11th Annual eBeam Initiative Survey Reports EUV Fueling Photomask Growth

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ABSTRACT

The eBeam Initiative completed its 11th annual opinion survey in July 2022 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. 2022 survey results reflect that EUV is fueling the photomask industry as 78 percent of survey respondents believe that EUV lithography will contribute to photomask (mask) revenue growth.

EUV remains the top reason cited by survey respondents for purchasing multi-beam mask writers. Access to multi-beam mask writers is seen as less of a barrier to curvilinear mask making compared to the 2021 survey. Confidence among luminaries in curvilinear mask making remains high, with 76 percent of respondents indicating that leading-edge mask shops can handle at least a limited number of such masks. With EUV providing the fuel, optimism for overall photomask market growth continued in 2022 with 70 percent of survey respondents predicting that mask revenues in 2022 will increase compared to 2021 revenues.

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 11 years that aims to provide anonymous forward-looking predictions by those who affect spending decisions. This is now known as the Luminaries Survey. There were 79 participants representing 44 different companies in the 11th annual survey conducted in July 2022. A majority (70%) of the participants represented mask shops or equipment providers. New questions were added to the 2022 Luminaries Survey to gauge perceptions on the readiness of the next generation of EUV lithography, high-numerical (high-NA) EUV. Of those responding, 59 percent predict that high-NA EUV will first be used in high volume manufacturing (HVM) by 2026 while 76 percent predict that broad HVM adoption of high-NA EUV by more than one company will occur in 2027 or beyond.

To view the entire 2022 Luminaries Survey, please go to www.ebeam.org under eBeam Education.

2. LUMINARIES SURVEY RESULTS

2.1 EUV Masks Viewed as a Positive for Mask Revenue

The survey results continued to be positive in 2022 about how the increased use of EUV would contribute to the size of the total mask revenues. 78% of the luminaries who responded indicated that EUV would have a positive impact on the total 2022 mask revenues compared to 74% of the luminaries who answered the same question for 2021, as shown in Figure 1.
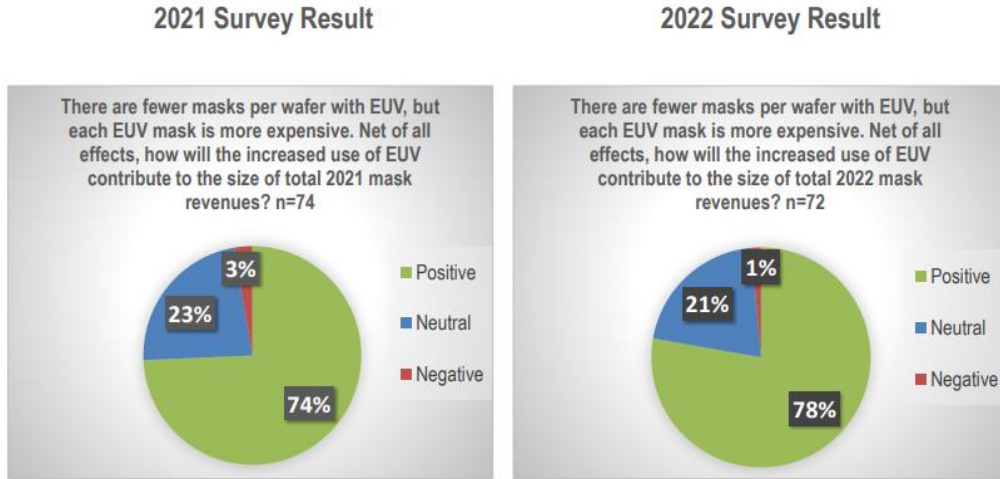

Figure 1: Survey Predictions - Impact of EUV on 2021, 2022 Total Mask Revenue

A more general question was asked again in 2022 about total mask revenue. The question asked what will happen to the size of 2022 total mask revenues as compared to 2021? The outlook remained positive as 70% predict total mask revenue would increase in 2022 while 72% predicted an increase in the 2021 total mask revenue, shown in Figure 2.
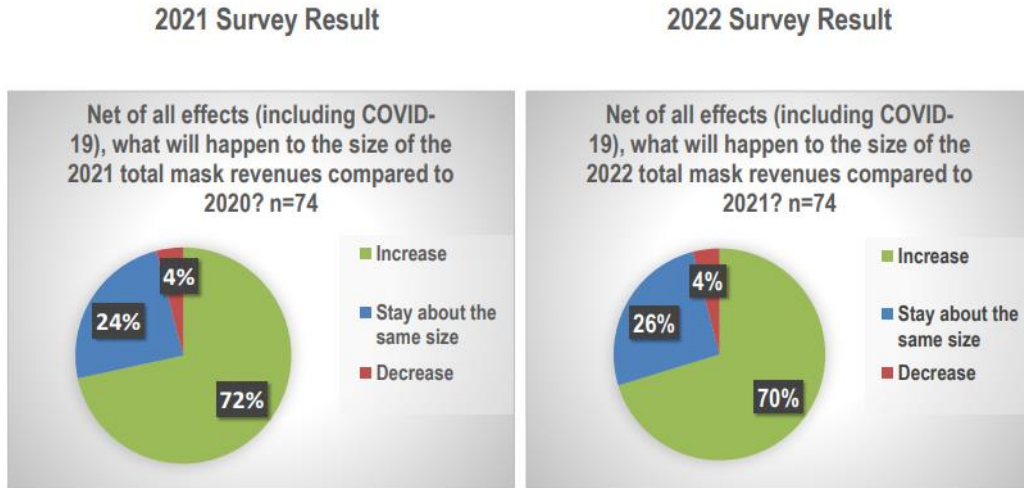

Figure 2: Survey Predictions – Size of 2021, 2022 Total Mask Revenue

2.2 Luminaries Predict Usage of EUV Inspection, Pellicles, and High-NA EUV

EUV mask inspection predictions for 2023 were explored in the survey and confidence remains high in the use of actinic inspection. As shown in Figure 3, 69% agree that actinic inspection will be used in the mask shop for .33 NA EUV HVM by 2023. Up from 60% in 2021, 71% agree that inspection of wafers will be used for the purpose of mask inspection for EUV HVM by 2023. Down from 42% in 2021, 24% agree that eBeam multi-beam inspection will be used in the mask shop for EUV HVM by 2023, and 39% agree that eBeam multi-beam inspection of wafers will be used for the purpose of mask inspection for EUV HVM by 2023.
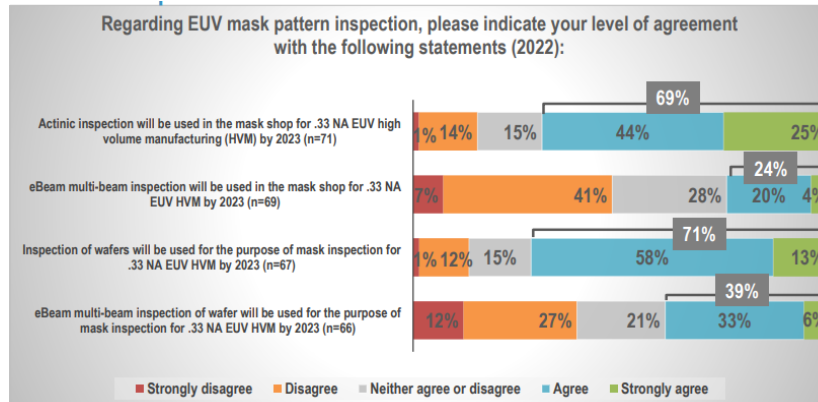

Figure 3: Survey Predictions – EUV Mask Inspection by 2023

A survey question about EUV pellicle usage was repeated for the third time since 2020. The question asked by the end of which year do you predict a pellicle will be used for EUV high volume manufacturing (HVM)? 23% of those who responded in the 2022 survey say EUV pellicles for HVM would be used by the end of 2022 as shown in Figure 4. The corresponding answer increased over the past three surveys where only 3% said in 2020 that EUV pellicles for HVM would be in use by the end of 2020, as shown in Figure 4.
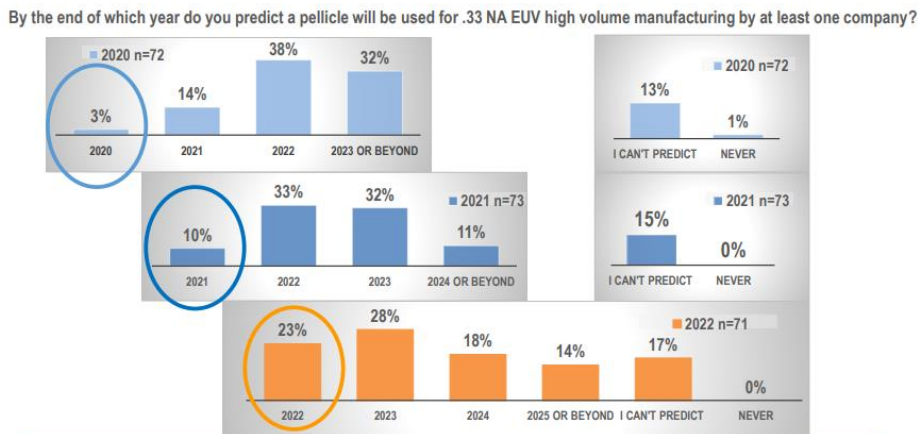

Figure 4: Survey Predictions – EUV Pellicles used in HVM

The survey included predictions for EUV mask turnaround time (TAT) in 2024 compared to leading-edge 193i mask turnaround time today. Of those responding to the survey, 70% predict that EUV mask TAT in 2024 will be longer as compared to 193i today. This compared to the 2021 survey result shown in Figure 5 where 74% predicted longer EUV mask TAT in 2023.
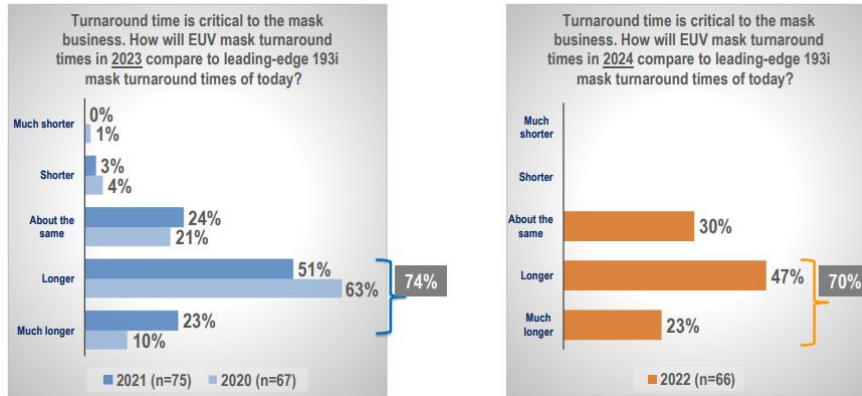

Figure 5: Survey Predictions – EUV Mask TAT in 2023, 2024 Compared to 193i TAT Today

Two new questions were added to the 2022 survey about the future readiness of high-NA EUV. The survey asked when high-NA EUV would first be used for HVM. Of those responding to the survey, 59% predict that high-NA EUV would first be used in HVM by 2026 as shown in Figure 6. Figure 7 shows the survey result when the question was changed to when there will be broad HVM adoption of high-NA EUV by more than one company. 76% of those surveyed say 2027 or beyond for HVM adoption by more than one company.
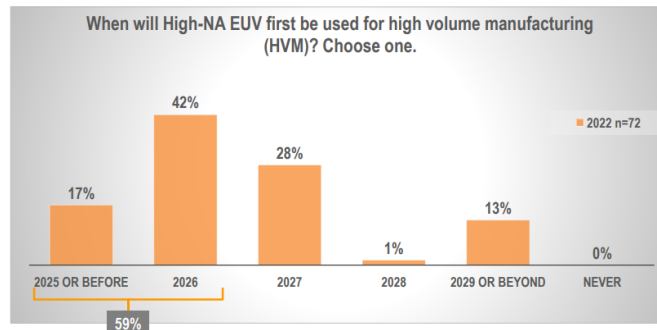

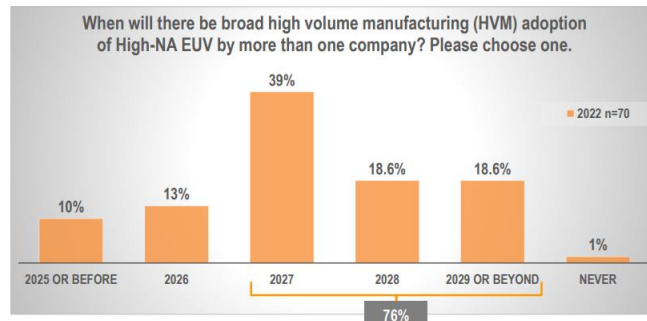Figure 6: Survey Predictions – High-NA EUV First in HVM

Figure 7: Survey Predictions – Broad High-NA EUV Adoption

2.3 EUV Precision Ranked #1 Reason to Buy Multi-Beam Mask Writers

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 2022 survey, a repeat result from the 2021 survey as shown in Figure 8. Also included in the results in Figure 8 is how the respondents ranked each reason plotted inside each rectangular chart. Looking at the plots for each reason in Figure 8, survey participants had mixed views when considering #2 more throughput for EUV masks and #4 curvilinear inverse lithography technology (ILT) for 193i masks as reasons to buy multi-beam mask writers.
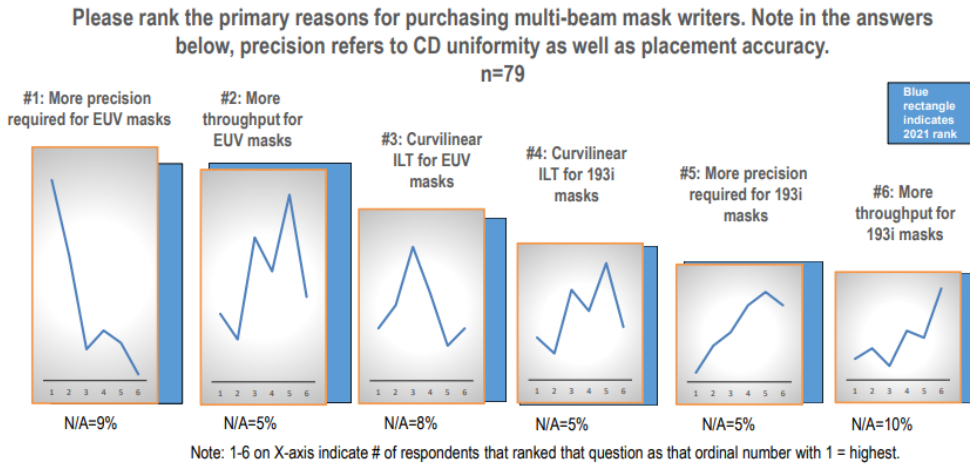

Figure 8: Survey Predictions – Reasons for Purchasing Multi-beam Mask Writers

93% of the 2022 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 9 for three years in a row. Predictions of increased purchases of laser mask writers rose for the third year in a row as shown in the circle in the upper right of Figure 9.
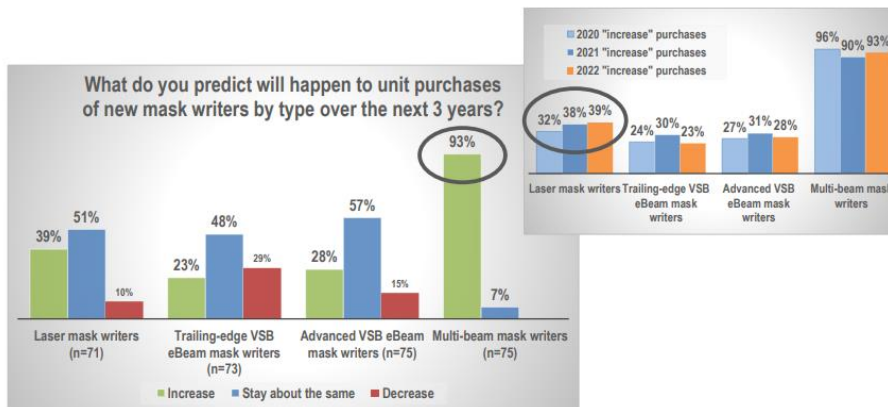

Figure 9: Survey Predictions – New Mask Writer Purchases by Type

2.4 Deep Learning Predictions Continue to Shift in Time

A new question about deep learning was added in the 2020 Luminaries Survey and repeated in the 2021 and 2022. 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 2022 survey, predictions shifted in time as 63% answered 2024 and beyond, shown in Figure 10.
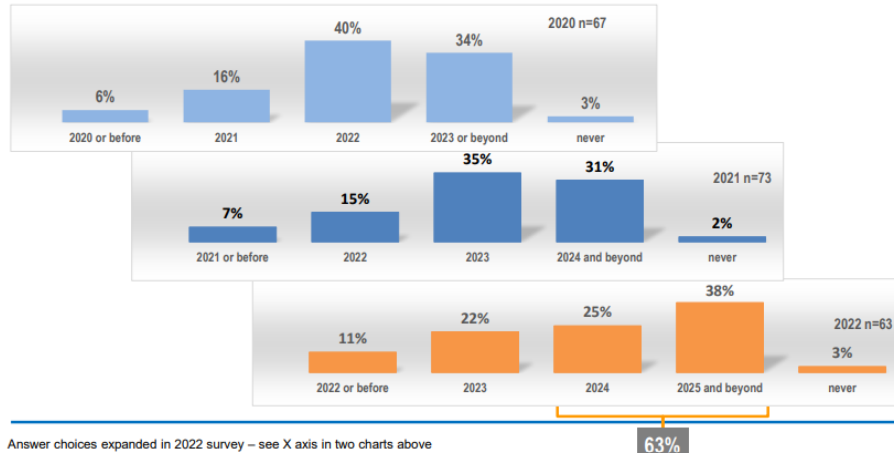

Figure 10: Survey Predictions – Deep Learning in Use in Mask Making

2.5 Survey Says ILT Consistently Used on a Few Critical Layers

A repeat survey question asked how broadly ILT is used for production chips today (2022) including use for hotspots only. Of those responding to the survey question, >90% say that ILT is used for production chips in 2022 when combining the responses indicating a few, some or all critical layers of leading-edge nodes use ILT. This is the sixth year this survey question has been used. The results are shown in Figure 11.
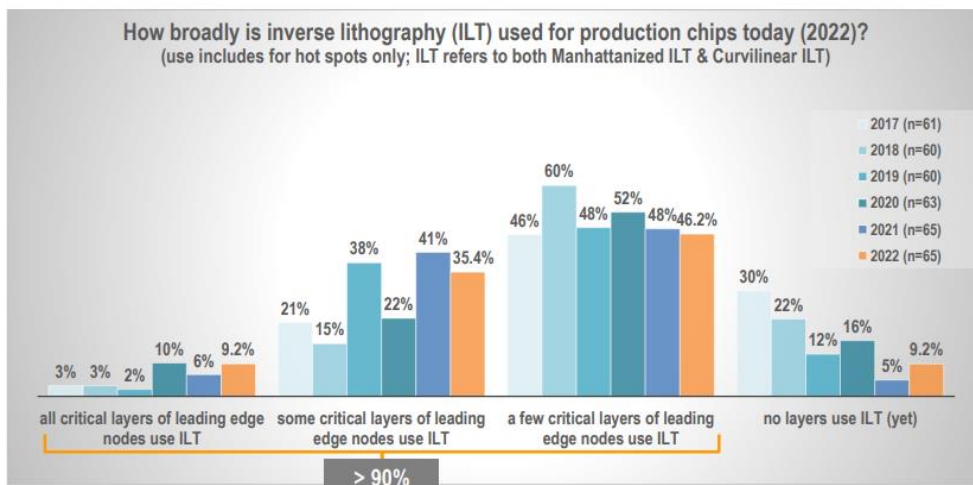

Figure 11: Survey Predictions – Production Use of ILT Today

2.6   Confidence in Manufacturing Curvilinear Masks Remains High

A new question was added in 2021 and repeated in 2022 where survey participants ranked six concerns in producing curvilinear masks, with a ranking of one representing the biggest concern. Mask shop software infrastructure was ranked number one in 2022 whereas mask inspection was ranked as the highest concern in 2021. Access to multi-beam mask writers was ranked as less of a concern in 2022 in fifth place compared to third place in 2021. The respondent rankings for each reason are plotted inside the corresponding rectangle in Figure 12.
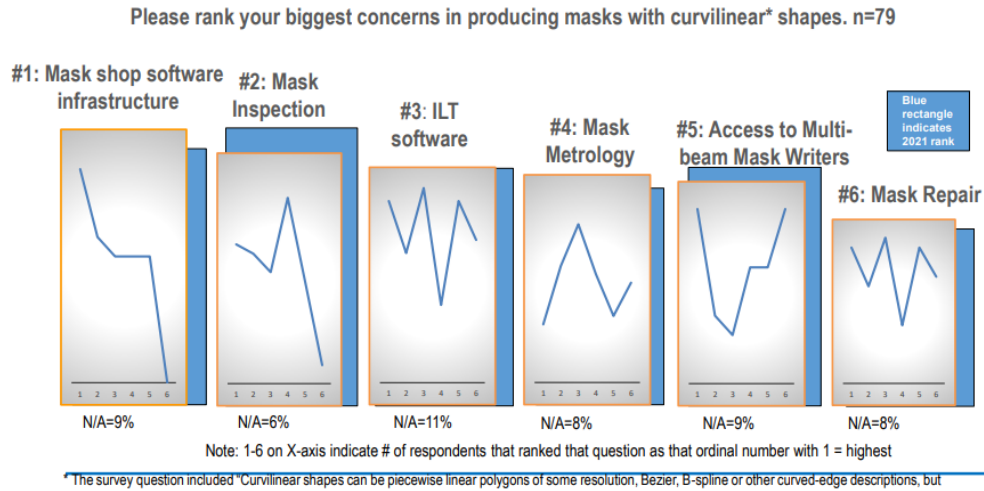

Figure 12: Survey Predictions – Ranking Concerns in Producing Curvilinear Masks

Building on the survey question in Figure 12, the survey asked a new follow-on question in 2021 which was repeated in 2022. Participants were asked to choose one statement they agreed with most regarding high volume manufacturing of masks containing curvilinear features by the end of 2023. Only 1% say that concerns are insurmountable for now as shown in Figure 13, while 76% indicate that leading-edge mask shops can handle at least a limited number of curvilinear masks, an improvement over the 2021 result of 71%.
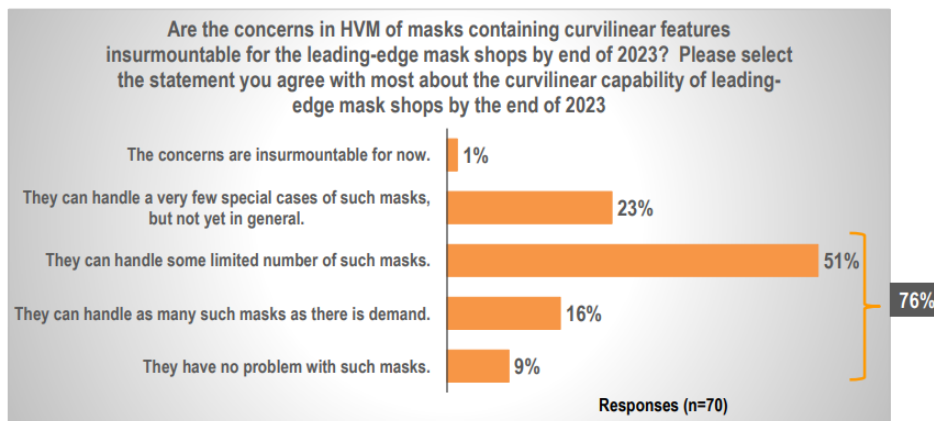

Figure 13: Survey Predictions – HVM of Curvilinear Masks by end of 2023

3. ACKNOWLEDGEMENTS

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