

10th Annual eBeam Initiative Survey Reports Photomask Market Optimism

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ABSTRACT

The eBeam Initiative completed its 10th annual opinion survey in July 2021 with anonymous feedback from industry luminaries representing 44 companies from across the semiconductor ecosystem – including photomasks, electronic design automation (EDA), chip design, equipment, materials, manufacturing and research. Started in 2012, the Luminaries survey is used each year to gather predictions of industry trends. The optimism for overall photomask market growth captured in the 2020 survey continued to increase in the 2021 survey.

72 percent of survey respondents predict that mask revenues in 2021 will increase compared to 2020 revenues, while 74 percent believe that EUV will contribute to mask revenue growth. EUV also remains the top reason cited by respondents for purchasing multi-beam mask writers. 90 percent of respondents believe that purchases of multi-beam mask writers will grow over the next three years, while purchasing sentiment for laser mask writers and variable shaped beam (VSB) eBeam mask writers has increased compared to last year's survey. Confidence in curvilinear mask making is also high according to a new survey question, with 71 percent indicating that leading-edge mask shops can handle at least a limited number of such masks. Taken together, the survey results reflect optimism for both business growth and technology adoption in the photomask market.

Keywords: photomask market, revenues, photomask, eBeam, multi-beam, EUV, deep learning, curvilinear, VSB, laser

1. INTRODUCTION

The eBeam Initiative has sponsored an opinion survey for the past 10 years that aims to provide forward-looking predictions by those who affect spending decisions. This is now known as the Luminaries Survey. There were 81 participants representing 44 different companies in the 10th annual survey conducted in July 2021. A majority (68%) of the participants represented mask shops or equipment providers.

The 2021 Mask Maker survey was conducted with a reduced number of participants due to the global COVID-19 pandemic and those results weren't shared publicly. Thus, no results from that survey are included in this manuscript.

To view the entire 2021 Luminaries Survey, please go to www.ebeam.org under eBeam Education.

2. LUMINARIES SURVEY RESULTS

2.1 Luminaries Survey Results on Size of Total Mask Revenue

The survey results were more optimistic for 2021 total mask revenue than the same survey question about 2020. 72% predicted total mask revenue would increase in 2021 as compared to 33% who predicted an increase in the 2020 total mask revenue, shown in Figure 1. The question asked was net of all effects (including COVID-19), what will happen to the size of 2021 total mask revenues as compared to 2020?

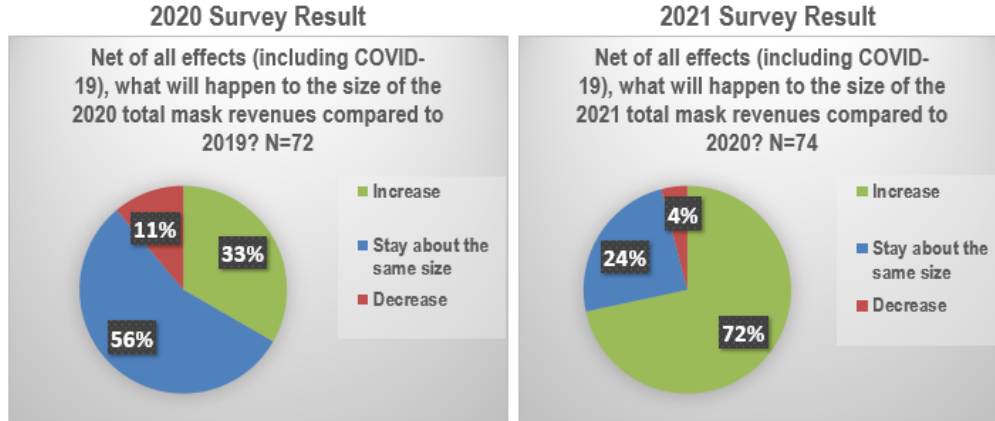


Figure 1: Survey Predictions – Size of 2020, 2021 Total Mask Revenue

In a separate question, it was stated that there are fewer masks per wafer with EUV, but each EUV mask is more expensive. The survey question asked how will the increased use of EUV contribute to the size of the total 2021 mask revenues, net of all effects? 74% of the luminaries who responded indicated that EUV would have a positive impact on the total 2021 mask revenues compared to 66% of the luminaries who answered the same question for 2020, as shown in Figure 2.

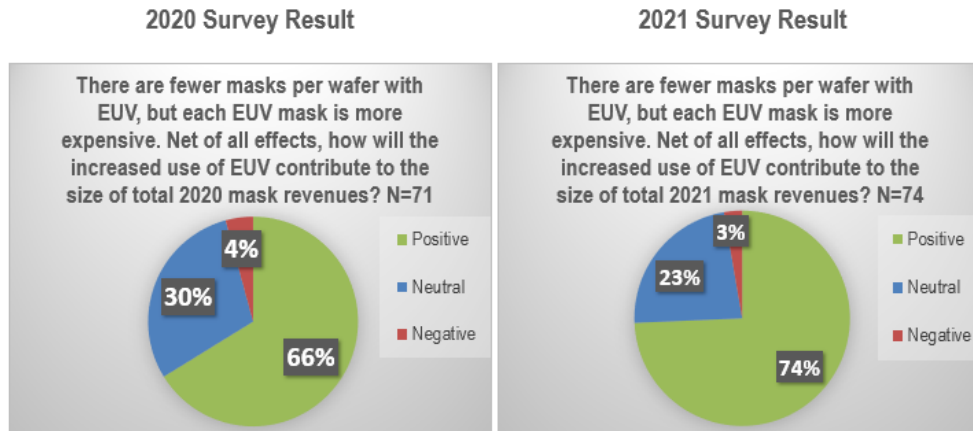


Figure 2: Survey Predictions - Impact of EUV in 2020, 2021 Total Mask Revenue

2.2 Luminary Survey Results for EUV: Pellicles, Mask Inspection and Turnaround Time (TAT)

In a question related to EUV pellicles, it was stated that EUV pellicles are available, but transmission loss seems to still be an issue. The question asked by the end of which year do you predict a pellicle will be used for EUV high volume manufacturing (HVM)? 75% of those who responded in the 2021 survey say EUV pellicles for HVM would be used by the end of 2023 as shown in Figure 3.

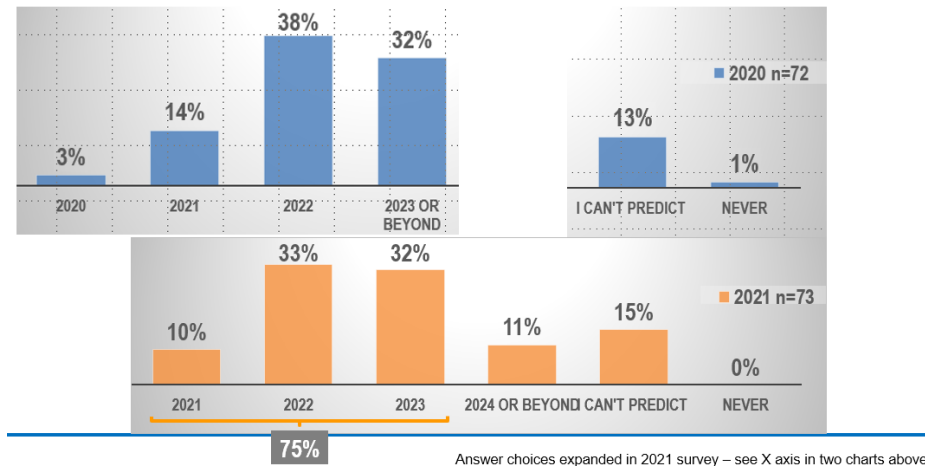


Figure 3: Survey Predictions – EUV Pellicles used in HVM

EUV mask inspection predictions for 2023 were explored in the survey. Of those responding to the survey, 72% agree that actinic inspection will be used in the mask shop for EUV HVM by 2023, 42% agree that eBeam multi-beam inspection will be used in the mask shop for EUV HVM by 2023, 60% agree that inspection of wafers will be used for the purpose of mask inspection for EUV HVM by 2023, and 37% agree that eBeam multi-beam inspection of wafers will be used for the purpose of mask inspection for EUV HVM by 2023 as shown in Figure 4.

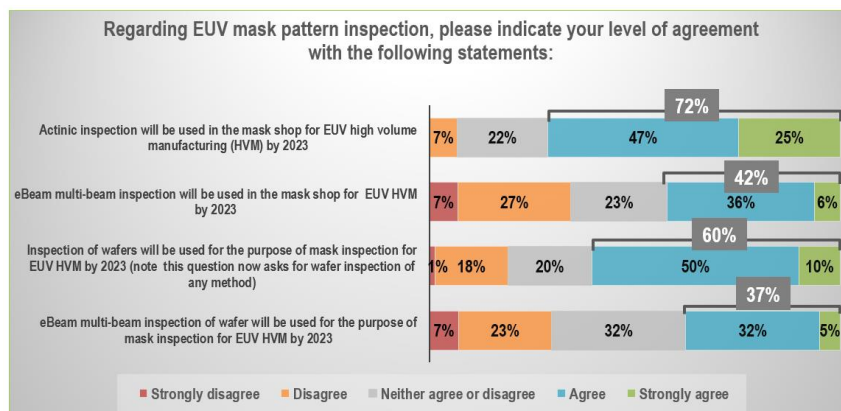


Figure 4: Survey Predictions – EUV Mask Inspection by 2023

The survey obtained predictions for EUV mask turnaround time (TAT) in 2023 compared to leading-edge 193i mask turnaround time today. Of those responding to the survey, 74% predict that EUV mask TAT in 2023 will be longer as compared to 73% who said the same in the 2020 Luminaries survey. However, 23% predict that EUV mask TAT would be much longer in the 2021 survey versus 10% who said that in the 2020 survey, shown in Figure 5.

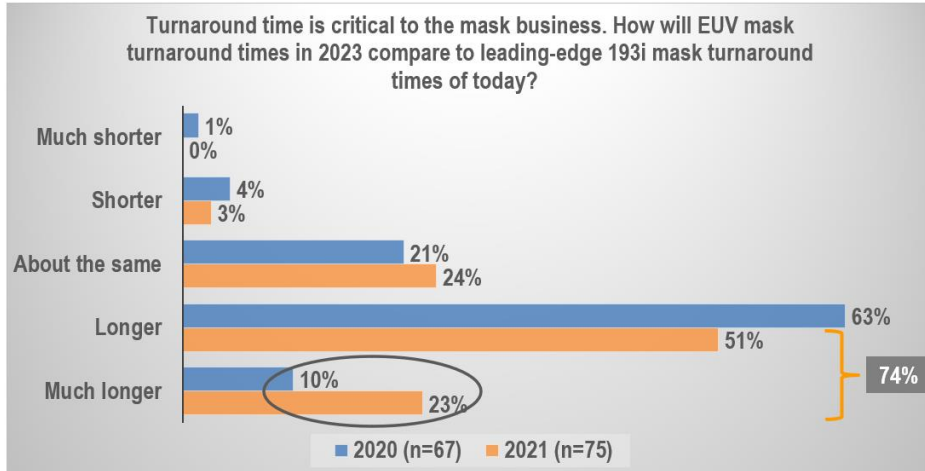


Figure 5: Survey Predictions – EUV Mask TAT in 2023 Compared to 193i TAT today

2.3 Luminaries Survey Results for Multi-beam Mask Writing

Survey participants ranked six reasons for purchasing multi-beam mask writers. Those responding to the question rank “more precision for EUV masks” as the number one reason in the 2021 survey and “more throughput for EUV masks” as the number two reason, as shown in Figure 6. Also included in the results in Figure 6 is how the respondents ranked each reason shown inside each rectangular chart. Taken together, EUV remains the top reason to buy multi-beam mask writers according to the Luminaries Survey.

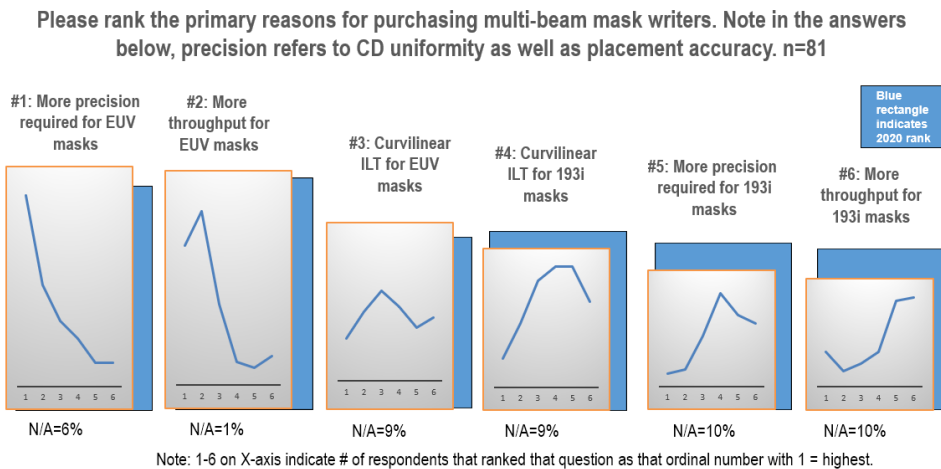


Figure 6: Survey Predictions – Reasons for Purchasing Multi-beam Mask Writers

90% of the 2021 survey participants predict unit purchases of new multi-beam mask writers will increase over the next three years, more than any other type of mask writer as shown in Figure 7. 2021 predictions of increases in unit purchases of all other types of mask writers increased over 2020 predictions, shown in the chart in the upper right of Figure 7.

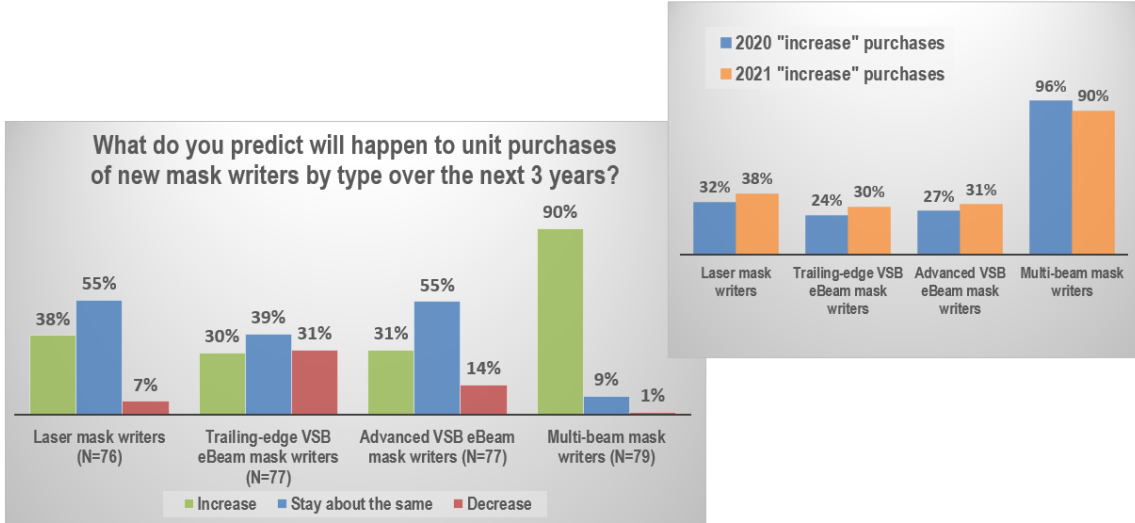


Figure 7: Survey Predictions – Predictions for New Mask Writer Purchases by Type

2.4 Luminaries Survey Results for Deep Learning

A new question about deep learning was added in the 2020 Luminaries Survey and repeated in the 2021 survey. In 2020, 62% answered 2022 or earlier in response to the question “in the mask industry, when will capabilities based on deep learning become a competitive advantage for any step in the mask making process?”. In the 2021 survey, predictions shift to 2023 and beyond with only 22% saying 2022 or earlier as shown in Figure 8.

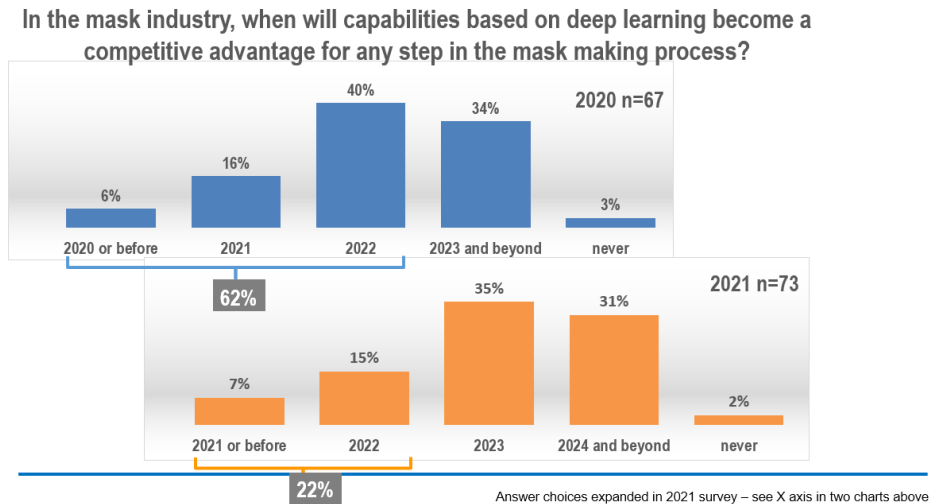


Figure 8: Survey Predictions – Deep Learning in Use as a Competitive Advantage

2.5 Luminaries Survey Results for Inverse Lithography Technology (ILT)

A repeat survey question asked how broadly ILT is used for production chips today (2021) including use for hot spots only. Of those responding to the survey question, 95% say that ILT is used for production chips in 2021 when combining the responses indicating a few, some or all critical layers of leading-edge nodes use ILT as shown in Figure 9. 41% say that some critical layers of leading-edge nodes use ILT, the highest percentage in five years of surveys, shown inside the circled area in Figure 9.

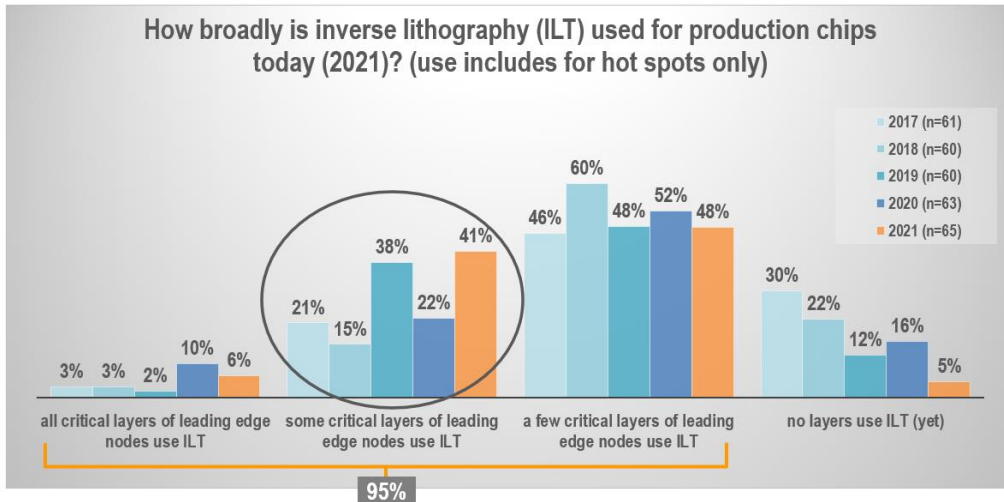


Figure 9: Survey Predictions – Production Use of ILT in 2021

2.6 Luminaries Survey Results for Curvilinear Mask Shapes

A new question was added in 2020 and revised in 2021 as manufacturing of curvilinear masks is a new trend enabled by multi-beam mask writers. The revised question in the 2021 survey asked what the average percentage of curvilinear shapes would be in 2023 for EUV and for 193i masks used in high volume manufacturing and containing some curvilinear shapes. Of those responding, 60% say more than 20% curvilinear shapes on average will be used for leading-edge 193i masks by 2023 as shown in the chart on the left of Figure 10. In the chart on the right, 39% say more than 20% curvilinear shapes on average will be used for EUV masks by 2023.

Among the 193i or EUV masks used in high volume manufacturing in 2023 that contain curvilinear features, what do you expect will be the average percentage of curvilinear shapes for such masks?

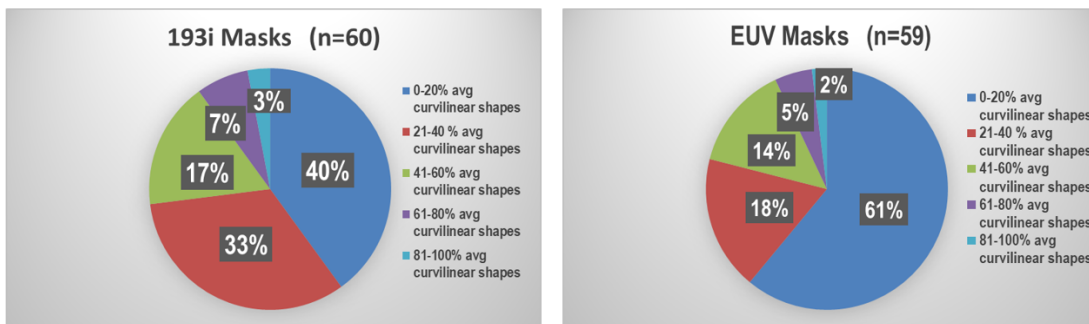
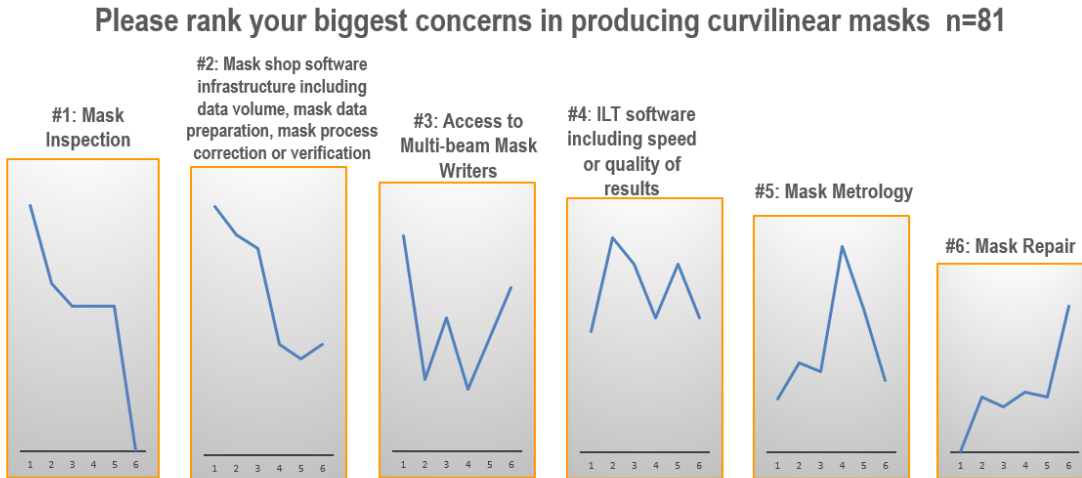


Figure 10: Survey Predictions – Use of Curvilinear Mask Shapes by 2023

A new question was added in 2021 where survey participants ranked six concerns in producing curvilinear masks, with a ranking of one representing the biggest concern. Mask inspection was ranked as the highest concern followed closely by mask shop infrastructure including data volume, mask data prep, mask process correction or verification. The respondent rankings for each reason are shown inside the corresponding rectangle in Figure 11.



Note: 1-6 on X-axis indicate # of respondents that ranked that question as that ordinal number with 1 = highest

Figure 11: Survey Predictions – Ranking Concerns in Producing Curvilinear Masks

Building on the survey question in Figure 11, the survey asked a new follow-on question in 2021. The additional new question asked the participants to choose one of five statements which they agree with most to reflect the extent of their concern in high volume manufacturing of masks containing curvilinear features by the end of 2022. Only 4% say that concerns are insurmountable for now, whereas 71% indicate that leading-edge mask shops can handle at least a limited number of curvilinear masks as shown in Figure 12.

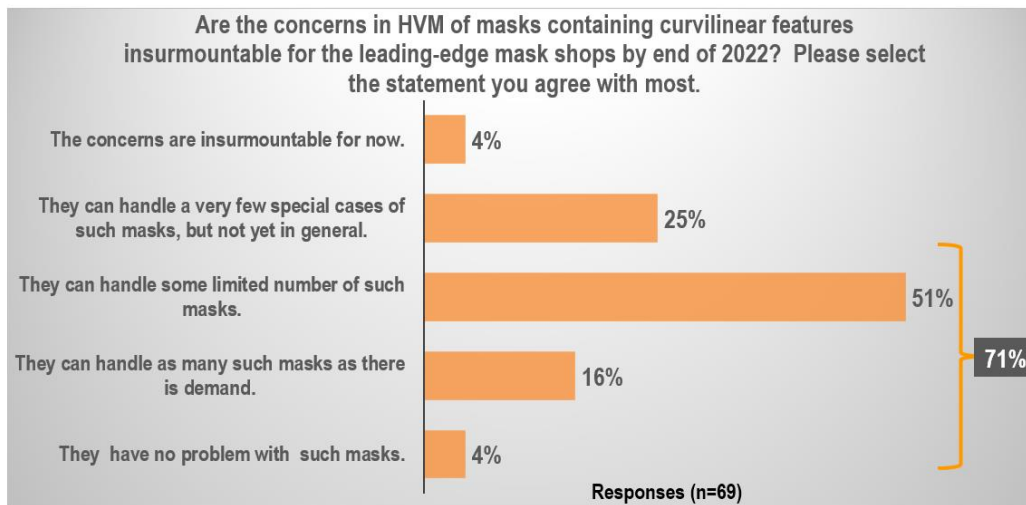


Figure 12: Survey Predictions – Extent of Concerns in HVM of Curvilinear Masks by end of 2022

3. ACKNOWLEDGEMENTS

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