ISMT / Motorola EUV Mask Mechanical Fixturing In Write, Inspection, and Exposure Tooling Meeting
(03/07/02 Westin Santa Clara CA)
Meeting Minutes (P. Seidel & P. Mangat)

ATTENDANCE: ~52 total (42 officially registered with additional 10 walk in's)

MEETING CHAIRS:

Pawitter Mangat	Motorola	Principal Meeting Chair
Phil Seidel	International Sematech	Meeting Facilitator (Co – Chair)

PURPOSE:

> Discuss industry technical opinion on EUV mask holders during mask fabrication and wafer exposure.

> Contribute to the understanding of image placement distortion issues involving mechanical fixturing of EUVL mask substrates in mask write tools, metrology tools and stepper tools.

> Provide guidance and information to lead to tool designs that support image placement specifications for EUVL masks based upon the leading strategies or any new strategies.

EXPECTED RESULTS:
Obtain industry technical direction. The benefits and penalties of the two strategies is exactly the topic to be explored at this meeting. The meeting will begin with reviewing outputs from the July 19th 2001 "EUV Mask Mechanical Fixturing..." meeting held during Semicon West. Then several proponents will advocate a particular approach, open up to discussion based on the invited presentations from different suppliers and organizations, and then conclude with attempting to pick a path toward standardization.

MEETING EXECUTIVE SUMMARY:
This meeting provided positive direction to establish a SEMI standard draft (ballot) for the needed EUV mask chucking requirements to meet the stringent image placement and overlay requirements forecasted for EUV technology applications at the 45nm ITRS node and below. The meeting attendance was comprised of the major stakeholders of EUV mask developers and end users (mask makers, tool suppliers, IC mfg.'s, university, labs, etc.). A total of nine presenters who represented particular stakeholders reviewed their latest data / modeling findings and proposals on preferred chucking methodologies or standardization concepts. Significant interactions by the attendees throughout the meeting added to the technical clarifications and direction. It was agreed that this standards group had enough initial input and direction based on this meeting and the prior meetings to develop a SEMI draft document in time for a review meeting by SPIE BACUS Sep / Oct 2002 or Semicon West. The SEMI draft would be based on the recommendation to that does not limit chucking approach such as mandating e-chucks over other clamping methodologies but outline the requirements and provide addendums that cover specific suitable clamping cases. Such a proposed approach that fit this strategy was the "3 rule" concept presented by ASML (S. Roux) that outlined the need to specify that all clamps must have a known bending stiffness, all clamps shall clamp with a known accepted pressure, and that all clamps meet a similar flatness requirements. The meeting output however identified additional action items or areas of needed investigation on the applicability of e-chucks into a mask manufacturing environment.

Meeting Agenda:

1.	Welcome; Activity Summary	Dr. Pawitter Mangat
2.	TIM meeting Update Semicon West;	Dr. Ken Blaedel
3.	Semi Standard requirements/guidelines:	Dr. Scott Hector
4.	UW-Madison results:	Prof. R. Engelstad / Dr. Ken Blaedel
5.	ASML Proposal:	Dr. Steve Roux
6.	Infineon Proposal:	Dr. Frank-Michael Kamm
7.	ETEC Approach:	Dr. Tom Newman
8.	Nikon Approach:	Dr. Kazuya Ota
9.	Canon Approach:	Dr. Yasuaki Fukuda
10.	Discussion and Future Activity	Dr. Pawitter Mangat / Phil Seidel

HIGHLIGHTS OF INDIVIDUAL SPEAKERS

1) *Pawitter Mangat (Motorola) Welcome & Meeting Overview*

Pawitter discussed history of this particular standardization effort that has dated back since early 2000 that included activity that was initiated by both Pawitter and Professor Roxanne Englestad (Un. of Wisconsin) 03/20/00 during the first SEMI standards meeting. The succession of several meetings since then resulted in the present status. These meetings were as follows:

- July 2000 Semicon West meeting: Here results of a preliminary survey was reviewed that included 7 responses that showed suppliers should have a choice in selecting mounting schemes, induced flatness issues from clamping are critical as it will impact overlay, and any specification should define the acceptable area on the reticle where handling or clamping should take place. Reviews of existing standards were made and reported. Initial modeling done by Univ. of Wisc. between a three point mount versus a complete clamping (e.g. e-chuck) showed that the In-Plane Distortion (IPD) of 56.1 nm versus 2.3 nm for the completely flat chucking case
- October 2000 NGL WS output revealed that EUV mask chucking standards were rated as the second highest needed standard following the P37 EUV substrate specification.
- March 2001 SPIE Meeting: Here results from a second survey that contained 13 responses (vs. the 1st survey of only 7) revealed that one standard chuck should not be specified and that one method of chucking should not be specified, there should not be a required reticle flatness specification for each EUV mask manufacturing process step, and there is support for having requirements for the substrate & the mounted mask. ASML details issues of defects generated during surface contacts as well as detailed issues with defects generated during surface contacts and shared preliminary data on clamping force needed to maintain overlay / image placement. The meeting also resulted in the motion to investigate two separate approaches prior to filing a SEMI draft ballot. These two approaches were to standardize mask flatness on finished mask over two spatial frequency ranges that included low frequency errors and high frequency and another approach to standardize attributes of the chucking method including stiffness of chuck surface, area, chucking force or pressure, etc.
- July 2001 Semicon West Photronics – MCoC / ISMT Technical Interface Meeting (TIM) which is reviewed by Ken Blaedel in the following session.

Pawitter outlined the required needs in order to proceed in the drafting of a SEMI specification that included critical inputs for chucking standards, modeling data on specifications, any experimental verification, and obtaining OEM supplier's positions. The timeline for completing these activities with a SEMI draft was outlined for a draft standard review at BACUS (Sep / Oct) 2002 with an update Dec 2002.

2) *Ken Blaedel (Lawrence Livermore National Labs) – Output from 07/19/01 Meeting*

Ken reviewed the major outputs from the last meeting on this topic held at Semicon West (July '01). Although 30 individuals attended this meeting from 22 different companies it was felt that metrology and tool inspection suppliers were not well represented and that time was needed to acquire these stakeholders opinions and inputs. Ken reinforced the need to maintain flatness control with EUV reticles and blanks as the current EUV substrate suppliers are 3x to 5x from the frontside flatness requirement of 50nm Peak to Valley (P-V) as specified in SEMI P-37. As the substrate suppliers meet these requirements there must also be assurance that the processing of the mask blanks and use of these reticles maintains the 50nm P-V flatness requirements.

The major output of the 07/19/01 meeting resulted in the two preferred methods to assure mask flatness. Ken reviewed the two approached and their positive and negative attributes. One approach is to specify that all mask writing, measurement and exposure be performed with reference to (i.e., within some tolerance of) the mask front surface being ideally flat, OR the other approach is to specify that an electrostatic chuck that will be universally used to physically flatten a mask

Approach 1 "Writing, inspection and exposure are each referenced to an ideally flat plane" has the following pros' and cons'.
(+) Does not limit the way that one wants to hold the mask
(-) There is the possible flatness error contribution caused by the backside flatness when the blank / mask is clamped electrostatically.

(-) Writer (if) 3-point support then e-chuck than backside flatness could be an issue. Compensation algorithms would need to be used.
(-) Not enough to just specify the way to clamp but actually to specify the forces used in the clamping
(-) Avoid substrate shapes that e-beam could write a good mask but not clamp it

Approach 2 "Standardize the attributes of a chuck that must be used to flatten a mask" has the following pros' and cons'.
(+) In plane distortion of the mask becomes insensitive to variation in friction
(+) Variation in out of plane distortion from chuck to chuck insensitive to backside flatness
(-) Locks in the design of a chuck (premature), requirements came from the exposure tool suppliers
(-) Chuck design for exposure tool may not be a good when applied to writing or measuring
(-) The possibility of lack of distinguishing between trapped particle causing distortions and a bad reticle (reticle with poor IP).

Ken concluded with remarks that the standard interacts with SEMI standards for substrates and blanks. The mask substrate must also pass inspection guaranteeing that it can be flattened in the exposure tool after coating and patterning. The mask could be written face up and then exposed face down and while writing and inspecting do not have to be done in the flat state, only that the exposure must be in a flat state.

Question #1: In this approach is it an ideally flat reference or do we pretend the surface is flat? OR we know the surface may not be flat but adjust process to write plate in the right location.

Answer #1 (K.B.) It is the latter. How do you qualify that the algorithm methodology is correct. But this may be up to the supplier to make sure algorithm is correct.

3) *Scott Hector (Motorola) – Chairman of SEMI EUV Mask Task Force - The SEMI standards process and EUV mask chucking:*

Scott reviewed all of the impacted areas of EUV masks that are being required to have some level of official standardization. These fall into general areas of the substrate, chucking, multilayer performance, and reticle handling. Of these four areas that are needed for standards in the EUV mask the mask substrate definition has the highest priority and recently passed as SEMI P37-1101. The 2nd standardization priority is chucking of the masks which is what this meeting is focused to move this forward. The 3rd priority to define ML and absorber buffer layer and it is in draft SEMI 3414. The 4th priority is the reticle handling standardization. Currently there are proposals from ASML on how to handle EUV reticles and Jerry Cullins (Intel / ISMT) is creating a working group to define this requirement.

Scott outlined the SEMI standards process. These specific EUV mask related standardization efforts were started by Harry Levinsen (AMD) March '99 and then transferred to Scott. Scott described the "SNARF" (Standards New Activity Request Form) process, SNARF approved by the NA Microlithography Committee and then is assigned as a ballot. The ballot then gets debated in the task force meetings. Informational "blue" ballots goes out to others that did not attend meetings. Seek approval on the letters or yellow ballot. Micropatterning committee requires that ballots need to 60% of the voting members to respond on any ballot. To accept the ballot as a specification 20% must accept. Any negatives must be less that 20% and each negative has to be address. If one of the negatives is technically persuasive it could negate / prevent acceptance of the ballot.

Scott also reviewed the Task Force Meeting ground rules that includes, anyone can participate, anyone can vote in task force meetings on motions, antitrust reminder, confidential information is not protected and any related patents to the ballot that has been filed or issues, you have the liability to tell the committee that this has been released to make the organization aware. Although this meeting is not an official SEMI meeting it does constitute needed activity that feeds into the SEMI process.

4) *Prof. R. Engelstad (Un. Wisc.) & Dr. Ken Blaedel (LLNL): Chucking of EUVL Masks*

Ken Blaedel from LLNL introduced the reasoning behind the Univ. of Wisc. EUV mask chucking modeling efforts. The recent P37 SEMI standard requires both frontside and backside flatness of 50nm P-V within a prescribed "quality area". The developments at the EUV substrate suppliers are focusing on developing finishing processes that meets all of the SEMI P37 requirements simultaneously.

It is being shown to be very difficult to meet these specifications at the same time. Within the conventional polishing processes is difficult to maintain figure and roughness at the same time. Ken showed a representative Power Spectral Density (PSD) plot with surface error or "ripples" that can be introduced while trading off on when attempting to meet figure (form) and roughness (finish). The "ripple" phenomenon tends to occur in a regime in between form and finish in the 1/mm spatial frequency and can be seen as having cycles on the order of 0.5mm to 10 mm periods. The use of proper mask clamping techniques may be able to relax these demanding specifications. If you can remove form errors by chucking (e-chuck) to take out "bow" for instance the polisher can target the waviness.

With the use of modeling mechanical distortion of the masks one can look at the various contributions of a substrates "non flatness". The use of mathematical equations or series called Legendre polynomial modes can describe the substrate / mask distortions. Up to a 4 x 4 degree polynomial matrix can adequately describe the substrates / masks distortion. One can then separate or "decouple" the Legendre modes and show that chucking approaches can impact the lower order modes. The higher polynomial modes (i.e. 3 and 4) can describe the finishing roughness that polishing accounts for.
This modeling activity helps us to understand and model the chuck's clamping ability n order to ensure a mask can be flattened. With this modeling approach the tooling suppliers can apply knowledge to flatten the low-order modes of deformation, understand the effect of crushing entrapped particle(s), and other inputs. As an additional benefit the industry may be able to relax the specification for substrates and blanks to capitalize on the chuck's flattening capability

Prof, Roxanne Engelstad
Roxanne reviewed the finite element (FE) modeling. The effort of the FE modeling work was to understand the maximum reticle-to-chuck gap within the flatness quality area (142 mm x 142 mm) as well as over the entire reticle that has been tracked as a function of clamping pressure. There are problems with the corners of the reticles with the mode shapes. The models only used "sinusoidal" terms but this was not enough to describe all of the other terms. These calculations matched fairly well to the previous work done by ASML's
U. Wisc. used the Legrendre coefficients. Allows stress free flat reticle
Reticle to chuck gap within the flatness quality area This includes alignment marks.

Shape 1:1 mode – consider the coefficient is positive or negative values. Mode 1:1 +/- is independent of sign. Peak to valley is 1.333 um. Radius of curvature near the edges of mask is large but you can flatten this.

The 0:2 mode looks like a paraboloid P-C 1 um this is dependant on the sign. Clamping pressures of 10 you cannot account for all. If you reverse the signs of this mode you can really drop the required clamping pressure.

Question #2: Is the delta the same between the two signs?

Answer #2: Yes. The 1:2 mode is a more difficult shape and the results show that you cannot flatten the substrate past 5 nm.

Question #3: If we do relate flatness requirements, maybe they should be relaxed convex up?

Answer #3: The Multilayer deposition (ie. Resulting stress) will have something to do about the flatness and sign.

Question #4: Is the gap remaining is the flatness error that remains versus the specifications that needs to be accounted for in error budget.

Question #5: Is a 1 um is a realistic for bow?

Answer to #4 & #5: YES

With the 2:2 mode analysis there is a 50nm gap after 15 kPa clamping pressure is used. However by reversing the sign this can be flattened to 10nm. The whole idea is combine the modes together.

Question #6: If you can take every mode and superposition the modes and add the curves to make the total deflection?

Answer #6: Some cases work some do not. Approximate error of 50% could result. It will be a case-by-case basis.

Legendre Modeling Summary:

Finite element models of the lower order Legendre modes have been utilized to determine the clamping response of the modes. The reticle-to-chuck clamping responses is a function of the reticle and chuck stiffness, the reticle and chuck shape, the clamping pressure, and the friction coefficient. Masks with corners or edges that bow up and away from the chuck require higher clamping pressures to flatten. In general, the gap at the center of the mask closes at relatively low clamping pressures. The goal of the superposition study is to determine how the clamping pressure required flattening a generic shape is related to the clamping pressure required to flatten each of the constituent Legendre shapes comprising the generic shape. Preliminary results are favorable; some cases better than others.

Question #7: Is there more success when mask is bowed down? This appears to be the case looking at the results.

Answer #7: Yes, this orientation gives us better prediction and assumes that we have a flat chuck to begin with.

Question #8: It appears that there is some difficult adding low order modes together with the super positioning. What is the probably of the higher order terms adding error?

Answer #8: the higher order modes are very computationally involved, for these cases our computers are still running. It is essentially double the # of calculations. Currently Wisconsin is in the middle of calculating mode row # 3.

Question #9: Even if you can clamp out lower order terms you can have higher order terms.

Answer #9: YES

Question #10: Does the series term, or higher energy terms may need higher KPa value to flatten out; but this seems to be the less likely to occur?

Answer #10: (Ken Blaedel) Yes; the amplitude does decay as you go to higher terms. Lower order terms have the higher amplitudes.

Question #11: Because you have decaying amplitudes with the higher terms, would you will have to reject the substrate?

Answer #11: Yes, you would reject the substrate and take a yield hit

Question #12: With the e-chuck approach there will be an electrical ground plane; would this effect e beam tool writer performance with having to deal with additional electro-magnetic grounding caused by the e-chuck?

Answer #12.1: You would need to look at the overall voltage potential; as you go to higher orders you could go to an anodic bond situation.

Answer #12.2: The 15kPa is the ASML's minimum clamping pressure that they will require in order to maintain the required force (no slip) at the higher 8 G reticle stage accelerations .

Question #13: The saddle and the 2:2 modes are very common shape in optical masks. Based on the modeling and 2nd bullet in summary, does this mean that values have to be identified in the standard?

Answer #13: All of the calculations is for chuck that is rigid and flat. As we introduce chuck non-flatness these results can be worse.

5) ***Dr. Steve Roux – ASML Proposal***

Steve reviewed the ASML position with the reasoning behind it. Attention was focused on the overlay errors due to clamping are caused by distortion of the reticle frontside as clamped. This distortion is the result of numerous factors including that the 35nm critical dimension node will have mixed machine overlay error of 15nm or less. 15nm total machine-to-machine overlay (OL) matching is required. This translates to 2.5nm at the wafer performance to hold on to the reticle +/- 10% – 15% in the lithography exposure tool alone allowing 2.5nm error in clamping at the wafer. There is also a 2nm clamping error resulting from the mask writer tool (this suggests a very large portion of the budget just to clamping)

The EUV reticles use in the exposure tool have both IPD of the pattern and OPD that are the two major error sources. Steve reviewed two options to deal with the IPD and OPD errors. Option 1 that specifies the reticle blank flatness that requires each tool to create an individual solution that meets the EUV overlay requirements. Or Option 2 that creates a standard that minimizes the overlay burden on each of the expose, write and inspect tools while allowing reasonable reticle flatness specs.

ASML proposes to pursue “Option 2” by using a ‘3- Rules’ approach that the industry can use as a SEMI / WORLDWIDE standard. These rules do not specify a specific clamping solution (e.g. does not specify an e-chuck) but specifies the clamping material properties, forces used, and finishing. These 3 rules are:
Rule 1. All clamps must have a bending stiffness of (TBD): Clamps used in mask writer inspect and exposure the clamping should be made of the same stiffness.
Rule 2. All clamps shall clamp with a pressure of TBD kPa Clamping pressure needs to be specification (15kPa ? only from accelerations)
Rule 3. All clamps meet a similar flatness requirement
Steve showed the previous overlay error analysis caused by clamping that reach 40nm over a large 150mm x 150mm plate area.

Steve reviewed the Pro’s and cons of the two options (Option 1 similar to current DUV) and Option 2 (ASML 3-rule) that were very similar to other presenters.

Option 1. Similar to DUV today (Pros) are that no standard needed and the industry is familiar with the way of working. (Cons) are those excessively tight specs required where writer must compensate for sag, blank flatness, clamping, and needed specification negotiations between tool suppliers.

Option 2. “3- Rule” SEMI Standard (Pros) are that a more robust overlay capability is present, blank flatness becomes less important, reduced clamp costs, reduction in development efforts. The (Cons) are that writer must change holding scheme (e- field shielding) for tools, a broad based cooperation is needed, and a diminished individual design freedom results.

Question #14: Why is there a concern for the use of a SEM that uses an e-chucking?

Answer #14.1: The electric field could cause, need to be more precise. Writer and distance metrology should be the types of tooling where e-chucks could introduce electro-magnetic field problems. High kvolt tool will not be an issue it would write at 49keV. Trying to be thorough.

Answer #14.2: We need to get comments from writer tool suppliers regarding e-chuck impact to writing EUV masks.

Question #15: What if the chucking is not be uniform across entire plate?

Answer #15: All of the fields should be defined across the entire backside of the plate.

Question #16 – More of a Comment: E-beam writers have very wide DOF = +/- 160 um (Hitachi) doesn’t this DOF performance negates this concern?

Answer #16: If you do not have the plate flat you will have to compensate for the distortions. The error budget is extremely small. Compensate with max error of 4%.

Comment # 17: The DOF does not matter today. Current optical litho has some sort of compensation. There are 1st wafer effects in optical exposures today that get compensated for.

Question #18: For the 130nm to 70 nm node how does one determine in plane distortion. There is no budget today?

Answer #18: Today it meets the error budget but they are shirking. The three rules should keep same pressure, flatness, etc. everything should remain consistent. The mask writer takes tricky compensation algorithms, with the use of these 3 rules the compensation algorithms are not required.

Comment #19: The compensation algorithms may not be all that hard, currently there is software in e-beam writers to automatically introduce OPC features today that are based on library compensation algorithms.

Comment #20: There could be another potential option where one could measure the flatness blank-by-blank and feed this information into writer.

Comment #21: You will need to know both frontside and backside clamping forces. If there is any change at all after you etch the 3 rules do not come into play. Amplitude changes when you etch the chrome. It will spring to shape that does not match the compensation.

Comment #22: The custom blank-by-blank variation / compensation may not be attractive.

Comment #23: Remember that we are still talking about the substrate alone; the ML will introduce even more distortion based on stresses.

Comment #24: The control of the ML stress needs to be at the 1% error level.

Steve concluded the ASML position with emphasizes and confirms the Un of Wisc work. If you don't specify all three things (three rules), then the mask writer can be held with a gap. The exposure tool may or may be able to entirely flatten the plate alone. The 15kPa level limit is based on needed forces to overcome accelerations as high as 8 G. The thickness of LTEM 17mm looking at 10nm chuck flatness requirements.

6) ***Frank Michael Kamm – Infineon / Leica Proposal***

Frank presented the joint Infineon and Leica Microsystems positions. Frank reviewed the critical issues for EUV mask chucking which includes placement budget allows only 2 nm placement error due to clamping, non-telecentricity and out-of-plane distortions (OPDs) affect in-plane-distortion (IPD) on wafer, translation of 0.7 nm IPD on wafer from a 50nm mask flatness roughness, OPD from ML stresses approach 1000nm, backside particles, and long-term stability of chucking forces and ML stresses.

The consequences of these critical issues are promoting the use of two different approaches; one being e-chucking and the other being a conventional 3-point mount used in some e-beam writer tools. The use of e-chucks can introduce additional substrate requirements that include, necessary backside coating, backside particle inspection, chucking forces has to be measured/controlled, electrical and surface properties of backside have to be controlled, shielding issues in e-beam tools, and particle attraction during use in metrology. The use of 3 point chucks also have issues such as bowing requires pattern correction or other use of compensation, placement results need transformation into flat state, particle generation control, and stress stability, absolute stress and stress homogeneity have to be controlled.

Infineon / Leica studies using a three point chuck pin approach can introduce an Out of plane distortion (OPD) of 1056 nm. With the use of mixed chucking approaches (3-point and e-chucks) a resulting maximum IPD of 42nm can be expected! With this mixture of 3-point chucks on writer and metrology tools and flat chucks in exposure tools can cause the effects of non-telecentricity not to be measured by metrology tools, the needed transformation of measurement result into flat state necessary and other potential error sources. With moving the inspection (LMS IPRO) tooling chucking to a flat e-chuck concept some benefits result with the e-beam writer continuing w/ 3-point strategy that does not need to have shielding issues of electrostatic field complications however the e-beam tool would need to specify layer stress and stress stability of every layer, apply pattern correction in e-beam writer or by FE model or adjust and control backside stress for bow compensation

In the casewhere e-beam writer is 3-point clamp a 40 MPa ML stress change on the full area plate can cause a 4.8 nm max IPD. This requires an absolute global stress value spec with ~8 MPa precision for 1 nm IPD control. Local variation of 40 MPa over a 40x40 mm^2 plate area causes 0.8 nm IPD. In the case where all chucking is standardized across all mask process tooling the benefits are there is no need for pattern correction and stress compensation not necessarily needed (within certain range). However this requires that integrate e-chuck into e-beam writer, control stability of chucking forces will be an issue, and potential source for backside particles are problematic.

There are significant amounts of remaining questions that need to be answered if an e-chuck is standardized.

Can e-chuck be replace by vacuum chucks ?
Particle attraction with e-chuck in air ?
Thermal control of metrology tools (LMS) ?
Stability of chucking forces overtime ?
Constraints on mask processing on backside surface (quality)
Backside coating to influence handling infrastructure ?

Infineon / Leica proposes a project dedicated to answering all of these technical issues. The project would integrate the results and inputs from FE modeling, standards activities, and contacts that feed into ISMT. The overall project goals would be to act as platform to combine various standardization activities, obtain input from tool suppliers as well as mask manufacturers, provide industry consensus on chucking issue, and accelerated development, driven by project frame. The scope of the project would be to compare and evaluate chucking concepts, design and build test chucks, verify chuck performance experimentally, and create standard for basic chuck properties.

Frank closed the Infineon / Leica proposal by outlining what the Mask makers boundary conditions are that would provide a suitable standards solution to this issue. Some of these conditions include
Layers backside need to be compatible with existing tools as much as possible
Processing compatible as much as possible as current processing
Different chucking concepts form different suppliers are <u>not</u> acceptable
Handling – chucking concepts and blank substrates have to be adjusted to handle concepts
Cost – chucking concepts should not reduce blank yield; (additional layers, additional constraints..)

Comment #25: I am worried about the compatible of this approach in one direction. If one goes and buys an early EUV specific process tool it will sit there for a while before other tools get developed. Would we require the current mask makers and tools to have “dual” chucks or require optical masks have metal layers

Comment #26: An intermediate layer used as a carrier or isolator that is removed can be implemented. This is being done today to my knowledge.

7) *Dr. Tom Newman - ETEC proposal*

Tom outlined the newest Etec mask stage for their advanced mask writer lines called the EXara stage. This stage is designed for a 50 keV e-beam writer tool, the stage is air bearing that provides low vibration and has no mechanical feed through. The stage construction is a Monolithic Zerodur, palate material, which was designed not to constrain the mask but allow it to flex within the center. Flexure mounts for contracting and expanding of the plate is within the design.

Question #27: not standardized. Buffer layers may not be conductive.

Answer #27: The blade used on the stage has a low angle of incidence.

Instead of pushing on the top of the mask the forces are opposing do not put in vertical forces.

Comment #28: The metal of sides of clamping for more uniform electro – magnetic forces. Make some isolations somewhere on the chuck.

The Exara stage supports the EUV Mask format and has the required mechanical system stability. The stage system also has correction capability. There is tool grid matching for another reference grid. Can use to change the grid mismatch. Bulk heating compensations can be used to correct for predictive mask distortion

Question #29: The thermal properties of EUV masks have a 30 ppb CTE. Would this cause a problem with this technique?

Answer #29: The approach / use of the Exara may still an option to consider.

Question #30: Can Etec comment on the mask flatness as held with the Exara system. Referenced on this mask holding approach?

Answer #30: The system has height mapping is done, can compensate for sag. Not introducing distortion can model as sag.

Question #31: What is the methodology of height mapping? How do you go about doing this

Answer #31: Glancing angle incidence is used not intereferometry, optical materials of the lenses and scan length scan time to compensate.

Question #32: If the mask is fidicualized for "Z" for bow, e.g. you could read these marks ?.

Answer #32: Yes, this is conceivable this can be used. Placement requirements on the mask ?
Comment: placement of the masks in the exposure tool in the mask, how do you view the mask
Grid matching can compensate if there are repeatable

Comment #33: The front to back thickness variations account for entire error budget. We do not think that we can use a three point mount. If it is a 3-point mount you will have to compensate front and backside.

Comment #34: Resolution within nanometers will not be accurate enough with the "grid matching"

8) *Dr. Kazuya Ota - Nikon Approach:*

Dr. Ota-san reviewed Nikon position. If Nikon is asked if it is needed to unify the mask chucks Nikon's answer is YES. Electro-static chucks will chuck the EUV masks within a flatness quality area. Some antigravity-clamps and anti-scanning acceleration-fixtures will be needed. It is desirable that the thermal expansion of e-chuck is equal to that of mask for the purpose of not slipping by thermal expansion.

OPD is proportional to the mask FLATNESS x FLATNESS (chuck of Exp.). There is no effect of chuck unification and the current flatness requirement for mask substrate is enough.
IPD is proportional to the mask FLATNESS x FLATNESS (chuck of Writer), FLATNESS(mask) * FLATNESS(chuck of Exp.)}. The flatness requirement~50nm may be insufficient for IPD. The unification of chucking method between writing and exposure tools will relax the flatness requirement, and 50nm is probably enough. The flatness of the unified chucks should be considerably better than 50nm.

Nikon views this approach as "Not a Nikon request" but an EUVL need / request

Question #35: Un. Wisc. did we considered CTE variation?

Answer #35: Mask and chuck move together (do not want to define CTE)

Comment #36: This is probably undesirable to do but could consider it

Question #37: Is the profile of the e-chuck that Nikon will use less than mask as shown in the picture?

Answer #37: May not be, the pictorial is only an idea and if there is any mask edge overhang it will be well analyzed.

Comment #38: The Univ. Wisc. modeling shows that edges are very important to clamp.

Comment #39: The continuous clamping at higher pressures will cause degradation on particles distortions. Etc.

Comment #40: 15kPa is not a lot of force. Work around 3 to 5 kPa that this is ok for mask fabrication but not for acceleration in the exposure tool. Can work with lower clamping forces

9) *Dr. Yasuaki Fukuda – Canon Approach*

Dr. Fukuda-san reviewed Canon's proposal. Mask flatness issue 50 nm to 2 um peripheral in non-quality area for DUV mask applications. The deformation due to chucking causes distortion and IPD
The issue of mask flatness is distortion 26nm Image Field deviation 0.09 um is not good for 130nm node production requirements.

EUV mask has 50nm flatness P-V requirements. The EUV mask has additional problems of thermal management that will be need strong retentvitiy against gravitation and scanning. In addition to this there can be No particles on backside. The backside of chuck must be done similar in write, metrology and exposure

10) End of meeting Brainstorming / Direction Setting & Timing:

Comments / Inputs

Question #41: When particles are pulled very hard, will mask rub and generate particles when you pull?
Answer #41.1: The particles will tend to disappear. The relative motion is elastic motion.
Answer #41.2: Not enough to generate particles displacement on order of um.

Question #42: There is no clear understanding how to measure 1-3 nm. If you cannot measure down to this level how can compensation algorithms be used?
Answer #42.1: Metrology has to be measured 40nm to predict ~1nm. Whole bunch of error contributions not just metrology error.
Answer #42.2: The composite errors are from write, inspect, etc.

Comment #43: Last meeting showed UoWis clamping levels at 1kPa forces
Answer #43: If you are off by ~2kPa you still meet error budget except for the higher order Legendre terms.

Comment #44: It will be very useful to do error budgets of each approach proposed.

Comment #45: Can we look at material layers that can accept or have particles embed without effect? This way trapped particles may not introduce IPD and OPD errors

Comment #46: [partial response to Comment #45] The Layer #3 may be too thick to control (i.e., stress, uniformity) if you want to have a layer that can mechanically absorb (embed) trapped particles.

Comment #47: Typical stresses of the ML are –450MPa (compr.) after M.L. like to use e-chuck approach. E-chucks are being used in current M.L. tool and a required conductive layer on the mask substrate is needed.

Comment #48: Is there a way that we can verify that substrate is flat before putting on M.L. or metal layer.

Comment #49.1: Has anyone looked into dynamic clamping approach? The OPD shows Bi modal response could use dynamic approach to relax clamping forces.

Comment #49.2: The dynamic clamping may be very difficult; e-chucks are difficult to control flatness at nm level.

Comment #49.3: What is the response feedback needed to compensate this effect?

Comment #49.4: Astronomical multimirrors use dynamic compensation technology. It is successfully used in other industries / applications.

Comment #49.5: The introducing of a 2nd "reference mask" could introduce errors.

“Direction to Move Forward”

1) Good next step – e-beam writer suppliers need to assess e-chuck use in writers.
    - commercial issues in mask shop; solution space that chuck be used for EUV and optical masks

2) 3 rule approach (ASML) does not specify e-chuck but good idea; but need to assess CTE.

3) Particle attraction using e-chucks is a concern; need to discuss specs.

Move forward in document that does not limit chucking approach but have addendums and consider activities of the following:

- Univ of Wisconsin work to prove that chucking approach can be done.

- Follow-on modeling and error budget studies

- Proposal by Frank Micheal Kamm should be considered (e-chuck testing) but not gate the chuck standardization effort

- Concern over timing and schedule needed to fit longer projects and meet standard timeline.

- Method of fiducializing blank or glass that can be used to measure IPD after M.L. are deposited.

- Timeline: Meeting at SEMICON S/W or BACUS