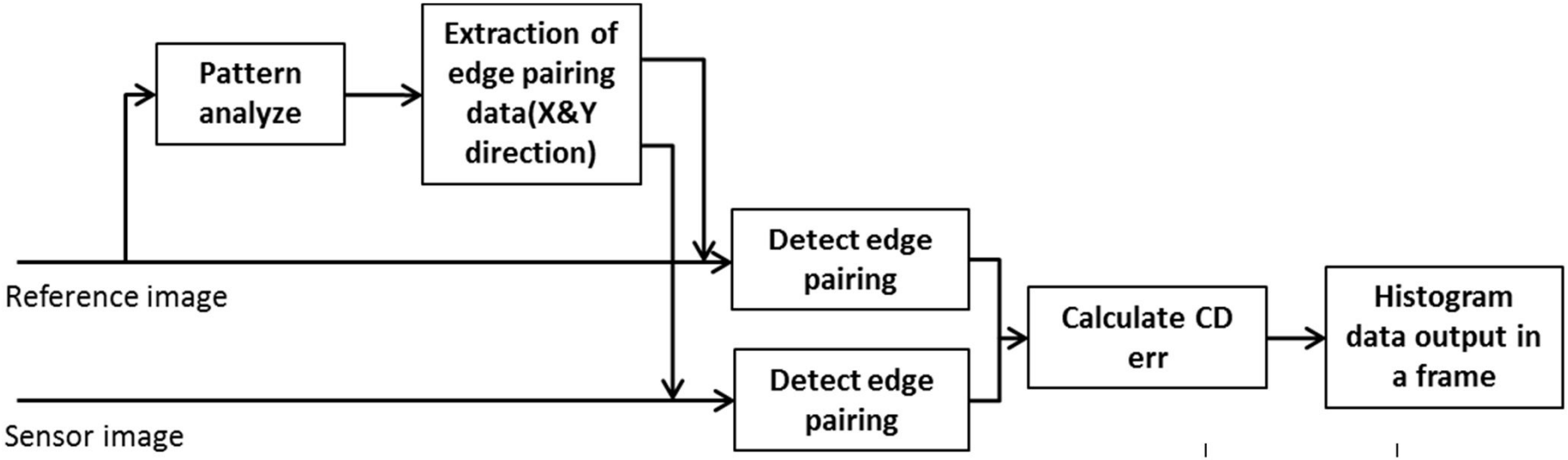
Functionality

Multi-Function Concept: full characterization in one scan

- Defect and particle detection
- CD uniformity; CD Map
- Pattern placement error; Registration Map

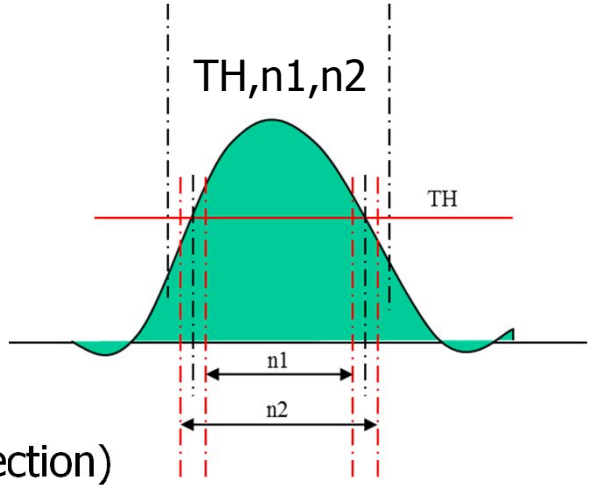


Method and Output of CDMAP function



Configurable parameter:

-Pattern edge detection threshold value (TH)
-Select pattern size(n1=minimum & n2=maximum)

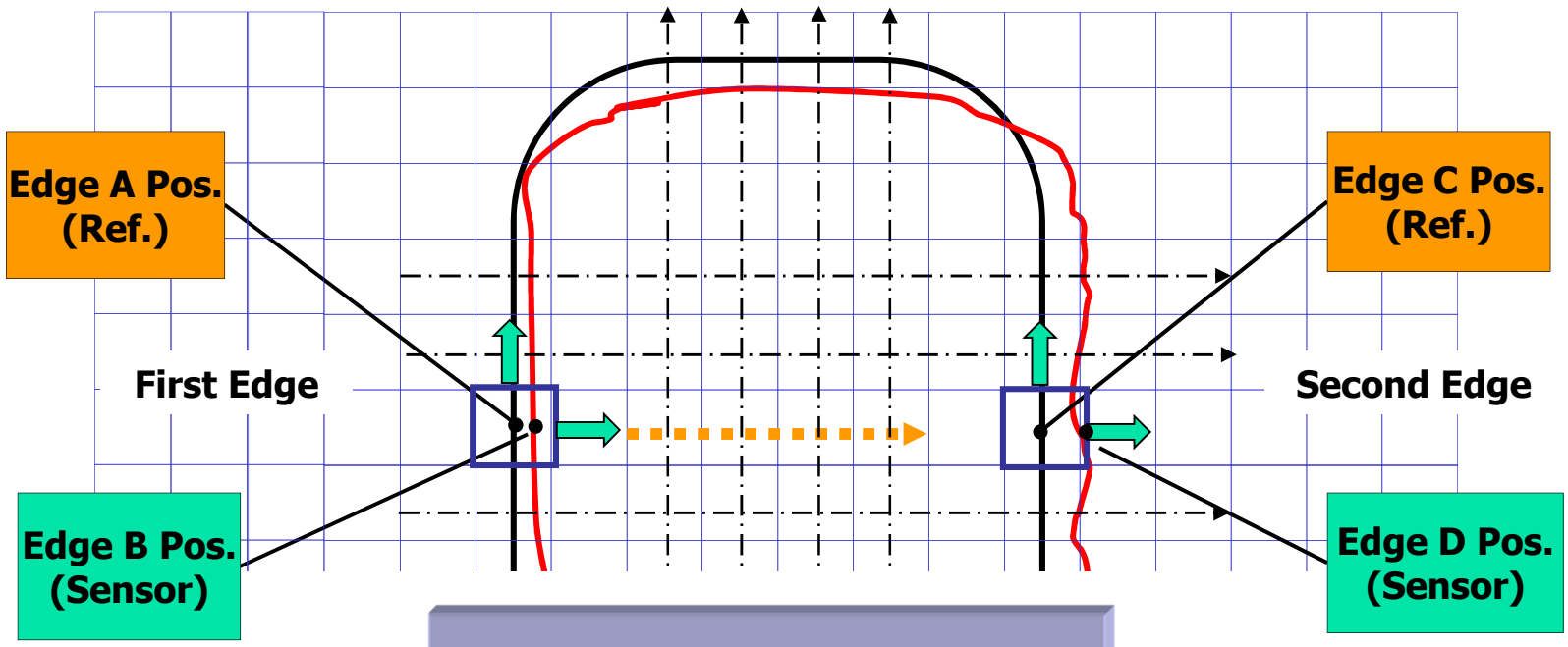


Output data:

-The histogram of CD error of the pattern in a frame*(X&Y direction)
-The histogram of position error** of the pattern in a frame (X&Y direction)

*frame size = 512x512 pixel
**Position err MAP(REGMAP) is under development.

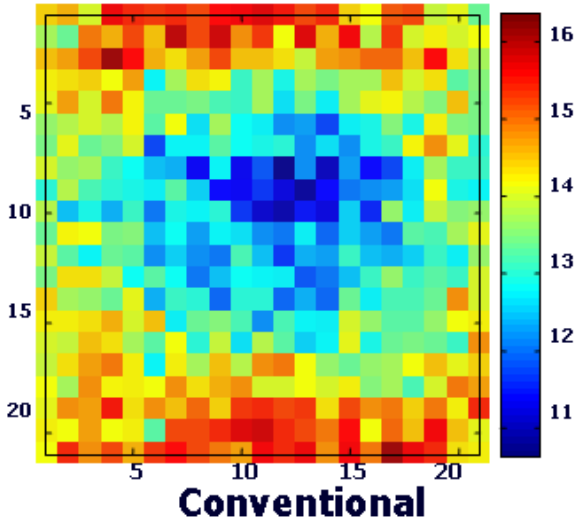
Edge definition for CD and Registration

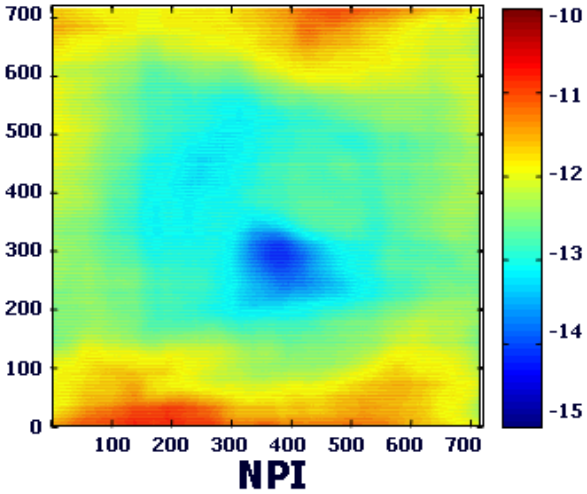


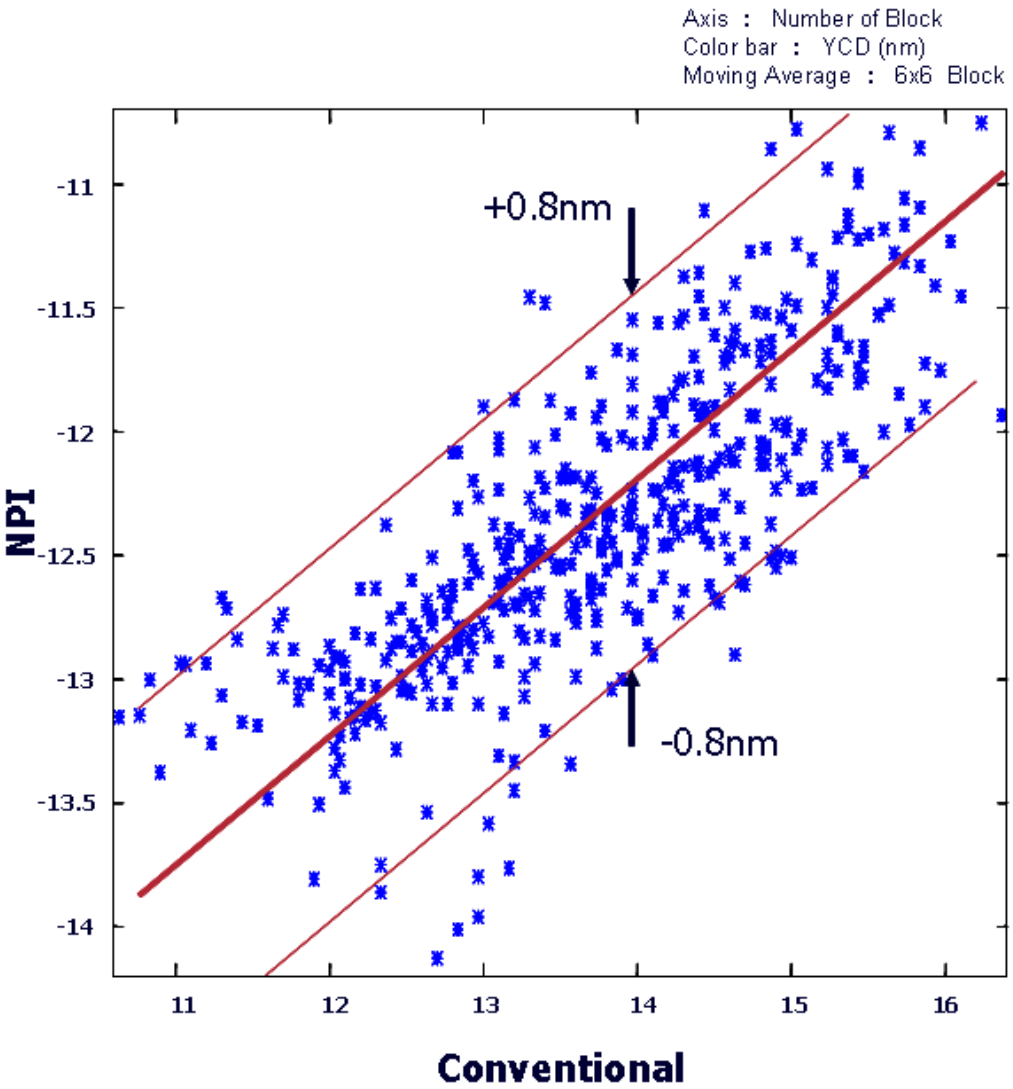
$\Delta CD = (B-A) - (D-C)$

$\Delta POS = \{(B-A) + (D-C)\}/2$

NPI CD Map and Conventional correlation



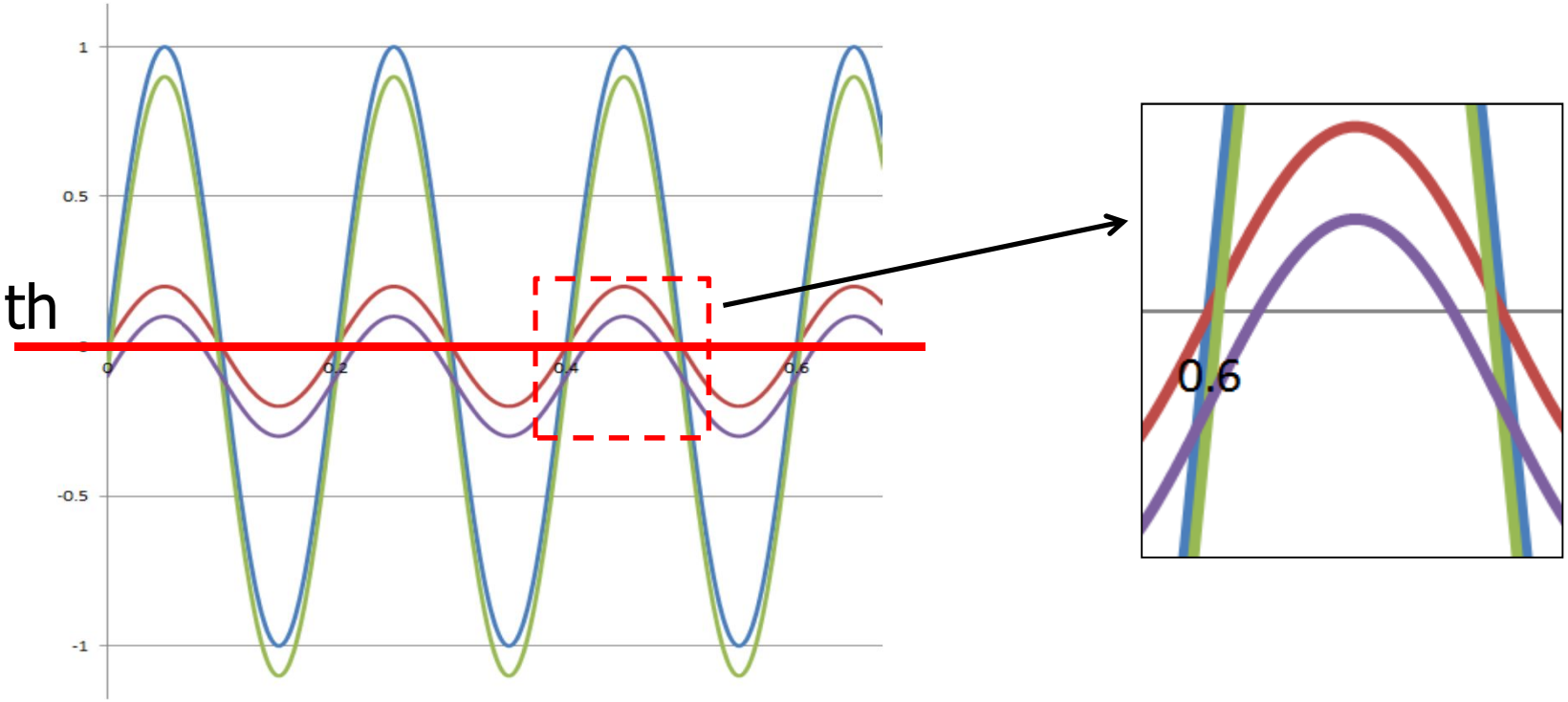




3σ of (NPICD-Conventional tool)<0.8nm

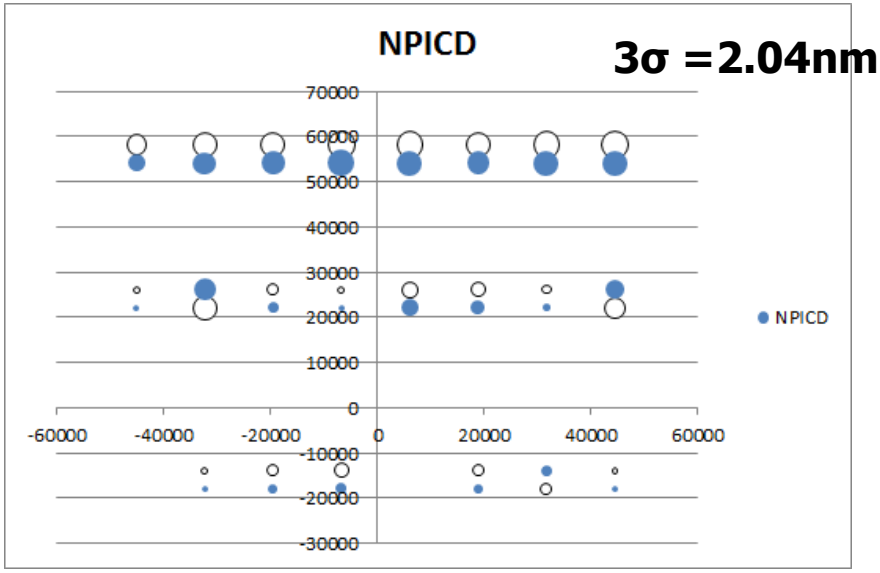
Problems of CDMAP in a low contrast image

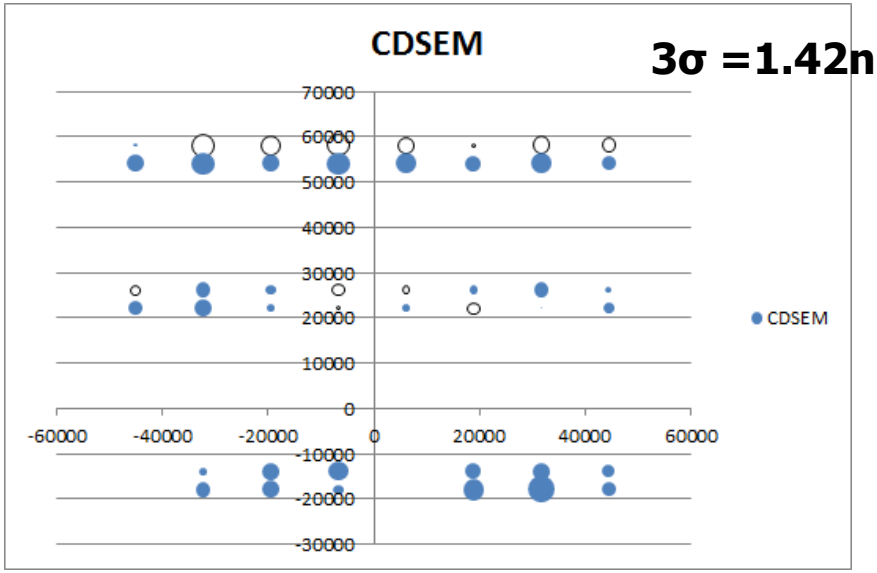
- With the error of a reference image and a sensor image, change of CD error value becomes large.

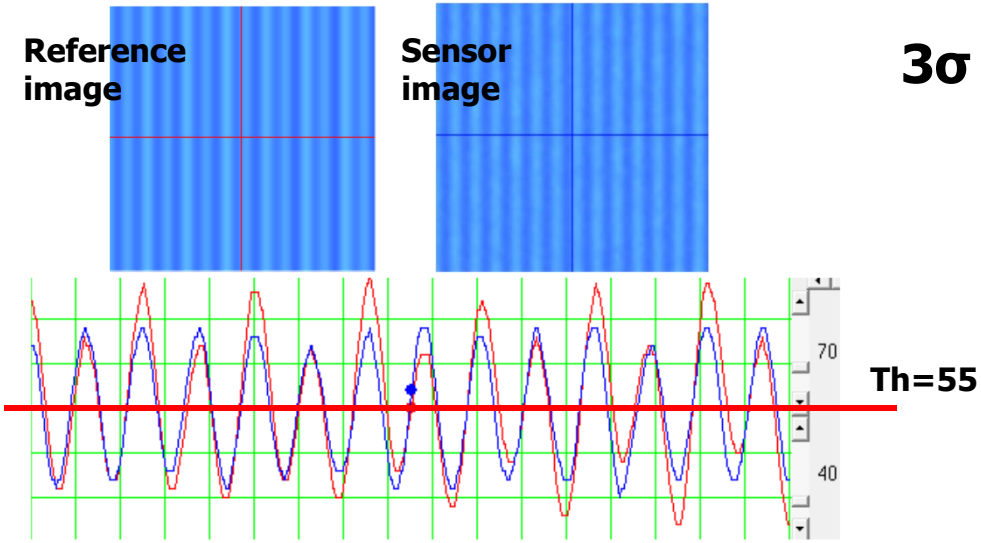


Applied results of CDMAP function to EUV mask

CDMAP of the EUV mask of a Hp30nm vertical pattern



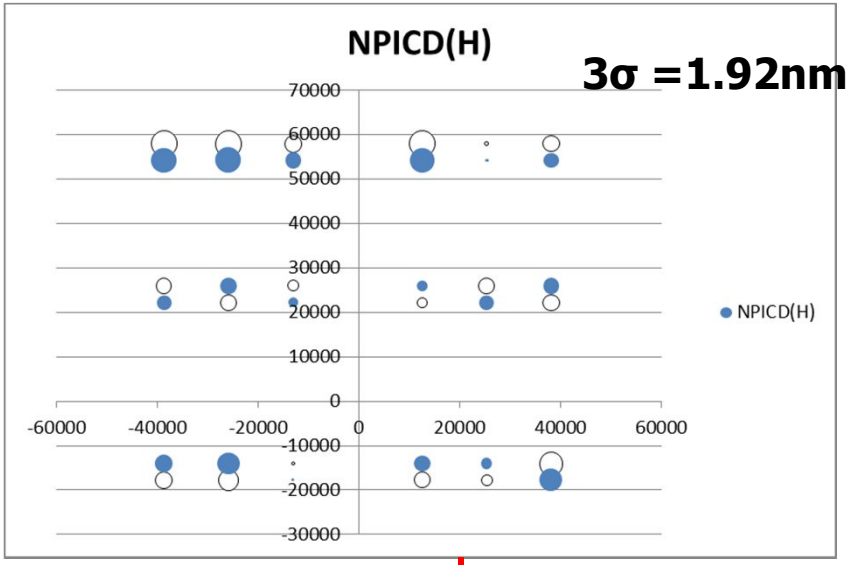


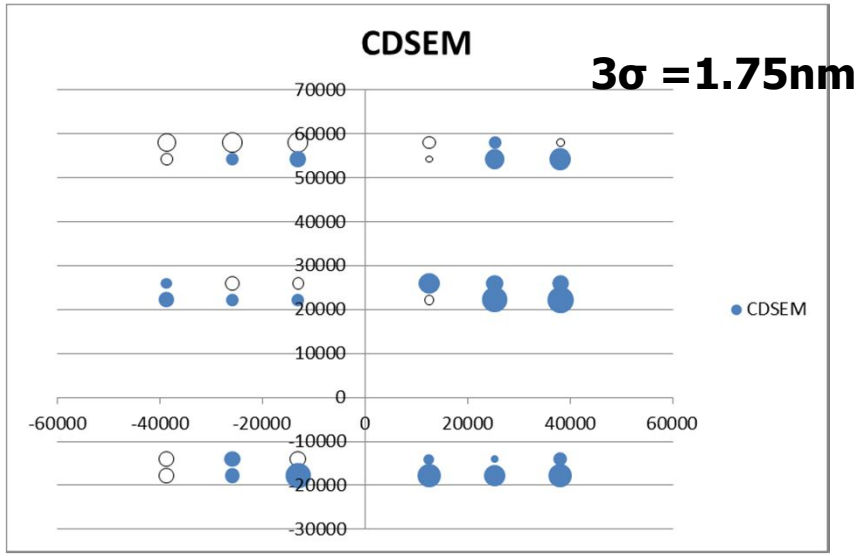


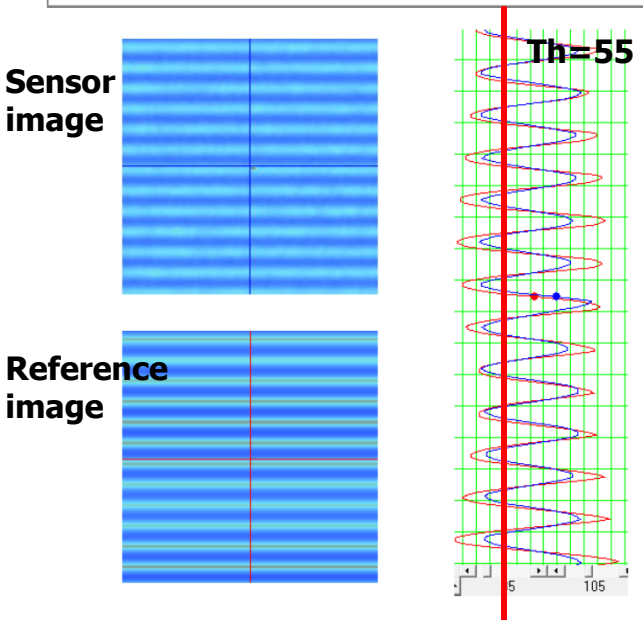
3σ of (CDSEM-NPICD)=1.57nm

Applied results of CDMAP function to EUV mask

CDMAP of the EUV mask of a Hp30nm horizontal pattern







3σ of (CDSEM-NPICD)=1.95nm

-The contrast center value of sensor image changes by a vertical and a horizontal pattern.
->Two or more threshold value parameters are required.

Conclusion and next works

-NPI-7000 with multi-functions was developed.

-The CDMAP function for photomask of NPI-7000 was applied to the EUV mask, and the possibility was examined.

-With the fall of contrast, CDMAP data becomes sensitive at a setup of a pattern edge recognition threshold value and an error of a reference image and a sensor image.

-Although it is sensitive to pattern edge roughness, there is little influence because of a statistical process for CDMAP data.

（**Future works**）
Advanced CDMAP is needed that robust for an error with reference image and a sensor image.

END

Study of EUV mask inspection is supported by NEDO