An Investigation of Flare Value at Pattern Edge Region in EUVL
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Introduction
- Extreme Ultraviolet Lithography (EUVL) is a leading candidate for 22nm half pitch technology and beyond. One of the critical issues in EUVL is Flare, which is integrated light scattering from surface roughness in an optical system.
- Flare degrades the control of critical dimension (CD) uniformity across the exposure field. Also, it generates more CD sensitivity as pitch size decreases. Therefore it is necessary to predict accurate flare value and compensate it at OPC level.
- Calculation of accurate flare value requires lots of computational time and resources. Thus we have to optimize the trade-off between accuracy and resolution.
- In this paper, we investigate a smart way to obtain accurate flare value saving computational time especially at the pattern edge area by MATLAB simulation.

Rule-based Flare Compensation Method
- Pedestal model
  \[ T_{\text{local}}(x,y) = PSF_{\text{calc}}(x,y) \otimes T_{\text{mask}} \]
  CD mask bias = \(-\text{CD} + \text{Flare}_{\text{local}}(x,y) \otimes \text{Flare}_{\text{calc}}(x,y)\)/\( \text{MEEF} \)
  : Computationally, flare is defined as a convolution of the flare point spread function (PSF) with the clear-field mask.

Point Spread Function (PSF)
- We have adopted the PSF of Alpha Demo Tool (ADT) that its maximum flare value is about 16%.
- The PSF of EUV extends several millimeters. Unless we manipulate the PSF, it could takes longer than a month by dual-core CPU to obtain the flare value.
- We can obtain the flare value in reasonable time as an expense of its accuracy.
- We divided the region of PSF in terms of its gradient, and set a different grid size for each region of PSF in order to circumvent the trade-off between resolution and computational time.

Integration Error VS Resolution
- The region 1 in the PSF causes approximately 1.3% of flare error for L/S layout. But most of the error comes from the short range where the gradient of the PSF is high. Thus, we need to divide the region 1 into short and mid range flare.

Flare Value at Pattern Edge Region
- Memory cells consist of repetition block of L/S patterns.
- We introduced a layout of L/S block. It consists of blocks of 25mm 1:1 L/S pattern, and spaces that are larger than 5um separating the blocks in between.

Rough Simulation
- We simulated the flare map with MATLAB under dual-core CPU, 2G RAM
- For 5mm x 5mm layout, it took about 2 hours with minimum grid of 1um.
- Flare value on L/S pattern was quite uniform except the edge area.

Robust Simulation
- Under the same H/W condition, it is impossible to conduct the simulation with 50nm grid over the entire area of 25mm². If we set the length of the short-range PSF at 3um, the influence of the short-range PSF reaches only 3um. Therefore we can separately obtain short range flare for the L/S block with 50nm grid as long as the separation between the blocks is larger than 3um.

Conclusion & Future Works
- For monotonous patterns like DRAM, we can obtain flare value faster than for logic patterns where patterns are not monotonous.
- As the gradient of PSF within 3um is high, this region of PSF causes most of the flare error in rough simulation. We have defined the flare value calculated by this region of PSF as short-range flare.
- If we apply this short-range flare only to pattern edge, we can obtain better accuracy without much increase in computational time.
- CD uniformity can only be ensured when accurate flare value is secured, also effort to decrease the maximum flare and CD sensitivity by flare should be made.

Flare value error at pattern edge by 1um grid of rough simulation compared to 50nm grid of robust simulation

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