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Pattern Shape Dependency of Mask Shadowing Effect and it's correction

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Introduction

Oblique incidence of EUV lithography system causes pattern shadow that cause H-V CD variation. This H-V variation is corrected easily by means of biasing mask CD. But Shadowing effect is not all the same for every type of pattern. Not merely pattern direction but its 2D shape affects H-V bias. So line and space pattern and contact hole pattern shows different H-V bias trend.

In this presentation, H-V bias line and space pattern and contact hole is compared. And then why the difference is originated is considered.

Shadow effect for Brick wall pattern is compared to line and space and contact hole pattern.

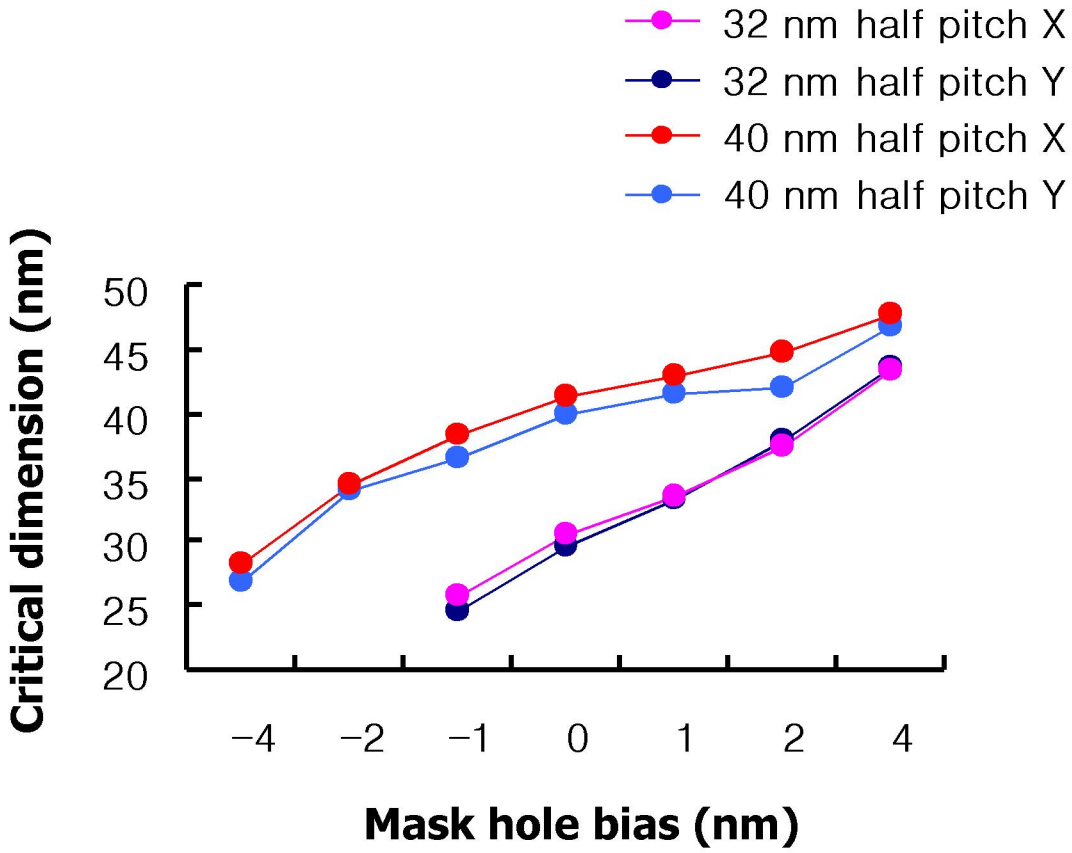
For all the pattern shape, same H-V bias correction rule is applied. Then it is examined that how the corrected H-V is working well.

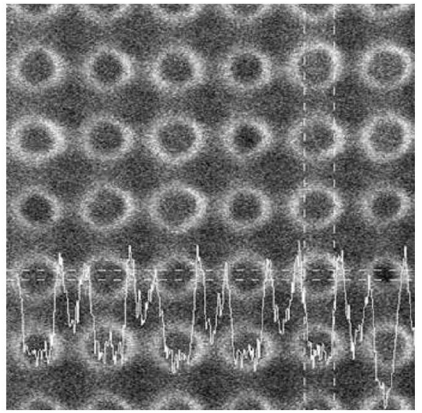
All the experiments are based on EUV ADT @ IMEC (0.25NA con.0.5)

H-V bias of C/H array pattern @ ADT

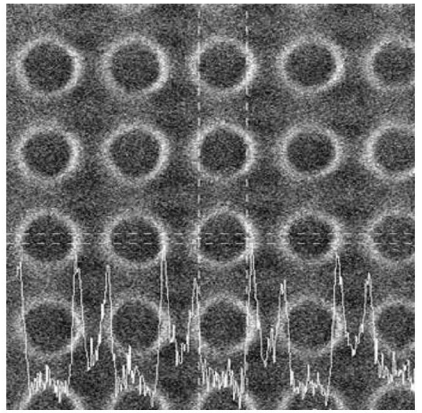
32 nm/ 40 nm Hole array X-Y CD difference

- **H-V bias of 32 nm is smaller than 40 nm C/H in contrary to normal L/S case.**





32 nm C/H array

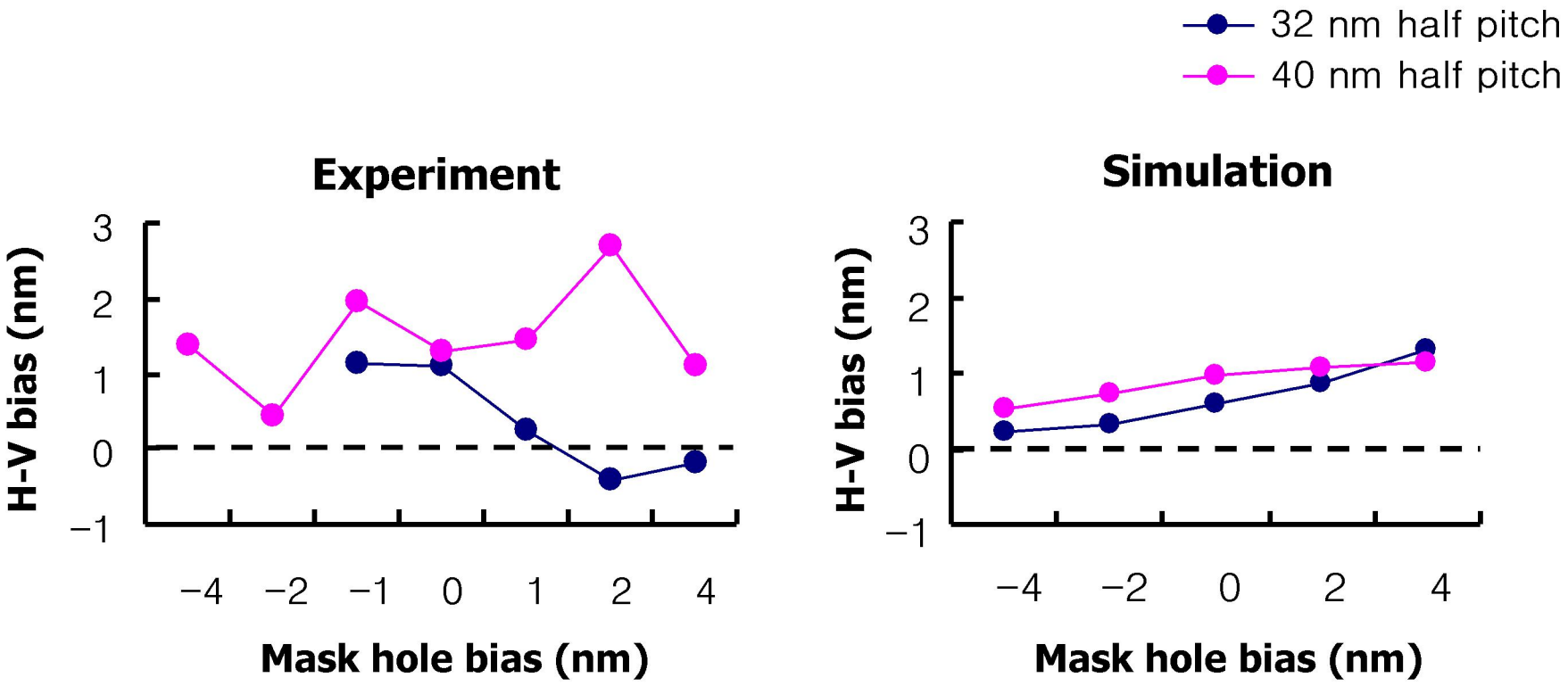


40 nm C/H array

C/H H-V bias according to mask CD

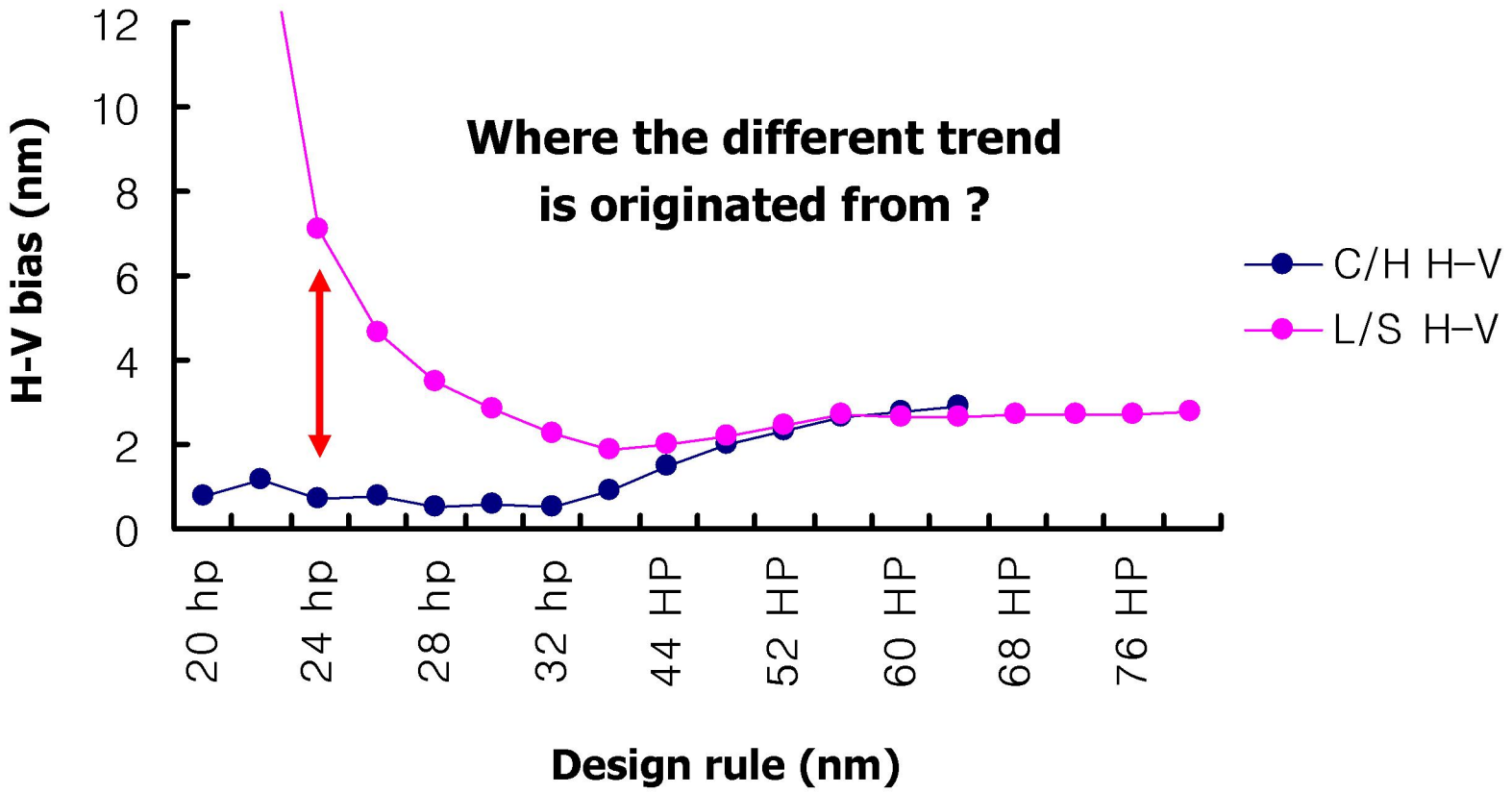
Experiment & Simulation H-V bias for 32 & 40 nm C/H

- 32 nm C/H shows smaller H-V bias in both experiment and simulation



H-V bias; L/S vs. C/H

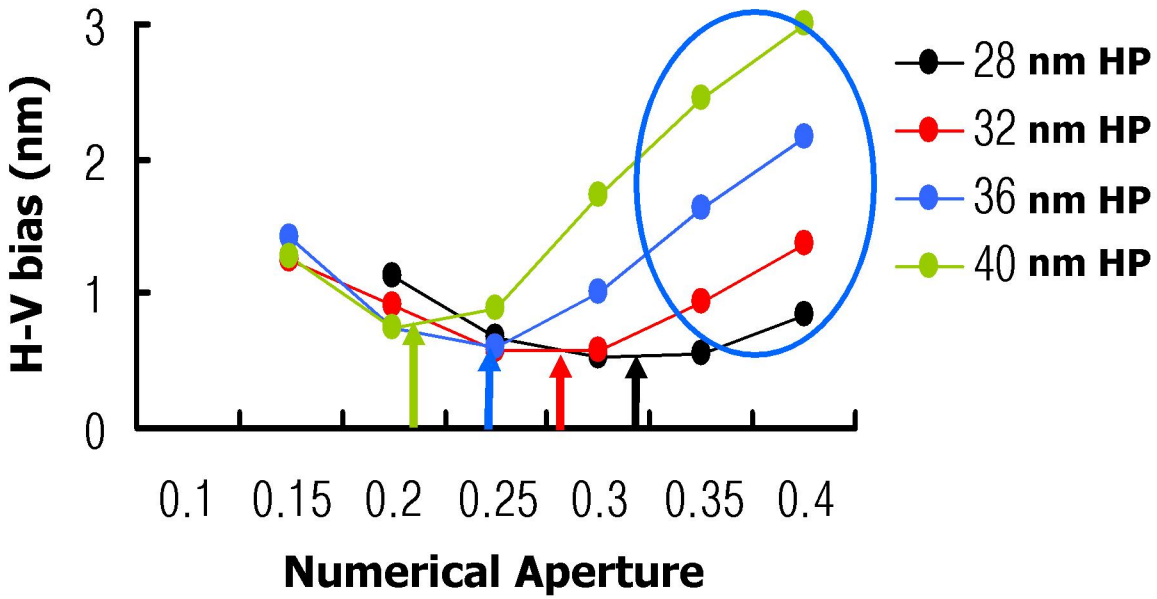
- **H-V bias trend is quite different**
  - **→ H-V bias is decreasing in pitch decreasing C/H**



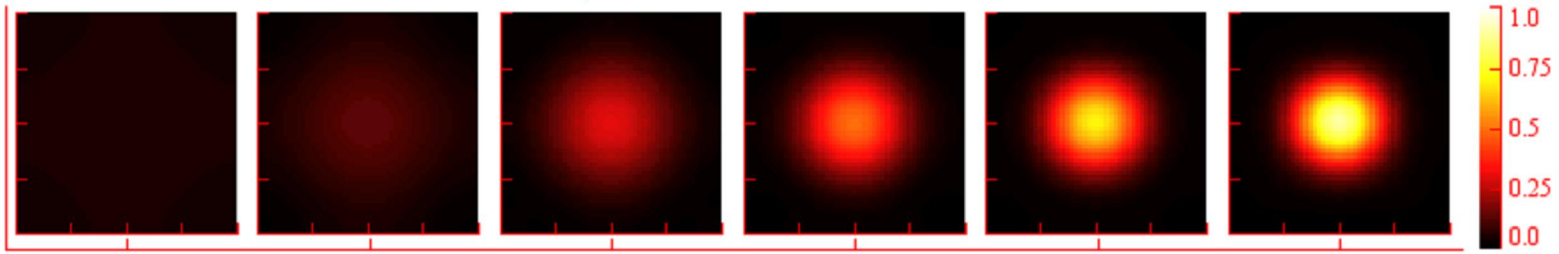
H-V bias vs. NA

NA effect for H-V bias of C/H pattern is checked

- **NA ↑, HV bias ↑**
- **C/H pitch ↓, NA of minimum HV bias ↑**



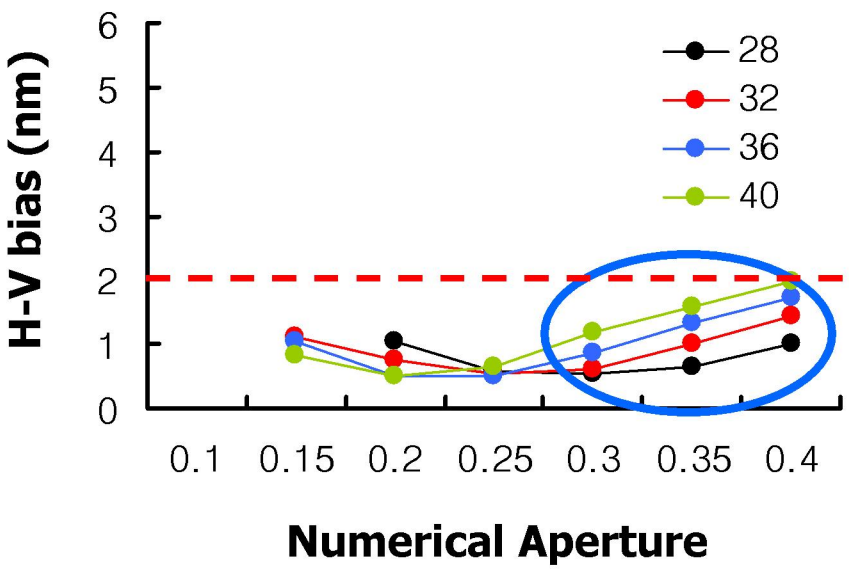
32 nm HP C/H aerial image



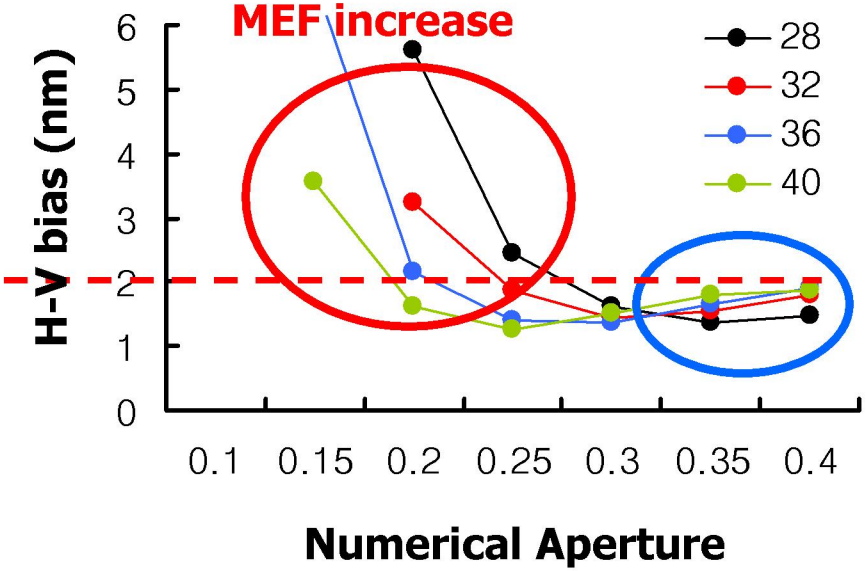
NA on H-V bias; C/H vs. L/S

- Simulation of Y-axis only biased C/H and L/S pattern with normal incidence.
- H-V bias trend in higher NA region is different with lower NA region.
- L/S & C/H H-V bias is similar at Larger NA region.

C/H with y-axis 1 nm bias

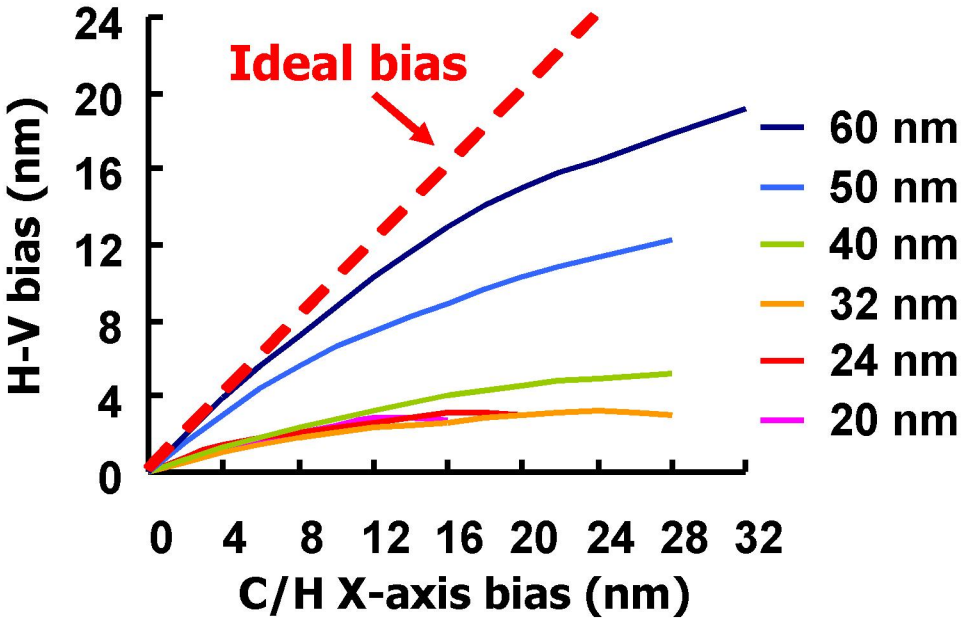


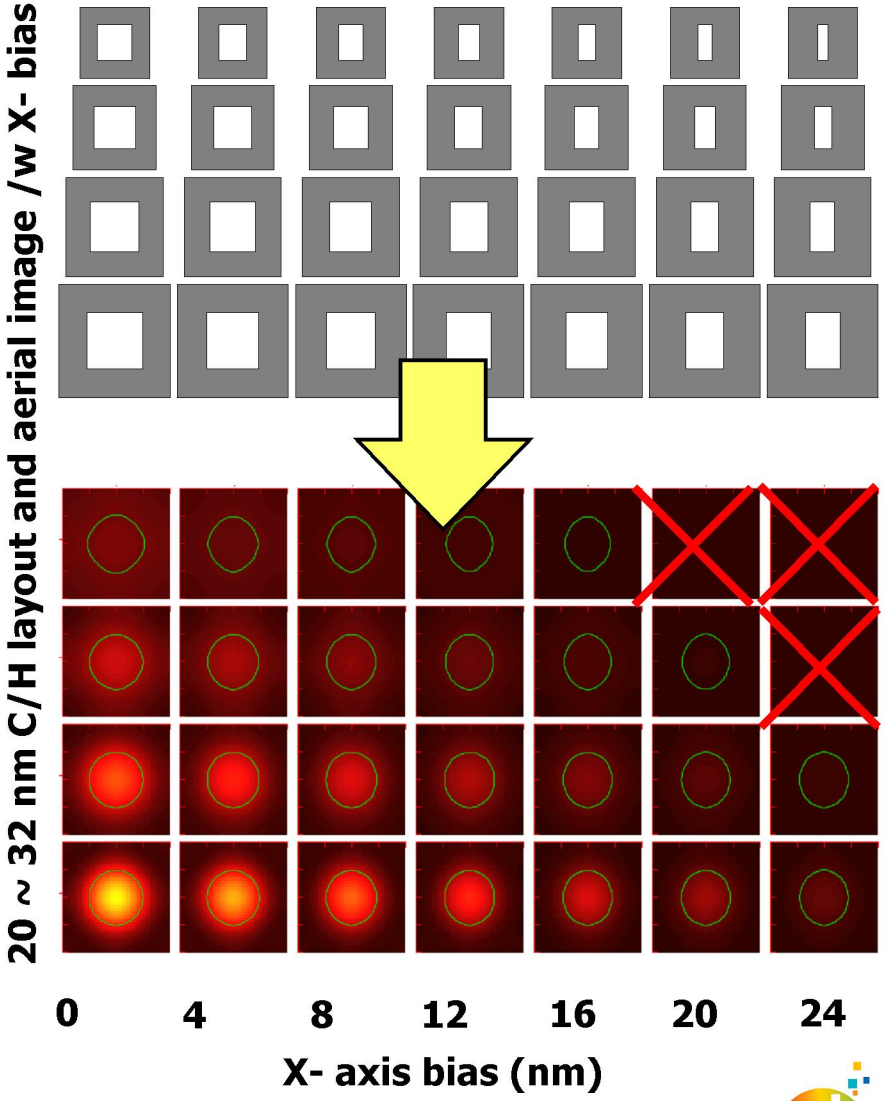
L/S with y-axis 1 nm bias



Patterning of asymmetric shaped C/H

- Mask X-Y asymmetry hardly distinguished because of not enough resolution.
- Smaller H-V bias is caused by poor resolution
- With Enough resolution X-Y dimension of mask can be distinguishable.





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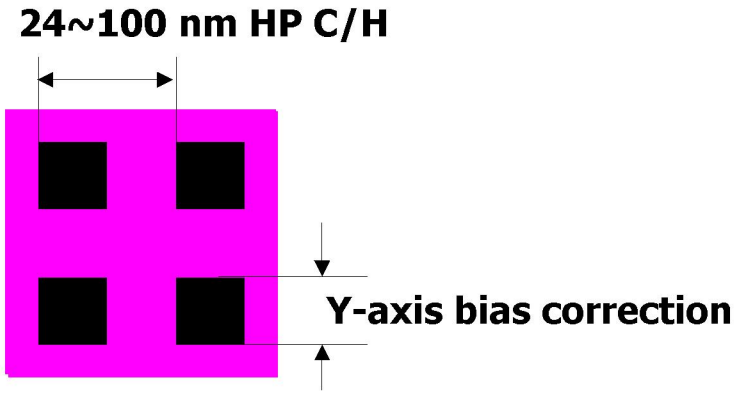
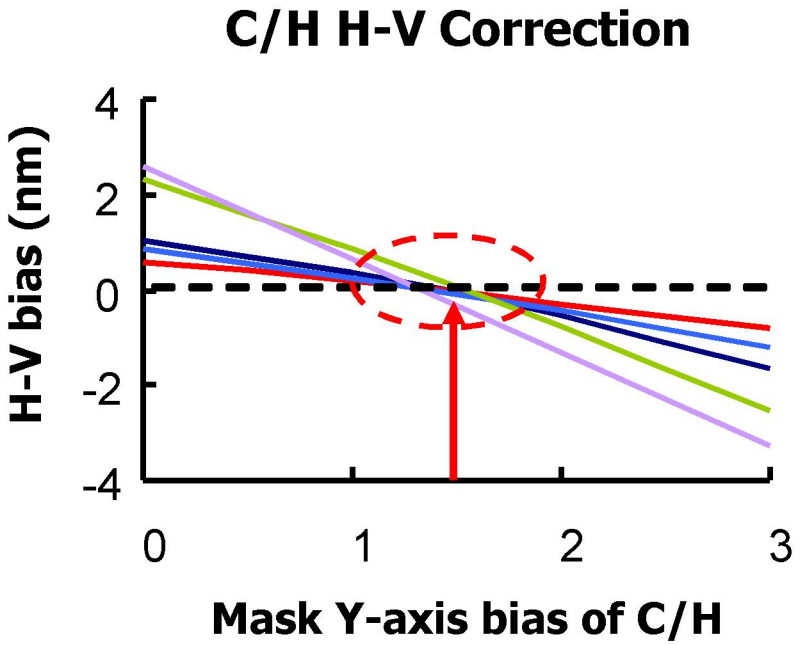
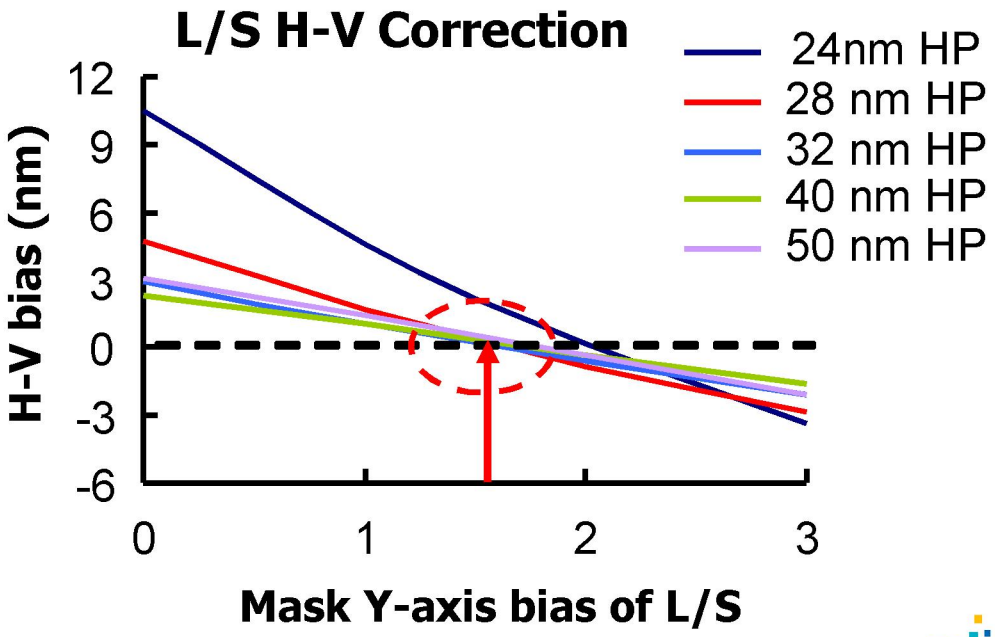
H-V bias correction

- Same bias can be applied to C/H and L/S of various size except for sub-resolution case







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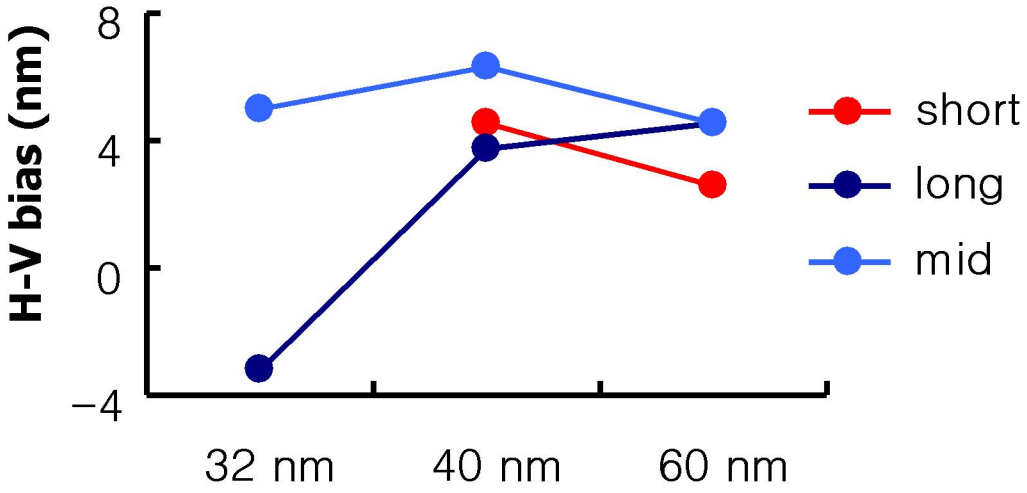
Brick wall pattern

H-V bias of Brick wall type(ISO) pattern

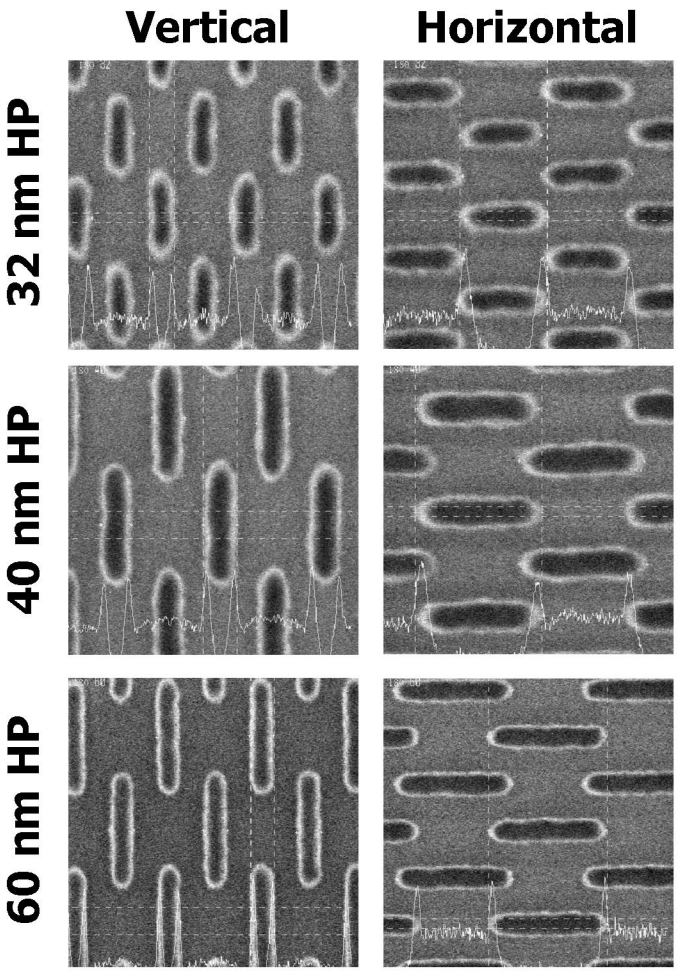
What a H-V trend ISO pattern will it be?

From wafer results Mid & Short CD of brick wall pattern is quite different with Long

For more wide range, H-V bias will be examined by simulation.

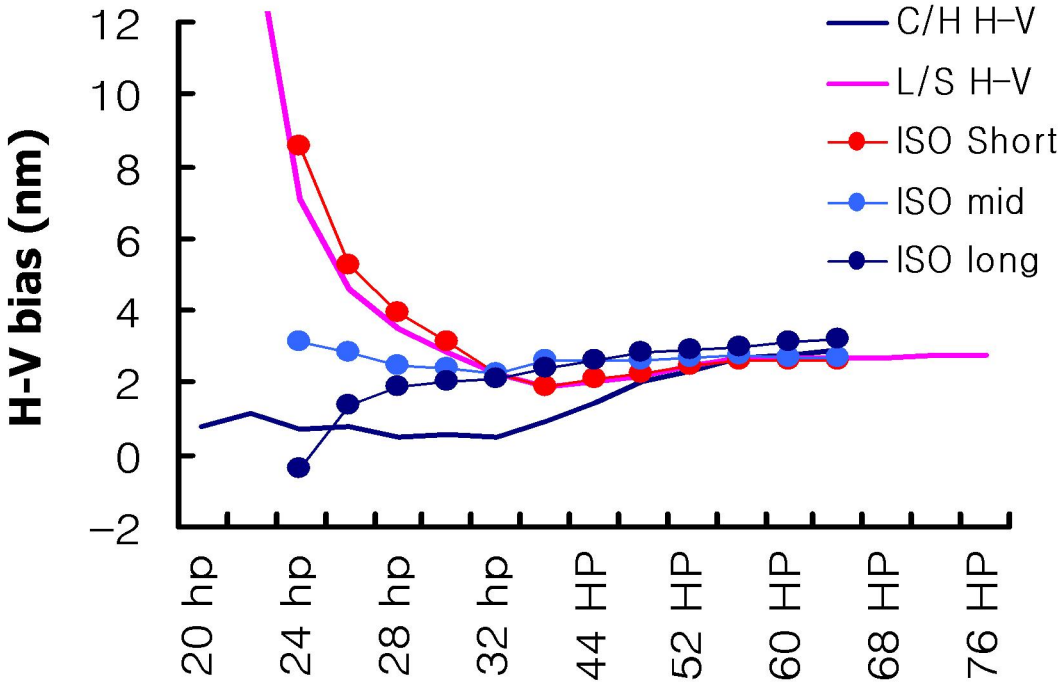


Design rule of Brick wall pattern. (nm)

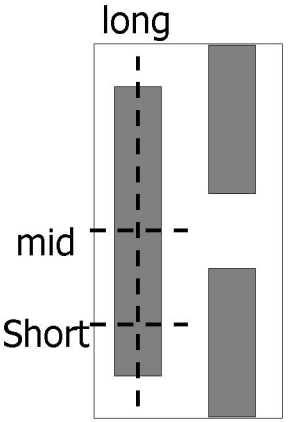


ISO H-V bias simulation vs. pitch

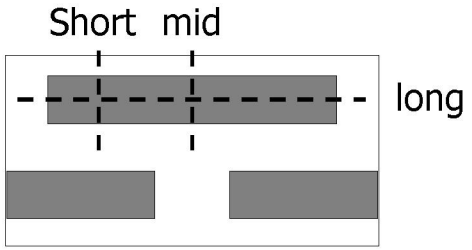
- Short CD shows H-V trend similar to L/S
- Long & mid CD has different trend



ISO Vertical

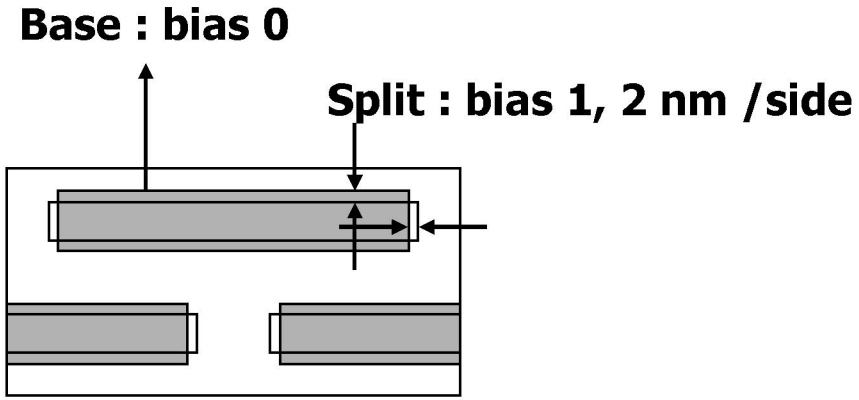


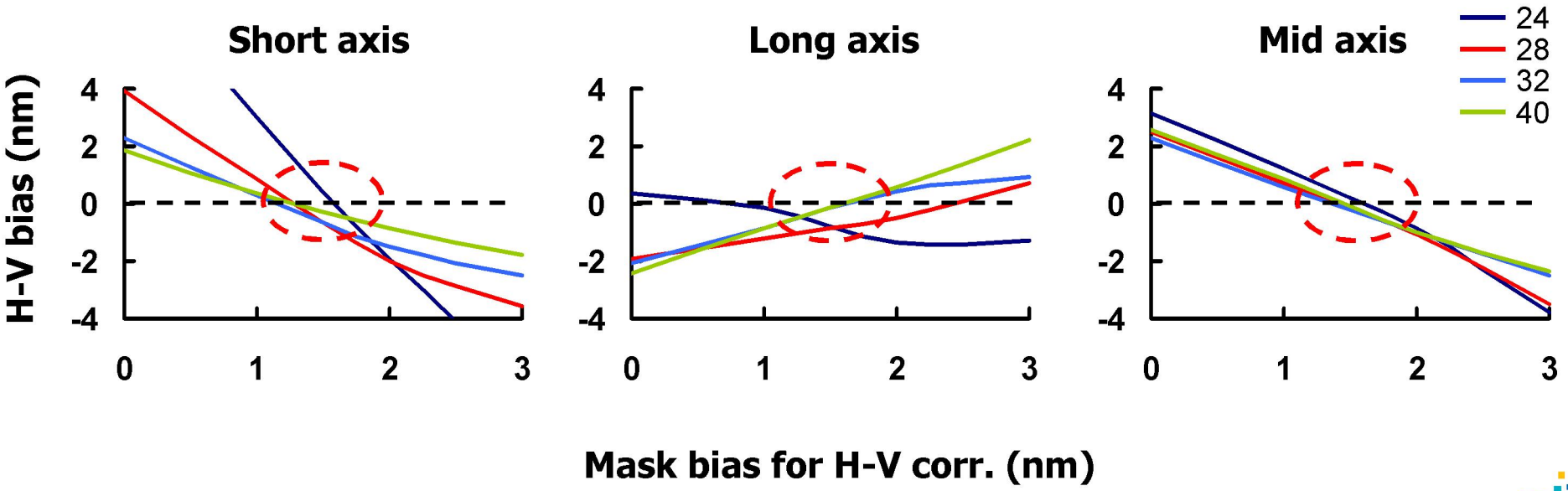
ISO Horizontal



ISO H-V bias correction

- Same bias can be applied to short, long and mid CD position.
- Same as C/H & L/S correction





Summary

1. Different H-V bias trend is detected between L/S and C/H pattern
2. From the NA split test, L/S and C/H pattern show same H-V bias trend
3. The difference is seems to be originated by difference of resolution limit for L/S and C/H
4. Mid & Long axis of brick wall pattern has different H-V bias trend from C/H & L/S
5. With same correction rule, H-V CD variation can be reduced effectively.

Acknowledgements

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