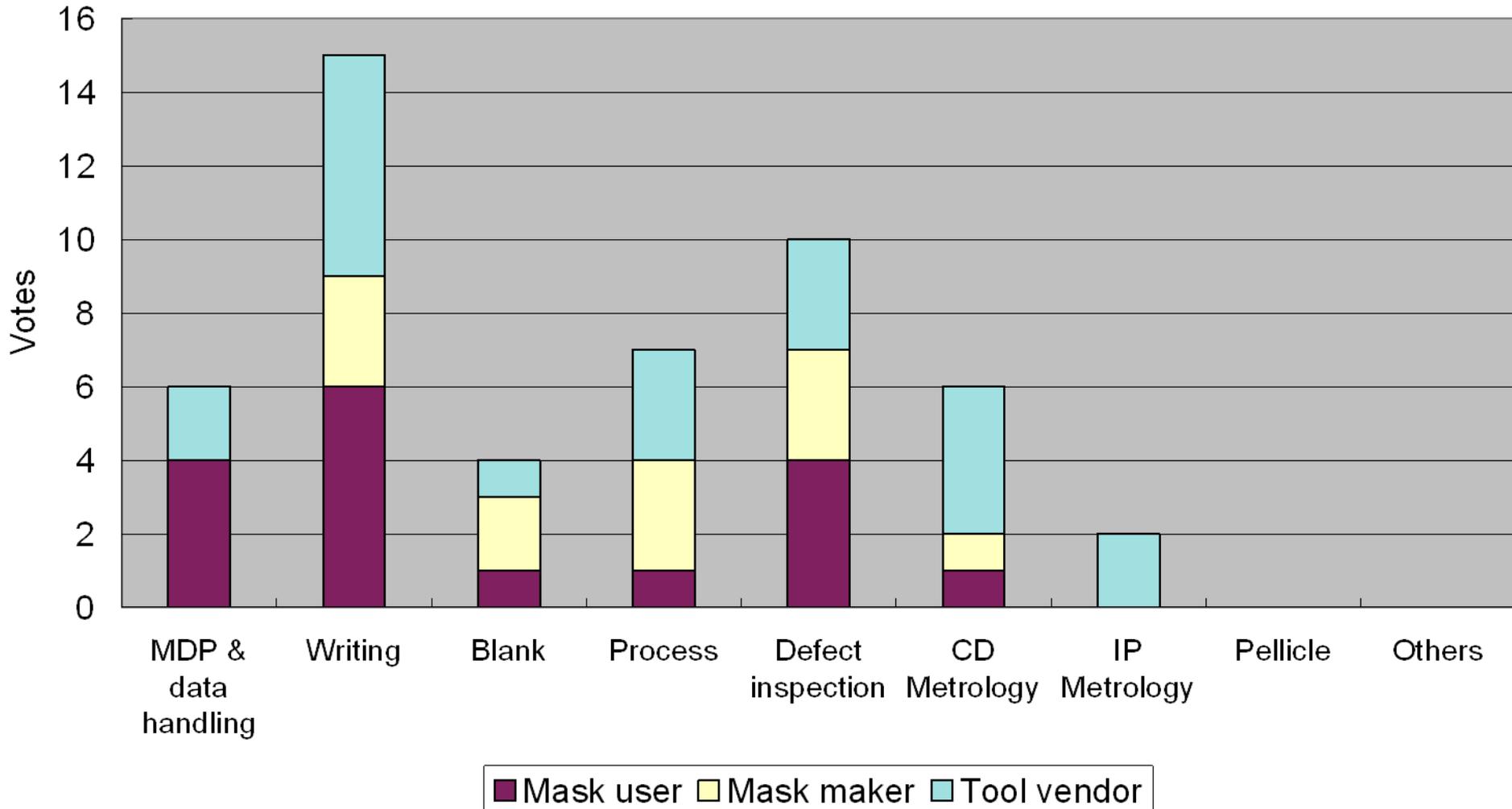


PMJ 2013 Panel Discussion

Future mask patterning technologies in the next decade: searching for the best mix solution

Question: What will be the toughest hurdle in mask making?



- “No one has been successful in predicting what the litho is going to be like in 10 years”
~*ASML W.Siegle* (cited by DNP Hayashi-san in his key note speech)
- Talk about the next year and the devil will laugh
~ *Japanese saying*
- But we know one organization is doing this job for us to predict future for years: ITRS

ITRS 2012

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
DRAM 1/2 pitch	28	25	23	20	18	16	14	13	11	10	8.9
MPU 1/2 pitch	27	24	21	19	17	15	13	12	11	9.5	8.4
Mask minimum feature size [nm]											
Optical (SRAF)	56	50	44	40	40	40	40	40	40	40	40
EUV	78	70	62	55	49	44	39	35	31	28	25
NIL	28	25	22	20	18	16	14	12	11	10	9
ML2											.8
CDU											
Optic											.6
EUV											.0
NIL											.8
ML2	2.1	1.9	1.7	1.6	1.5	1.3	1.2	1.1	1	0.9	0.8
Data Volume[GB]											
Optical	2220	2580	2970	2970	2970	2970	2970	2970	2970	2970	2970
EUV	1300	1700	2100	2600	3300	4200	5200	6600	8300	10000	13000
NIL	940	1200	1500	1900	2400	3000	3800	4700	5900	7400	9300
ML2	820	1000	1300	1700	2000	2600	3300	4200	5200	6600	8300
ML2 specific numbers [nm]											
Grid size	0.25	0.25	0.25	0.25	0.25	0.25	0.125	0.125	0.125	0.125	0.125
Beam blur	25	22	20	18	16	14	13	11	10	9	8

Can all the requirements be met by one writing architecture?

Panelists

Mask Writer Users

EDA vendors

Samsung Electronics	Photronics	D2S
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Mr. Inkyun Shin

Dr. Chris Progler

Mr. Aki Fujimura

Dr. Tor Sandstrom

Dr. Hans Loeschner

Dr. Hiroshi Matsumoto

Mask Writer Makers	Micronic Mydata	IMS Nanofabrication	NuFlare
# of Beams	1M	256K	1
Address Grid	1.25nm	0.1nm	0.1nm
Gray Scale	64	241	64K

8 questions for future patterning technology

Q1) (question about professional background)

Q2) What will be the required addressing grid in 2023?

Q3) What is the acceptable TAT for mask writing per one critical mask layer in 2023?

Q4) What is the acceptable TAT for MDP per one critical mask layer in 2023?

Q5) Which writing technology will be mostly used in mask writing of critical layers in 2023?

Q6) Which lithography application will be supported by which mask writing technology the most?

Q7) What is your preference for pattern data format?

Q8) What is your opinion about pipelining MDP and writing?

Future mask patterning technologies in the next decade: searching for the best mix solution

PMJ2013 Panel Discussion Survey Result

PMJ2013 Panel Discussion Survey Result

- Distributed to PMJ & BACUS program committee member
- Anonymous survey
- Total 32 people participated
- 8 questions + other comments

Q1) Question about professional background

PAGE: ABOUT YOUR PROFESSION

1. What part of the photomask/semiconductor ecosystem is your primary focus?
Please choose one.

 Create Chart  Download

		Response Percent	Response Count
Equipment		40.6%	13
Materials		15.6%	5
Process		9.4%	3
Chip Design		3.1%	1
EDA/IP		6.3%	2
Manufacturing		9.4%	3
Services		0.0%	0
Research		9.4%	3
Other		6.3%	2
		answered question	32
		skipped question	0

Q2) What will be the required addressing grid in 2023

PAGE: ADDRESSING GRID

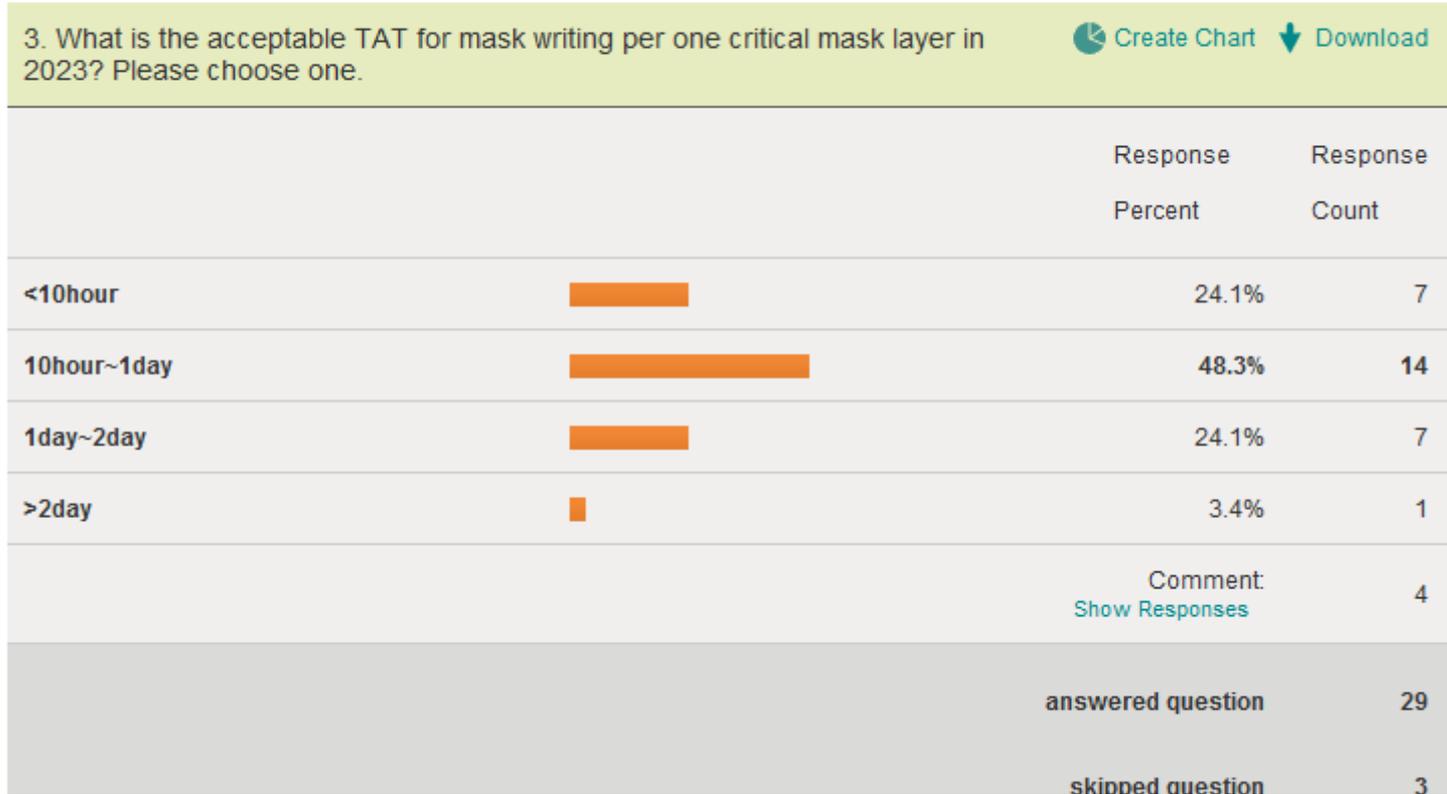
2. What will be the required addressing grid in 2023? Please choose one.

 Create Chart  Download

	Response Percent	Response Count
<0.01nm	12.9%	4
0.01~0.05nm	51.6%	16
0.05~0.1nm	19.4%	6
>0.1nm	16.1%	5
	Comment: Show Responses	2
	answered question	31
	skipped question	1

Comment: We should all agree on the digitized/gridded design based on the achievable LSB expression defined by process and tool capability

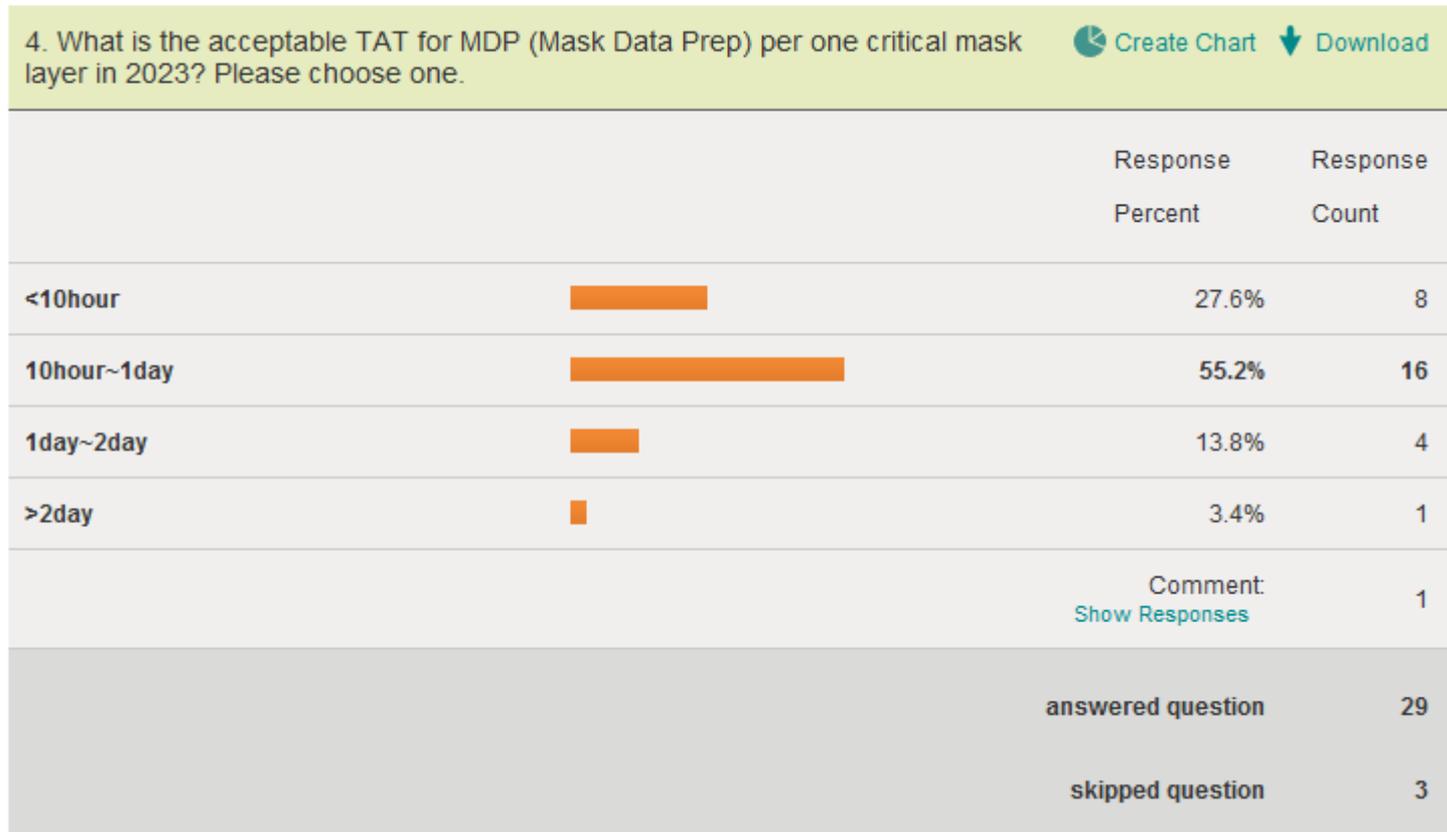
Q3) What is the acceptable TAT for mask writing per one critical mask layer in 2023?



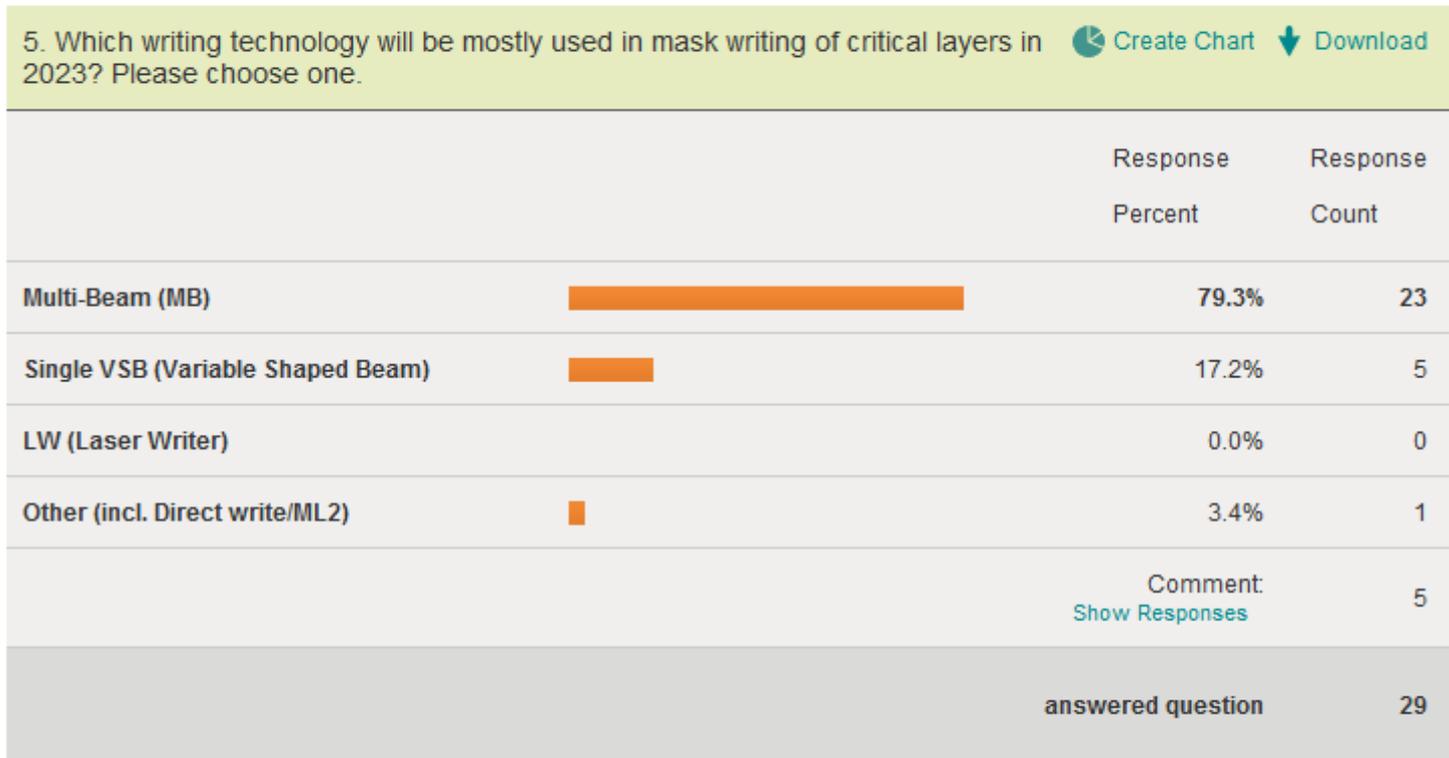
Comments:

- Target should be around 12 hours
- Less than 10 hours is ideal. Over 10 hours but less than 1 day can be tolerated. Anything more than 1 day is crazy.
- Assume multi-beam system is in production.

Q4) What is the acceptable TAT for MDP per one critical mask layer in 2023?



Q5) Which writing technology will be mostly used in mask writing of critical layers in 2023?



Comments:

- It hasn't been invented yet.
- Multi-column is the only solution. It needs development from the level of reliable parts, but who will pay the cost?
- I believe VSB with productivity enhancing technique, like model-based approximation, is the best enabling solution.

Q6) Which lithography application will be supported by which mask writing technology the most?

6. Which lithography application will be supported by which mask writing technology the most?						Create Chart	Download
	MB	Single VSB	LW	Other	Rating		
					Count		
ArF masks	53.6% (15)	39.3% (11)	7.1% (2)	0.0% (0)	28		
EUV masks	60.7% (17)	39.3% (11)	0.0% (0)	0.0% (0)	28		
NIL masks	38.5% (10)	42.3% (11)	3.8% (1)	15.4% (4)	26		
DSA masks	40.7% (11)	40.7% (11)	14.8% (4)	3.7% (1)	27		
				Comment	2		
				Show Responses			
				answered question	28		
				skipped question	4		

Comment: Are we really, really serious about DSA?

Q7) What is your preference for pattern data format?

PAGE: MASK DATA FORMAT

7. What is your preference for pattern data format?		Create Chart	Download
		Response Percent	Response Count
Cross-vendor/Public/License-free data format is preferred.		63.0%	17
Private/Proprietary data format is preferred.		7.4%	2
Data format does not matter.		29.6%	8
Other		0.0%	0
		Comment: Show Responses	2
		answered question	27
		skipped question	5

Comment: Diversity of data format is a source of benefit for MDP companies

Q8) What is your opinion about pipelining MDP and writing?

PAGE: PIPELINING OF MDP (MASK DATA PREP) AND MASK WRITING

Pipelining of MDP and writing means a sequence to start mask writing as soon as a part of the data conversion is finished and ready for writing.

[Create Chart](#) [Download](#)

		Response Percent	Response Count
Conventional separate/sequential streaming process is preferred.		7.1%	2
Pipeline is acceptable if verification is included, or reliability of each side is much more enhanced.		82.1%	23
Pipeline will be mandatory.		10.7%	3
Other		0.0%	0
		Comment: Show Responses	2
		answered question	28
		skipped question	4

Comment: Pipelining can be a viable technique if data prep behavior is predictable. It cannot be slower than predicted and be a bottleneck to writing.

Other comments

PAGE: THANK YOU!

9. If you have more opinions or suggestions, please share them with us.

 [Download](#)

Comments:

- How fast MB could be delivered in 2023?. Compare to current VSB tool.
How small beam blur is expected in 2023?
- High resolution resist with lower dose requirements required for NIL especially if MB does not become available.

Timeline

- Presentation by Panelists (17:25 – 18:40)
 - 10 minute talk by each panelist
 - A couple of questions from the audience accepted after each panelist's presentation
- Open discussion (18:40 – 19:05)
- Summary (19:05 – 19:10)