Thank you - 10th Annual Luminaries Survey
81 luminaries across 44 different companies in July 2021

What part of the semiconductor ecosystem is your primary focus?

- Chip design: 10%
- EDA/IP: 4%
- Mask: 37%
- Equipment: 10%
- Materials: 2%
- Chip manufacturing: 5%
- Services: 1%
- Research: 31%
72% Say 2021 Mask Revenues Will Increase
Only 33% predicted increase for 2020 Mask Revenues

2020 Survey Result
Net of all effects (including COVID-19), what will happen to the size of the 2020 total mask revenues compared to 2019? N=72

- 33% Increase
- 11% Stay about the same size
- 56% Decrease

2021 Survey Result
Net of all effects (including COVID-19), what will happen to the size of the 2021 total mask revenues compared to 2020? N=74

- 72% Increase
- 4% Stay about the same size
- 24% Decrease
74% Say EUV Contributes to 2021 Mask Revenues
Increased from 66% in 2020

2020 Survey Result

There are fewer masks per wafer with EUV, but each EUV mask is more expensive. Net of all effects, how will the increased use of EUV contribute to the size of total 2020 mask revenues? N=71

Positive: 66%
Neutral: 30%
Negative: 4%

2021 Survey Result

There are fewer masks per wafer with EUV, but each EUV mask is more expensive. Net of all effects, how will the increased use of EUV contribute to the size of total 2021 mask revenues? N=74

Positive: 74%
Neutral: 23%
Negative: 3%
75% Say EUV Pellicles for HVM by 2023
Two year trend points to 2023

EUV pellicles are available, but transmission loss seems to still be an issue. By the end of which year do you predict a pellicle will be used for EUV high volume manufacturing by at least one company?

Answer choices expanded in 2021 survey – see X axis in two charts above
Confidence in Actinic EUV Inspection Remains High
72% say actinic inspection for EUV HVM by 2023

Regarding EUV mask pattern inspection, please indicate your level of agreement with the following statements:

Actinic inspection will be used in the mask shop for EUV high volume manufacturing (HVM) by 2023

- Strongly disagree: 7%
- Disagree: 22%
- Neither agree or disagree: 47%
- Agree: 25%
- Strongly agree: 7%

eBeam multi-beam inspection will be used in the mask shop for EUV HVM by 2023

- Strongly disagree: 7%
- Disagree: 27%
- Neither agree or disagree: 23%
- Agree: 36%
- Strongly agree: 6%

Inspection of wafers will be used for the purpose of mask inspection for EUV HVM by 2023 (note this question now asks for wafer inspection of any method)

- Strongly disagree: 1%
- Disagree: 18%
- Neither agree or disagree: 20%
- Agree: 50%
- Strongly agree: 10%

eBeam multi-beam inspection of wafer will be used for the purpose of mask inspection for EUV HVM by 2023

- Strongly disagree: 7%
- Disagree: 23%
- Neither agree or disagree: 32%
- Agree: 32%
- Strongly agree: 5%
More Think EUV TAT is “Much” Longer

23% say EUV TAT “much longer” vs 10% last year

Turnaround time is critical to the mask business. How will EUV mask turnaround times in 2023 compare to leading-edge 193i mask turnaround times of today?

- Much shorter: 1% (2020), 0% (2021)
- Shorter: 4% (2020), 3% (2021)
- About the same: 21% (2020), 24% (2021)
- Longer: 63% (2020), 51% (2021)
- Much longer: 10% (2020), 23% (2021)

2020 (n=67) vs 2021 (n=75)
EUV Remains Top Reason to Buy Multi-Beam Writers
EUV precision ranked #1 reason in this year’s survey

Please rank the primary reasons for purchasing multi-beam mask writers. Note in the answers below, precision refers to CD uniformity as well as placement accuracy. n=81

#1: More precision required for EUV masks
#2: More throughput for EUV masks
#3: Curvilinear ILT for EUV masks
#4: Curvilinear ILT for 193i masks
#5: More precision required for 193i masks
#6: More throughput for 193i masks

Note: 1-6 on X-axis indicate # of respondents that ranked that question as that ordinal number with 1 = highest.
Purchasing Sentiment Rises for Laser, VSB Writers
Multi-Beam sentiment remains high at 90%

What do you predict will happen to unit purchases of new mask writers by type over the next 3 years?

- Laser mask writers (N=76)
  - Increase: 38%
  - Stay about the same: 55%
  - Decrease: 7%

- Trailing-edge VSB eBeam mask writers (N=77)
  - Increase: 30%
  - Stay about the same: 39%
  - Decrease: 31%

- Advanced VSB eBeam mask writers (N=77)
  - Increase: 31%
  - Stay about the same: 55%
  - Decrease: 14%

- Multi-beam mask writers (N=79)
  - Increase: 9%
  - Stay about the same: 90%
  - Decrease: 1%

2020 "increase" purchases:
- Laser mask writers: 32%
- Trailing-edge VSB eBeam mask writers: 24%
- Advanced VSB eBeam mask writers: 27%
- Multi-beam mask writers: 96%

2021 "increase" purchases:
- Laser mask writers: 38%
- Trailing-edge VSB eBeam mask writers: 30%
- Advanced VSB eBeam mask writers: 31%
- Multi-beam mask writers: 90%
Deep Learning Predictions Shift to 2023 & Beyond
Only 22% say 2022 vs 62% in last year’s survey

In the mask industry, when will capabilities based on deep learning become a competitive advantage for any step in the mask making process?

Answer choices expanded in 2021 survey – see X axis in two charts above
95% Say ILT in Use Today
41% say “some critical layers” use ILT

How broadly is inverse lithography (ILT) used for production chips today (2021)? (use includes for hot spots only)

- All critical layers of leading edge nodes use ILT
- Some critical layers of leading edge nodes use ILT
- A few critical layers of leading edge nodes use ILT
- No layers use ILT (yet)

- 2017 (n=61)
  - 3% all critical layers use ILT
  - 3% some critical layers use ILT
  - 10% a few critical layers use ILT
  - 6% no layers use ILT

- 2018 (n=60)
  - 2% all critical layers use ILT
  - 15% some critical layers use ILT
  - 22% a few critical layers use ILT
  - 12% no layers use ILT

- 2019 (n=60)
  - 10% all critical layers use ILT
  - 21% some critical layers use ILT
  - 46% a few critical layers use ILT
  - 16% no layers use ILT

- 2020 (n=63)
  - 6% all critical layers use ILT
  - 38% some critical layers use ILT
  - 52% a few critical layers use ILT
  - 48% no layers use ILT

- 2021 (n=65)
  - 3% all critical layers use ILT
  - 41% some critical layers use ILT
  - 48% a few critical layers use ILT
  - 48% no layers use ILT

95%
Among the 193i or EUV masks used in high volume manufacturing in 2023, what do you expect will be the highest percentage of curvilinear shapes on any given mask? (Curvilinear shapes can be piecewise linear polygons of some resolution, or spline-like form)

**Highest %**

- **EUV**
  - 6%: 47%
  - 8%: 31%
  - 11%: 38%
  - 22%: 69%
  - 53%

- **193i**
  - 6%: 38%
  - 17%: 31%
  - 11%: 47%
  - 22%: 69%
  - 53%

**Average %**

- **EUV**
  - 2%: 81-100%
  - 5%: 61-80%
  - 14%: 41-60%
  - 19%: 21-40%
  - 11%: 0-20%

- **193i**
  - 3%: 81-100%
  - 7%: 61-80%
  - 17%: 41-60%
  - 33%: 21-40%
  - 14%: 0-20%
Survey participants ranked six biggest curvilinear mask concerns. Please rank your biggest concerns in producing curvilinear masks, n=81:

1. Mask Inspection
2. Mask shop software infrastructure including data volume, mask data preparation, mask process correction or verification
3. Access to Multi-beam Mask Writers
4. ILT software including speed or quality of results
5. Mask Metrology
6. Mask Repair

Note: 1-6 on X-axis indicate # of respondents that ranked that question as that ordinal number with 1 = highest
Only 4% Say Curvilinear Concerns Insurmountable
71% say LE mask shops can handle at least limited number

Are the concerns in HVM of masks containing curvilinear features insurmountable for the leading-edge mask shops by end of 2022? Please select the statement you agree with most.

- The concerns are insurmountable for now. 4%
- They can handle a very few special cases of such masks, but not yet in general. 25%
- They can handle some limited number of such masks. 51%
- They can handle as many such masks as there is demand. 16%
- They have no problem with such masks. 4%

Responses (n=69)
Luminaries Say Mask Revenue to Increase in 2021

- Sentiment that mask revenue is increasing grew stronger

- Mask writer purchasing sentiment increased for Lasers and VSB machines while Multi-Beam remains high

- Luminaries’ confidence in curvilinear mask making is high
Thank you to those who participated in the survey!

Luminaries survey results available on www.ebeam.org