AGENDA
EUV Mask Chucking Standards

12:30PM-1:00PM	**Lunch**
1:00-1:10PM	**Welcome; Activity Summary: Pawitter Mangat/Phil Seidel**
1:10-1:20PM	**TIM meeting Update Semicon West; Dr. Ken Blaedel**
1:20-1:40PM	**Semi Standard requirements/guidelines: Dr. Scott Hector**
1:40-2:10PM	**UW-Madison results: Prof. R. Engelstad/Dr. Carl Martin**
2:10-2:30PM	**ASML Proposal: Dr. Steve Roux**
2:30-2:50PM	**Infineon Proposal: Dr. Frank-Michael Kamm**
2:50-3:00PM	**Break**
3:00-3:10PM	**ETEC Approach: Dr. Tom Newman**
3:10-3:20PM	**Nikon Approach: Dr. Kazuya Ota**
3:20-3:30PM	**Canon Approach: Dr. Yasuaki Fukuda**
3:30-4:00PM	**Discussion and Future Activity**

Next Meeting continues (4:00-5:00PM)

Semi-Standards on Mask Substrates/Multilayers and other initiative:Scott Hector.

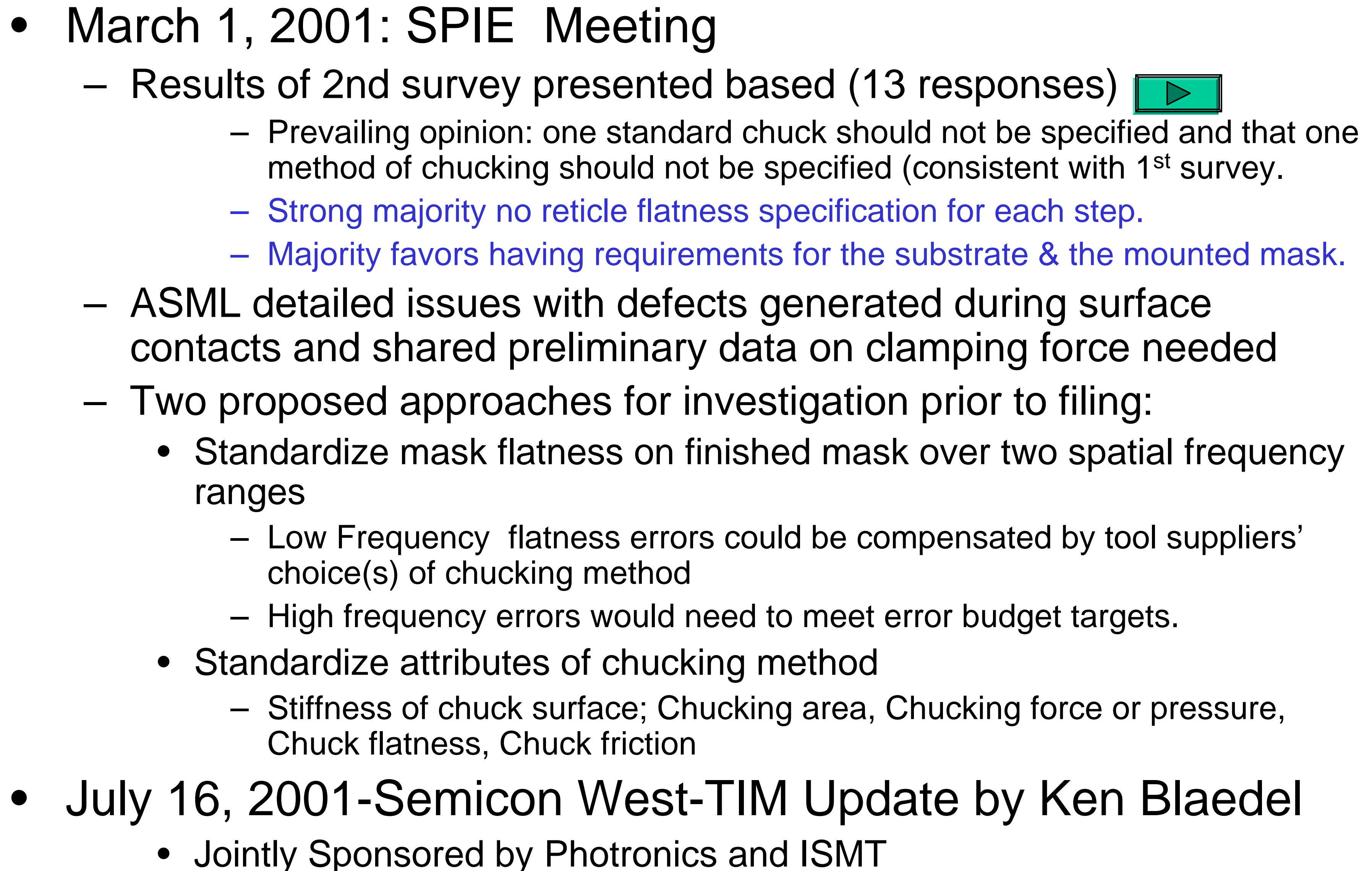
Chucking Standards Activities Summary

Pawitter Mangat-Motorola

2000 Activity Update

- March 2, 2000 SPIE SEMI standards meeting
  - Need for chucking standard identified
    - Pawitter Mangat and Roxann Engelstad agreed to lead the development
- July 10, 2000 Semicon West
  - Results from first preliminary survey (7 Participants)
    - Mounting method should not be specified: Vendor Choice
    - Flatness after mounting and its impact on overlay: Critical
    - Specification should be limited to reserving areas on the reticles for reticle handling and/or particulate protection.
  - Literature survey on existing related standards
  - Mounting in-plane/out-plane distortions(UW-Madison)
    - IPD and OPD were compared for two cases of e-beam mounting: three point and completely flat (e. g. with an e-chuck).
    - The mask chucking in the exposure tool was completely flat.
      - The IPD for the three point mount case was 56.1 nm versus 2.3 nm for the completely flat chucking case
- October, 2000 ISMT EUV Workshop
  - **Need for chucking standard rated as next most important to P37 standard**

EUVL


2001 Activity Update
• March 1, 2001: SPIE Meeting
– Results of 2nd survey presented based (13 responses)
– Prevailing opinion: one standard chuck should not be specified and that one method of chucking should not be specified (consistent with 1st survey.
– Strong majority no reticle flatness specification for each step.
– Majority favors having requirements for the substrate & the mounted mask.
– ASML detailed issues with defects generated during surface contacts and shared preliminary data on clamping force needed
– Two proposed approaches for investigation prior to filing:
• Standardize mask flatness on finished mask over two spatial frequency ranges
– Low Frequency flatness errors could be compensated by tool suppliers' choice(s) of chucking method
– High frequency errors would need to meet error budget targets.
• Standardize attributes of chucking method
– Stiffness of chuck surface; Chucking area, Chucking force or pressure, Chuck flatness, Chuck friction
• July 16, 2001-Semicon West-TIM Update by Ken Blaedel
• Jointly Sponsored by Photronics and ISMT
EUVL

How should be proceed??

- We need to define/identify critical inputs for chucking standard
  - Modeling data for specifications
  - Experimental Verification methods, if needed
  - OEM's position
  - – Agenda for this afternoon encompasses all these elements.

- Targeted timeline:
  - – First draft of the standard for review at BACUS-2002
  - – Updated draft for wider circulation : Dec 2002
    - Amendments can always be incorporated over time
  - – Review of draft response : SPIE 2003

EUVL

BACK UP(History)

Steps for Mounting/Pellicle Standard (Action List)-March 2000

- Phase 1: Survey and compiling the data and specify terminology for the specifications
  - Following activities are part of phase 1.
    - Flatness data on chucking (Avi Ray-Chaudhuri, LLC)
    - Compare ASML(Eric) and CMC flatness data (Roxann)
    - SVGL chucking and flatness details (Noreen, SVGL)
    - SVGL pellicle set up details (Noreen, SVGL)
    - Pellicle Approach (LLC)
    - Flatness measurement methods (J. Valley)
    - Search on existing related SEMI standards (Pawitter)
  - Review of Phase 1: Semicon West

Activities

- Survey sent out and response received from the interested few.
  - Type of Fixture, Mounting Method, pellicle option
  - 7 responses received
  - Key Feedback
    - Mounting method should not be specified: Vendor Choice
    - Flatness after mounting and its impact on overlay: Critical
    - Specification should be limited to reserving areas on the reticles for reticle handling and/or particulate protection.
    - Top referencing format
- Issue:
  - Common Standard for mounting on different tools
    - E-beam patterning, Metrology(incl. Reflectometry), Exposure

EUVL

Modeling Activities

- SVGL/UW-Madison
  - Dialogue in progress
    - Chucking and flatness details
    - SVGL pellicle set up details
- ASML/UW-Madison Interaction
  - Dialogue in progress
- Nikon, Canon, and USAL(Ultratech)
  - Need to initiate dialogue
- Modeling activities at UW-Madison(in progress)
  - Mounting in-plane/out-plane distortions
    - Vertical/Horizontal
    - Electrostatic/Mechanical

EUVL

Literature Survey Results

- Four related SEMI standards
  - SEMI E 100-0200
    - Specification for a reticle SMIF pod used to transport and store 6 in or 230mm Reticles
  - SEMI P33-0998
    - Provisional Specifications for Developmental 230mm Square Hard Surface Photomask Substrate
  - SEMI P5-94
    - Specification for pellicles
  - SEMI F51-0200
    - Guideline for Elastometric Sealing Technology

Summary of July 10, 2000 SEMI standards meeting on EUVL masks

- The meeting was held during the SEMICON West convention in San Francisco, CA.
- The draft SEMI standard (3148) for mask form factor was reviewed.
  - Further formal response to the blue ballot was requested.
  - Concerns with the draft standard were discussed and solutions proposed.
- A proposed standard for mask chucking was discussed.
  - A survey indicated that standardizing the chucking apparatus is not favored.
    - Interactions with suppliers and other SEMI standards that might be used as a basis were reviewed.
  - A survey will be conducted to determined whether to standardize the mask flatness as mounted or the properties of the mounting technique such as clamping force, etc.
- 26 attendees from 21 companies or organizations signed in.
  - Substrate suppliers represented included Corning, Hoya, Rodel and Schott ML.
  - Mask users attending included Intel and Motorola.
  - Exposure tool suppliers represented included ASML, Canon, Nikon, and SVGL.
  - Mask suppliers represented included Photronics/MCOC.
  - Mask equipment suppliers included ADE Phase Shift, Applied Materials, ETEC, and Invax.
  - EUV LLC, Lawrence Livermore National Lab, Sandia National Labs, and University of Wisconsin were represented.

Summary of FEA simulations of mask mounting effects

- In-plane (IPD) and out-of-plane (OPD) distortion were simulated for a typical EUVL mask processing sequence.
  - Example film stress and thickness values were used.
  - IPD and OPD were compared for two cases of e-beam mounting: three point and completely flat (e. g. with an e-chuck).
  - The mask chucking in the exposure tool was completely flat.
- The IPD for the three point mount case was 56.1 nm versus 2.3 nm for the completely flat chucking case.
- Formulas for translating spherical OPD at the writing step into IPD errors were presented.

Action items (cont.)

- Survey EUVL mask standards stakeholders to determine approach for standardizing chucking. (Engelstad and Mangat) Two proposed approaches:
  1 Standardize mask flatness on finished mask over two spatial frequency ranges
    - Low frequency flatness errors could be compensated by tool suppliers' choice(s) of chucking method
    - High frequency errors would need to meet error budget targets.
  2 Standardize attributes of chucking method
    - Stiffness of chuck surface
    - Chucking area
    - Chucking force or pressure
    - Chuck flatness
    - Chuck friction

  All quantities must be measurable.

  Interaction of removable pellicle with mounting must be considered.

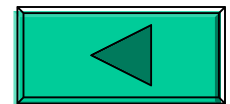
Action items from March 1, 2001 meeting

- Analyze the number of process steps and tools that are affected by various mask requirements that might be standardized. (Hector and Bednarek) (10/16/00)
- Recommend requirement for spatial frequency of flatness requirements (Taylor)
- Share experience with use of datum locations on mask substrates (All)
- Draft ID mark location and chucking standard (Mangat)
- Draft multilayer coating and absorber layer standard (Hector)
- Solicit wish list on removable pellicle and storage container attributes (Hector)
- Determine if Steve Nash can lead a storage container standardization effort (Lercel)

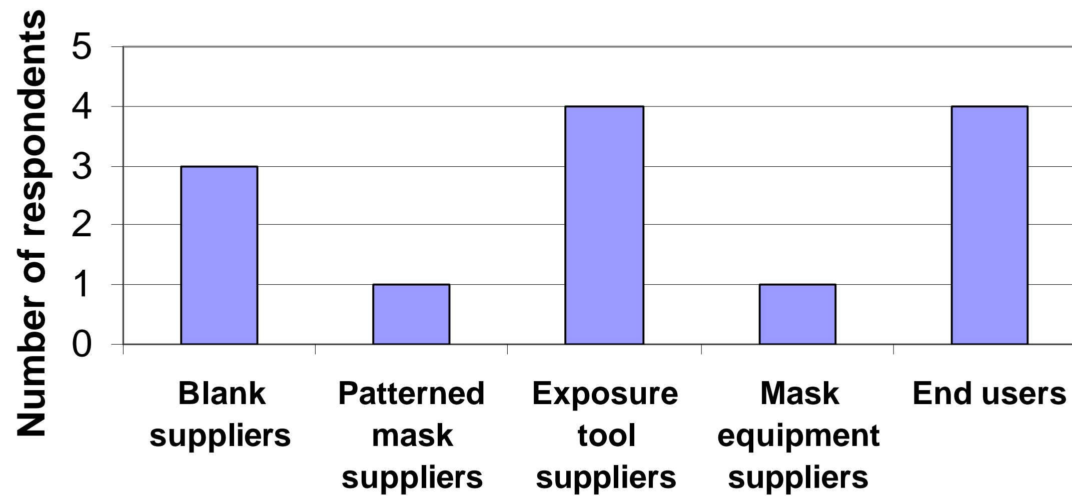
EUVL

Survey on mask chucking standard Pre-meeting SPIE-2001

- There should be one standard chuck for all EUV reticle manufacturing, metrology and exposure tools
- There should be a Reticle flatness specification for every major reticle fabrication process step (ML deposition, absorber deposition, E-beam patterning, IP metrology, Pattern transfer)
- The Reticle flatness specification for reticle manufacturing tools should be equivalent to exposure tool reticle flatness specification
- The only reticle flatness specifications should be the substrate flatness and the patterned reticle flatness as mounted in the exposure tool
- The method of chucking should be excluded from Reticle chucking standard
- My company’s main business

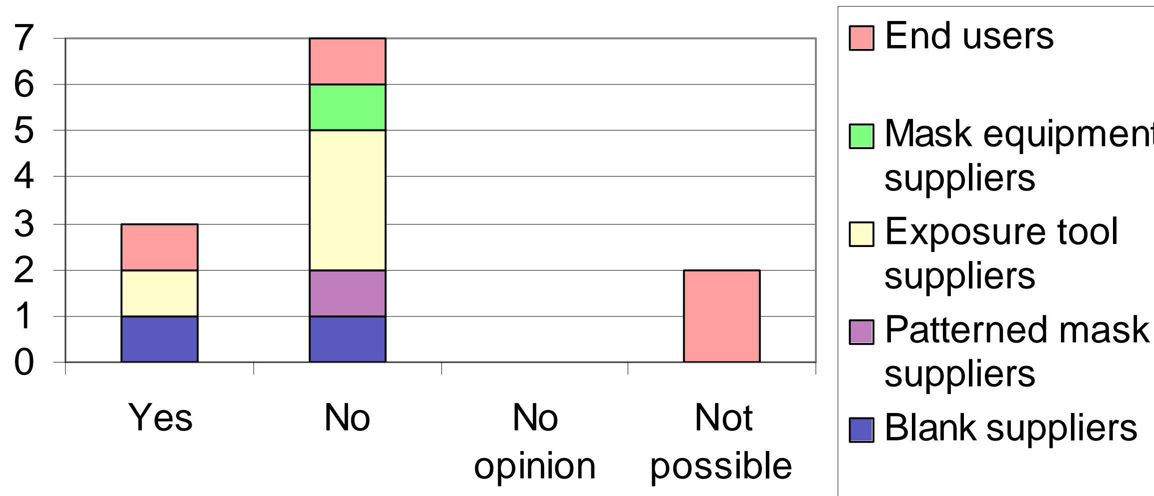


Survey respondents



13 companies/organizations responded to the survey

1) There should be one standard chuck for all EUV reticle manufacturing, metrology and exposure tools

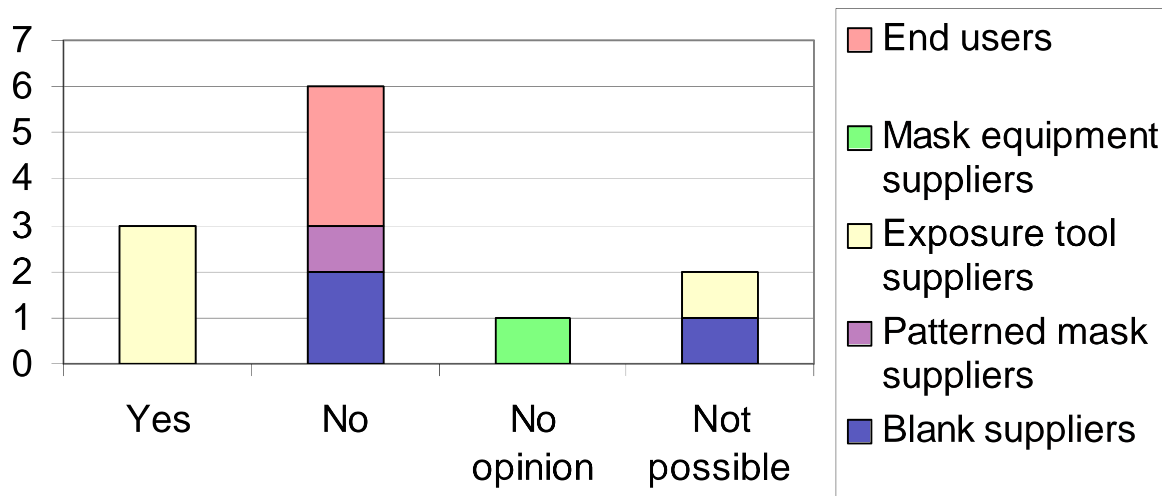


Comments from respondents (paraphrased unless quoted):

- Flatness error of chucks is individual, so one common chuck would not be meaningful
- e-beam tool chucks designed to compensate for placement errors can and should continue to be used
- Matching the chucks for placement metrology and for exposure would have the greatest impact, but the mask will be facing different directions in each step, so one common chuck probably cannot be specified

EUVL

2) There should be a Reticle flatness specification for every major reticle fabrication process step (ML deposition, absorber deposition, E-beam patterning, IP metrology, Pattern transfer)



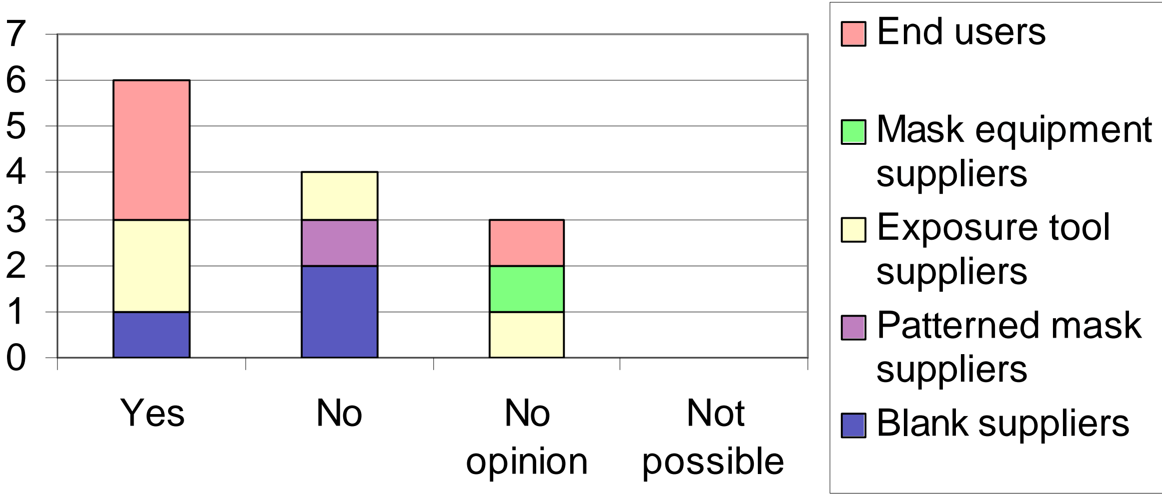
Comments from respondents (paraphrased unless quoted):

- There should be a specification, but it is too early to define it.
- There should be specifications only for substrates, blanks and patterned masks
- Too difficult to specify
- One more comment quoted on next page.

Further comment on question 2

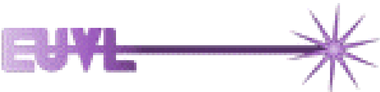
- “... in order to ensure reticles that passed the image placement accuracy specification during inspection still meet the specification during exposure, the flatness of the reticle within the inspection tool should be nearly identical to that within the exposure tool. In order to maximize the opportunity for passing the image placement accuracy specification during inspection, the patterning tool may be required to hold the reticle to nearly identical flatness during patterning as inspection (and thus exposure). That said, it is conceivable that a reticle manufacturer may create a process which deterministically removes the effects of mechanical distortion, so that a reticle that is distorted during patterning passes the image accuracy specification when flattened during inspection. In this case, the flatness specification for the patterning process may not be desirable.

The Reticle flatness specification for reticle manufacturing tools should be equivalent to exposure tool reticle flatness specification

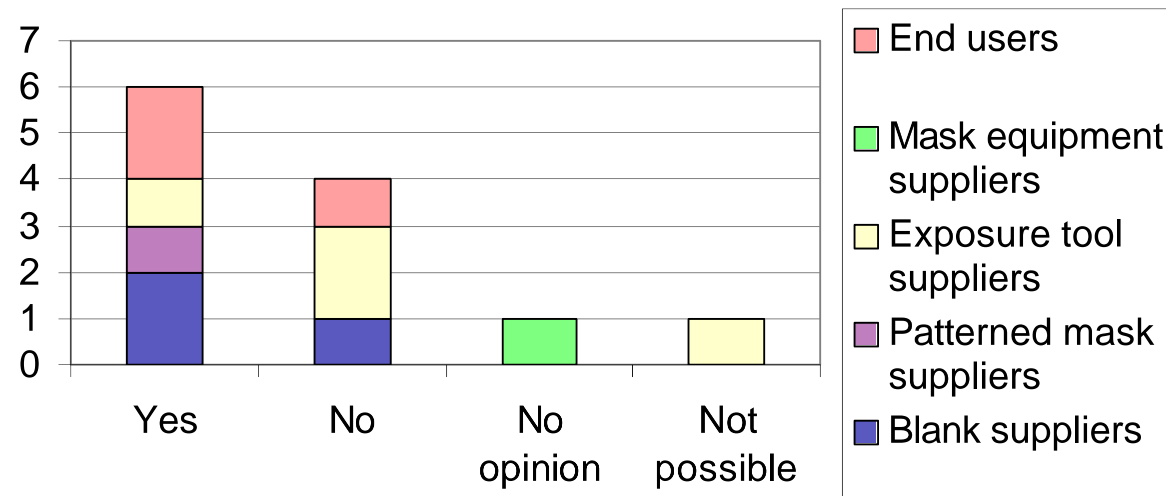


Comments from respondents (paraphrased unless quoted):

- Some confusion over the meaning of this question



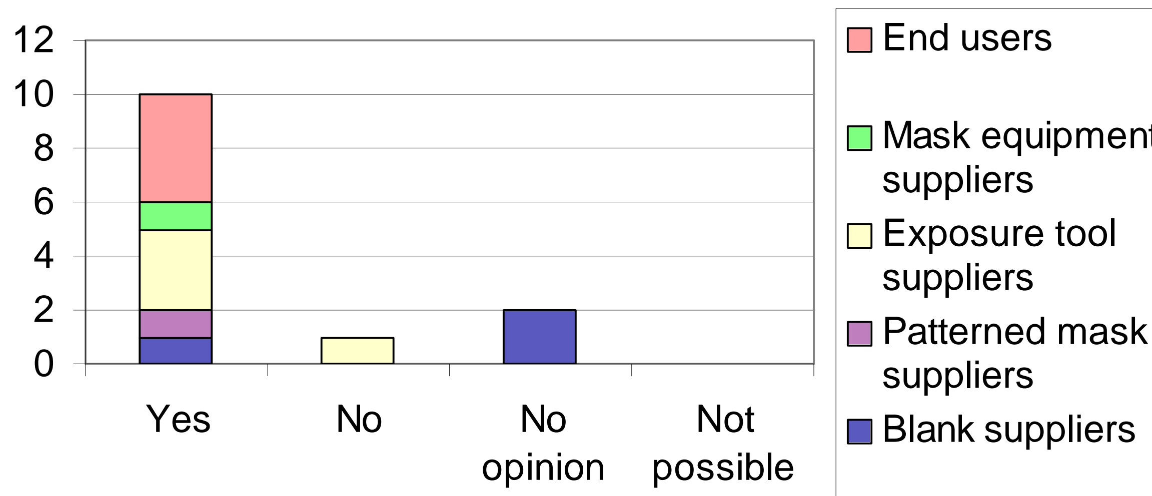
The only reticle flatness specifications should be the substrate flatness and the patterned reticle flatness as mounted in the exposure tool



Comments from respondents (paraphrased unless quoted):

- The flatness during placement metrology is also critical.

The method of chucking should be excluded from Reticle chucking standard



Comments from respondents (paraphrased unless quoted):

- Not meaningful to specify the method of chucking
- Intellectual property problems might arise if it is specified
- "We expect to use the full design space in order to provide near-perfect front-surface flatness. Additional constraints on the method of chucking will only reduce our ability to satisfy overlay requirements."

EUVL

Summary-Survey SPIE-2001

- Prevailing opinion is that one standard chuck should not be specified and that one method of chucking should not be specified
  - This is consistent with previous surveys.
- A strong majority prefer that there not be a specification of reticle flatness for each step.
- A majority favors having requirements for the substrate and the mounted mask.

EUVL

Summary of July 16, 2001 SEMI standards meeting on EUVL masks

- 30 attendees from 22 companies or organizations signed in.
  - Blank suppliers represented included Asahi, Hoya, Rodel, Schott Lithotec, Schott Glass and Xenocs.
  - Mask users attending included IBM, Infineon, Intel, Motorola and Philips.
  - Mask equipment suppliers included ETEC and Blazers.
  - Exposure tool suppliers represented included ASML, Canon and Nikon.
  - Mask suppliers represented included Photronics/MCOC.
  - EUV LLC, Lawrence Livermore National Lab, NIST and University of Wisconsin were represented.
- The status of draft SEMI standard (3148) for mask substrates was reviewed.
  - The standard needs to be approved by the SEMI North American Regional Standards Committee.
- A standard for chucking was drafted but not distributed awaiting discussion on July 16 and 19. A proposed chucking standard was provided by ASML.
- A standard for mask blank absorbers and multilayers was drafted (3414), distributed for initial comments, and discussed further at the meeting.
- A survey on elements of reticle handling needing standardization is needed.
- The next meeting is planned for October 29, 2001 in Matsue, Japan.

Proposed mask chucking standard approaches

- Draft standard to include alignment mark locations
  - Use reticle layout proposed by SVGL in October 2000 as a starting point
- Prepare a standard that defines the flatness errors permissible on one or more of the following:
  - Blanks
  - Patterned masks
  - During the image placement metrology step
  - As mounted in the exposure tool (100-nm P-V flatness proposed by SVGL in October 2000)

and/or

- Standardize the attributes of the mounting method
  - Clamping force
  - Chuck flatness
  - Hardness
  - Stiffness
  - CTE of mounting reference surface

Mask chucking standard proposal

- ASML proposed standardizing a mask chucking approach to include requirements on the e-beam writer, placement metrology and exposure tool chucking methods.
  - A chuck that has a flat reference surface with <1 μrad local tilt over any 10 by 10 mm area was proposed
  - The chuck stiffness must be much larger than the mask stiffness so that the mask conforms to the chuck
  - A clamping force of 15±0.15 kPa was proposed
    - This force is sufficient to hold a mask at <8g acceleration with a 25% safety margin
    - The mask would suitably conform to the flat chuck surface
    - Initial experiments at ASML indicate that an electrostatic chuck with this force can be built, but the details were not shared
  - The target overlay error budget for in-plane and out-of plane errors due to mounting is 2.5 nm 3σ for the exposure tool and 2 nm 3σ for the writer and metrology tools.
  - Neither chuck material nor surface (flat or pin) would be specified, nor would its CTE.
  - In-plane distortion due to backside flatness errors would not affect overlay with this approach.
- The SEMI standards task force did not object to using this proposal as the basis of the draft standard.

Chucking discussion at TIM on July 19, 2001

- The ASML chucking proposal was repeated.
- Modeling data from University of Wisconsin was presented.
  - The data presented on July 16 was repeated, but some new information on IPD resulting from backside flatness errors on the mask substrate chucked against a flat reference surface was also presented.
- A counter-proposal to standardize the performance of the mount in terms of maximum allowable placement error induced and flatness error was supported by most participants (proposed by ETEC).
  - Standards should define interface specifications between tools or users, not chuck design or attributes
  - Deterministic errors from mounting in the metrology and writing tools can be removed by calculations and height mapping in these tools.
    - The amount of IPD error from patterning stressed absorber and buffer layer films would need to be calculated and predicted.
    - Uncertainty in the calculations was raised as a potential issue.
  - Standardizing the chuck attributes might stifle creative approaches to dealing with the mounting errors.
    - No chucking method has been experimentally demonstrated that meets all requirements.
- An analysis of the errors that would result from the proposed ASML approach should be compared to the proposed approach of removing errors by calculation.

Summary of chucking modeling

- University of Wisconsin shared finite element modeling results of EUVL mask patterning and chucking and concluded (chuck stiffness 30 times more than mask and made of LTEM with 150 W/mK chuck-to-mask heat conductivity):
  - Using flat chucking on both the exposure tool and e-beam tool will result in 2.3 nm in-plane distortion error for a perfectly flat mask substrate with pattern on only one half of the mask. Using a three point mount for both tools would result in 8-10 nm of in-plane distortion.
  - At >10 kPa clamping pressure, the in-plane distortion due to clamping and after heating when clamped (3.75W of heat) was about the same for chuck static friction coefficient values between 1e-4 and 0.3. >1 kPa was sufficient to flatten the mask.
  - Cooling the chuck near the top of the chuck body results in the least thermal deformation and the lowest temperature rise. Cooling at the top, for a 80 wph production tool thermal load of 3.75W, the OPD would be 2.5 nm, and the IPD would be 1.1 nm due to thermal deformation.
  - Using between 1 and 2 kPa of backside He gas, >150 W/m-K thermal conductivity between the chuck and the mask can be achieved at up to a 500 μm pin height.
  - Thermal gradients surrounding pins on a chuck surface will not likely cause significant IPD, but OPD of a clamped mask between pins needs to be analyzed.
  - For backside flatness errors with cosine shape, 25 nm flatness error with spatial period of about 3 waves over the edge length causes a worst case IPD error of 9 nm.

University of Wisconsin modeling plans

- Parametric studies, rather than specific designs are being examined (layer stress values, chuck stiffness, flatness of the chuck and mask, friction, etc.)
  - Parametric studies have been conducted for friction so far.
  - Mathematical basis sets will be used to describe flatness error as an input to the simulation.
  - Specific designs can be examined on request, however.