2019-2020 Mask Maker Survey Results

Jan Willis and Aki Fujimura for eBeam Initiative
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?
Masks per Mask Set Data was Inconclusive
Insufficient number of respondents for 7-11nm to report

Q: What was the average # of masks per mask set 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.

Historical High for Masks per Mask Set

In these years, we had sufficient number of responding companies to report 7-11nm
Multi-Beam Masks More than Doubled

Q: What was the % written by the following pattern generation?
   eBeam (VSB), eBeam (multi-beam), eBeam (raster), LASER, Other
Q: What was the average write time for each type of pattern generation?*

For Weighted Avg, each response of each writer type is weighted by percentage share of that company of total reported masks of that type.
Longest Write Time Reported is VSB ~57 Hours
~30 hour longest Multi-Beam Write Time Reported (n=3)

Q: What was the longest write time for each type of pattern generation?

Note: n=10 for 2020 are different 10 companies than n=10 for 2019, 2018
Q: What was the largest data volume for any mask level for each type of pattern generation?
Q: What was the % by...?
Binary, AttPSM, AltPSM, EUV, Other

* Yearly comparisons inconclusive due to participant change
Q: In the past year, what was the highest dose resist used in production for each category?
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
Clear Defect of Absorber Affecting EUV Yield

NEW Q: For EUV mask in the past year, what defects affected the yield by category?
For All Masks, More Opaque than Clear Defects*

Q: What was the average number of defects per mask?

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.

* Yearly comparisons inconclusive due to participant change
Chromium is Dominant Substrate at 81.2%
36% of the Reported Masks used Dry Etch Correlates to leading edge masks

Q: What was the percentage by…? Wet Etch, Dry Etch
65% of Masks “No Repair”*

Q: What was the percentage of masks repaired by...No Repair, eBeam, LASER, Nanomachining, FIB

* Yearly comparisons inconclusive due to participant change
Soft & Hard Defects More than Half of Returns
0.19% of Masks returned from the fab

Q: What percentage of masks were returned from the fab?
Q: Of the masks returned from the fab, what percentage were attributed to the following causes?

- Soft Defects, 34%
- Hard Defects, 19%
- Mask data prep errors, 19%
- Wrong Pellicle/Damage, 9%
- OPC/ILT errors, 4%
- Bad repair, 1%
- Haze, 3%
- Other, 11%
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.)

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.

"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.
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.)
Multi-Beam and EUV Trends Becoming Visible

- 558,834 masks reported by 10 different companies than last year
- Masks written with Multi-Beam Mask Writers more than doubled
- EUV mask yield reported at 91%
- MPC usage increasing at leading edge nodes
PDFs, Videos, and Panel Discussion at www.ebeam.org