# Luminaries Report Positive EUV Impact on Mask Trends
11th Annual Luminaries Survey - July 2022

- **EUV viewed as a positive impact for mask revenue**

- **EUV remains the top reason for purchasing multi-beam mask writers**

- **Confidence remains high in ability to make curvilinear masks with availability of multi-beam mask writers less of an issue this year**

Thank You to Those Who Participated
## 79 luminaries across 44 different companies in July 2022

What part of the semiconductor ecosystem is your primary focus?

- Chip design
- EDA/IP
- Mask manufacturing
- Equipment
- Materials
- Chip manufacturing
- Services
- Research
- Other
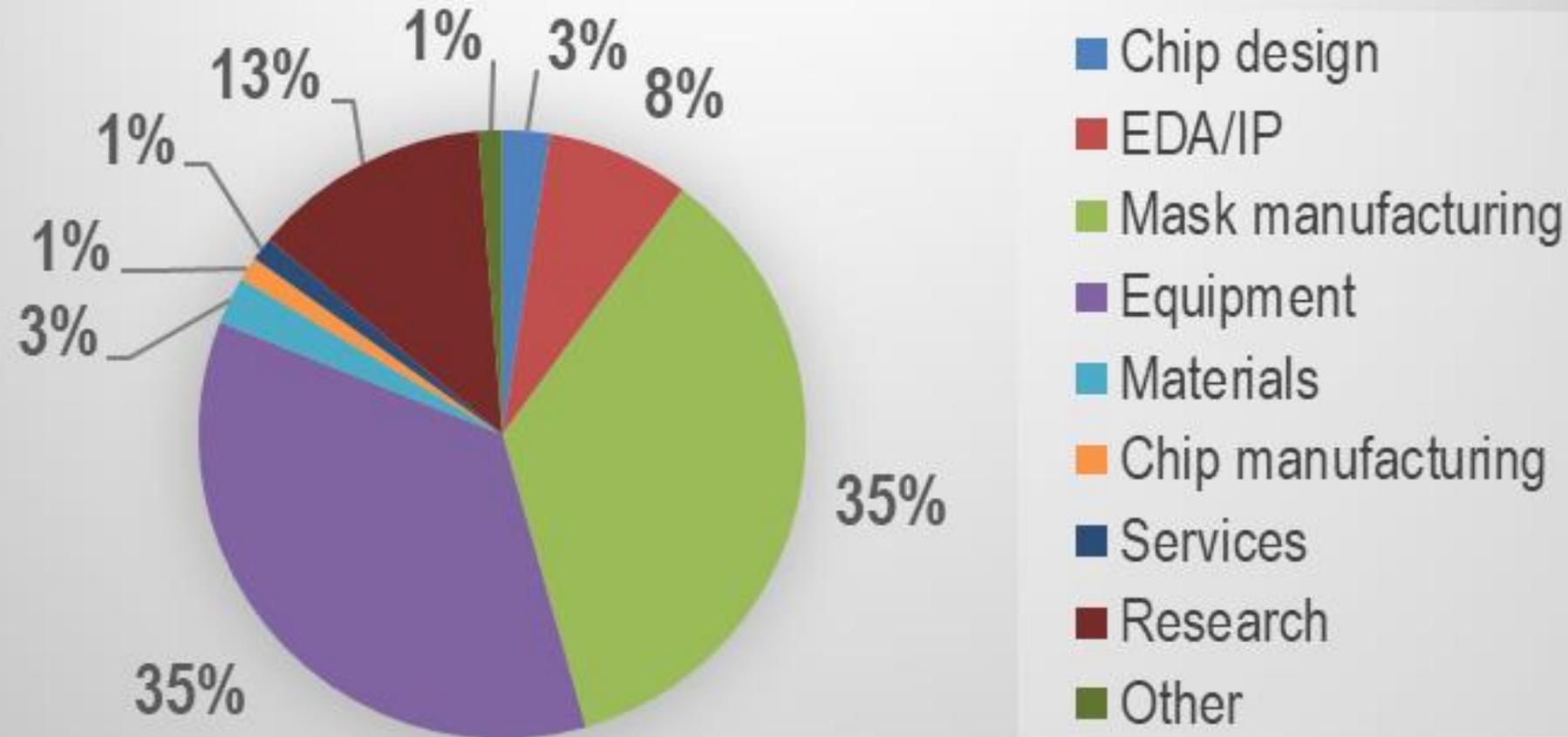
EUV Masks Viewed as a Positive for Mask Revenues
78% say so in 2022 and 74% in 2021

2021 Survey Result

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 2021 mask revenues? n=74

- Positive
- Neutral
- Negative

3%
23%
74%
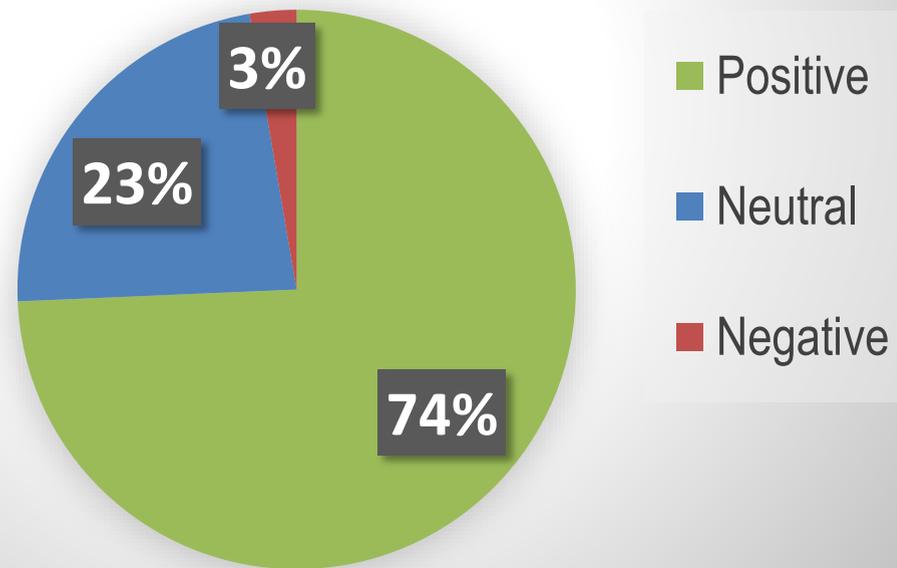
2022 Survey Result

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 2022 mask revenues? n=72

- Positive
- Neutral
- Negative

1%
21%
78%
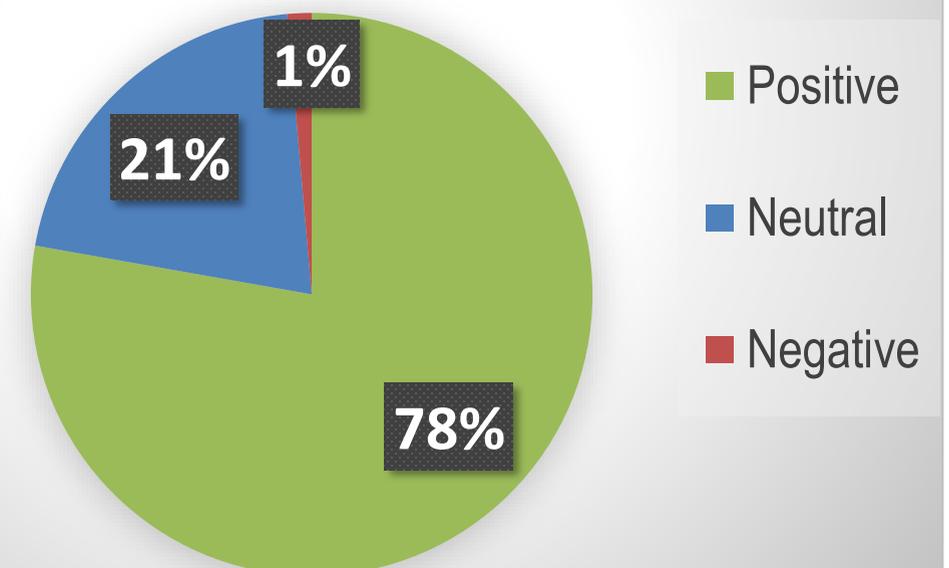
70% Say Mask Revenues to Increase Again in 2022

e Beam Initiative

2021 Survey Result

Net of all effects (including COVID-19), what will happen to the size of the 2021 total mask revenues compared to 2020? n=74

- Increase
- Stay about the same size
- Decrease

4%

24%

72%
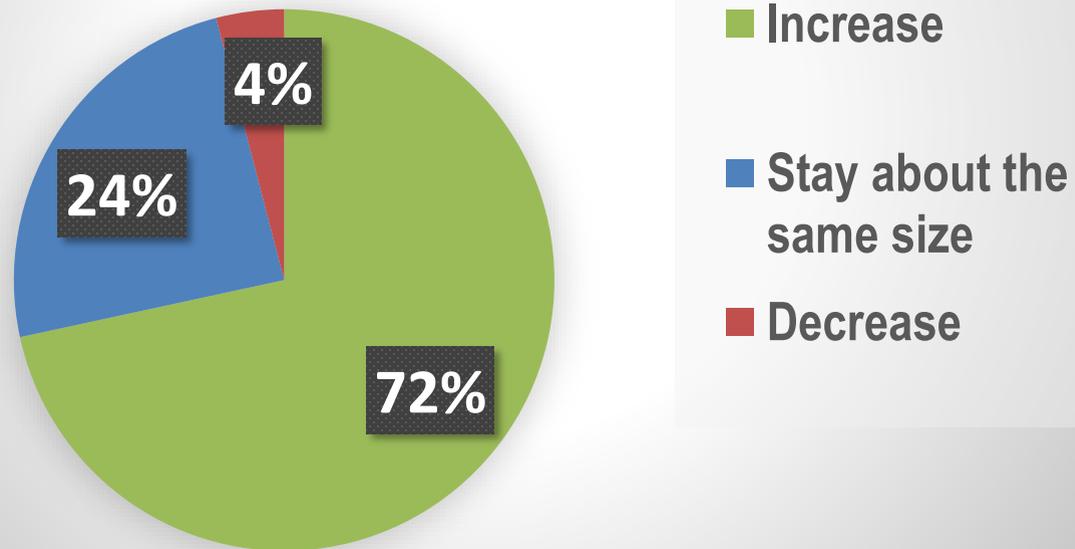
2022 Survey Result

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

- Increase
- Stay about the same size
- Decrease

4%

26%

70%
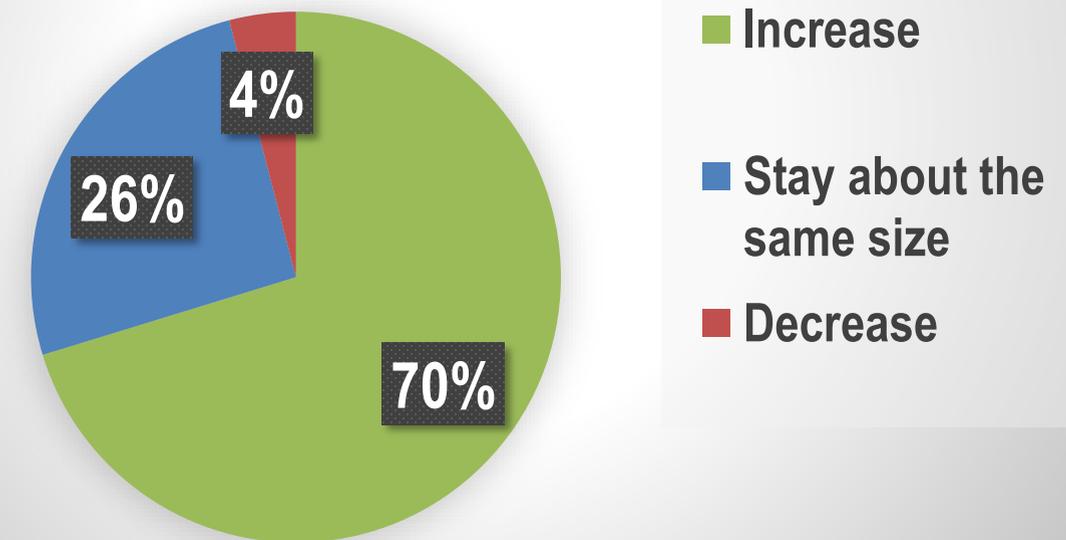
Confidence in Actinic EUV Inspection Remains High

Wafer inspection agreement up to 71% from 60% in 2021; eBeam mask inspection down to 24% from 42% in 2021


Regarding EUV mask pattern inspection, please indicate your level of agreement with the following statements (2022):

Actinic inspection will be used in the mask shop for .33 NA EUV high volume manufacturing (HVM) by 2023 (n=71): 1% | 14% | 15% | 44% | 25% — **69%**

eBeam multi-beam inspection will be used in the mask shop for .33 NA EUV HVM by 2023 (n=69): 7% | 41% | 28% | 20% | 4% — **24%**

Inspection of wafers will be used for the purpose of mask inspection for .33 NA EUV HVM by 2023 (n=67): 1% | 12% | 15% | 58% | 13% — **71%**

eBeam multi-beam inspection of wafer will be used for the purpose of mask inspection for .33 NA EUV HVM by 2023 (n=66): 12% | 27% | 21% | 33% | 6% — **39%**

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

5

23% Say EUV Pellicles for HVM by end of 2022

First year answers have trended up from 3% in 2020 to 23% in 2022

By the end of which year do you predict a pellicle will be used for .33 NA EUV high volume manufacturing by at least one company?

2020 n=72

2020	2021	2022	2023 OR BEYOND
3%	14%	38%	32%

I CAN'T PREDICT	NEVER
13%	1%

2021 n=73

2021	2022	2023	2024 OR BEYOND
10%	33%	32%	11%

I CAN'T PREDICT	NEVER
15%	0%

2022 n=71

2022	2023	2024	2025 OR BEYOND	I CAN'T PREDICT	NEVER
23%	28%	18%	14%	17%	0%

Answer choices expanded in 2022 survey – see X axis in two charts above

6
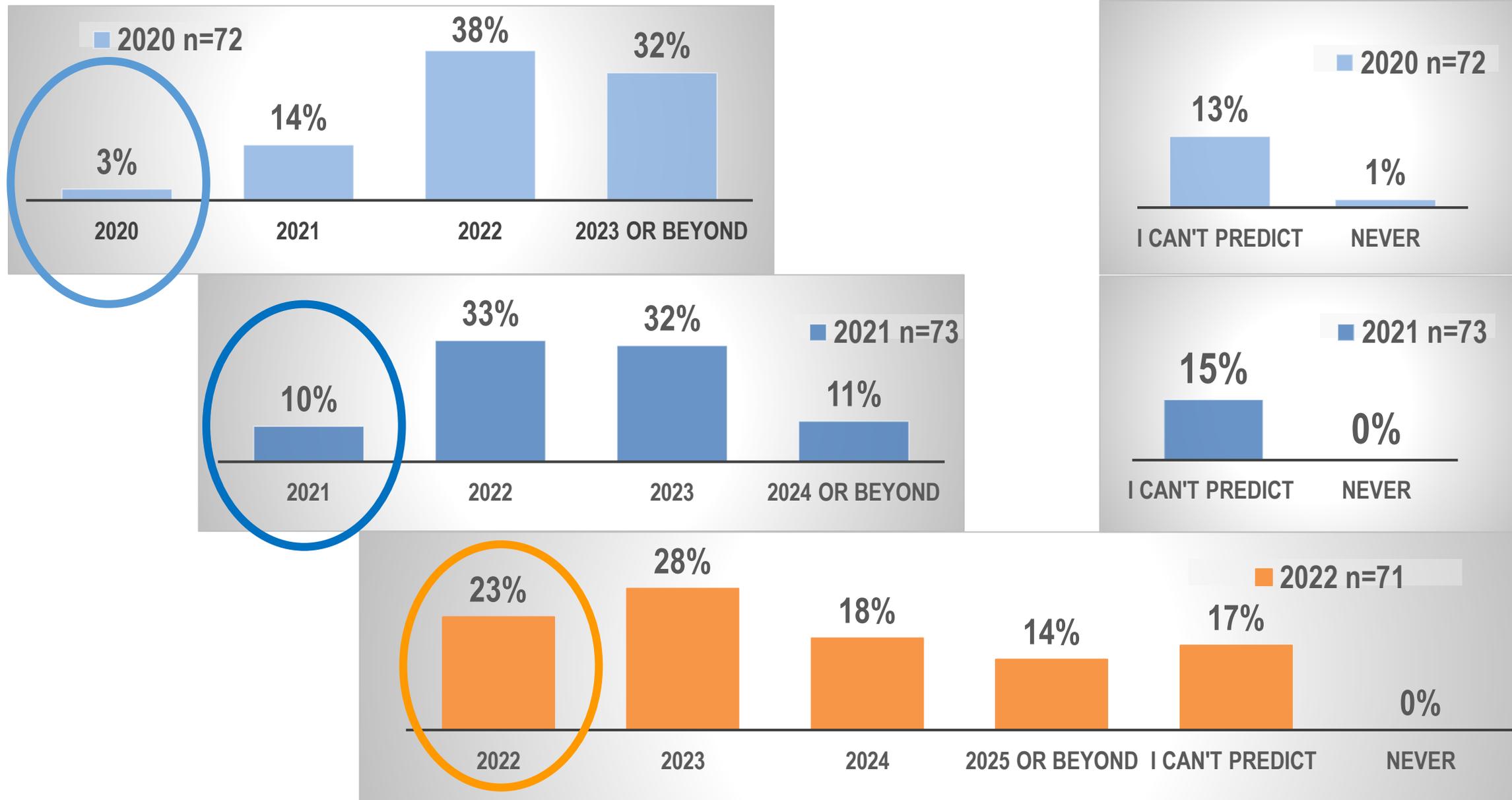
EUV TAT To Remain Longer vs 193i in 2024
70% say so for 2024; 74% said so for 2023 last year

Left chart: Turnaround time is critical to the mask business. How will EUV mask turnaround times in <u>2023</u> compare to leading-edge 193i mask turnaround times of today?

Category	2021 (n=75)	2020 (n=67)
Much shorter	0%	1%
Shorter	3%	4%
About the same	24%	21%
Longer	51%	63%
Much longer	23%	10%

Longer + Much longer: **74%**
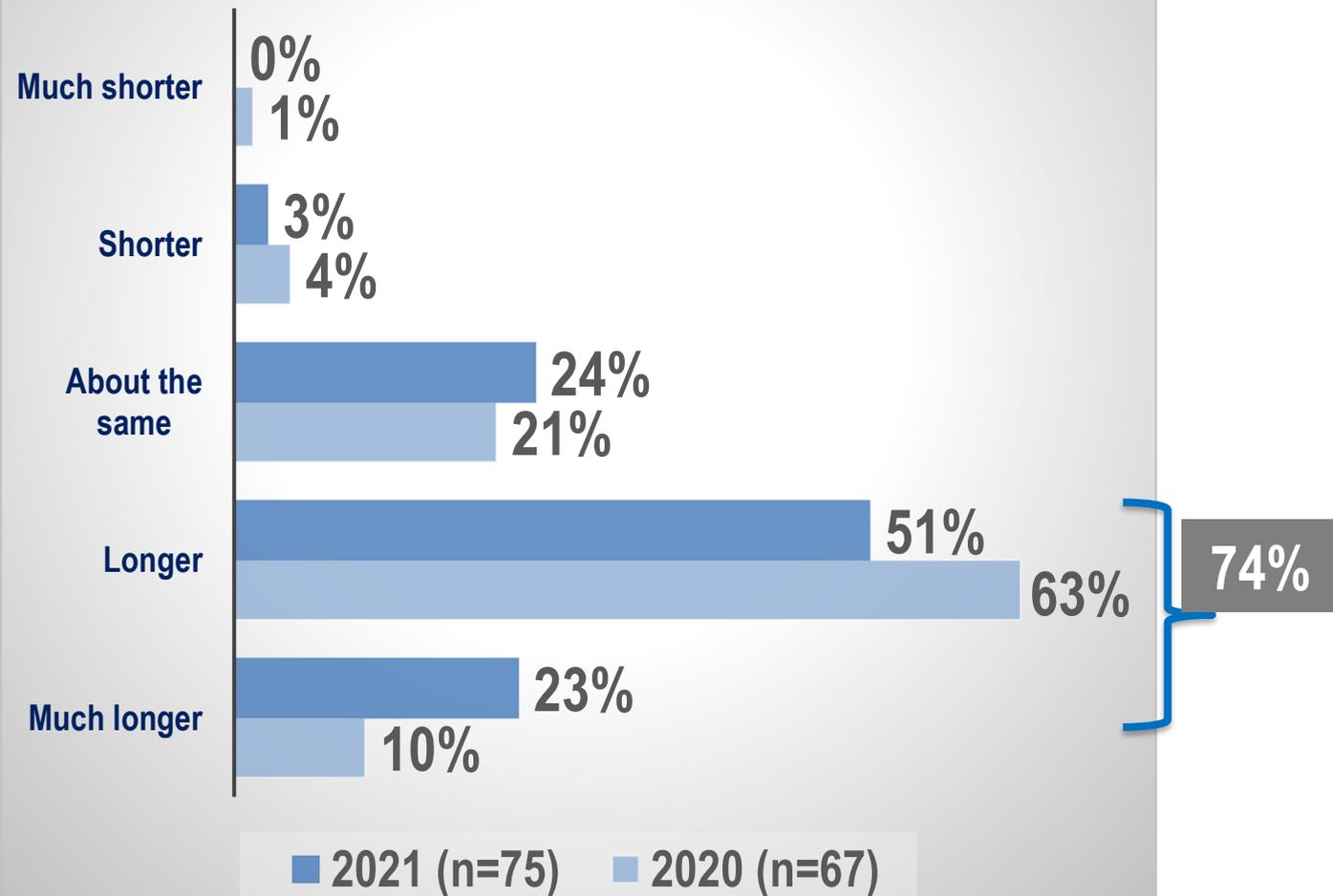
Right chart: Turnaround time is critical to the mask business. How will EUV mask turnaround times in <u>2024</u> compare to leading-edge 193i mask turnaround times of today?

Category	2022 (n=66)
Much shorter	
Shorter	
About the same	30%
Longer	47%
Much longer	23%

Longer + Much longer: **70%**
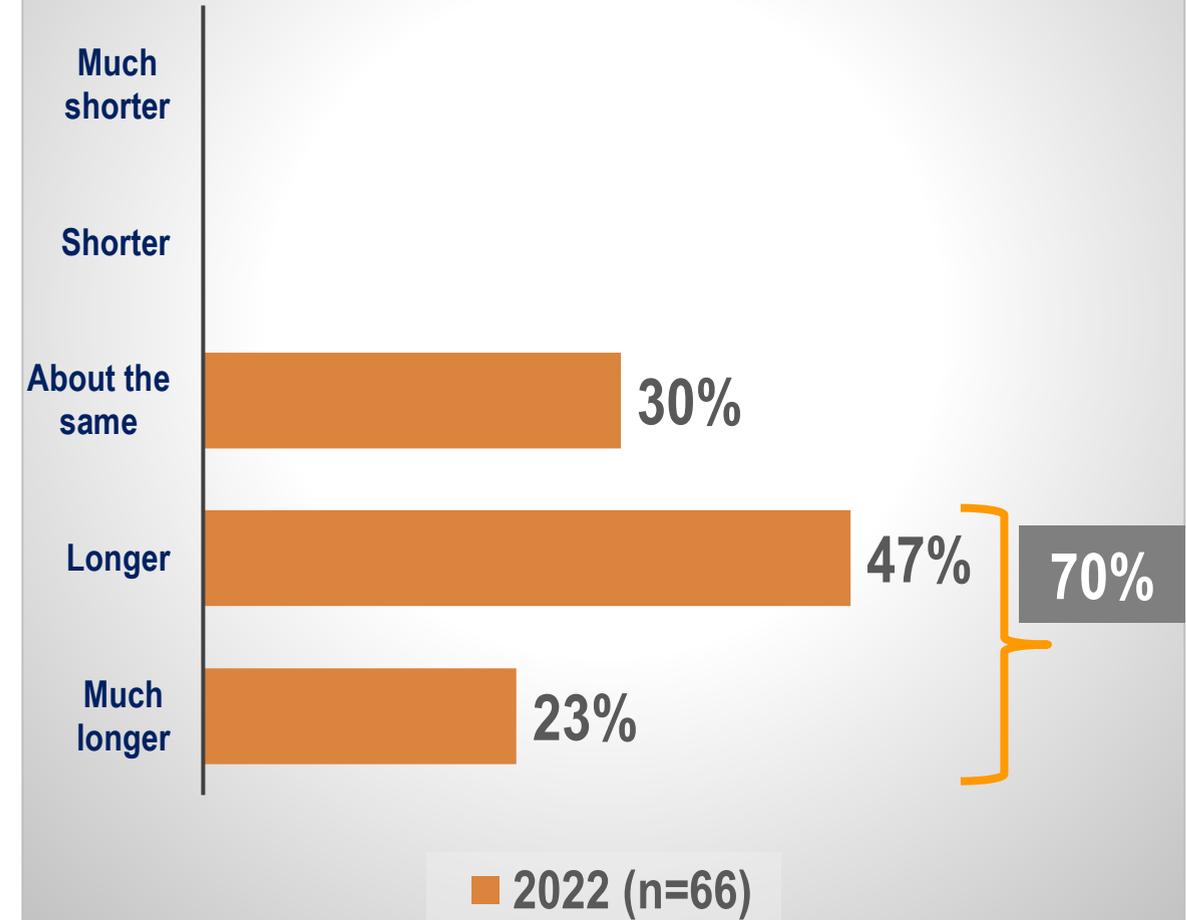
59% Predict High-NA EUV First HVM Usage by 2026

When will High-NA EUV first be used for high volume manufacturing (HVM)? Choose one.

Legend: 2022 n=72

- 2025 OR BEFORE: 17%
- 2026: 42%
- 2027: 28%
- 2028: 1%
- 2029 OR BEYOND: 13%
- NEVER: 0%

59%
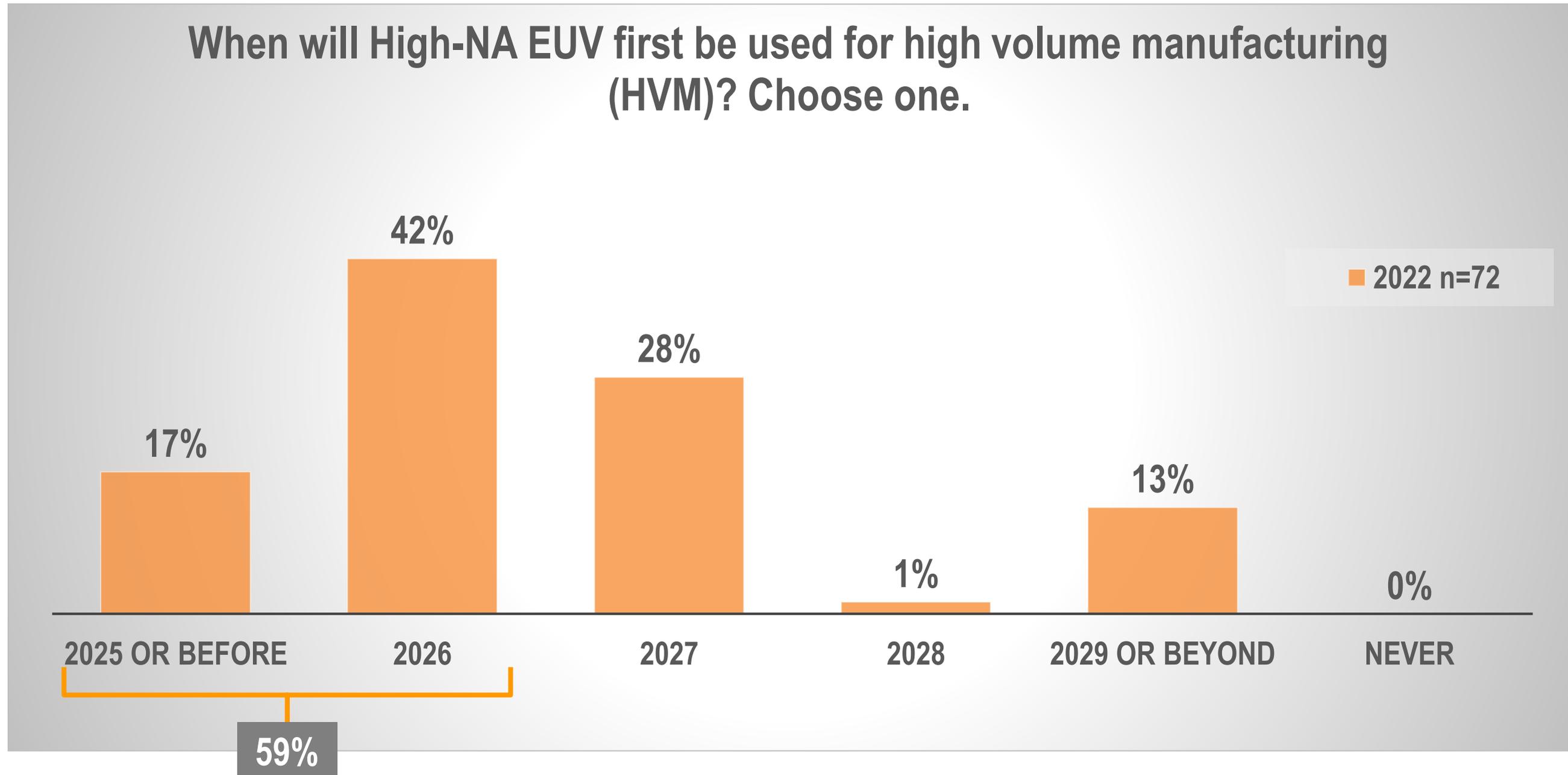
But Broad High-NA EUV in HVM To Take Longer
76% say 2027 or beyond

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

2022 n=70

| Category	Value
2025 OR BEFORE	10%
2026	13%
2027	39%
2028	18.6%
2029 OR BEYOND	18.6%
NEVER	1%

76%
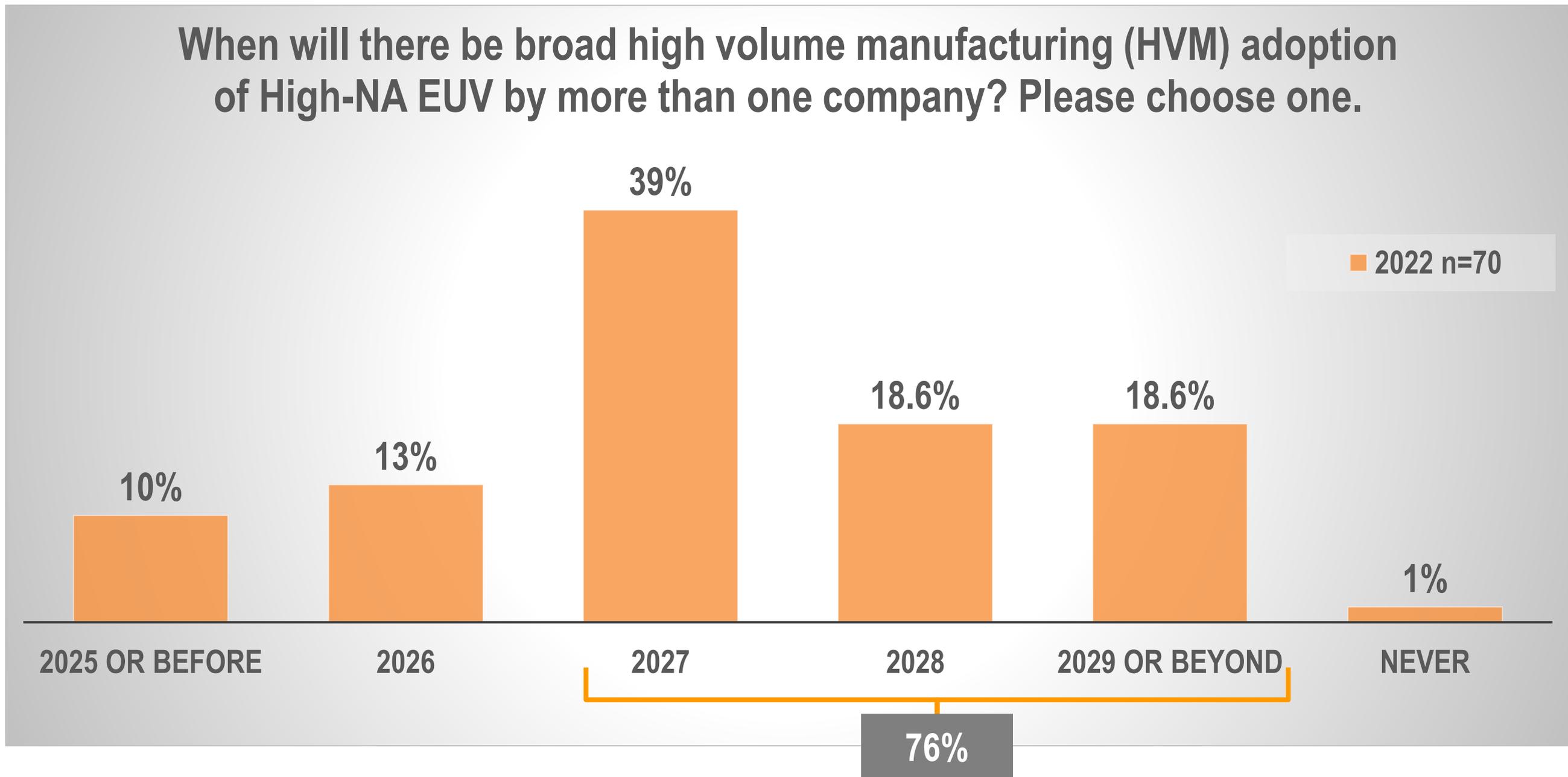
Deep Learning Predictions Continue to Shift in Time
## 63% say 2024 or beyond vs 31% last year

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

2020 n=67

6%	16%	40%	34%	3%
2020 or before	2021	2022	2023 or beyond	never

2021 n=73

7%	15%	35%	31%	2%
2021 or before	2022	2023	2024 and beyond	never

2022 n=63

11%	22%	25%	38%	3%
2022 or before	2023	2024	2025 and beyond	never

63%

Answer choices expanded in 2022 survey – see X axis in two charts above

10
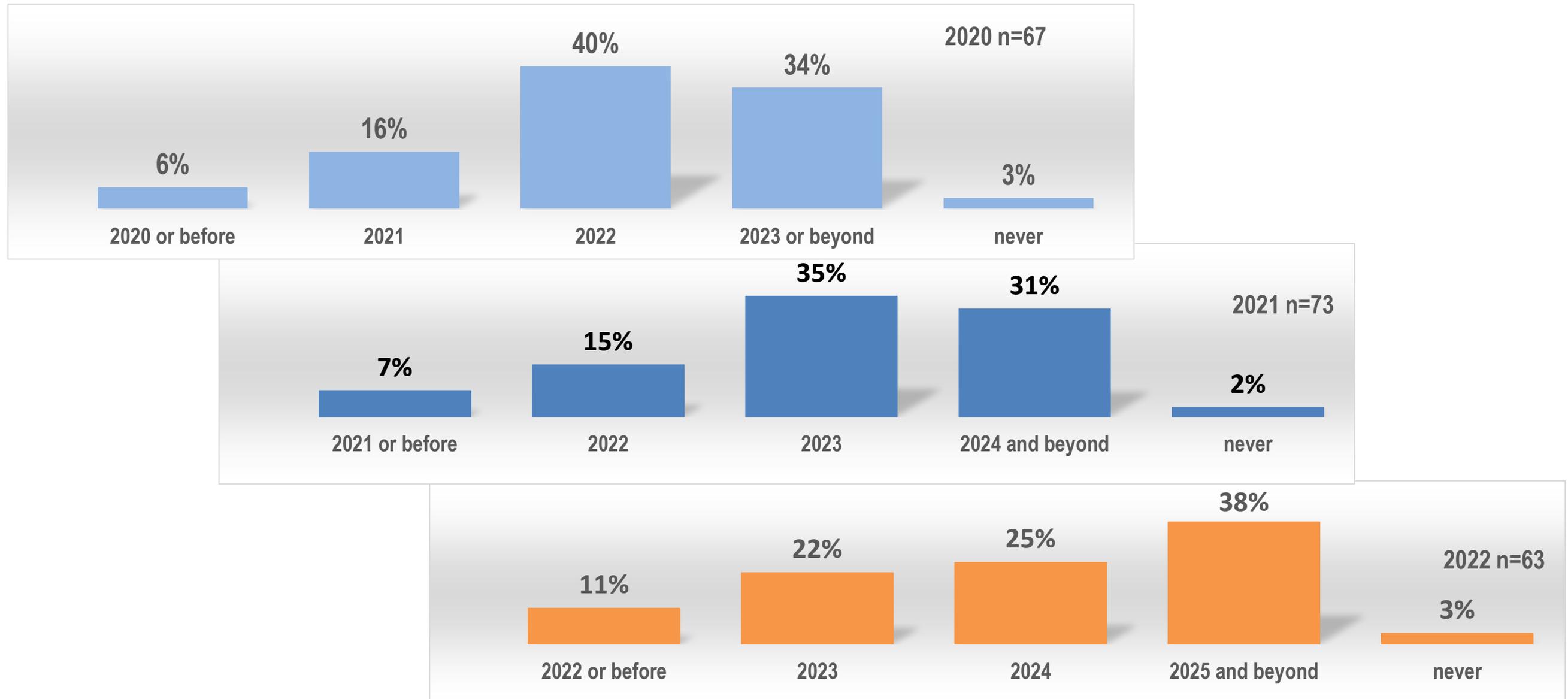
EUV Precision #1 Reason to Buy Multi-Beam Writers
Mixed Views on EUV Throughput, 193i Curvilinear ILT reasons

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=79

Blue rectangle indicates 2021 rank

#1: More precision required for EUV masks N/A=9%

#2: More throughput for EUV masks N/A=5%

#3: Curvilinear ILT for EUV masks N/A=8%
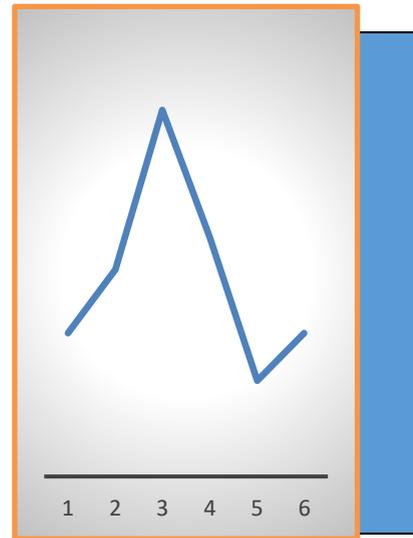
#4: Curvilinear ILT for 193i masks N/A=5%

#5: More precision required for 193i masks N/A=5%
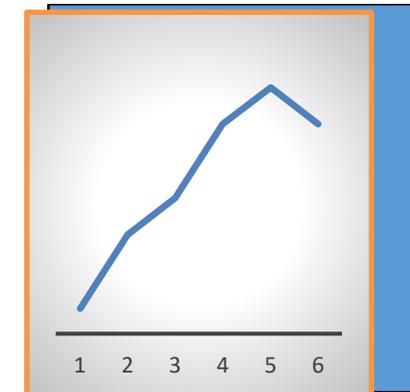
#6: More throughput for 193i masks N/A=10%

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

Multi-beam Writer Unit Sales Predicted to Increase
Sentiment rose again for increased Laser Writer sales
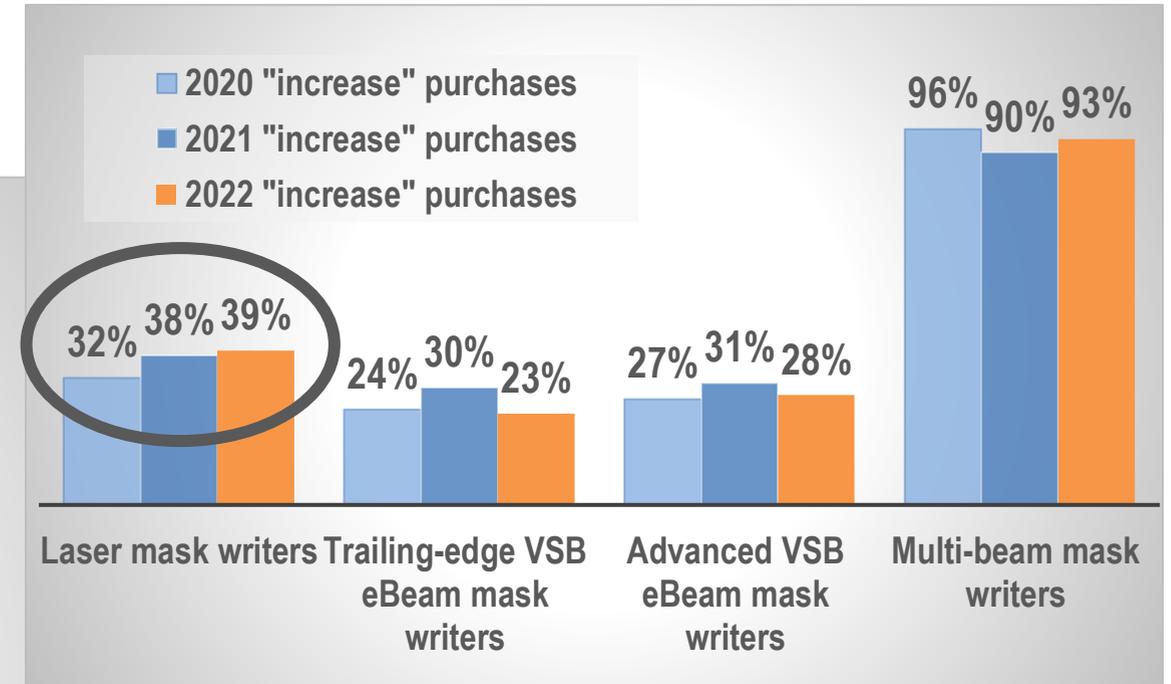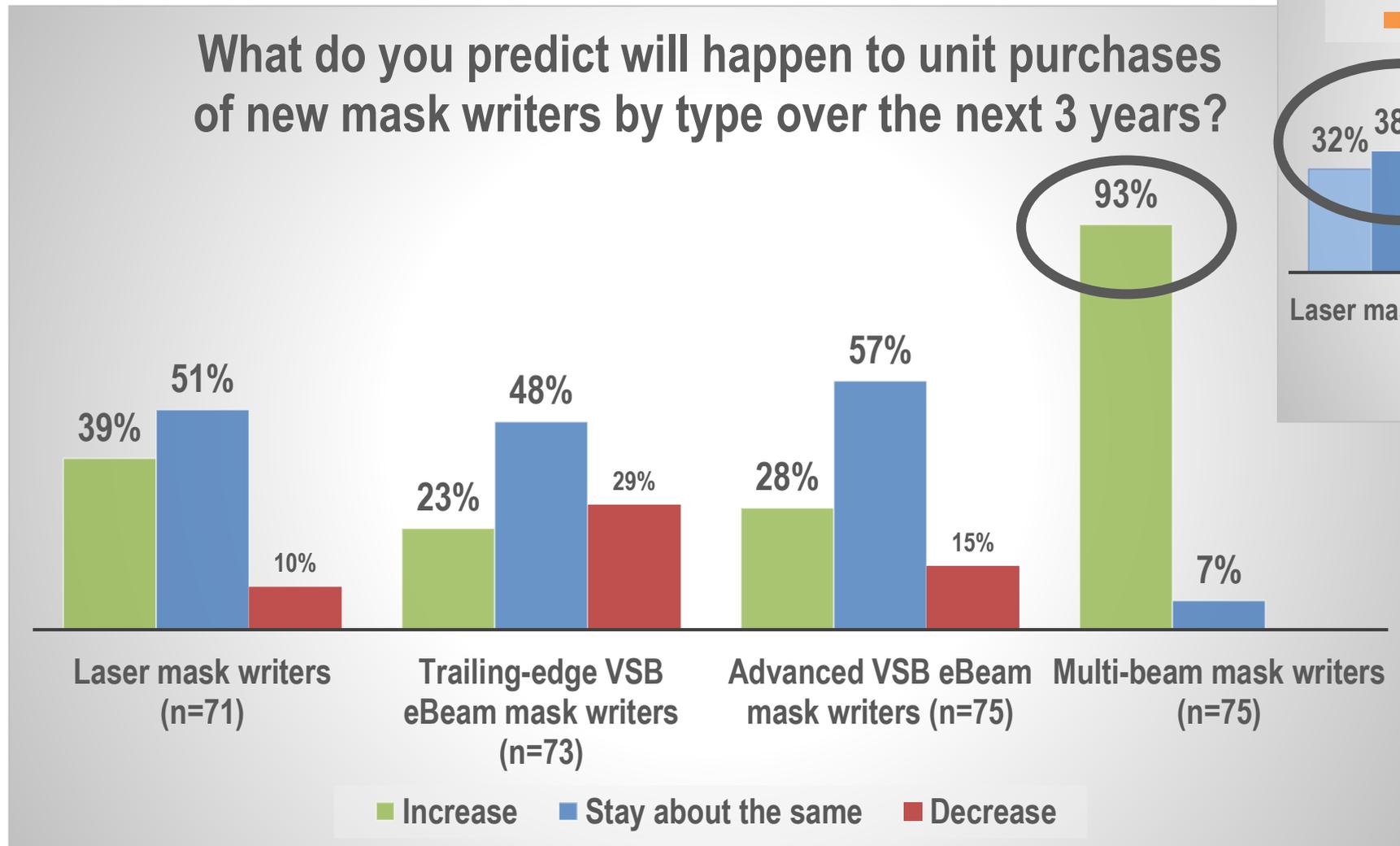
ILT Now Consistently Used on a Few Critical Layers
Year-to-year trend not clear

How broadly is inverse lithography (ILT) used for production chips today (2022)?
(use includes for hot spots only; ILT refers to both Manhattanized ILT & Curvilinear ILT)

Legend:
- 2017 (n=61)
- 2018 (n=60)
- 2019 (n=60)
- 2020 (n=63)
- 2021 (n=65)
- 2022 (n=65)

all critical layers of leading edge nodes use ILT: 3%, 3%, 2%, 10%, 6%, 9.2%

some critical layers of leading edge nodes use ILT: 21%, 15%, 38%, 22%, 41%, 35.4%

a few critical layers of leading edge nodes use ILT: 46%, 60%, 48%, 52%, 48%, 46.2%

no layers use ILT (yet): 30%, 22%, 12%, 16%, 5%, 9.2%
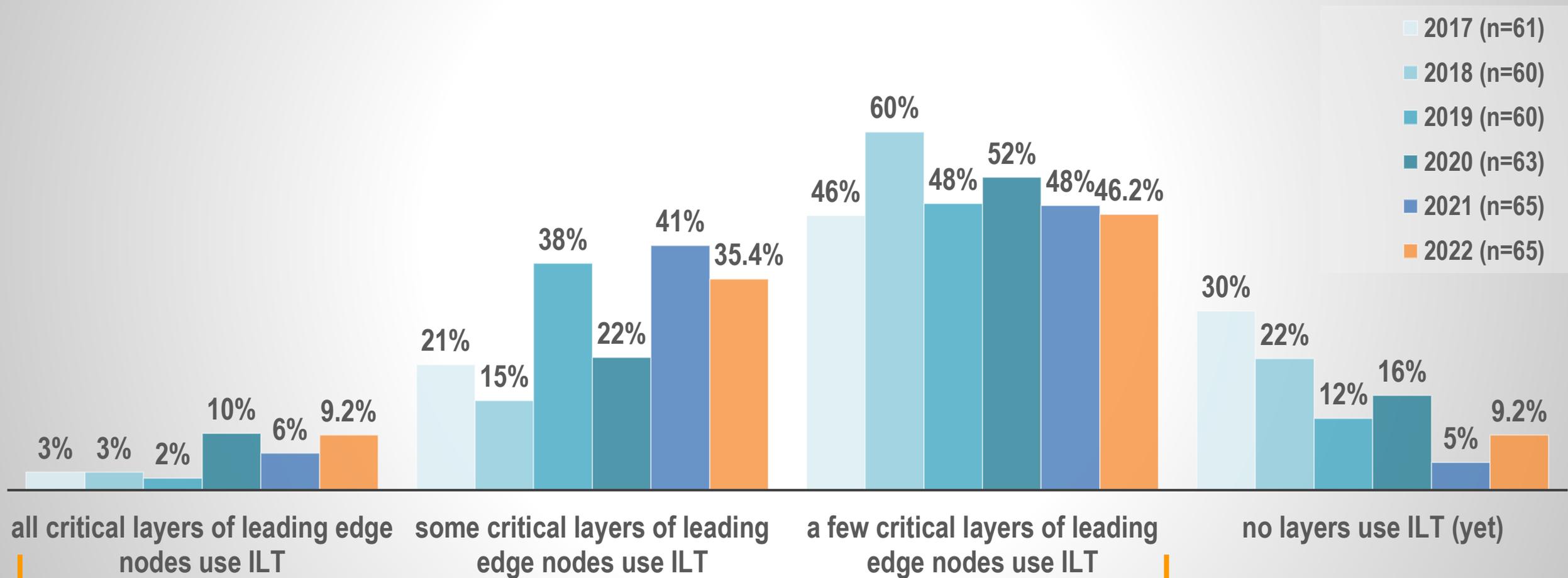
> 90%

Mask Infrastructure Tops Curvilinear Concerns
While access to Multi-beam mask writers less a barrier (from #3 to #5)

Please rank your biggest concerns in producing masks with curvilinear* shapes. n=79

#1: Mask shop software infrastructure

#2: Mask Inspection

#3: ILT software

#4: Mask Metrology

#5: Access to Multi-beam Mask Writers

#6: Mask Repair

Blue rectangle indicates 2021 rank
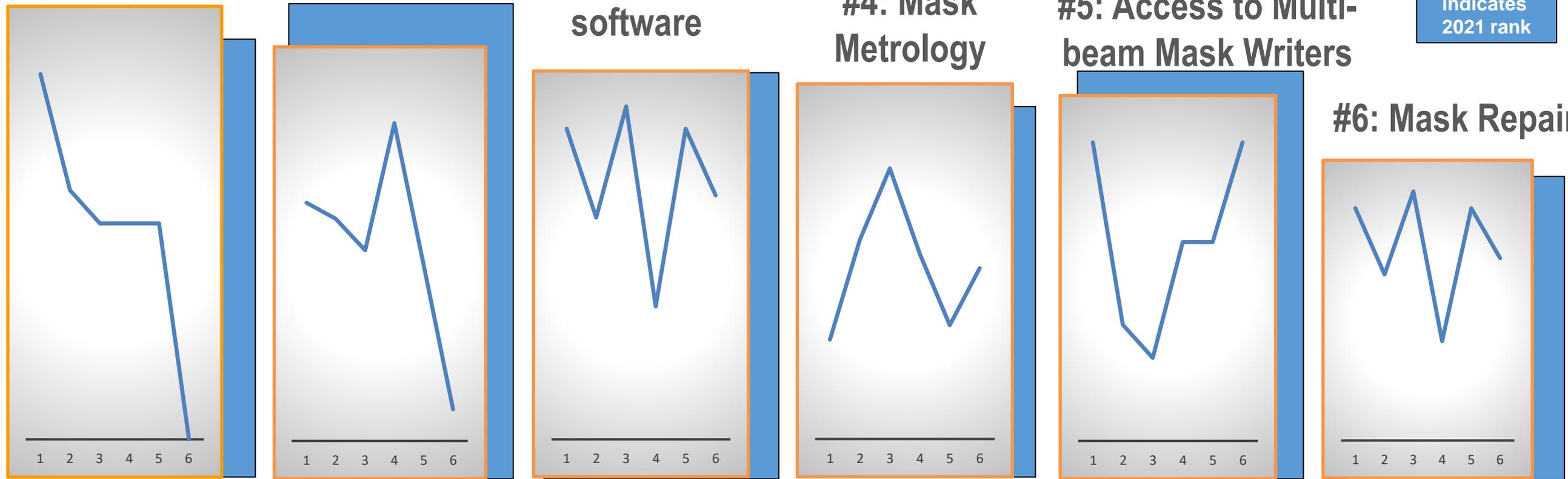
N/A=9%   N/A=6%   N/A=11%   N/A=8%   N/A=9%   N/A=8%

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."

14

Confidence in Curvilinear Mask Making Remains High
76% 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

- The concerns are insurmountable for now. — 1%
- They can handle a very few special cases of such masks, but not yet in general. — 23%
- They can handle some limited number of such masks. — 51%
- They can handle as many such masks as there is demand. — 16%
- They have no problem with such masks. — 9%

76%

Responses (n=70)

15
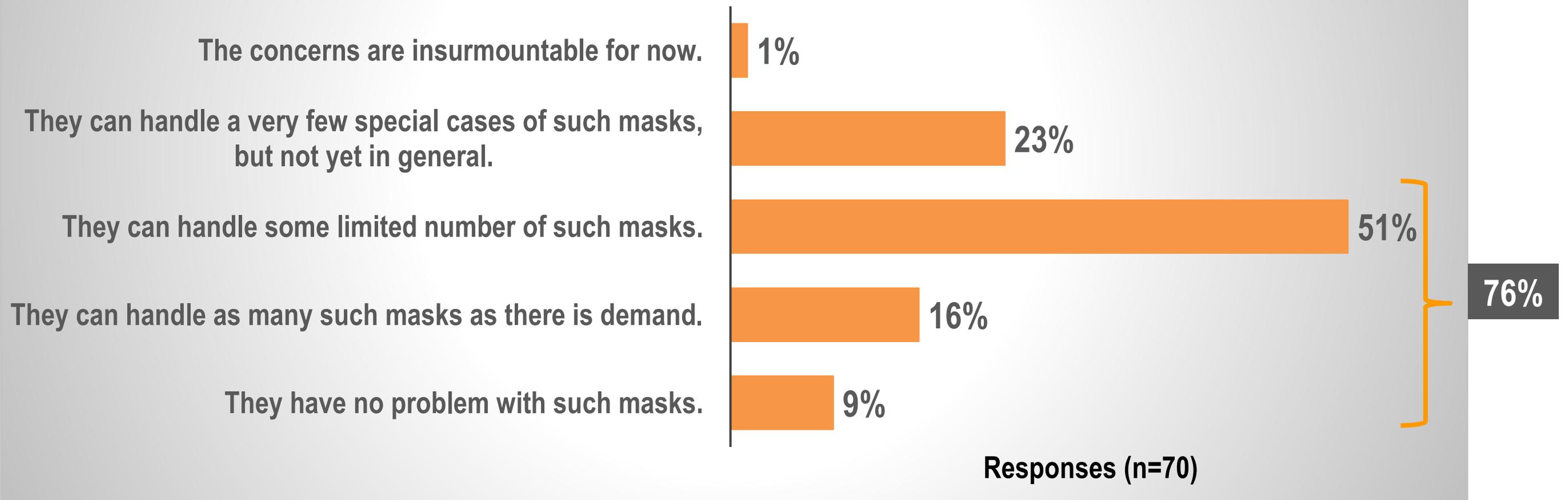
Luminaries Report Positive EUV Impact on Mask Trends

- **EUV viewed as a positive impact for mask revenue**

- **EUV remains the top reason for purchasing multi-beam mask writers**

- **Confidence remains high in ability to make curvilinear masks with availability of multi-beam mask writers less of an issue this year**

Thank you to those who participated in the survey!

Luminaries survey results available on www.ebeam.org