

From Technologies to Market

# Lithography Technologies for More than Moore

**2018 LETI – Lithography Workshop**

*Amandine Pizzagalli*

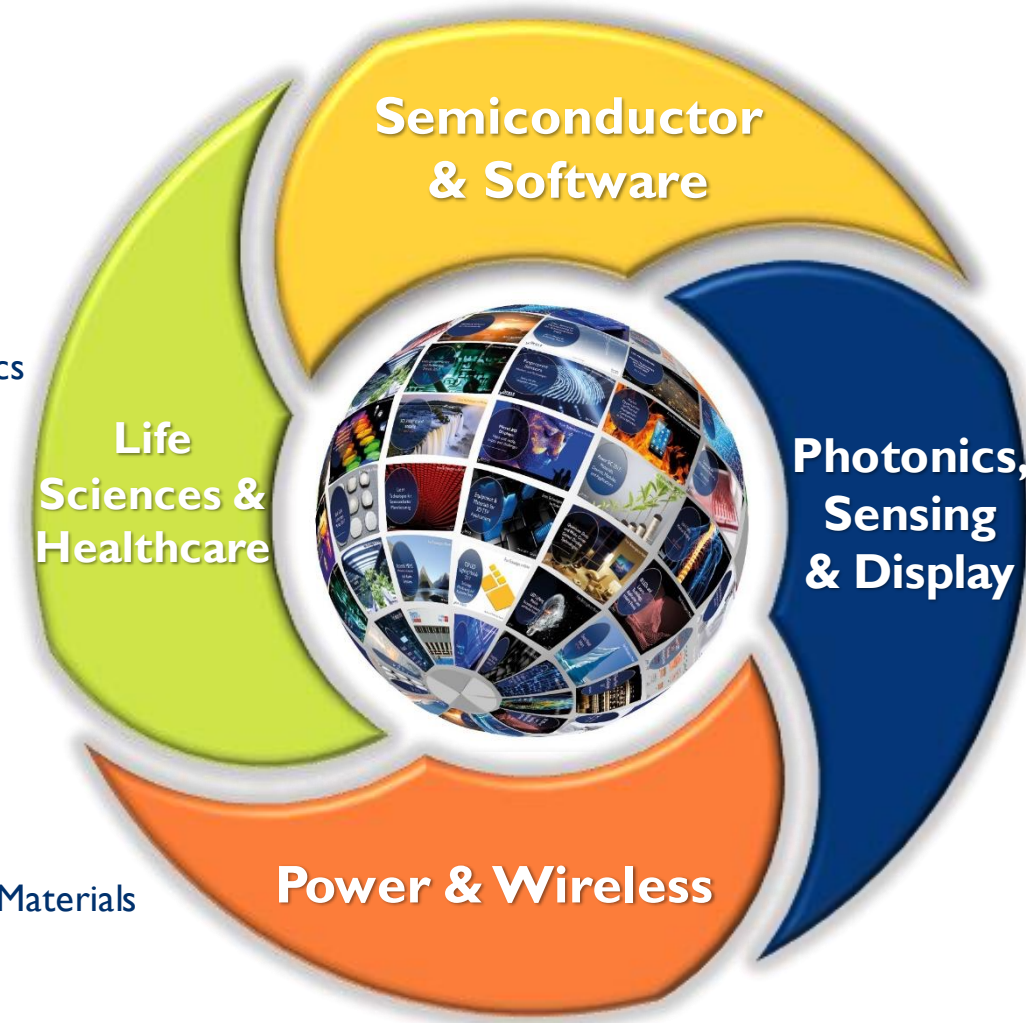


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- BioMEMS
- Inkjet Printing
- Solid-State Medical Imaging & BioPhotonics
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- Power Electronics
- Batteries & Energy Management



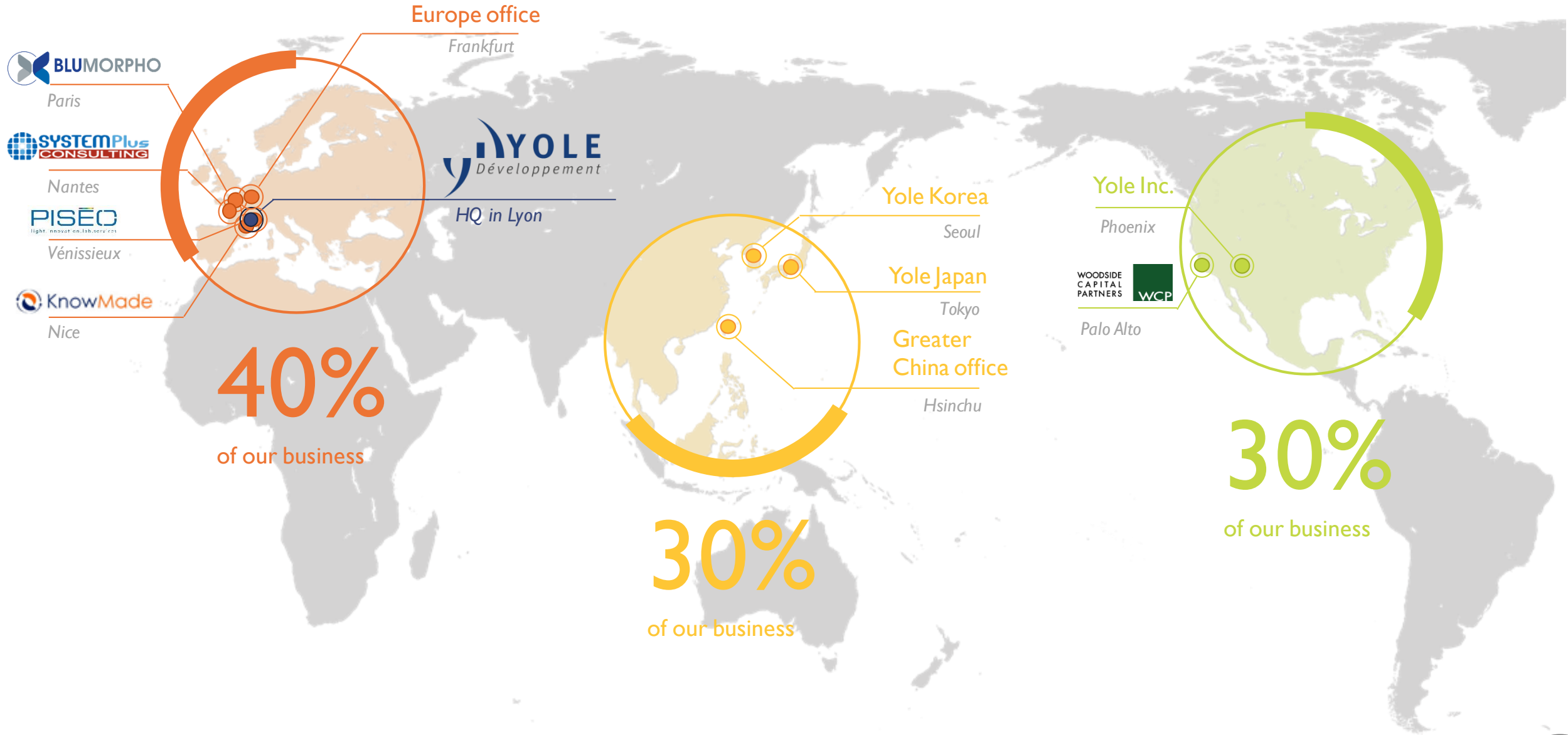
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## *Lithography technology and trends for More than Moore devices*

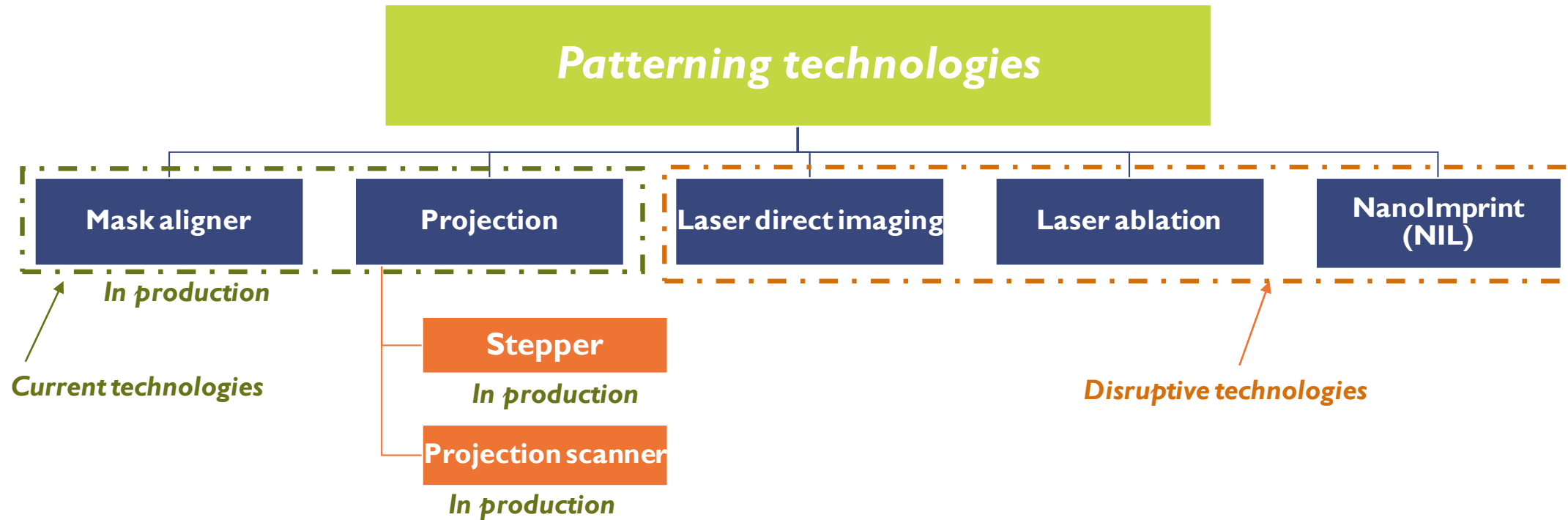


- Overview of the lithography technologies
- Lithography requirements for More than Moore devices
- Lithography equipment suppliers in the More than Moore devices
- Conclusions

# LITHOGRAPHY TECHNOLOGIES - OVERVIEW



- There are five main technologies that could be used in the semiconductor area



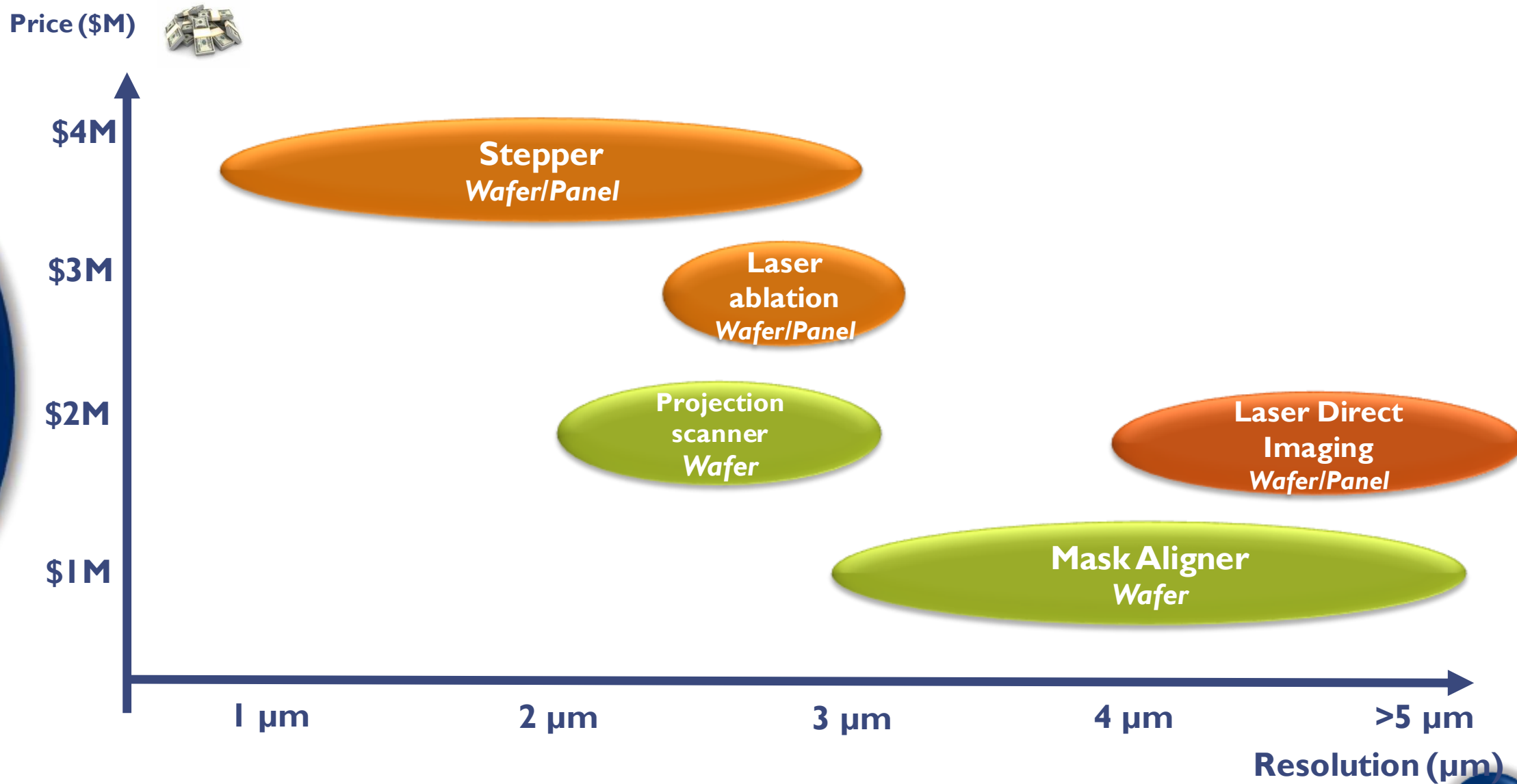
Patterning in semiconductor is used in microfabrication to pattern parts of a thin film or the bulk of a substrate. It is used for Via formation, bumping process, RDL...

- Today, patterning is performed by various photolithography solutions such as mask aligners, projection steppers, and scanners
  - There are two laser patterning types (laser direct imaging and laser ablation that could be alternative solutions to the lithography technologies currently used)

# WHAT IS THE PRICE/COST GAP?



From a technical feature perspective, steppers are very attractive but there is a price penalty to pay





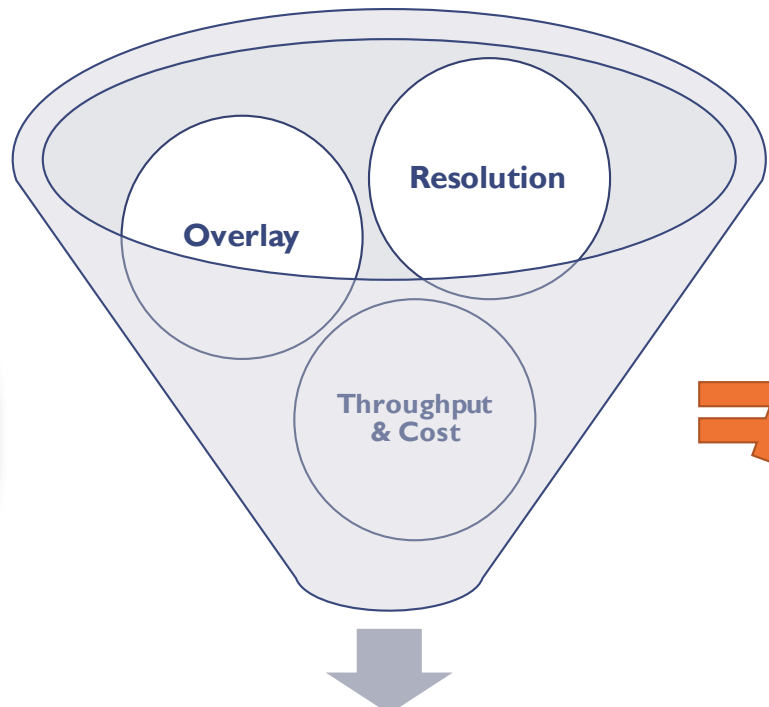
# Lithography requirement for More than Moore devices

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# LITHOGRAPHY CONCERNS ARE DIFFERENT IN ADVANCED PACKAGING & MEMS

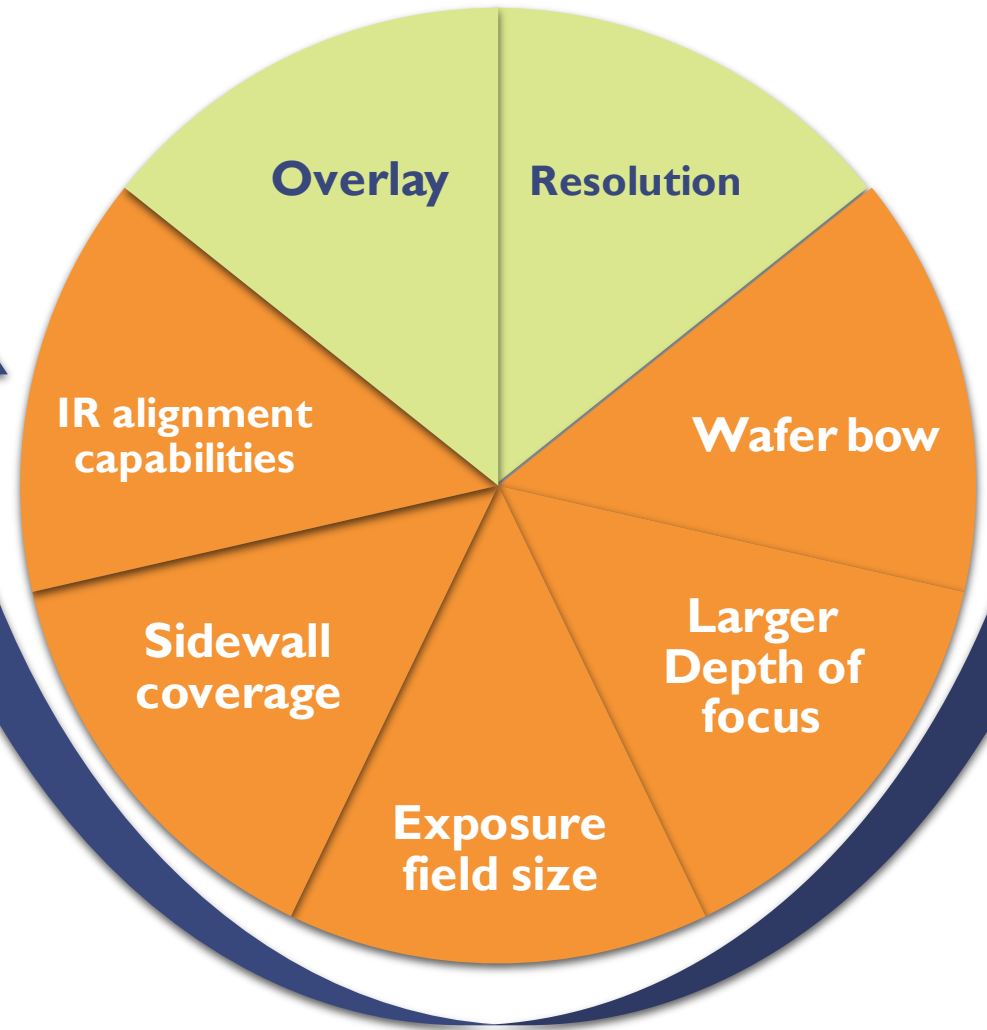
Differentiation between Front-end and More than Moore device

Needs and challenges in packaging lithography are different from front-end lithography



Manufacturing requirements in common between **front-end** and **More than Moore**

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New key requirements different from the **Front-end area**

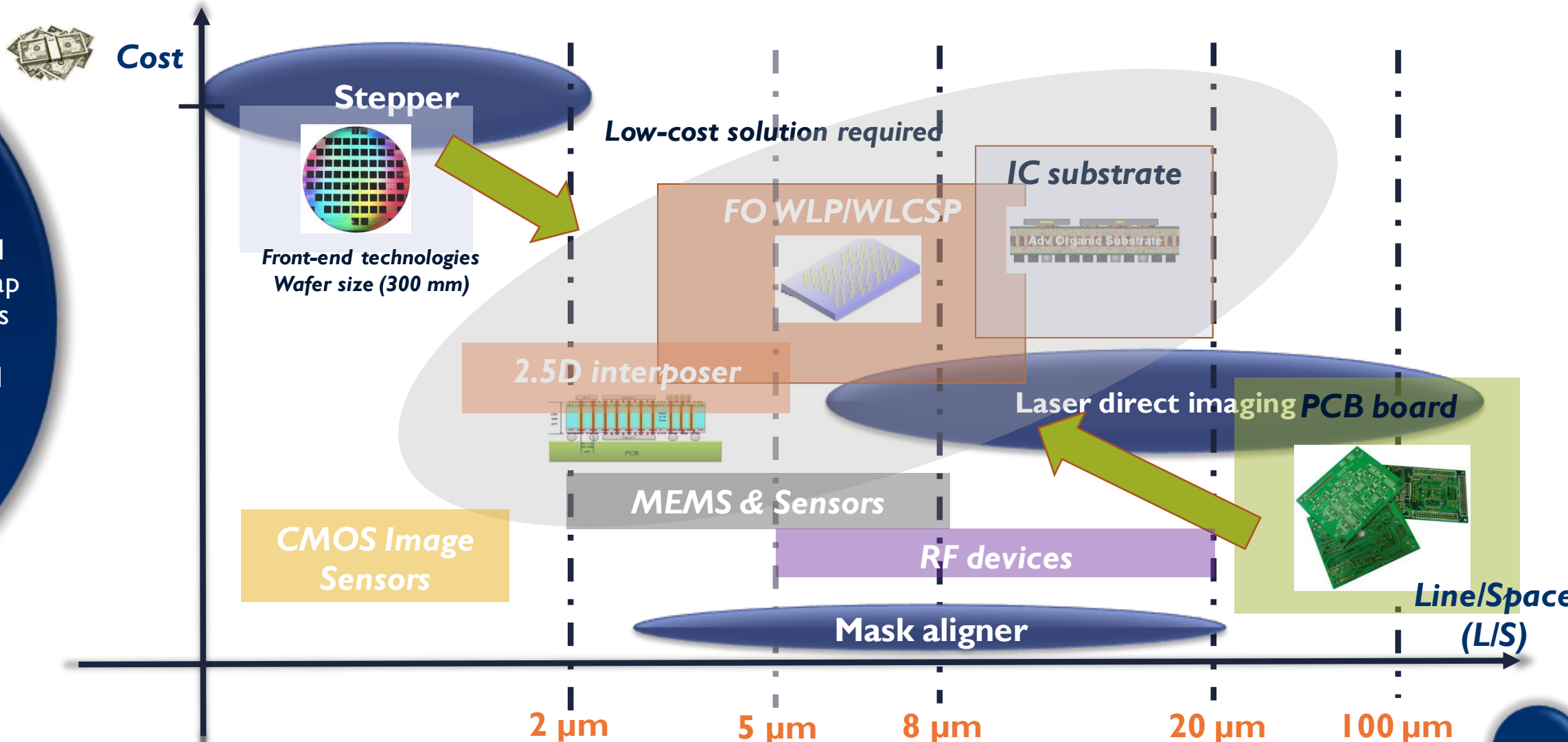


# TECHNICAL GAPS BETWEEN THE WAFER AND PCB INFRASTRUCTURES

Filled by the More than Moore devices infrastructure

- In terms of technical features, a big gap exists between the front-end and back-end/PCB infrastructures

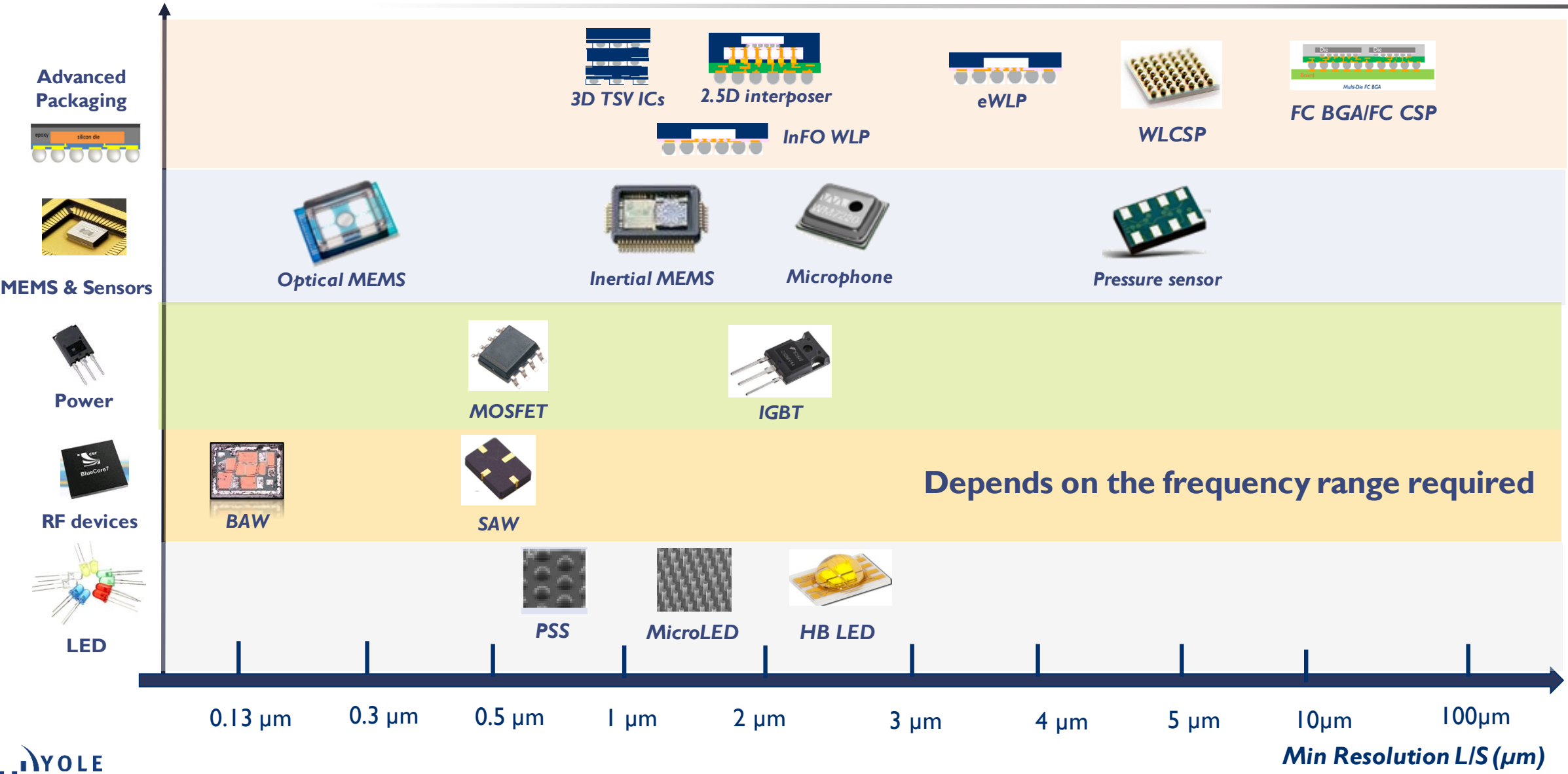
Between the front-end and PCB areas, a gap exists in terms of cost structure and technical features





# MIN RESOLUTION REQUIRED

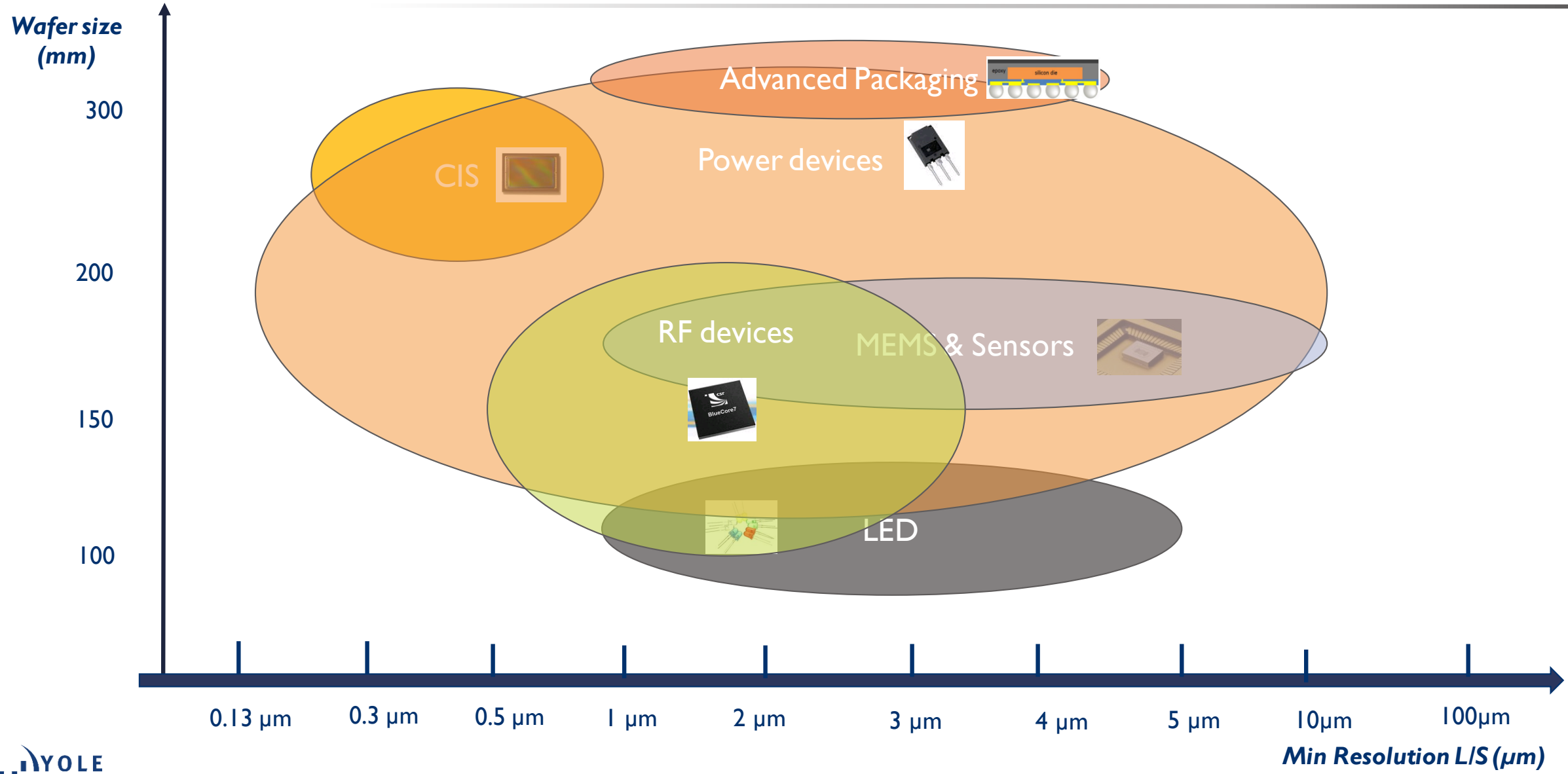
## More than Moore devices





# LITHOGRAPHY RESOLUTION VS WAFER SIZE

More than Moore devices



# GENERAL LITHOGRAPHY REQUIREMENTS

Value required

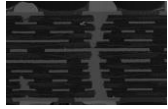
Key  
Lithography  
Requirements

Lithography  
requirements for  
Advanced Packaging

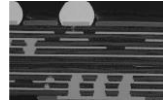
- Minimum resolution:  $1\ \mu\text{m}$
- Overlay accuracy:  $0.3\ \mu\text{m}$  (layer to layer)
- Exposure field size:  $> 45\text{mm}^2$
- IR alignment:  $< 1\ \mu\text{m}$
- Depth of focus:  $> 15\ \mu\text{m}$  @  $2\ \mu\text{m}$
- Wafer warpage:  $5\ \text{mm}$
- CD control/sidewall angle:  $< 10\%/80^\circ$

# RESOLUTION TRENDS (L/S = LINE/SPACE) - SEMICONDUCTOR ROADMAP

Courtesy of System Plus

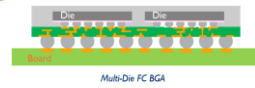


HDI PCBs



PCB rigid/flex

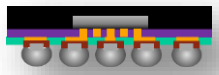
## Advanced Packaging



FC BGA/FC CSP



WLCSP

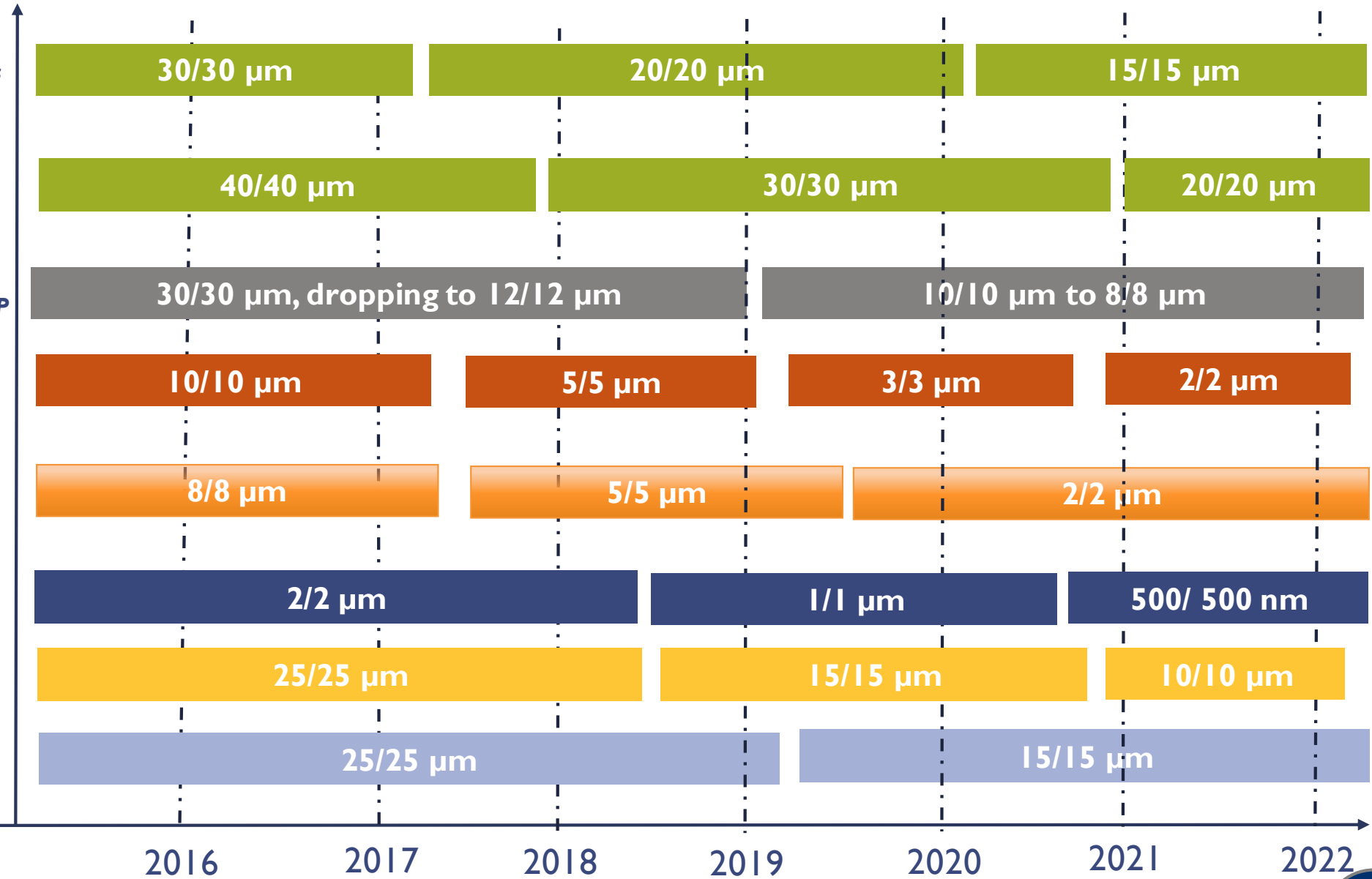


FO WLP

2.5D interposer/3D IC

Embedded die

FO WLP panel/organic/glass panel interposer



# LITHOGRAPHY EQUIPMENT TECHNOLOGIES BY MORE THAN MOORE DEVICE



		Advanced Packaging (all advanced packaging platforms included)	MEMS devices	LED devices	Power devices	RF devices
Equipment t suppliers	Mask aligner	✓	✓	✓	✓	✓
	Projection	Stepper	✓	✓	✓	✓
		Projection on scanner	✓	✓	✓	
	Laser ablation	✓	Not applied			
	Laser direct imaging	✓	Not applied			
	NanoImprint (NIL)	Not applied	Not applied	✓		

✓ **Currently used in HVM production**

✓ **Currently used in Low/Medium Volume production**

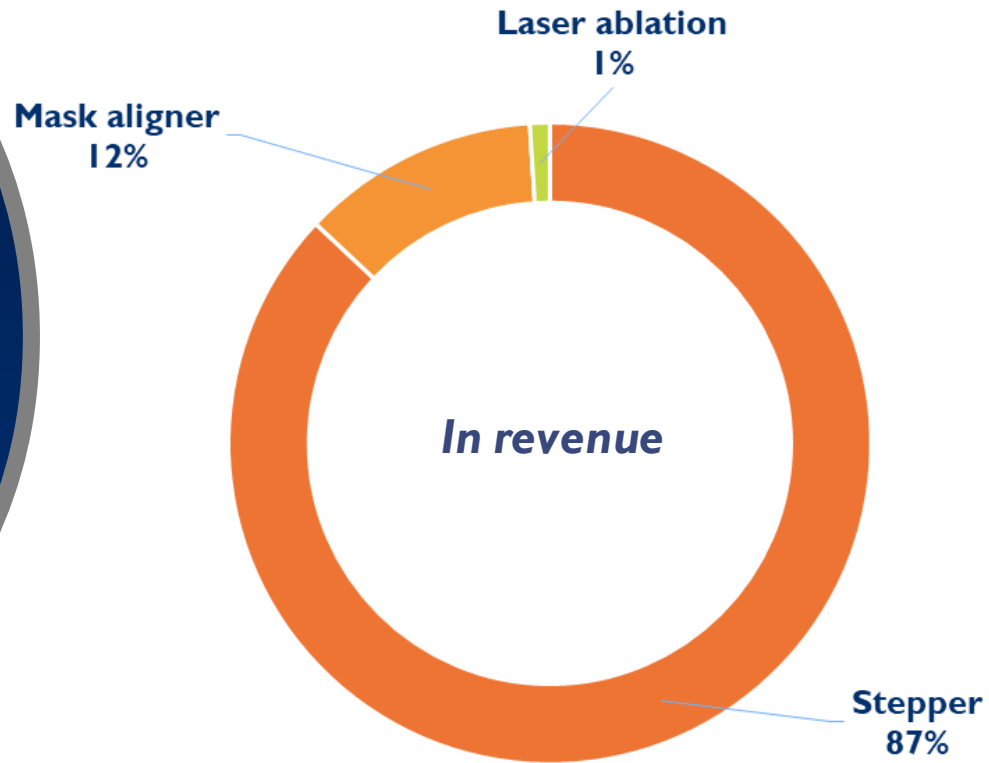
✓ **Under Evaluation**

# ADVANCED PACKAGING PROJECTION SYSTEMS

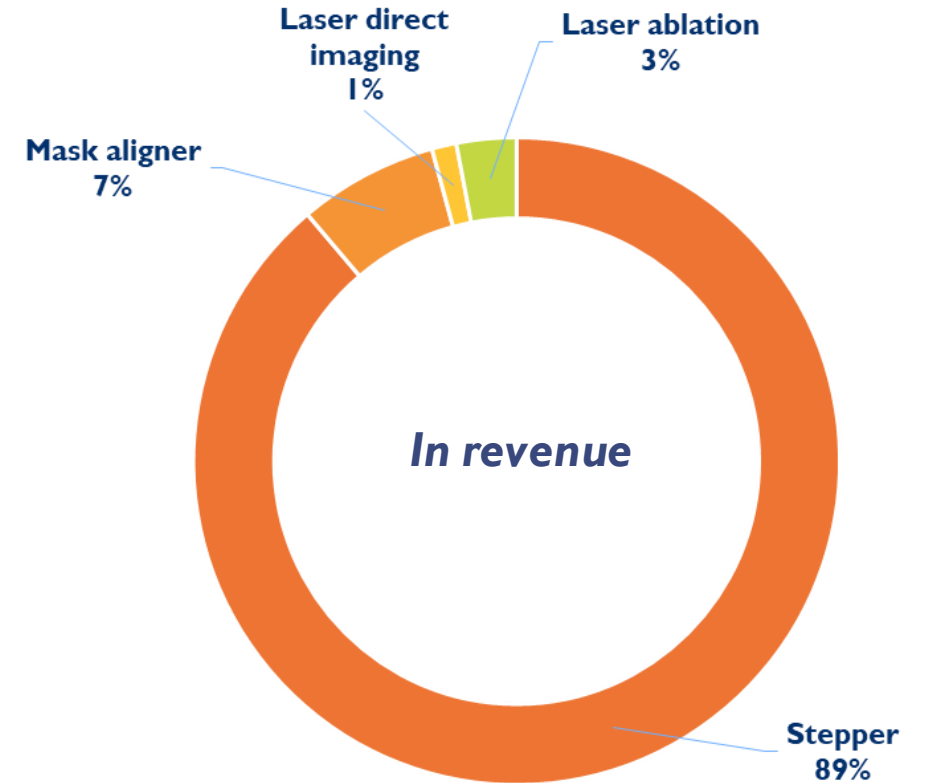
## Advanced Packaging projection systems breakdown 2017 vs 2023

Projection  
steppers  
represent the  
majority of  
lithography  
systems used  
for Advanced  
Packaging

**2017 Advanced Packaging Projection systems  
Breakdown by lithography technology**



**2023 Advanced Packaging Projection systems  
Breakdown by lithography technology**



# MEMS PROJECTION SYSTEMS

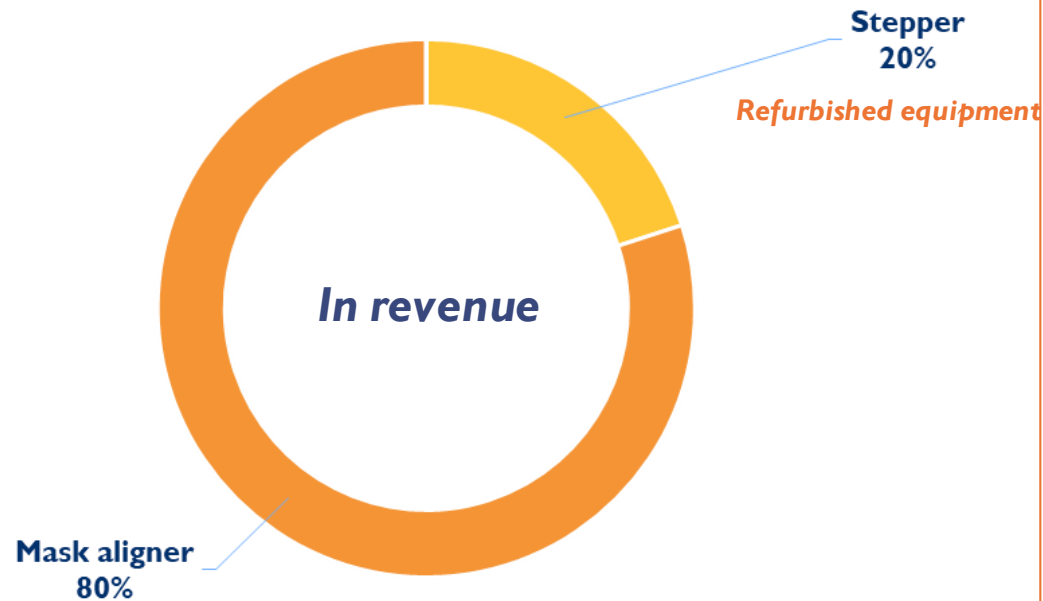
## MEMS & Sensors projection systems breakdown 2017 vs 2023

Mask aligners are mainly used for non-CMOS processes in MEMS devices

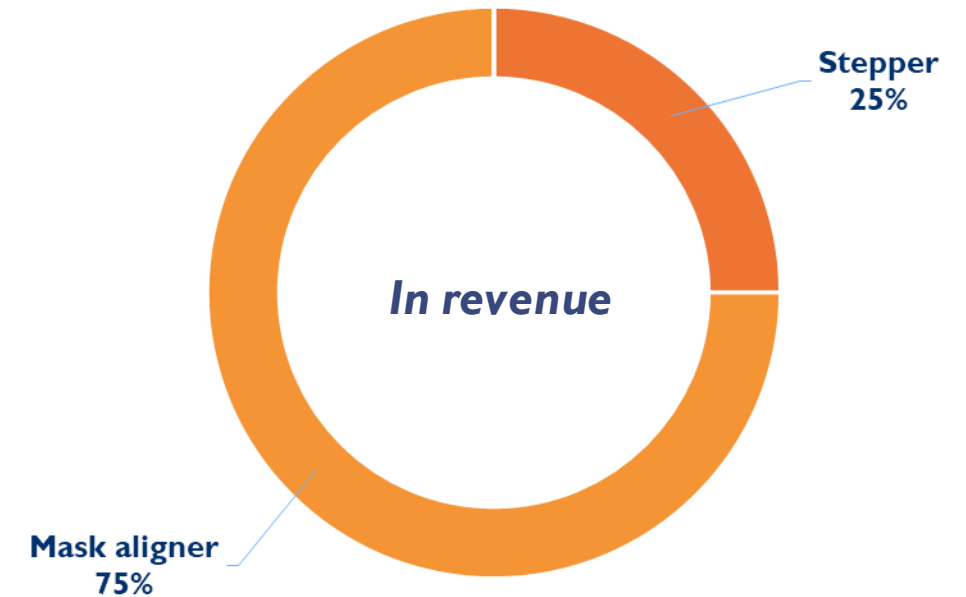
Steppers are used for the CMOS part of MEMS devices or for the most challenging lithography step

Mask aligners represent the majority of projection systems used for MEMS devices

2017 MEMS Projection systems  
Breakdown by lithography technology



2023 MEMS Projection systems  
Breakdown by lithography technology







# Lithography equipment suppliers

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# LITHOGRAPHY EQUIPMENT COMPETING LANDSCAPE










































## Key Equipment Suppliers

Wide variety of lithography equipment suppliers



# LITHOGRAPHY EQUIPMENT SUPPLIERS BY DEVICE (NON EXHAUSTIVE LIST)



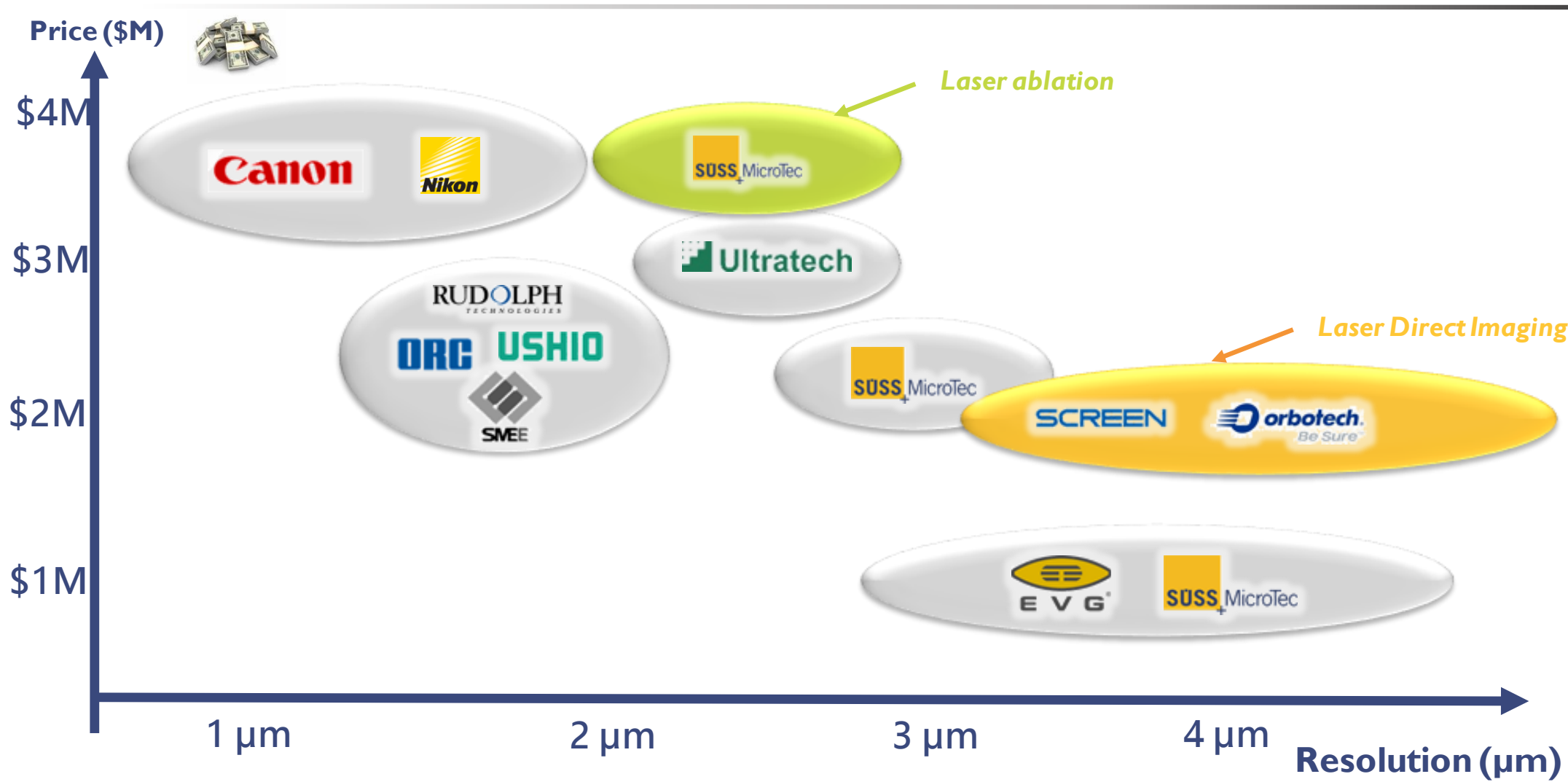
		Advanced Packaging (all advanced packaging platforms included)	MEMS devices	LED devices	Power devices	RF devices
Equipment nt suppliers suppliers	Mask aligner	 	 	 	 	 
	Projection (Stepper & & full-field)	       	    	      	   	  
	Laser ablation		Not applied			
	Laser direct direct imaging	  				

Refurbished equipment

# LITHOGRAPHY EQUIPMENT TECHNOLOGY

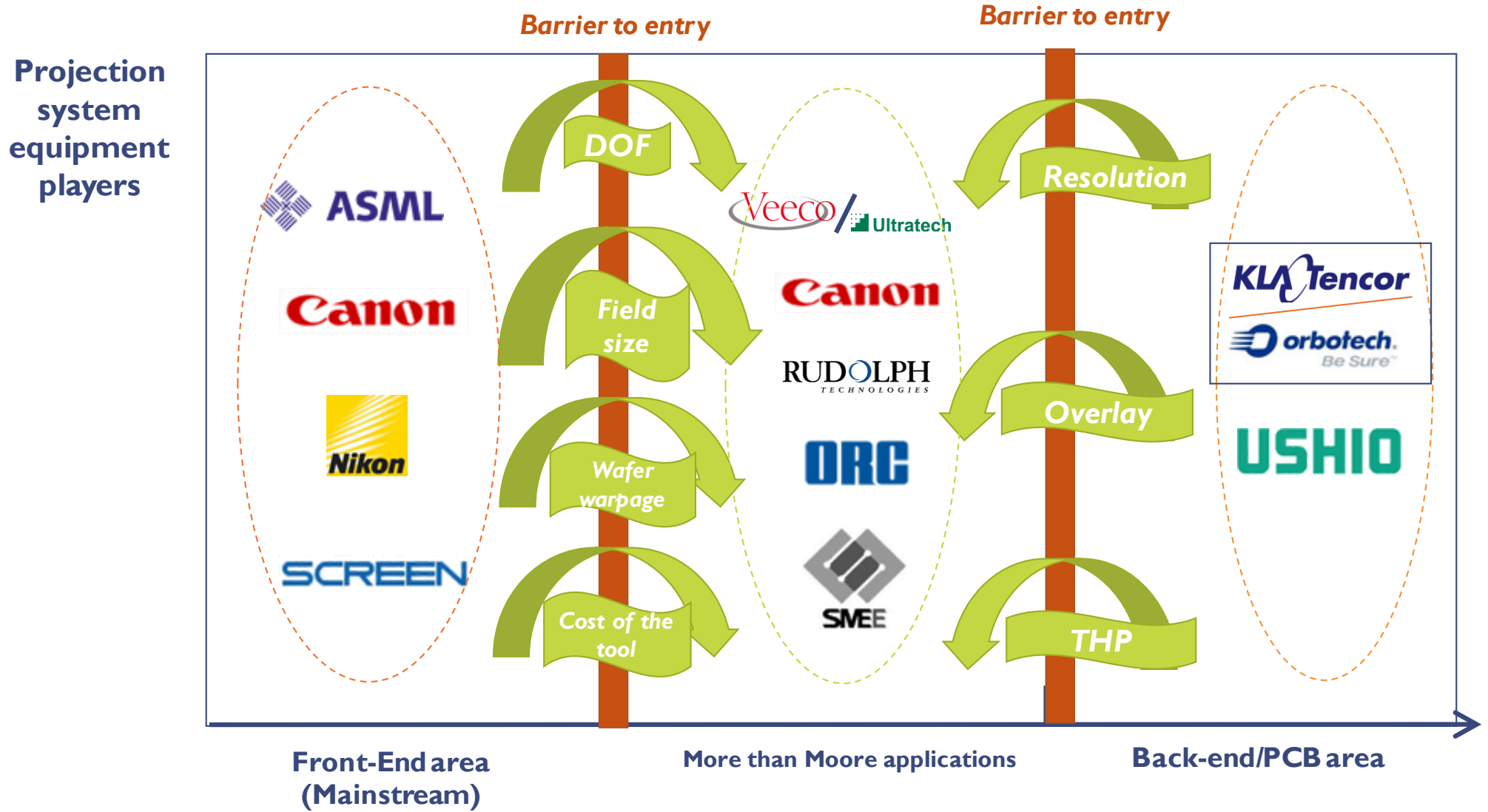
## Price vs Resolution capabilities

Top-tiers vs specialized equipment vendors



# PROJECTION TOOL VENDORS: POSSIBLE RESHAPING OF THE INDUSTRY

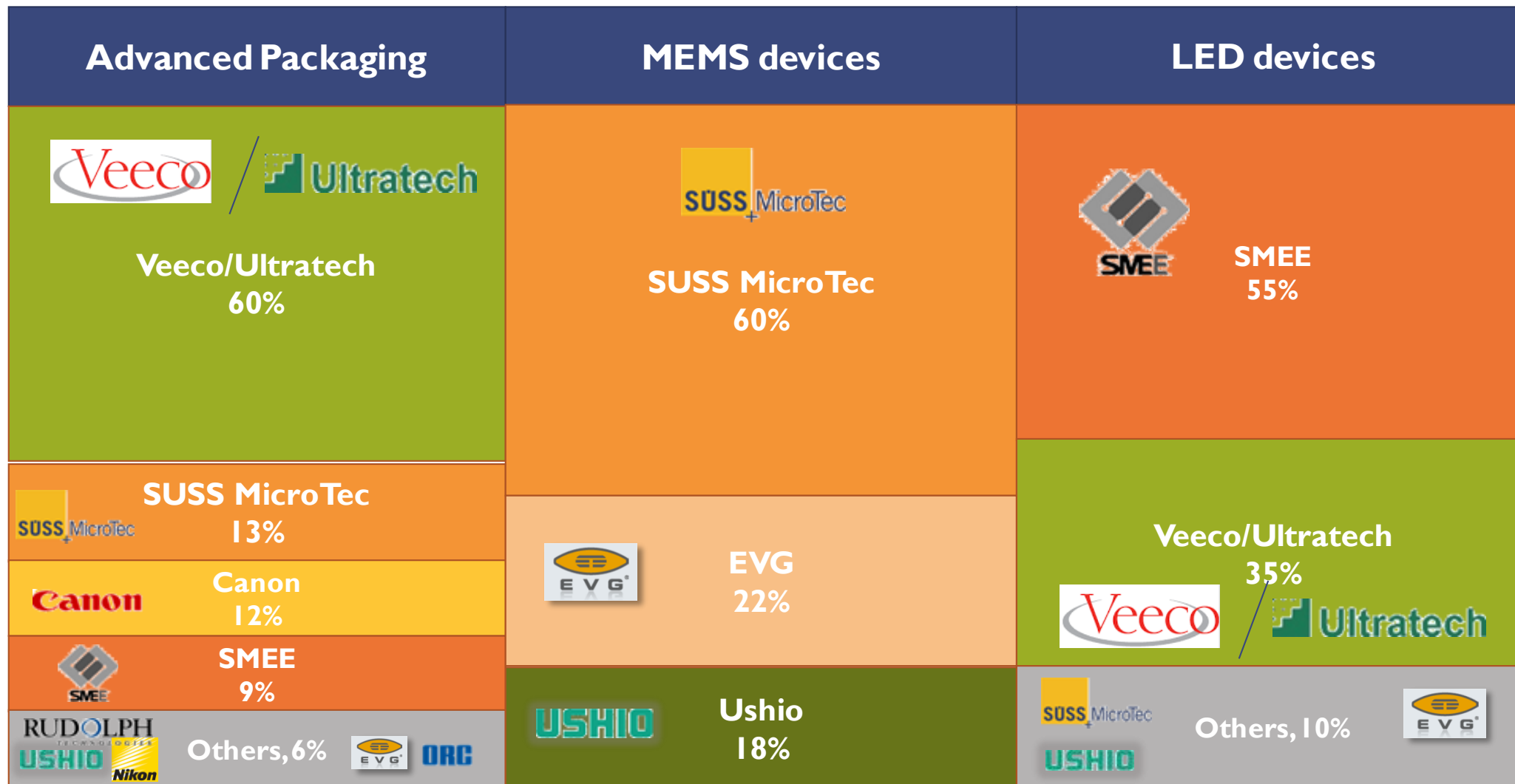
There are barriers to entry for both front-end and back-end lithography vendors

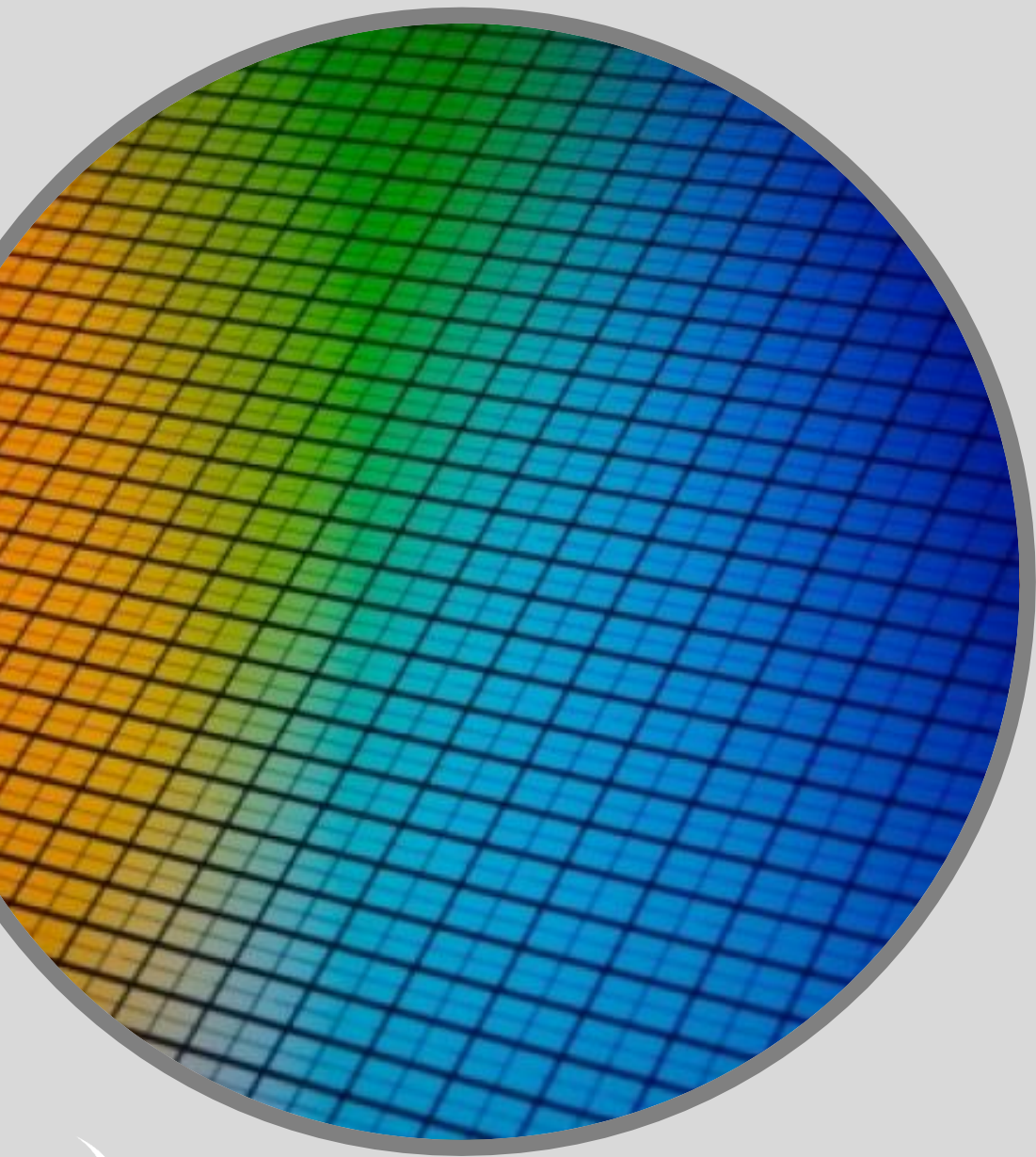


# EQUIPMENT SUPPLIERS' MARKET SHARES

## New Brand Equipment

Lithography vendors' market shares across Advanced Packaging and MEMS





# The Last Word ...

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# CONCLUSIONS

- More than Moore devices have very complex technical specifications which differ from those associated with the front-end area.
- There is a compromise between cost effectiveness and better performances that is becoming increasingly important in the photolithography business
- Some More than Moore devices have relaxed specifications compared to the packaging area.
- MEMS photolithography market benefits from a high percentage of re-used/retrofitted equipment coming from the mainstream front end semiconductor industry.
- Although mask aligner and steppers are already well established, disruptive technologies such as laser direct imaging (LDI) and laser ablation might emerge and could contribute and gain a small market share in coming years.





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*Thank You!*