eBeam Initiative Annual Survey Results
Photomask Japan 2021

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Survey Says Net Neutral COVID-19 Business Impact
By 2021, 24% positive vs 20% negative predictions

What business impact do you think COVID-19 will have on (2020, 2021) total mask revenues?

2020 n=74
- 24% Positive
- 6% Neutral
- 70% Negative

2021 n=71
- 20% Positive
- 24% Neutral
- 56% Negative
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%
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 (HVM)?

- 55% Say EUV Pellicles for HVM by End of 2022
- 38% Predict 2022
- 32% Predict 2023 or beyond
- 14% Predict 2021
- 13% Can't predict when
- 3% Predict 2020
- 0% Predict Never

n=72
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 agree: 74%
  - Agree: 51%
  - Neither agree or disagree: 23%
  - Disagree: 9%
  - Strongly disagree: 1%

- **eBeam multi-beam inspection will be used in the mask shop for EUV HVM by 2023**
  - Strongly agree: 48%
  - Agree: 39%
  - Neither agree or disagree: 23%
  - Disagree: 27%
  - Strongly disagree: 3%

- **eBeam multi-beam inspection of wafers will be used for the purpose of mask inspection for EUV HVM by 2023**
  - Strongly agree: 51%
  - Agree: 42%
  - Neither agree or disagree: 25%
  - Disagree: 22%
  - Strongly disagree: 3%
EUV is Driving Multi-Beam Writer Purchases
Survey participants ranked six reasons

Q: 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=77

1. More throughput for EUV Masks
2. More precision required for EUV Masks
3. Curvilinear inverse lithography technology (ILT) for 193i
4. Curvilinear inverse lithography technology (ILT) for EUV
5. More precision required for leading-edge 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
84% Say ILT in Use Today

How broadly is inverse lithography (ILT) used for production chips today (2020)? (use includes for hot spots only)

- 84% (2020, n=63)
- 52% (2019, n=60)
- 22% (2018, n=60)
- 10% (2017, n=61)
- 16% (2020, n=63)

- 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)
Manufacturing of curvilinear masks is enabled by multi-beam mask writers. How extensively will curvilinear shapes be used for leading-edge (EUV, 193i) masks intended for high volume manufacturing (HVM) by 2023?

- **EUV Masks**
  - Entire reticles of curvilinear shapes: 15%
  - A hybrid of mostly curvilinear shapes and some Manhattan shapes: 6%
  - A hybrid of mostly Manhattan shapes with some curvilinear shapes: 33%
  - Only Manhattan shapes including 45 degree shapes: 46%

- **193i Masks**
  - Entire reticles of curvilinear shapes: 6%
  - A hybrid of mostly curvilinear shapes and some Manhattan shapes: 12%
  - A hybrid of mostly Manhattan shapes with some curvilinear shapes: 20%
  - Only Manhattan shapes including 45 degree shapes: 62%
Multi-Beam and EUV Trends Becoming Visible

• Thank you to 10 participating companies in 2020 Mask Makers Survey:
  • AMTC, DNP, HOYA, Intel, Micron, Photronics (incl PDMC), Samsung, SMIC, TMC, Toppan
  • Independently collected by David Powell, Inc.

• Not the same participating companies as last year so yearly comparisons inconclusive in most cases

• Collected data “for the last 12 months (July 2019 to June 2020)”

• Survey slides available at www.ebeam.org
558,834 Masks Delivered by 10 Companies

Q: What was the number of masks delivered?

Q: Percentage of the total number of masks in the preceding question by Ground Rules of the critical layers?
Multi-Beam Masks More than Doubled

Q: What was the % written by the following pattern generation?
- eBeam (VSB), 26.2%
- eBeam (multi-beam), 0.2%
- eBeam (raster), 1.2%
- LASER, 72.4%

Masks Written by eBeam (Multi-Beam)

- 2020: 800
- 2019: 200

Masks Delivered by Pattern Generation 2020 (n=10)
94.2% Mask Yield Reported*
EUV Mask Yield Reported was 91%

Q: What was your overall mask yield?  
Q: What was your percent mask yield by category?

* Yearly comparisons inconclusive due to participant change
Q: What was your average Turn-Around-Time (TAT) per mask for critical layer masks by Ground Rules in the past year? (Please note, this question is only asking about critical layer masks, not the average of all masks.)

Normalized Average of TAT Change as Ground Rules shrink (n=8)

"Normalized average" takes a ratio of a company’s response to that company’s response for ≥11nm and <16nm and then averages for all companies that responded for that ground rule.
Q: What was the average data prep time (starting point defined as RET output) by Ground Rules?

Weighted Average is computed by averaging each company response of each category multiplied by that company's percentage share of reported masks of that category.
MPC Usage Increasing at Leading Edge Nodes

Revised Q: What percentage of critical layer masks by Ground Rules had Mask Process Correction (MPC) applied in the past year? (Please note, this question is only asking about critical layer masks, not the percentage of all masks. MPC is defined as offline manipulation of geometry and/or dose of mask shapes during mask data preparation of the specified mask shapes received from OPC/ILT in order to more reliably manufacture the specified mask shapes on the physical mask or to maintain site-to-site compatibility. PEC, LEC, FEC, and other corrections performed by the writer are not considered MPC. But if, for example, EUV mid-range correction is performed offline during mask data preparation instead of using the inline writer capability, then this should be considered MPC.)
Exciting Times in the Photomask Industry

- Growing market
- EUV
- Multi-beam
- Curvilinear