



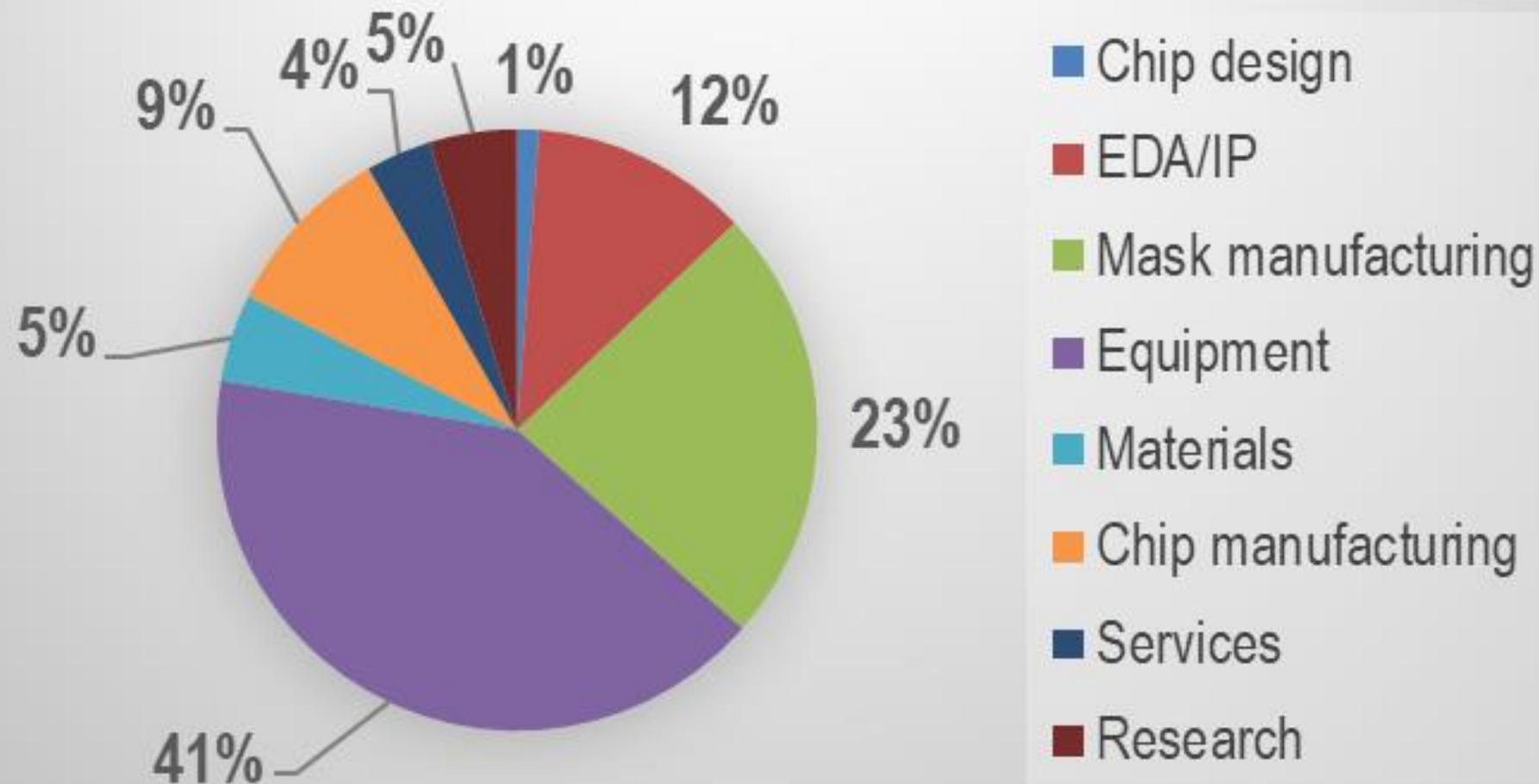
**Beam**  
**Initiative**

# 85 Luminaries Participated in the 12<sup>th</sup> Annual Survey

Representing 47 different companies in July 2023



What part of the semiconductor ecosystem is your primary focus?



# Luminaries Confident in High-NA EUV and Curvilinear Masks

## 12<sup>th</sup> Annual Luminaries Survey - July 2023



- **Luminaries remain confident in broad High-NA EUV adoption by 2028**
- **Confidence doubled in leading-edge mask shops handling curvilinear mask demand**
- **Curvilinear masks aren't just for EUV**
- **Luminaries are more confident about 2023 mask revenues than SEMI**

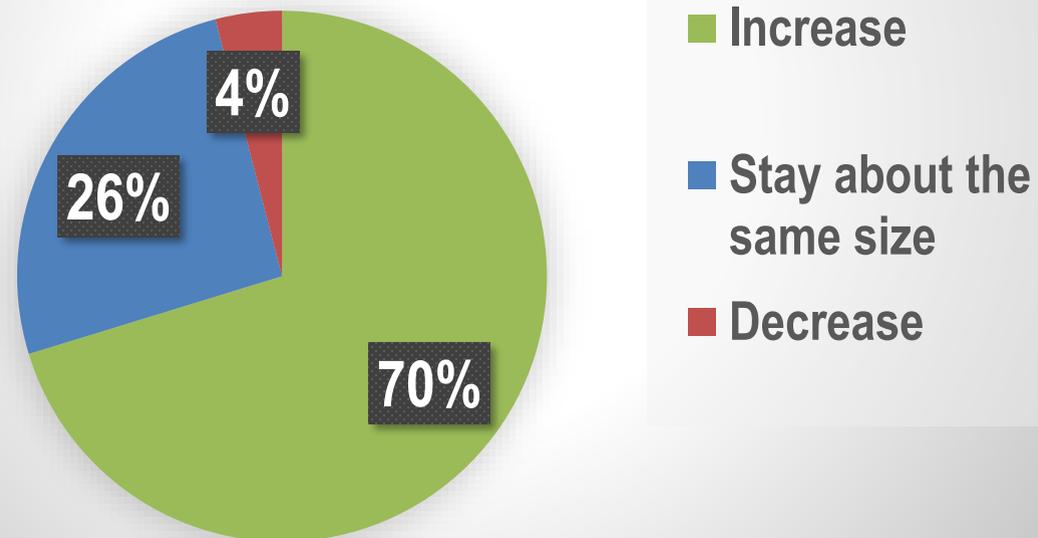
# 83% Say 2023 Mask Revenues Increase or Stay the Same

## While SEMI predicts a 3% contraction for 2023



### 2022 Survey Result

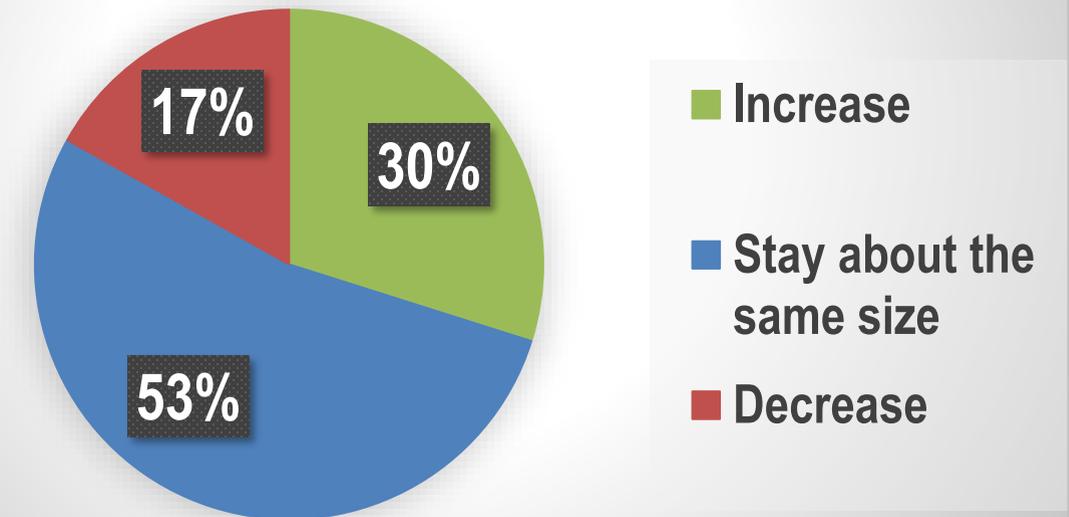
Net of all effects (including COVID-19), what will happen to the size of the 2022 total mask revenues compared to 2021? n=74



### 2023 Survey Result

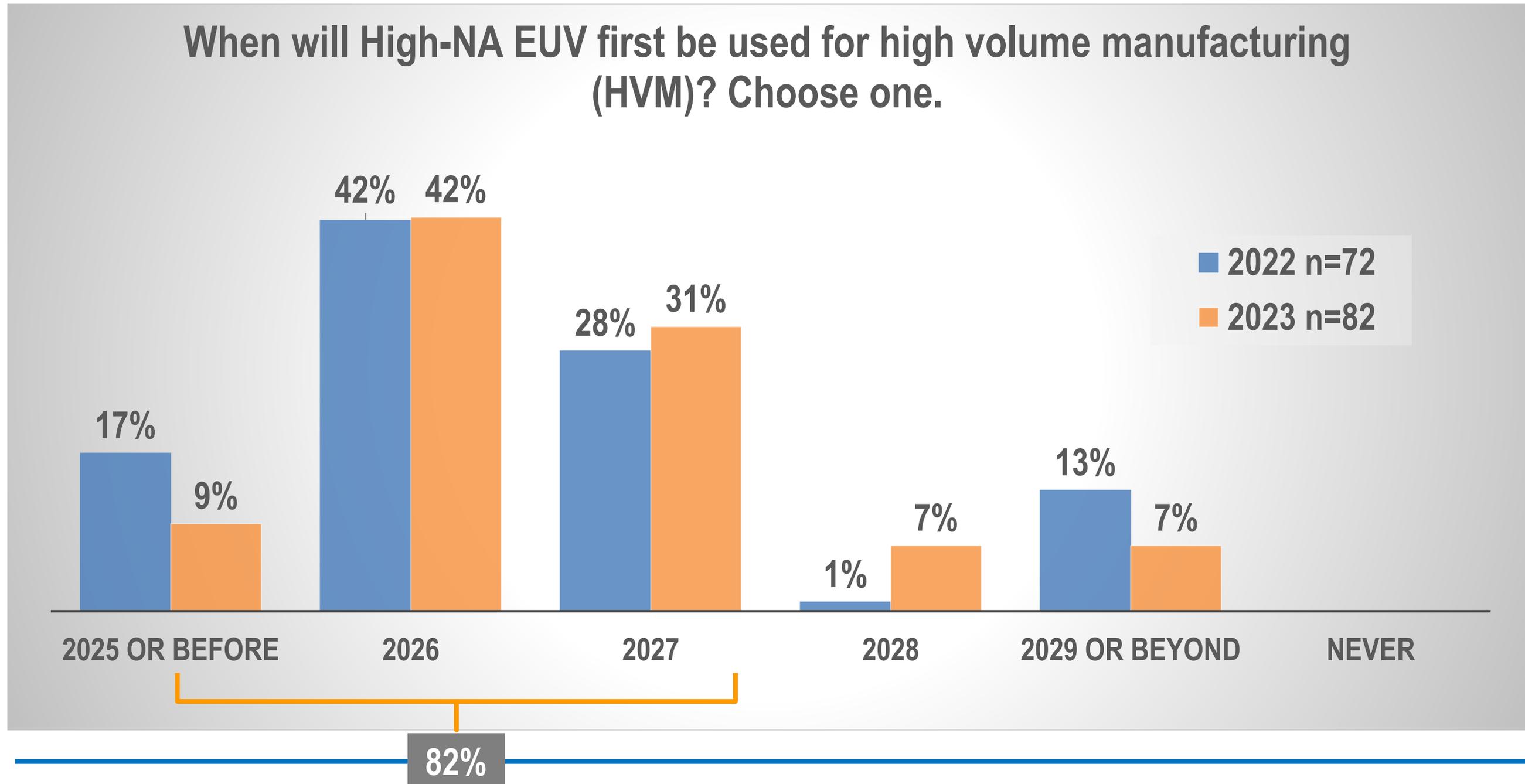
According to SEMI's 2022 Photomask Characterization Study, the worldwide semiconductor photomask market achieved its tenth consecutive year of growth in 2022 amounting to \$5.5 billion. A contraction of 3% is projected by SEMI in 2023 due to the macroeconomic headwinds and the overall semiconductor industry slowdown.

Net of all effects, what will happen to the size of the 2023 total mask revenues compared to 2022? n=77



# 82% Predict High-NA EUV First HVM Usage by 2027

## Similar to last year

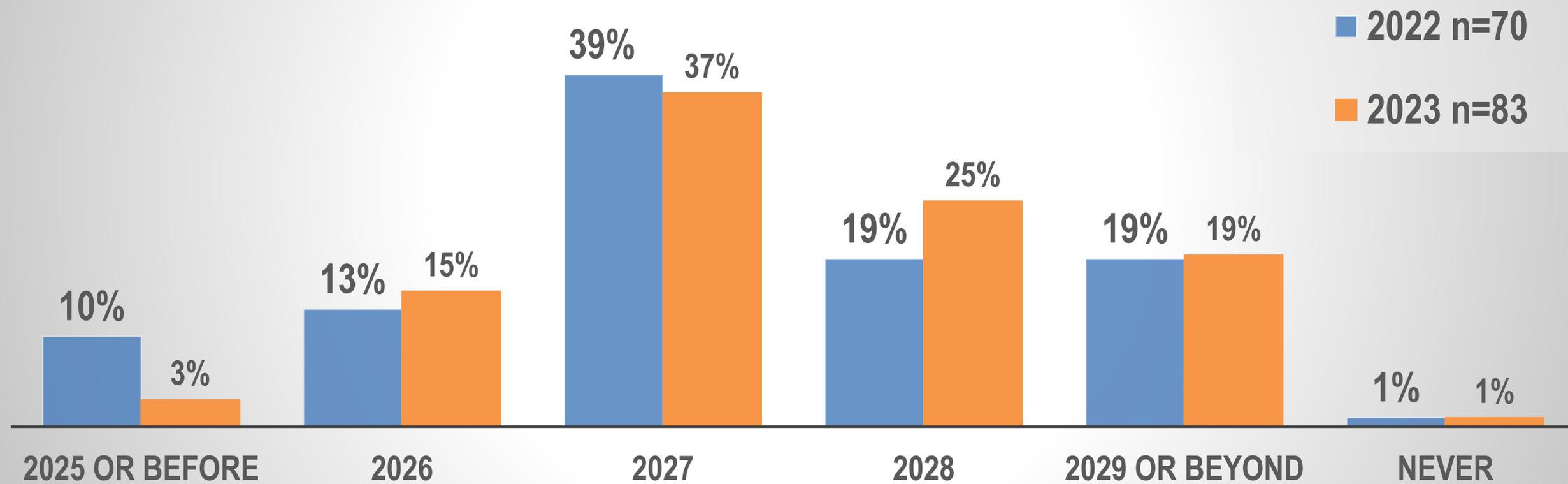


# Broad High-NA EUV Adoption to Ramp Up by 2028

80% say by 2028 or before, same as last year



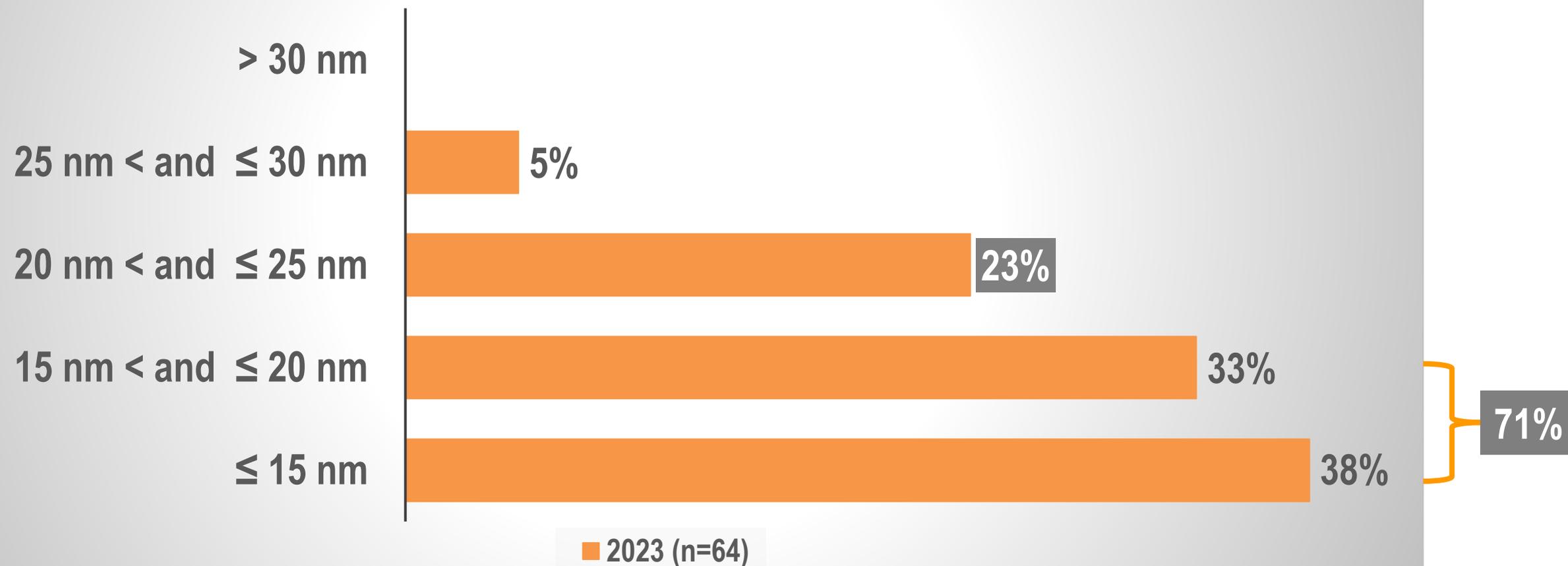
When will there be broad high volume manufacturing (HVM) adoption of High-NA EUV by more than one company? Please choose one.



80%

# 71% Say Min Mask Dimension for High-NA EUV $\leq 20\text{nm}$

New: SRAFs in the 4X dimension for High-NA EUV masks will need to be smaller. What will be the required minimum dimension (on mask) that mask shops need to manufacture for HVM production using High-NA EUV?

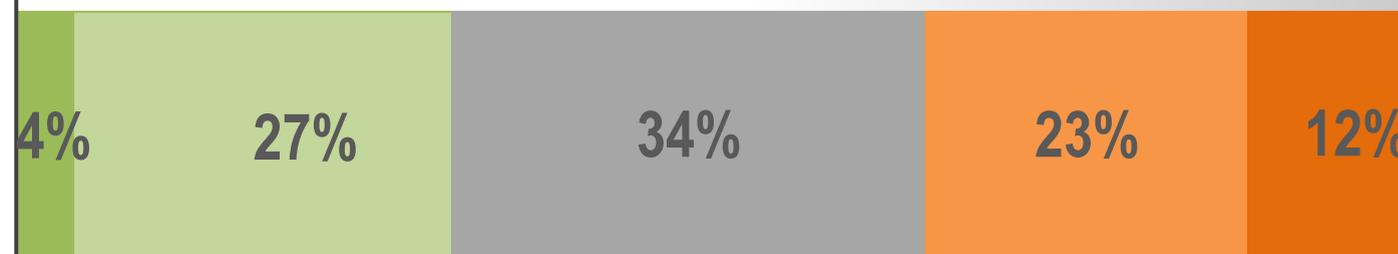


# No Agreement on Larger High-NA EUV Mask Size

New question may have been confusing

New: Please indicate your level of agreement or disagreement with the following statements:

High-NA EUV masks will be larger in dimensions. (n=74)



■ Strongly agree ■ Agree ■ Neither agree or disagree ■ Disagree ■ Strongly disagree

# 95% Agree Multi-Beam Mask Writers Needed for EUV

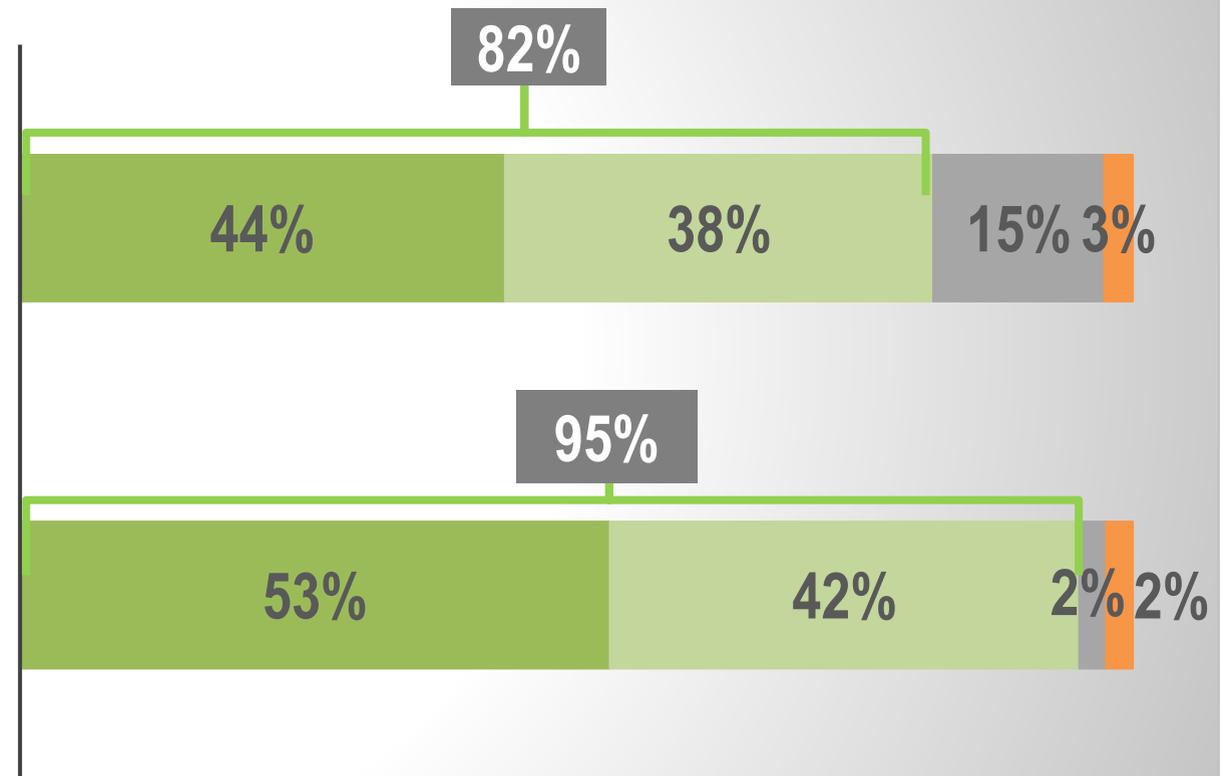
## 82% agree they are more accurate/precise vs leading-edge VSB



New: Please indicate your level of agreement or disagreement with the following statements:

Multi-beam mask writers are more accurate/precise as compared to leading-edge VSB writers. (n=78)

Multi-beam mask writers are needed to write EUV masks, whether for Manhattan or curvilinear shapes. (n=83)

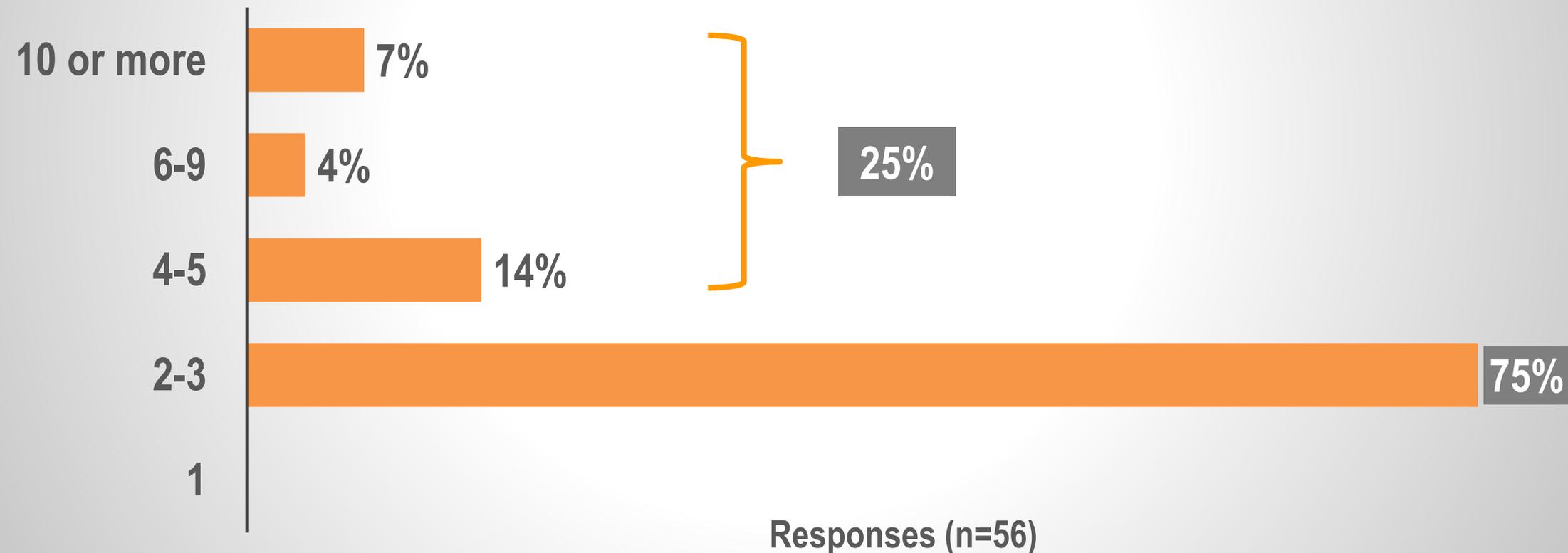


Strongly agree Agree Neither agree or disagree Disagree Strongly disagree

# 75% Say 2-3 EUV Masks Needed If No Pellicle

25% think 4 or more, some much more

New: On the average overall for the whole industry, for EUV masks without pellicles, how many masks will be produced per exposure layer of a mask design this year?

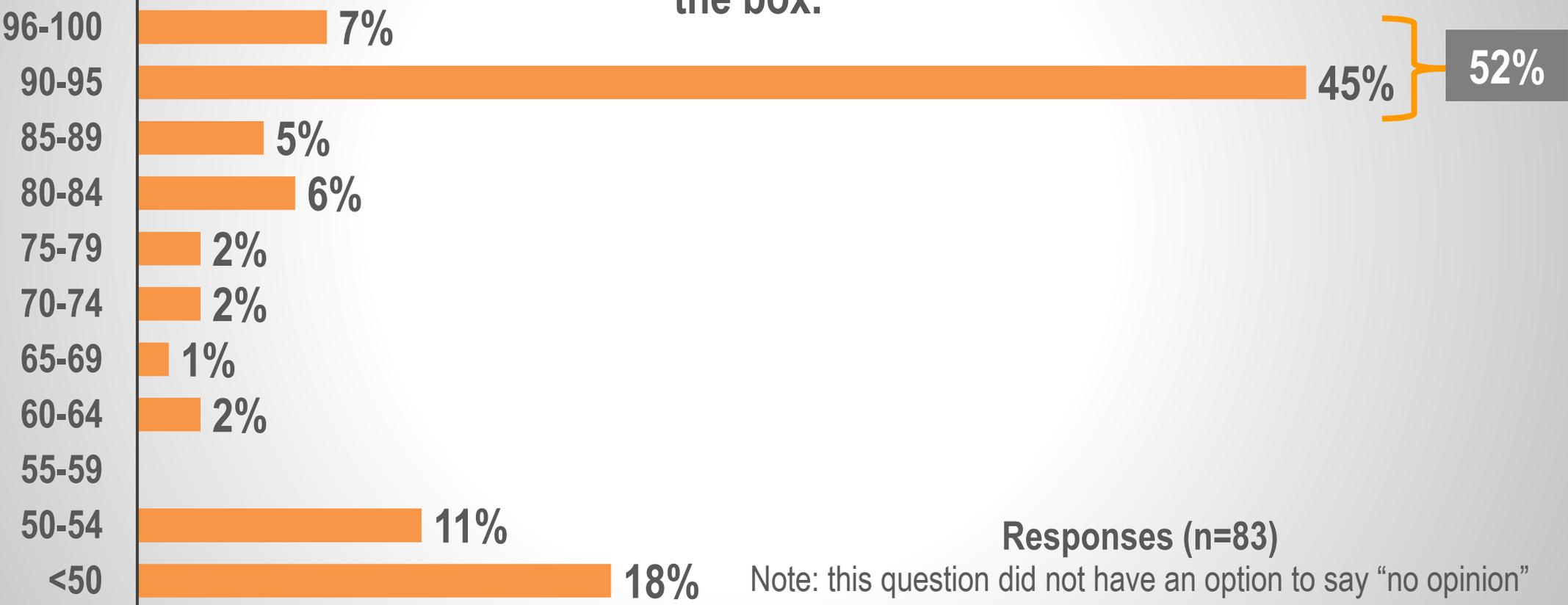


# Half Say $\geq 90\%$ Transmission Rate to Use EUV Pellicle

## Wide range expressed by other half of respondents



New: At what one-way transmission rate do you think most of .33 NA EUV high volume manufacturing (HVM) masks will end up with pellicles on them? You can answer by sliding the bar or inputting a number in the box.

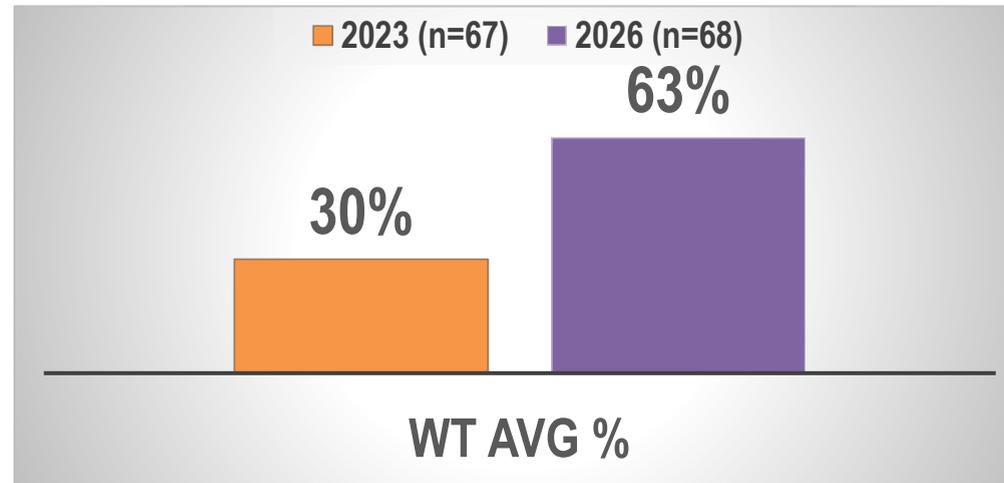


Responses (n=83)

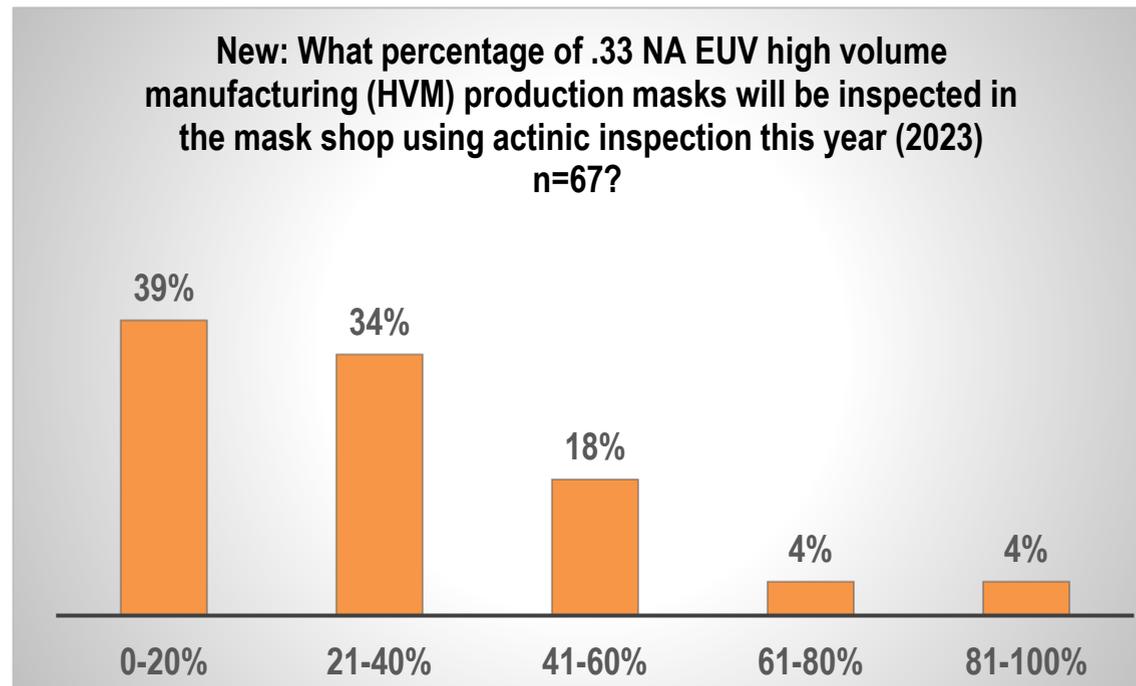
Note: this question did not have an option to say “no opinion”  
Two respondents didn’t complete this question.

# EUV Masks Inspected by Actinic to Double in 3 Years

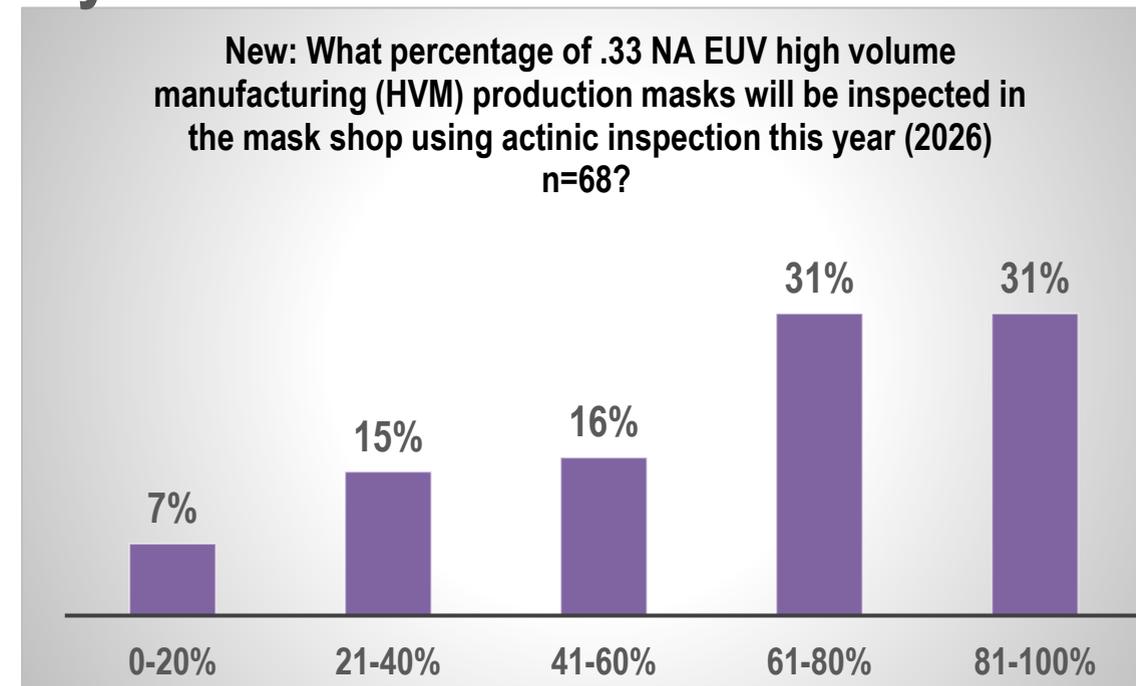
## Survey says it will double to >60% by 2026



### By 2023



### By 2026



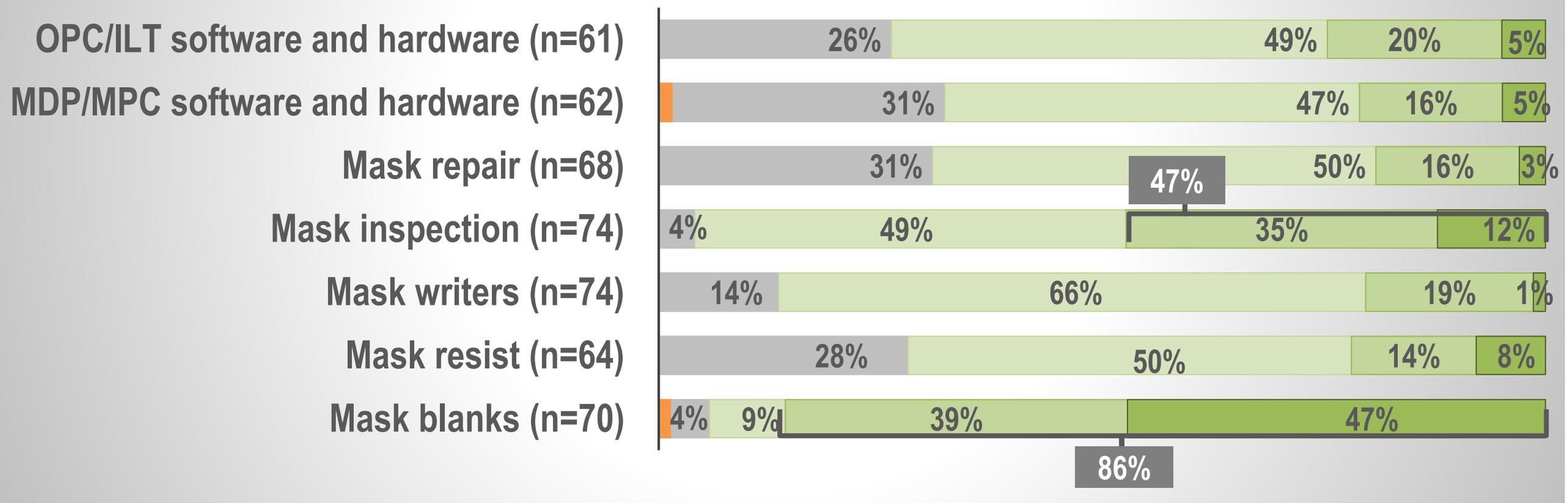
# Majority Say All of EUV Mask Making is More Expensive



86% say EUV blanks, 47% say EUV inspection equipment >2X cost of 193i

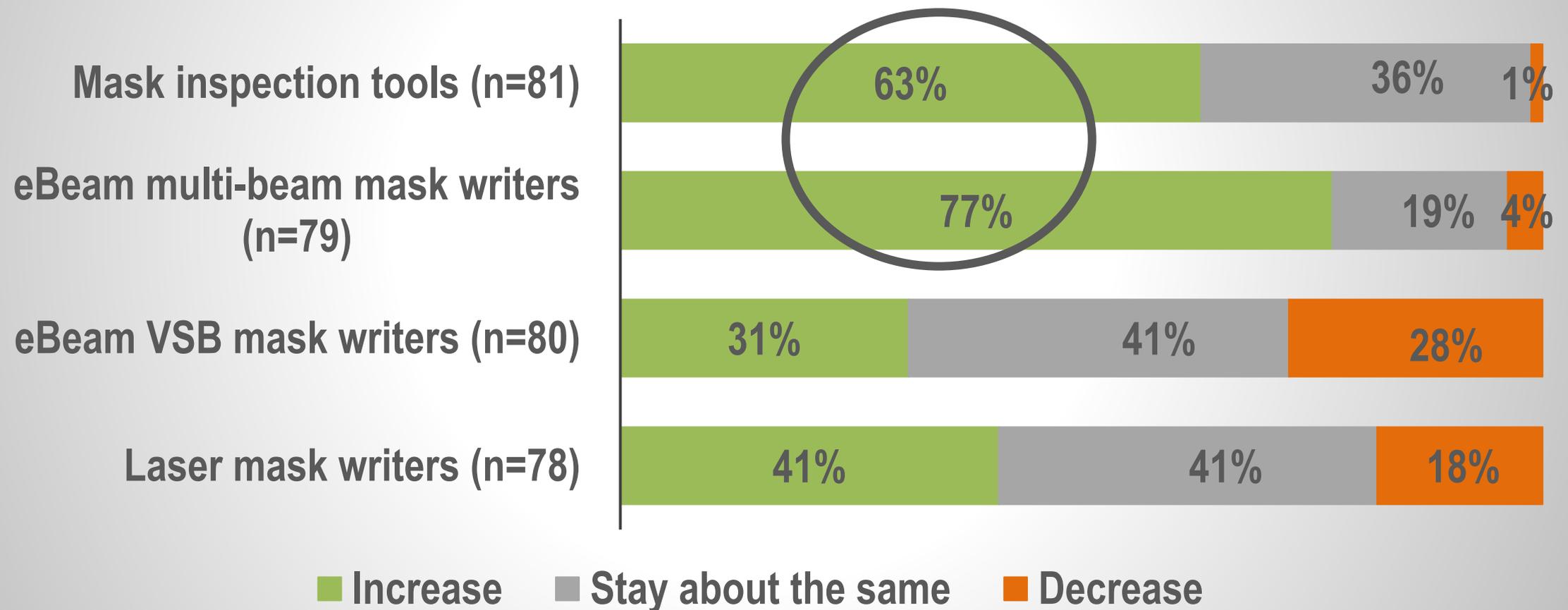
New: How much more expensive is EUV versus 193i leading-edge mask equipment, materials and software?

■ Cheaper 
 ■ About the same 
 ■ More expensive (up to 2X) 
 ■ Very expensive (up to 5X) 
 ■ Significantly more expensive (>5X)



# Mask Inspection and Multi-beam Mask Writer Investment Predicted to Increase for 193i

New: What do you predict will happen to overall investment in equipment purchase for 193i only over the next 3 years?

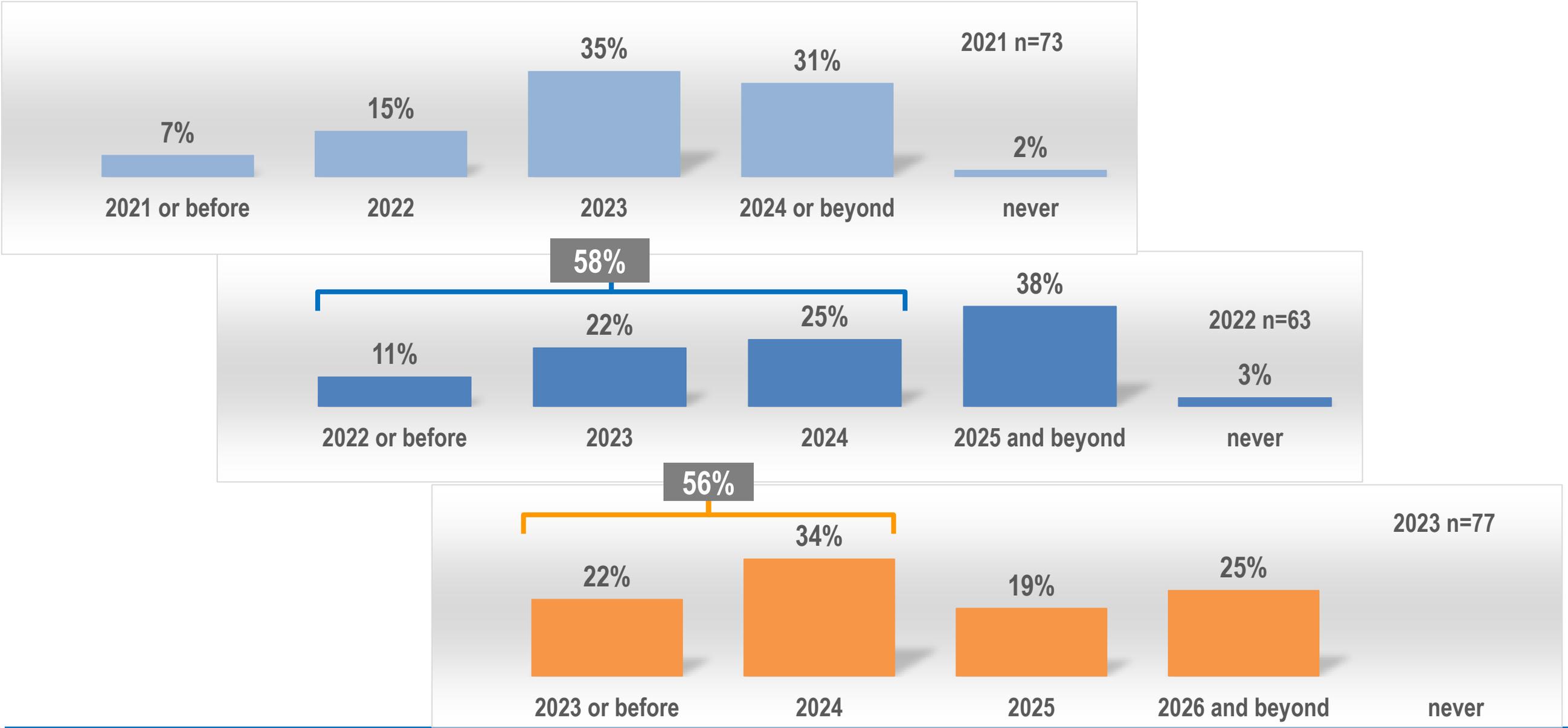


# Deep Learning Perception No Longer Shifting Into Future

## 56% say 2024 or before this year and 58% last year

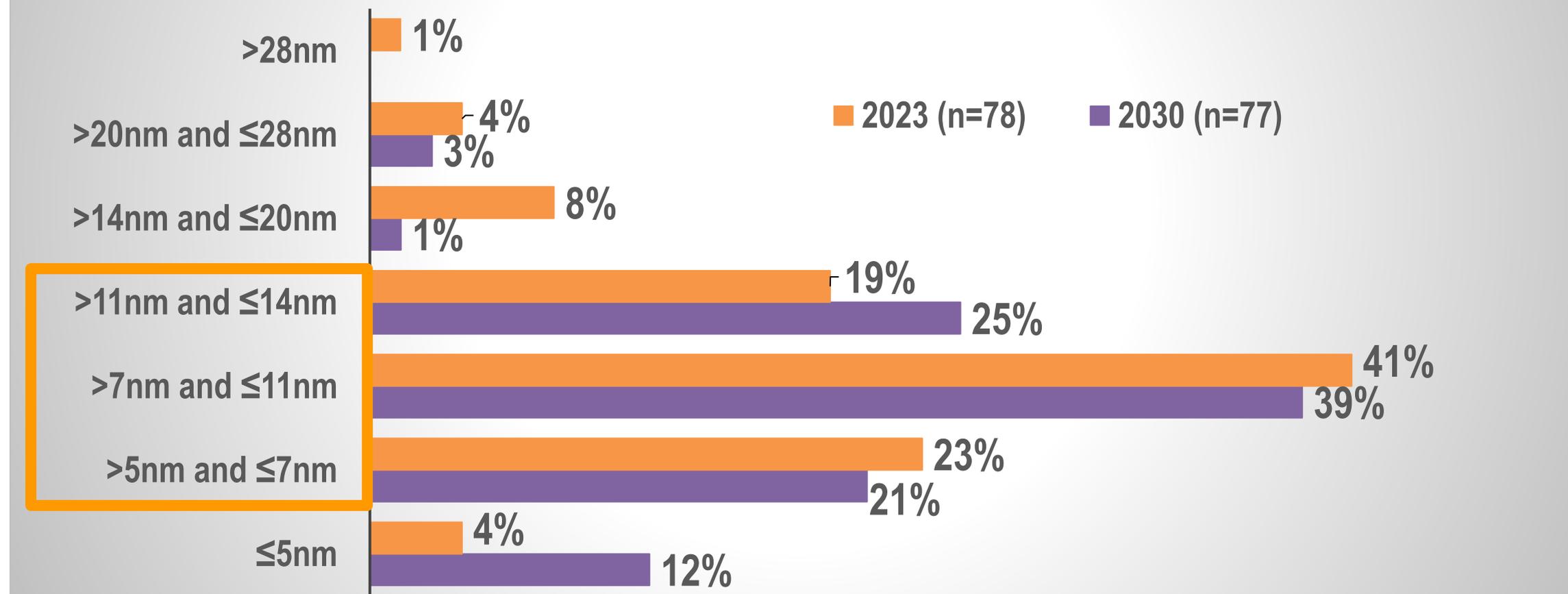


In the mask industry, when will capabilities based on deep learning become a competitive advantage for any step in the mask making process?



# “Non-EUV Leading Edge” Node Ranges >5nm to ≤ 14nm

New: "Non-EUV leading edge for the industry" is a node at which fabs using 193i lithography reaches a practical limit of economic viability.  
Which logic node is that today (2023) and in 7 years (2030)?



# Survey Predicts Curvilinear ILT for 193i as well as EUV

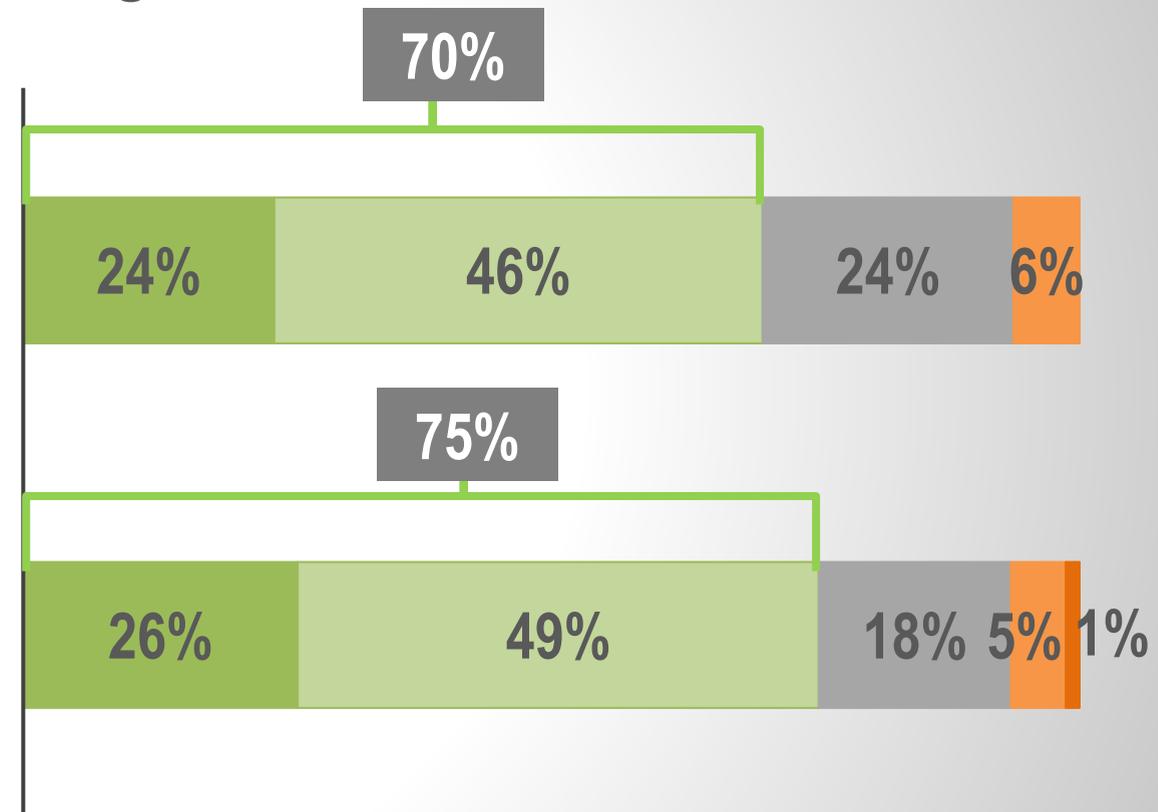
70% agree useful for 193i, 75% agree needed for 2nm .33 NA EUV



New: Please indicate your level of agreement or disagreement with the following statements:

Curvilinear ILT is useful for 193i for non-EUV leading-edge nodes. (n=80)

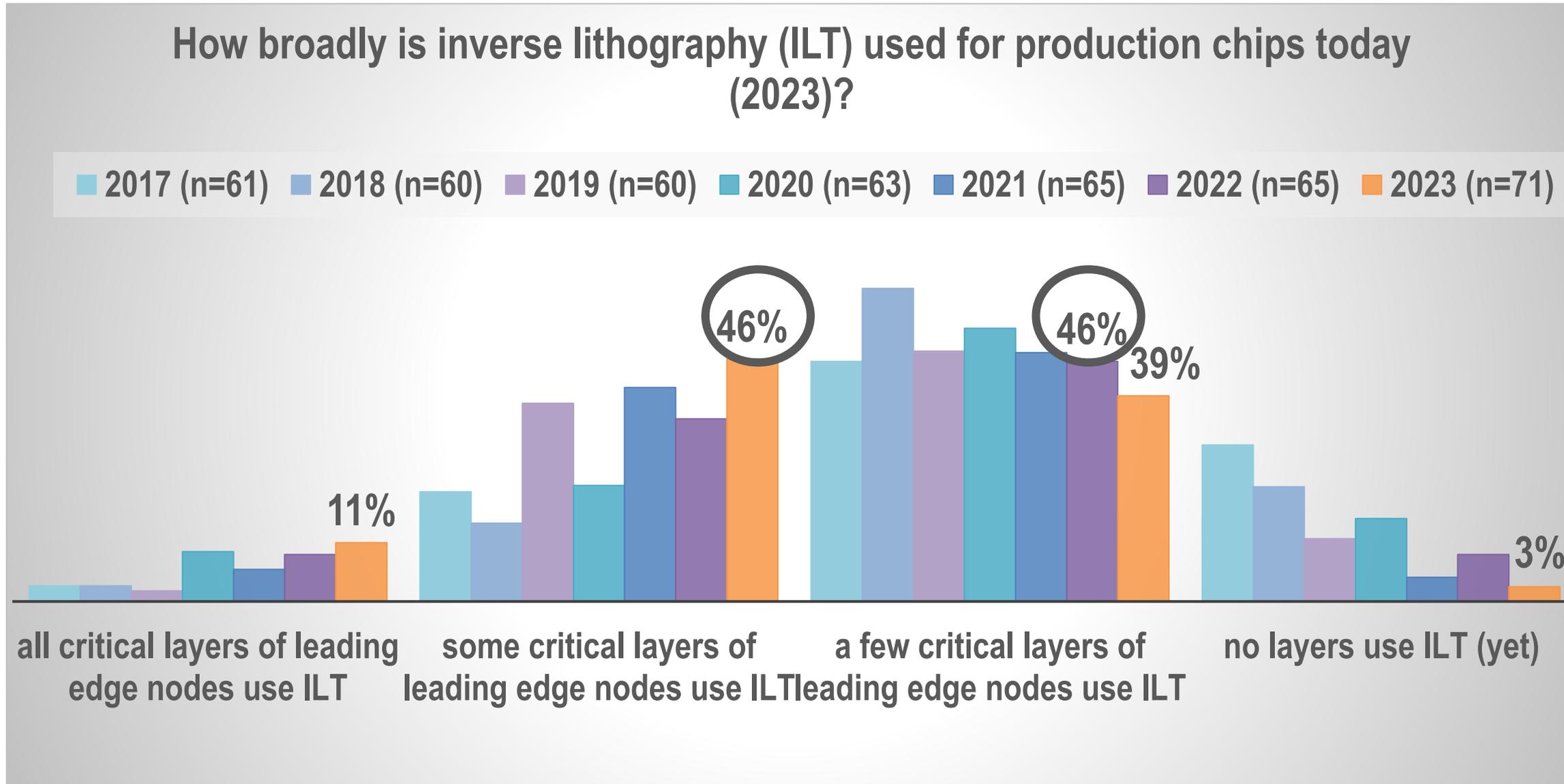
Curvilinear ILT is needed for 2nm logic with .33 NA EUV at least for hot spots. (n=77)



Strongly agree Agree Neither agree or disagree Disagree Strongly disagree

# Survey Trend is Towards More Critical Layers Using ILT

46% say “some critical layers” in 2023 vs 46% said a “few” in 2022

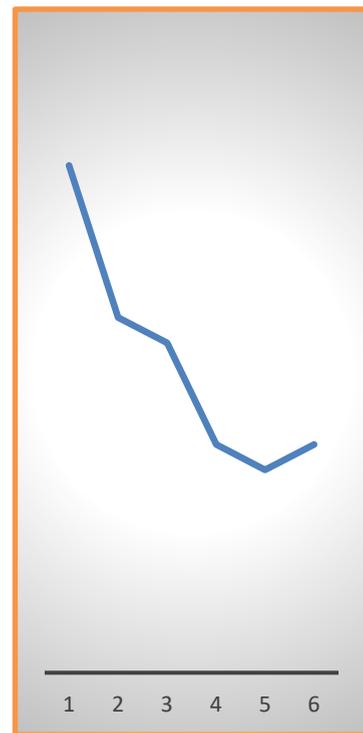


# No Major Change in Curvilinear Mask Making Concerns



Please rank your biggest concerns in producing masks with curvilinear\* shapes. n≥71

**#1: Mask shop software infrastructure**



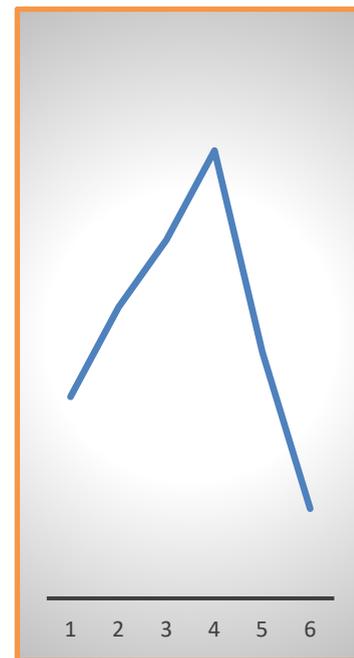
N/A=14%

**#2: Mask Inspection**



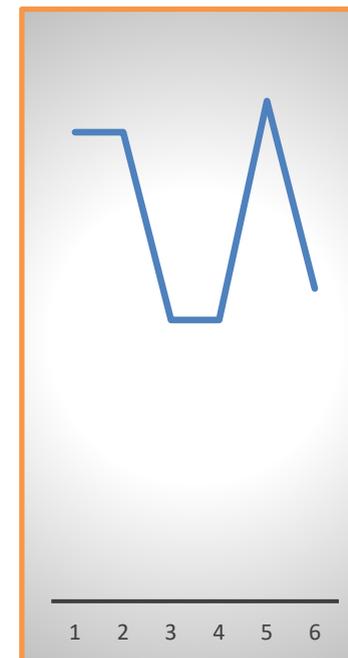
N/A=13%

**#3: Mask Metrology**



N/A=14%

**#4: ILT software**



N/A=13%

**#5: Access to Multi-beam Mask Writers**



N/A=16%

**#6: Mask Repair**



N/A=15%

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

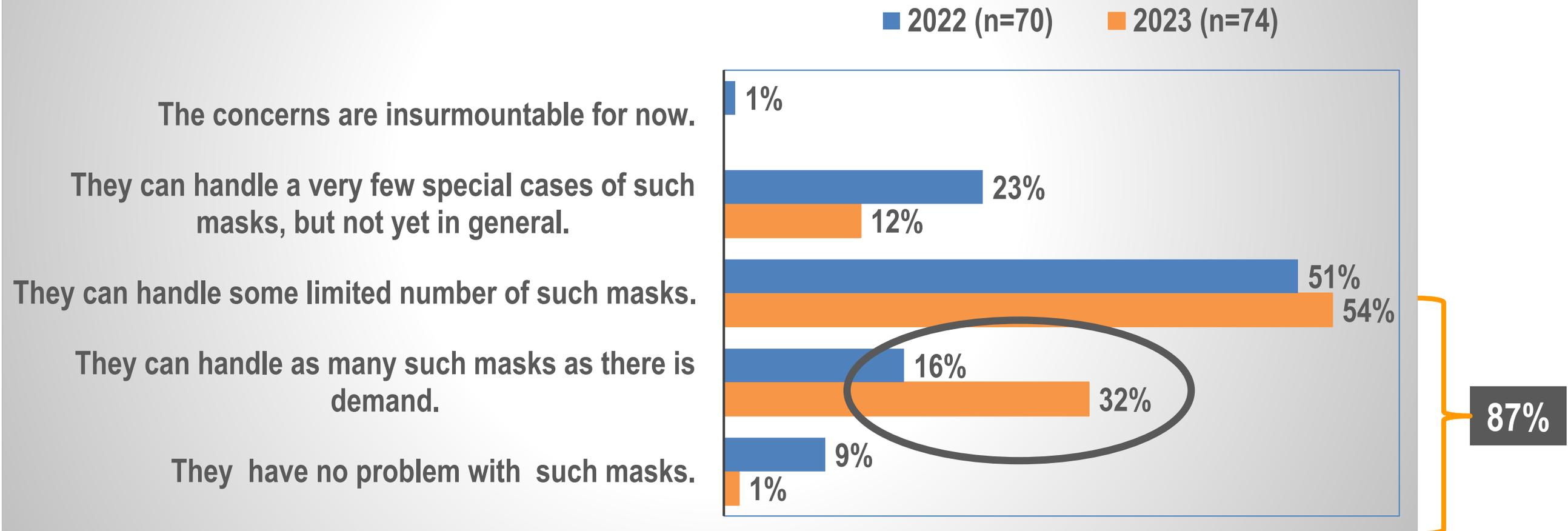
\* The survey question included "Curvilinear shapes can be piecewise linear polygons of some resolution, Bezier, B-spline or other curved-edge descriptions, but excludes shapes that only contain Manhattan or 45-degree straight edges."

# Confidence Doubled in Handling Curvilinear Mask Demand

## 87% say leading-edge 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 2023? Please select the statement you agree with most about the curvilinear capability of leading-edge mask shops by the end of 2023



# Luminaries Confident in High-NA EUV and Curvilinear Masks

## 12<sup>th</sup> Annual Luminaries Survey - July 2023



- **Luminaries remain confident in broad High-NA EUV adoption by 2028:** 80% of Luminaries surveyed say more than one company will adopt High-NA EUV by 2028, same as last year.
- **Confidence doubled in leading-edge mask shops handling curvilinear mask demand:** 32% said they can handle the demand vs 16% last year; while 87% of Luminaries say leading-edge mask shops can handle at least a limited number.
- **Curvilinear masks aren't just for EUV:** 70% of Luminaries say curvilinear masks are useful for non-EUV leading edge nodes.
- **Luminaries are more confident than SEMI about 2023 mask revenues:** 83% of Luminaries say 2023 mask revenues will increase (30%) or stay the same (53%) despite SEMI forecasting a contraction of 3%.

**Thank you to those who participated  
in the survey!**

**Luminaries survey results available on [www.ebeam.org](http://www.ebeam.org)**