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Novel EUV mask black border suppressing EUV and DUV OOB light reflection

Shin Ito, Yutaka Kodera, Norihito Fukugami, Toru Komizo, Shingo Maruyama, Genta Watanabe, Itaru Yoshida, Jun Kotani, Toshio Konishi, and Takashi Haraguchi, Toppan Printing Co., Ltd. (Japan), 7-21-33 Nobidome, Niiza-shi, Saitama 352-8562, Japan

ABSTRACT

EUV lithography is the most promising technology for semiconductor device manufacturing of the 10nm node and beyond. The image border is a pattern free dark area around the die on the photomask serving as transition area between the parts of the mask that is shielded from the exposure light by the Reticle Masking (REMA) blades and the die. When printing a die at dense spacing on an EUV scanner, the reflection from the image border overlaps edges of neighboring dies, affecting CD and contrast in this area. This is related to the fact that EUV absorber stack reflects 1-3% of actinic EUV light. To reduce this effect several types of image border with reduced EUV reflectance (<0.05%) have been proposed; such an image border is referred to as a black border. In particular, an etched multilayer type black border was developed; it was demonstrated that CD impact at the edge of a die is strongly reduced with this type of the black border (BB). However, wafer printing result still showed some CD change in the die influenced by the black border reflection. It was proven that the CD shift was caused by DUV Out of Band (OOB) light from the EUV light source. New types of a multilayer etched BB were evaluated and showed a good potential for DUV light suppression.

In this study, a novel BB called 'Hybrid Black Border' (HBB) has been developed to eliminate EUV and DUV OOB light reflection by applying optical design technique and special micro-fabrication technique. A new test mask with HBB is fabricated without any degradation of mask quality according to the result of CD performance in the main pattern, defectivity and cleaning durability. The imaging performance for N10 imaging structures is demonstrated on NXE:3300B in collaboration with ASML. This result is compared to the imaging results obtained for a mask with the earlier developed BB, and HBB has achieved ~3x improvement; less than 0.2 nm CD changes are observed in the corners of the die. A CD uniformity budget including impact of OOB light in

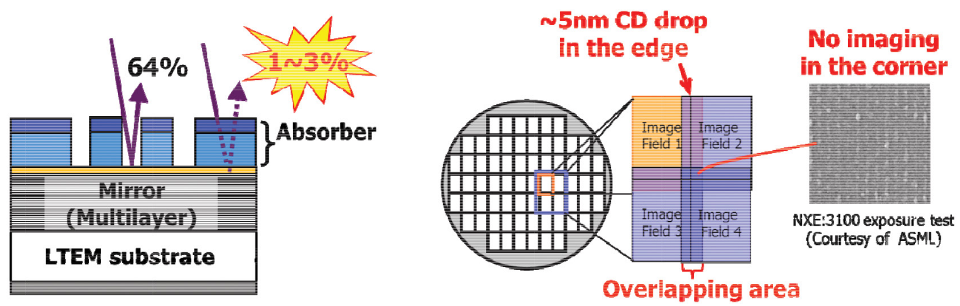

Figure 1. Schematic view of EUV mask (left) and die to die interactions on wafer. EUV light is reflected at the image border andimpacts imaging in the neighboring die. In the corners of the dies reflections from the three neighboring image borders overlap with die area. As a result, it caused CD drop or pattern resolution problem in the worst situation.

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EDITORIAL

Complexity, Simplicity and Elegance…

Shane R. Palmer, Nikon Research Corporation of America

Following the insightful Keynote Address "Make Lithography Great Again" provided by Chris Progler (CTO Photronics) at this year's Photomask meeting, I could not help but reflect on the statement he made about "whole societies have been known to collapse" due to over-complexity. Chris's comment was in reference to our current situation in lithography and based on his recent perusal of an archaeology study by Joseph A. Tainter in 1990 called "The Collapse of Complex Societies". I must admit, the first thing that came to mind were the correlative words in the essay "An Anglosphere Future" by the late Christopher Hitchens: "The US Constitution can be printed on twelve pages of A4-sized paper while the (unreadable and impenetrably complicated) European Union Constitution runs to 256." The elegance and lucidity of the US Constitution remains despite two centuries of amendments. I'm not suggesting an imminent collapse of the EU, but couldn't they have drafted a shorter and more viable Constitution?

So we return to Dr. Progler's keynote. Is lithography getting too complicated? Simplifying, i.e. KISS, and applying the elegant Pareto analysis methods are good initial recipes to follow with solving complex problems, but they do not always help. Sometimes the trivial many become the mob that destroys the solution (society). So what do you do when a problem just can't be simplified? We can't stop, raise our hands and give up. We need to decide. It might be helpful if we review a few past examples (as did CP in his talk).

157 nm lithography: As I understood it, the primary reason for failure of this F_2 excimer based lithography was implacable "mother nature" response to this near vacuum UV wavelength. There just weren't high-quality materials for the immersion fluid, pellicle, resist and optics. Sure we were able to conjure up $BaLiF_3$, Germanate Garnets and various "perfluoropolyethers" liquids from expensive developments that showed promise. But the devil was in the details and despite the large investments on "clocking" the optics, introducing a "flat" final element and the excellent work by resist polymer chemists, none of it worked well in a cost effective way.

X-ray Lithography: In the beginning everything seemed right for this to work. The optics (grazing incident scanning), scanner and source were fine (especially if you had a synchrotron), however in the end, this became our "Waxahachie Supercollider" due to expense overruns and complications of the 1X mask that contained distorting metallic absorbers on a thin membrane...

EPL and SCALPEL: Both of these projects should have succeeded. Yes the plasmon "blur" was a serious issue (especially with SCALPEL), but there were ways to mitigate this effect, i.e. by using an ultra-thin membrane or simply applying a stencil mask. Also, as a pure "cutting" tool, e.g., printing contact-like features, which still remain a bane to lithographers, these technologies were the cat's whiskers! They had huge DoF and exposure latitude. However, in the end, despite the excellent physics and use of a 4X mask, EPL failed for reasons of requirements of "complementary masks" and low throughput as a result of avoiding space-charge effects from a large flood of electrons.

So that brings us to our current state of affairs for the contenders of next-generation lithography: The details we must consider with 193 nm immersion with multi-patterning, EUV and Nano-Imprint lithography. A start of the list for the Pareto analysis might be…

NIL: 1X mask, overlay, throughput, cost …

MP-193i: Overlay, throughput, complex masks, cost...

EUV: Throughput (source), cost, multi-layer masks, lifetime/uptime of mask and tool…

Of course there are more to add to these lists. We can certainly pencil in our guesstimates for cost, timelines (to solve) and other details to assign numbers to each. We can also consider past track records. And as with some past technologies, we will likely miss a few critical "devilish details" hidden in the trivial many. Consider imprint lithography. What could be simpler? No Optics! No Pellicle? Yes, but a 1X difficult mask that needs to be squeezed to feel the burn. And speaking of burn… No. I won't go there. If you saw the lampooning video during the BACUS banquet, you'd know. In the end you must decide. Do you go with the "devil you know" or the "devil you don't know"? Yes, the "devil is in the fiery details"…

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Managing Editor/Graphics Linda DeLano
Advertising Melissa Farlow
BACUS Technical Group Manager Pat Wight

SPIE.

P.O. Box 10, Bellingham, WA 98227-0010 USA
Tel: +1 360 676 3290
Fax: +1 360 647 1445
www.SPIE.org
help@spie.org

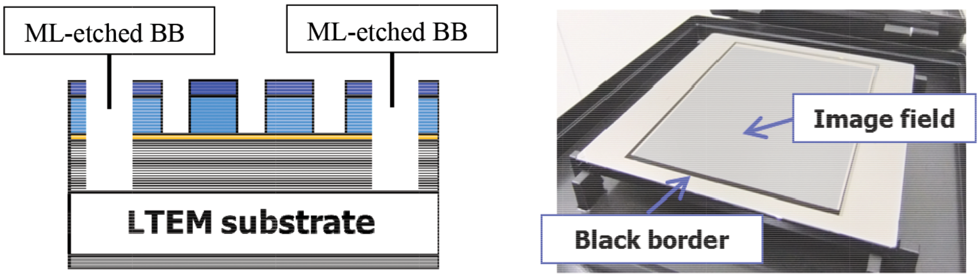

Figure 2. Schematic view and photo image of fabricated EUV test mask with ML-etched black border. Absorber, ruthenium and multilayer are etched down to LTEM substrate.

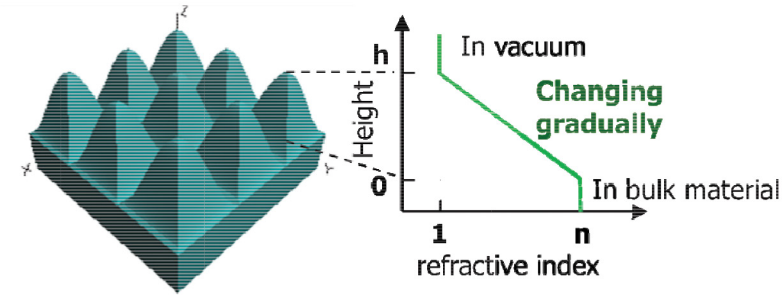

Figure 3. Concept of Hybrid Black Border. The surface of black border needs to possess a gradual refractive index change to eliminate EUV and DUV reflection.

the die edge area is evaluated which shows that the OOB impact from HBB becomes comparable with other CDU contributors in this area. Finally, we state that HBB is a promising technology allowing for CD control at die edges.

1. Introduction

Extreme Ultraviolet (EUV) Lithography is expected to be the most promising candidate for semiconductor device manufacturing below 10nm and beyond. As EUV lithography matures, the specification for EUV mask quality has been getting difficult to meet the requirements for high production yield and compatibility with the existing processes in terms of wafer layout, overlay, and CD uniformity. An opaque image border is intended to overcome the limitation of the reticle masking blades (ReMa blades) of the scanner, in providing sufficiently sharp and accurate image on wafer. On the other hand, thinner absorber is preferable to reduce shadowing effect causing HV CD offset due to oblique incidence of EUV light and mask topography, however, the reflectance of absorber border tends to get higher (typically 1-3%) as the thickness of the absorber becomes thinner as shown in the left side of Figure 1.[1] It means the image border is not fully black. Undesired EUV light is reflected from the image border through the thin absorber, and residual reflection of the image border around the die image is exposed onto wafer. Therefore patterns at the edge of the die receive 1-3% extra background light while in the corners this can be as much as 3-9%. As a result, CD degradation could be observed on wafer as shown in the right side of Figure 1 that was reported previously.[2,3,5]

To avoid the phenomenon, a solution is to reduce EUV reflectance of image border. For this purpose, several types of black border like stacked absorber type and ML-etched type have been proposed in the past,[6] and the most commonly applied method to create black border uses removal of the multilayer mirror in the image border because EUV reflectance is cut to practically zero.[1] (Figure 2) On this black border (Normal BB), the absorber and multilayer mirror are etched down to the glass substrate, and the EUV reflectance of the region is lowered below 0.05% which is lower than measurement limit of the reflectometer, however, the DUV reflectance is still around 5% for both ArF and KrF light.[3,4]

As it was mentioned, black border is required to be optically dark for both EUV light and DUV Out of Band light simultaneously. But it is known that DUV spectrum emitted from EUV light source is broad band 140-400nm.[8] And generally, EUV resists tend to be sensitive for shorter wavelength from 100nm to 300nm range.[9] Therefore, it is important the new black border should be able to control the DUV wavelength range.

In this paper, a novel BB called 'Hybrid Black Border' (HBB) is developed which allows to eliminate both EUV and DUV OOB light reflection. We optimize the best BB structure by optical simulation, experimental mask fabrication, and quantification of the effectiveness of OOB light reflectance reduction by mask standalone measurement. Then, we will confirm the stability of mask features such as CD performance, defectivity, and cleaning durability between pre and post HBB fabrication process. Furthermore, we will investigate direct black Border OOB test and die to die imaging performance of 16nm patterns by means of exposing wafers with the reticle with the new BB on ASML NXE:3300B EUV lithography scanners. Finally we will confirm whether HBB can be a promising technology for the future EUV lithography technique. The confirmation of exposure test has been presented in SPIE Advanced Lithography 2016,[10] so we focused on the mask performance.

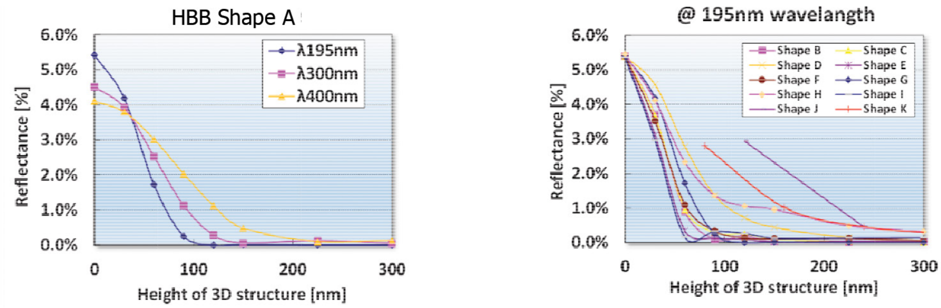

Figure 4. OOB reflectance simulation result for HBB shape optimization. Left: Focusing on a specific 3D shape, reflectance varies due to wavelength and height of3D structures. Right: Different HBB structures showed different HBB structures showed different reflectance signatures.

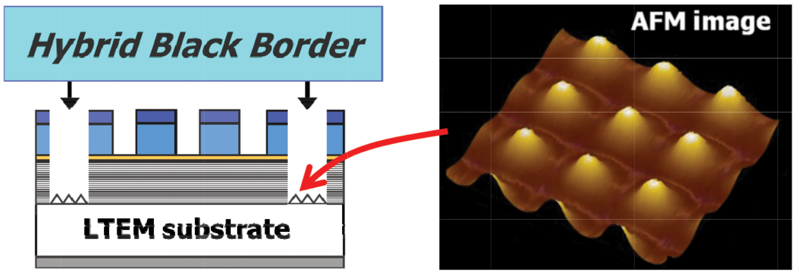

Figure 5. AFM image of experimentally fabricated HBB. 3D structure was successfully fabricated on the surface of ML-etched black border as designed.

2. Fundamental Experiment

2.1 Requirement for the Mask with Hybrid Black Border

From the perspective of mask quality, there are several requirements that has to be maintained as well as regular masks. First of all, main pattern in the image field should be protected during mask fabrication process. That is to say, no mask pattern degradation, no defect/particle adder, and no changing of DUV or EUV reflection during HBB process are required. Also, cleaning durability of those features after HBB process is a practical issue.

Secondly, of course, HBB needs to be functional of zero EUV light reflection and low OOB light reflection. Thus, HBB should have an anti-reflection function EUV light as same as ML-etched BB and needs to have new optical function against DUV OOB light reflection.

Finally, HBB needs to be stable against EUV and DUV irradiation. So, the material for HBB may need to be selected from inorganic materials. The cleaning durability is also practical issue as same as the main pattern, so the structure of HBB and the fabrication process should be a simple as possible.

2.2 Concept of Hybrid Black Border

In order to explore the best HBB structure, the requirements described above need to be taken into account however the most crucial challenge is how the reflection of both EUV light and DUV OOB light can be eliminated from the surface of black border. Regarding the EUV reflection, it is necessary to get rid of multilayer to achieve zero EUV light reflection. So the basic structure of HBB should be similar to ML-etched BB, and absorber, ruthenium and multilayer need to be etched down to LTEM substrate.

As for DUV OOB light, we conducted optical simulation, and concluded that the surface of black border should have a gradual refractive index change to provide anti-DUV reflective function. More specifically, 'Moth-Eye' like 3D structure with fine pitch is assumed to be the best structure to achieve such a gradual refractive index change as shown in Figure 3, and if the surface of black border has such a 3D structure on it, it is expected to suppress both EUV and DUV OOB reflection.

2.3 Fundamental Study (Simulation)

In consider of the HBB concept, optical simulation using FDTD method (Finite-Difference Time-Domain method) was conducted to investigate the best HBB mechanism for more than 300 combinations of materials and structures. Figure 4 shows the example of the optical simulation results. The left of Figure 6 is the simulated reflectance change as a function of height for specific HBB structure Shape A. OOB reflectance varies due to wavelength and height of 3D structure, and reflectance gets lower as the height of 3D structure gets higher for all OOB wavelength. Right side of Figure 4 shows the simulated reflectance of many 3D shapes and heights, and different HBB structures showed different reflectance signatures. From these results, it is required to control the shape and the height of HBB structure carefully to obtain the best OOB reflectance suppression performance.

2.4 HBB Manufacturing

Based on the simulation work, 108 types of HBB structure candidates were chosen for experimental mask fabrication. Since the 3D structure needs to be fabricated on the surface of black border precisely, it was judged the conventional EUV mask fabrication process was not applicable for HBB fabrication. So special micro-fabrication process was developed to overcome the difficult requirement for HBB quality. However as mentioned before, mask manufacturability is one of the key factor for HBB structure consideration. So not only EUV and DUV OOB light suppression performance but also mask manufacturability were considered

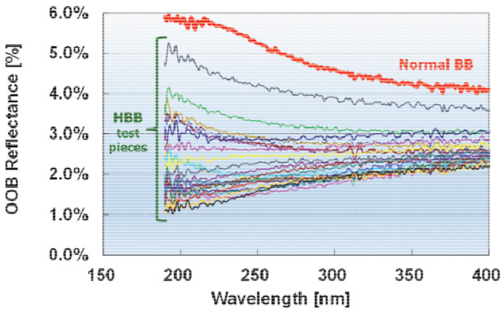

Figure 6. OOB reflectance measurement result of the Normal BB and various HBB candidates. The measurement was conducted by microscopic reflectometer.

Table 1. Reflectance data table of 3 different image border structures. It is obvious the HBB can eliminate both EUV and DUB OOB light reflection. It can be said Hybrid effect.

			DUV OOB light		
Function	Stack	EUV 13.5nm	F2 157nm	ArF 193nm	KrF 248nm
Absorber (No Black Border)	70nm Abs/Ru/ ML/LTEM	1.4%	No data	20.8%	9.6%
Normal Black Border (2012)	Etched-ML /LTEM	< 0.05%*	No data	5.9%	5.2%
Hybrid Black Border (2015)	Etched-ML with 3D structure /LTEM	< 0.05%*	1.6%** (PTB)	1.1%	1.5%

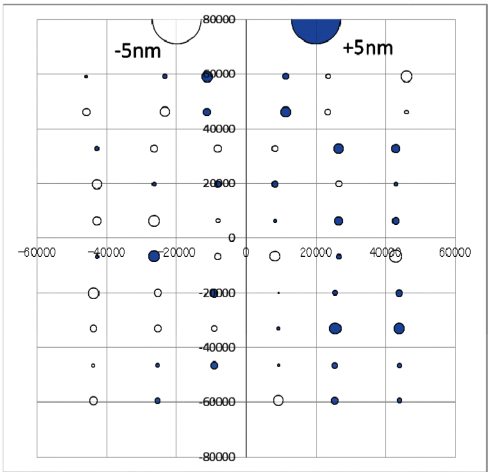

Figure 7. Delta CD (After HBB process – Before HBB process) caused by the HBB fabrication process.

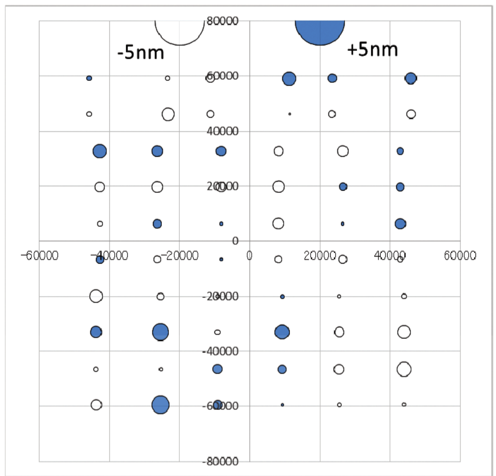

Figure 8. Delta CD (After cleaning – Before cleaning) caused by ten times cleaning process.

to choose the candidates. Several test masks were fabricated, and the shape of all HBB candidates were characterized by AFM (Atomic Force Microscope) measurement.

Figure 5 shows AFM measurement result of one of the fabricated HBB structures. It was confirmed the 3D structure to lower the EUV and DUV reflectance was successfully fabricated on the surface of ML-etched black border as designed.

3. Results and Discussion

3.1 OOB Reflectance Measurement

After verifying the shape of HBB structure, the OOB reflectance was measured on fabricated 108 HBB structure candidates by microscopic reflectometer. The measurement results are shown in Figure 6. In this graph, the results of 17 representative structures and Normal BB are shown. From the measurement result, all HBB test pieces showed better OOB reflectance reduction effect than that of the Normal B. But OOB reflection signatures of all HBB candidates are unique due to the combination of materials and structures. And it is confirmed the best HBB structure achieved 70% reflectance reduction from Normal BB in 190nm – 300nm wavelength range.

Finally, we selected the best of best HBB structure base don the all evaluation results and mask manufacturability. As for the best HBB structure, we additionally measured the reflectance of 157nm wavelength at PTB (Physikalisch-Technische Bundesanstalt, Germany). Table 1 shows the reflectance summary table of 3 image borders, absorber border (which is to say 'no special black border structure'), the Normal BB, and the HBB. From the measurement result, it was confirmed the HBB successfully achieved >0.05% EUV reflectance as same as that of the Normal BB and ~1% reflectance for all measured DUV OOB wavelength which is about 805 lower than that of the Normal BB. It is very obvious the newly developed HBB is very effective to eliminate both EUV light and DUV OOB light reflection. And this is the reason why we call the new technology 'Hybrid Black Border'.

3.2 Evaluations of the mask with Hybrid Black Border

As mentioned above, confirming the stability of mask features during HBB fabrication process is important. CD performance in the image filed on the mask was evaluated before and after HBB process. CD on the mask causes directly to the quality of the transferred CD on wafer.

64nm line and space patterns on the mask were measured to evaluate CD performance using CD-SEM. Figure 7 shows the result of CD changes (After HBB process – Before HBB process)

Table 2. Defect inspection result through the HBB process and cleaning process.

	Blank Defect	Mask Process Defect
Before HBB Process	5	2
After HBB Process	5	2
After Cleaning	5	2

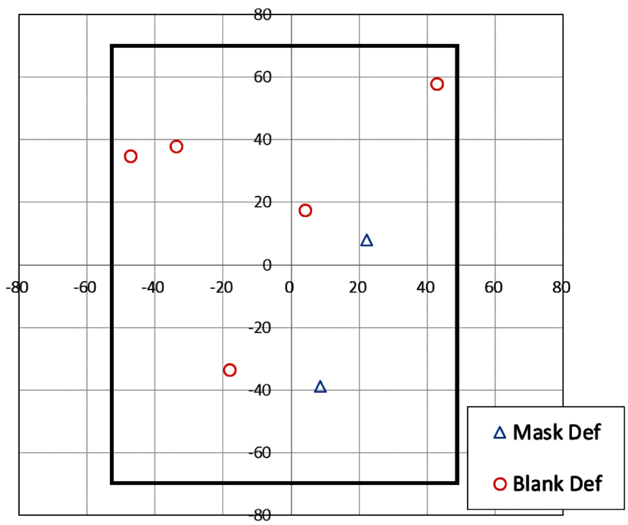

Figure 9. Defect map through the HBB process and cleaning process.

caused by HBB process, and the average delta CD of space patters is 0.18nm; this is in the range of measurement variability. It means that the effect of the HBB fabrication process for CD performance is negligible.

Cleaning durability for CD performance is also evaluated, because cleaning fluid might cause chemical reaction on main patters, and the surface of the mask might be degraded. Cleaning process has conducted 10 times, and the result of delta CD (After cleaning – Before cleaning) is shown in Figure 8. The average delta CD of space patterns is -0.79nm; the degradation of space pattern may be caused by chemical reaction by cleaning fluid.

The defectivity on the image field during HBB process is also important. Through the HBB process and cleaning process, there is possibility that defectivity might be degraded. So, defectivity was evaluated using the latest DUV pattern inspection tool, and 40nm defect sensitivity was applied. The number of detected defect is shown in Table 2, and the defect map is shown in Figure 9. As a result, five blank defects and two mask process defects were detected, and it was confirmed there was no adder during the HBB process and cleaning process. Furthermore, it was confirmed there was no tendency on defect location which was suspected to be caused by cleaning process.

After the fabrication of EUV mask the HBB, cleaning durability was evaluated to confirm mask quality degradation during HBB process. If the surface of HBB is degraded by cleaning liquid, the OOB reflection would increase. So, OOB reflection from HBB was measured before and after the cleaning process. The subtraction of OOB reflection (After cleaning – Before cleaning) is shown in Figure 10, and the average value is only -0.017% at 190=300nm wavelength. The value of OOB reflection is nearly the same during the cleaning process, so cleaning durability is judged to be sufficient.

3.3 NXE:3300B Exposure Test

The OOB levels needed to be determined as they were used to determine the OOB reflectance and OOB CD sensitivity. These tests allow proper judgement of the effects of the Normal BB and the HBB. This wafer exposure test on NXE:3300B was conducted in collaboration with ASML.

The test mask with the HBB which showed the best OOB reduction effect in the mask stand-alone test was fabricated to investigate whether the new HBB is really effective to eliminate both EUV light and DUV OOB is actual wafer imaging environment. The configuration of the applied EUV blank was LTEM substrate with a 280nm 40-pair bilayer mirror, a 2.5nm capping layer and a 70nm absorber.

The main test block of the mask consists of repeating dense line and space patterns with various sizes. The black border was fabricated in the image border area that encloses the full image field. In this test, 16nm dense line patterns were focused to investigate the HBB performance by wafer imaging on ASML NXE:3300B EUV exposure tool. As a reference, the Normal BB mask with same main test block as HBB test mask was exposed on wafer as well, and the results of these 2 masks were compared.

Then, OOB exposure on die to die interaction was tested. The goal of the test was to determine the influence of the Normal BB and the HBB on CD at field edges and field corners. In this test, butted and spaced field were exposed side-by-side, and the average dies of the butted and spaced fields were generated. The term 'butted' here means the gap between die to die is set up to 0, and the OOB reflection from BB area overlaps with the edges and corners of the neighboring dies. Especially on the corners of the image field, the additional OOB exposure from BB is even

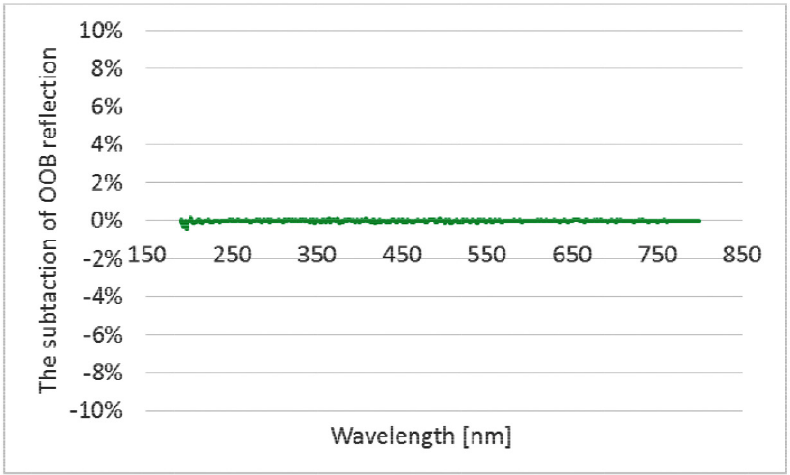

Figure 10. Subtraction of OOB reflection from HBB (After cleaning – Before cleaning).

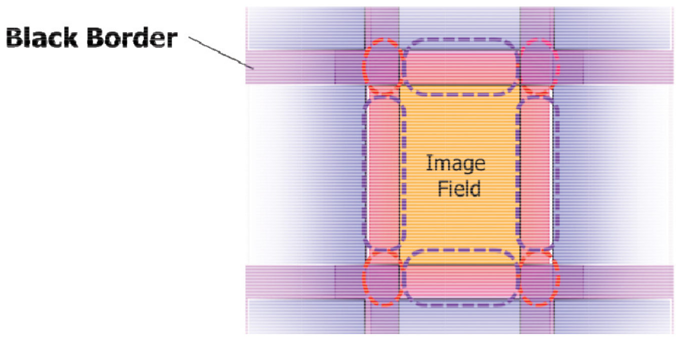

Figure 11. Schematic view of OOB exposure on die to die interaction test. OOB reflection from BB areas of neighboring dies is superimposed on the edge and the corner of the image field.

tripled because the OOB reflection from three neighboring dies are potentially overlapped on the area, as shown in Figure 11. And the term 'spaced' means the gap between die to die is set up enough big to avoid OOB overlap exposure on neighboring dies. It means, the exposure result is considered to show pure CD signature of the test masks because no OOB overlap exposure happens on both edges and corners. Finally these 2 dies were subtracted from each other resulting in point difference maps for each reticle. Then the CD drops were calculated for center vs edges and center vs corners. By this method, it is possible to eliminate the noise from wafer process and extract the influence of OOB overlap exposure.

Figure 12 shows the intra field CDU performance comparison between the Normal BB and the HBB for 16nm Dense Line. From the comparison result, very obvious CD-drops in the edges and especially in the corners can visually be observed on the Normal BB exposure result, in the meanwhile, the CD uniformity on the HBB exposure result looks very uniform. CD-drops in the edge and corner area as compared to the average CD in the center of the field are shown in Figure 13. From this result, the average CD-drop at the edges was 0.18nm in case of Normal BB, and HBB showed CD-drop only 0.09nm. And in the corners where the OOB overlap exposure is tripled, the average CD-drop was improved form 0.49nm to 0.19nm by applying HBB instead of Normal BB.

4. Conclusions

CD changes at the edges and the corners of neighboring die happen if a mask with absorber image border is exposed onto the wafer. To prevent the CD changes, ML-etched black border with almost zero EUV light reflection is proposed, however, even if the black border is applied, DUB OOB light reflectance is still around 5~6%. It was confirmed the additional DUV light also caused some CD changes on wafer. So it is necessary to eliminate this additional OOB light reflection to improve the CD change.

In this paper, a novel BB called 'Hybrid Black Border' has been developed which allows to eliminate both EUV light and DUV OOB light reflection. To decide the best structure of the black border, optical simulation using FDTD method was conducted for more than 300 combinations of materials and structures. Special microfabrication technique for HBB was developed to realize the optimal 3D structure on the surface of black border.

Based on the simulation result and the consideration of mask manufacturability, 108 black border test pieces and masks were fabricated and measured DUB OOB reflectance. The best candidate showed 3x better effectiveness than Normal BB to lower the OOB reflectance. From the result, it was confirmed the new black border can eliminate both EUV light and DUV OOB light.

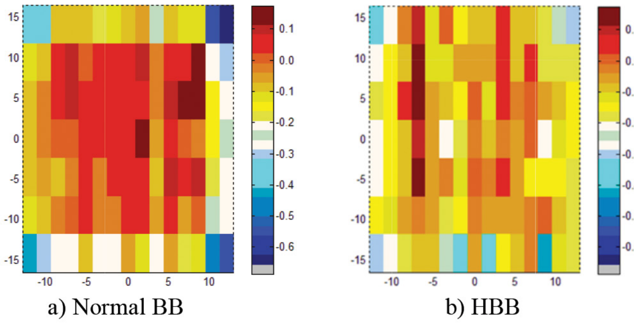

Figure 12. 16nm Dense Line intra field CDU comparison. CD-drops at the edges and especially in the corners are much more pronounced for the Normal BB mask than the HBB mask.

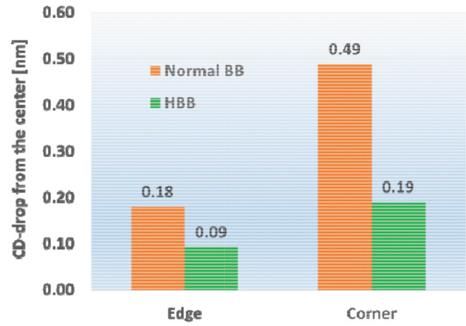

Figure 13. CD-drops in the edge and corner area (16nm DL) as compared to the average CD in the center ot the field. The center of the field is assumed not to be influenced by neighboring fields.

Then, a new full field test mask with HBB was fabricated. CD performance and defectivity through the HBB process and cleaning process was evaluated, and DUV reflection was also evaluated before and after cleaning process. Delta CD in the main field is negligible, so it is judged the HBB fabrication process never impact on mask quality. The number of inspected defect is the same through those processes. The OOB reflectance from HBB has maintained through cleaning process. Thus, mask features showed sufficient result through the HBB process and cleaning process.

Finally, wafer imaging test was conducted to determine the OOB reflectance and OOB CD sensitivity. OOB exposure on Die to Die interaction was tested to determine the influence of Normal BB and HBB on CD at field edges and field corners. It was confirmed the newly developed HBB performed a very good OOB suppression effect in real wafer exposure situation by NXE:3300B and showed 3x better intra field CDU than that of Normal BB.

As a result, it is expected the implementation of the HBB will help to mitigate the effects of possible increases of OOB light in future higher power EUV sources.

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Industry Briefs

Speeding Up Mask Production: D2S Rolls Out Faster Hardware

Mark Lapedus, Semiconductor Engineering

For chip production, more complex and expensive at each node, pressing needs in the photomask shop include more computational horsepower. A growing number of applications in both the photomask shop and the fab require faster computations as the data sets are becoming larger. Looking to address the issues, D2S has rolled out its fourth-generation computational design platform (CDP), a specialized, GPU-based acceleration hardware platform that enables 400 teraflops (a trillion floating point operations per second). The CDP is based on a combination of both graphics processing units (GPUs) and microprocessors. The system is powered by two of Nvidia's K-80 GPUs and two of Intel's Xeon E5-2630 v3 CPUs on each node.

In one mask data prep test, the CDP is said to be ten times faster than a CPU-only system. D2S' system is targeted for several applications. For example, it is being used for model-based mask data preparation (MB-MDP), where leading-edge photomasks are becoming increasingly complex. More complexity of the shapes to manipulate, more shapes, and for each of those things, the demand to be more precise, creates an increasingly difficult computational situation. All of that points to simulation-based processing.

The system is also geared for CD-SEM metrology, mask writing, and for inline thermal-effect correction of e-beam mask writers as a means to reduce the write times. GPUs can also speed up EDA software tools. "Massive parallel computation is still the path to contain run times, and we are continuing to invest and expand our technology in that direction with very good results using many-core CPUs," said Juan Rey, senior director of engineering for Calibre at Mentor Graphics, in a recent interview. Cadence recently acquired Rocketick Technologies, a developer of an x86-based acceleration solution. Using x86-based servers, Rocketick's technology accelerates Cadence's simulator in order to provide faster RTL, as well as gate-level and DFT simulations.

http://semiengineering.com/speeding-up-mask-production/

Update from EUVL Workshop in Berkeley

Vivek Bakshi, EUV Litho, Inc.

The 2016 EUVL Workshop at LBL in Berkeley presented the latest news on EUV Lithography R&D development. Since the Workshop ended, both TSMC and Samsung have announced plans to use EUV Lithography in production at the 7 to 5nm node and receive the NXE3400 production-level EUVL scanner during the first half of next year, to adapt for 7nm node products. This speaks for itself in terms of EUVL readiness for production.

EUV source power continues to make progress, with meaningful demonstration of >200 W by both Cymer (an ASML company) and Gigaphoton. Both suppliers now think that 500 W EUV power is feasible. Not long ago, sources appeared to be the main obstacle to the introduction of EUVL into commercial production. We expect 200+ W to be achieved in fabs sometime in 2017.

Although chipmakers have figured out how to live with mask defects for now via defect avoidance and repairs, mask defect reduction is certainly on the wish list. Patterned mask defect inspection (PMI) is being done in different ways, with wafer inspection being one of them. Lack of a specific PMI tool remains a key issue for cost-effective, EUVL based manufacturing. Lack of commercial metrology EUV sources that meet brightness requirements to support PMI and other actinic inspection tools remains a big gap. Pellicles to protect masks can now withstand 125 W of thermal load, with 250 W as the present goal.

The Industry is also realizing that in order to make substantial progress in developing EUV resists, we need to get back to basics and better understand how they work. As EUV resists operate differently than 193nm resists (via secondary electrons), there's a lot that we still need to understand. This year's Workshop, the ninth to date, was the best-attended yet and offered the most papers ever.

http://electroiq.com/euvl-focus/2016/07/22/update-from-euvl-workshop-in-berkeley/

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About the BACUS Group

Founded in 1980 by a group of chrome blank users wanting a single voice to interact with suppliers, BACUS has grown to become the largest and most widely known forum for the exchange of technical information of interest to photomask and reticle makers. BACUS joined SPIE in January of 1991 to expand the exchange of information with mask makers around the world.

The group sponsors an informative monthly meeting and newsletter, BACUS News. The BACUS annual Photomask Technology Symposium covers photomask technology, photomask processes, lithography, materials and resists, phase shift masks, inspection and repair, metrology, and quality and manufacturing management.

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Calendar

2017

SPIE Advanced Lithography
26 February-2 March 2017
San Jose Marriott and
San Jose Convention Center
San Jose, California, USA
www.spie.org/al

SPIE Photomask Technology and SPIE International Conference on Extreme Ultraviolet Lithography 2017
11-14 September 2017
Monterey, California, USA

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SPIE.
International Headquarters
P.O. Box 10, Bellingham, WA 98227-0010 USA
Tel: +1 360 676 3290
Fax: +1 360 647 1445
help@spie.org • www.SPIE.org

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