

104572
DFD9001V3 Y
9051 WP

DA8703
5993
JS19010 2

115392
SD9001V4 X
9057A

070350
D8944 1
A 9045

M9006
M1881M

HEF4051B
LNS8201B

HEF4051B
LNS8931A

330nK
63

2n2K63

100nK63

470nK
63

10 K63

1K
63

SINGAPORE
9060

The Global Semiconductor Industry

Financial Opportunities Forum

Raunak Onkar - June 2021

INDUSTRY HEADACHE

Can't Meet Demand

Reduced Production

SEMICONDUCTOR SHORTAGE

Factory Shutdown

Work Stoppage

Supply Chain Nightmare

BOTTLENECK

**How to understand this
sector?**

Understanding Semiconductors

- History & The Benefit of Hindsight
- Types of Semiconductor Businesses
 - Ecosystem of Vendors
- Chip Shortage
- Geo-politics of Chip Manufacturing
- Outlook for India

**BEWARE
OF**

**WELL...
JUST
BEWARE**

Beware

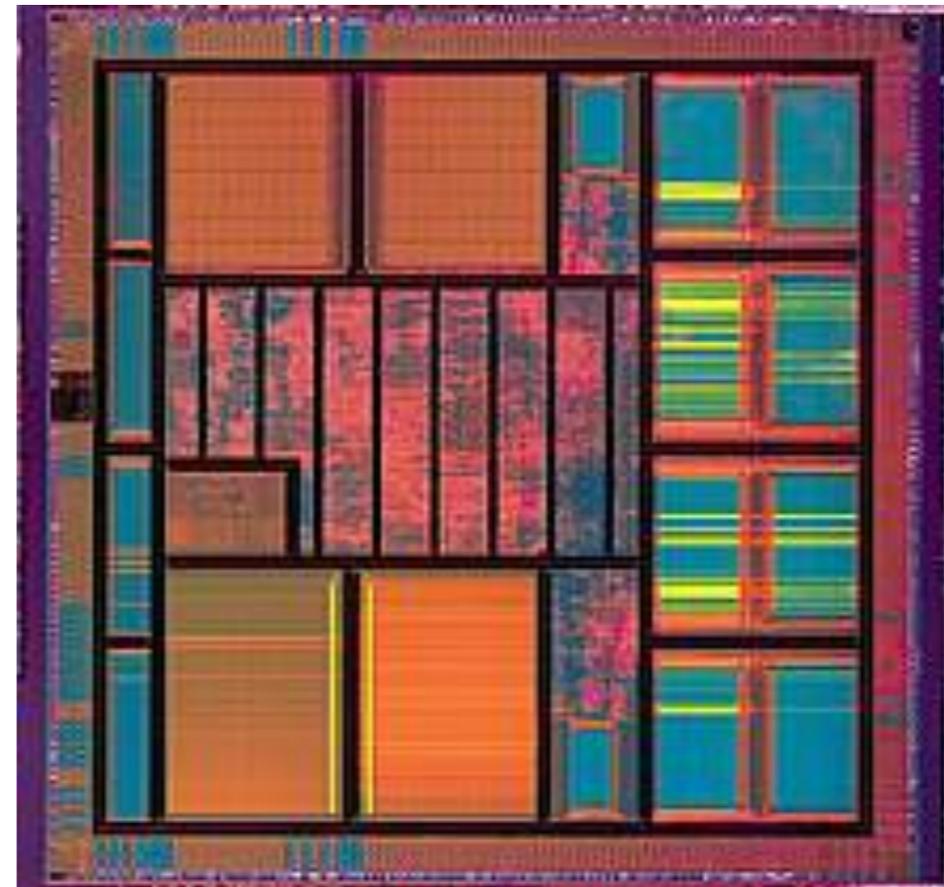
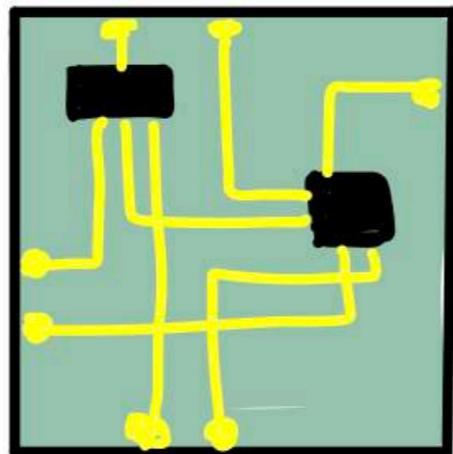
- “Slight” Oversimplification
- Limited coverage of Semiconductor Industry
- Extremely Technical Design & Manufacturing
- Simple Business Models
- Difficult to Map Future Winners / Losers
- Difficult to Map Capital Cycle

History & The Benefit of Hindsight

SCALED INTEGRATION

INTEGRATED CIRCUITS

SILICON
TRANSISTOR



1947

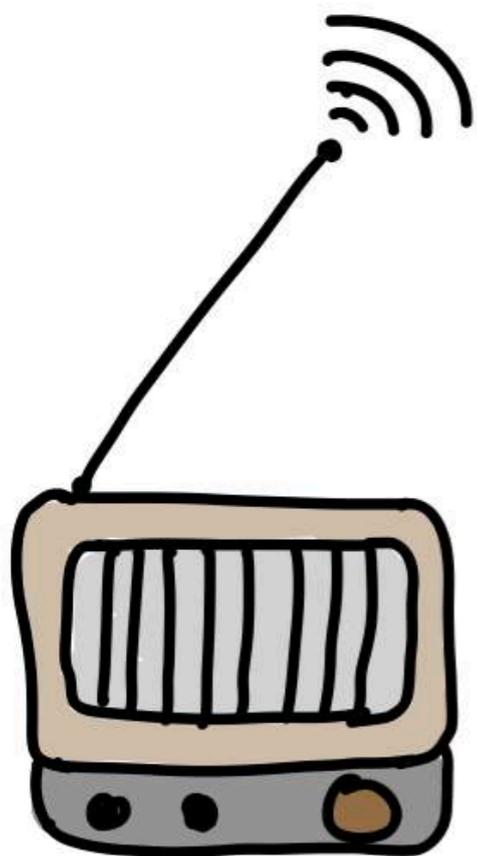
1958

1970's

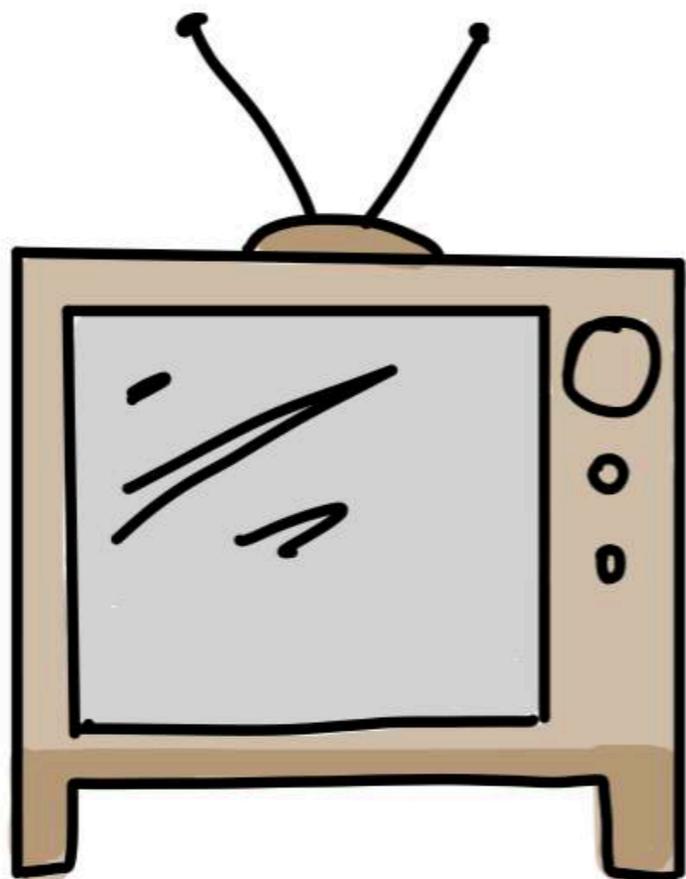
- - - -

2010's

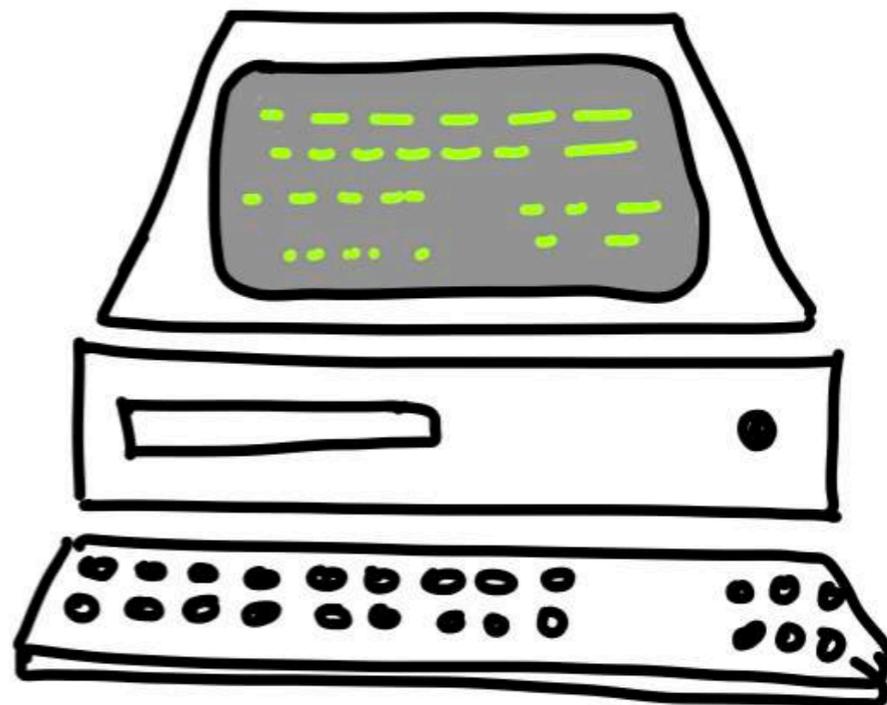




1950's

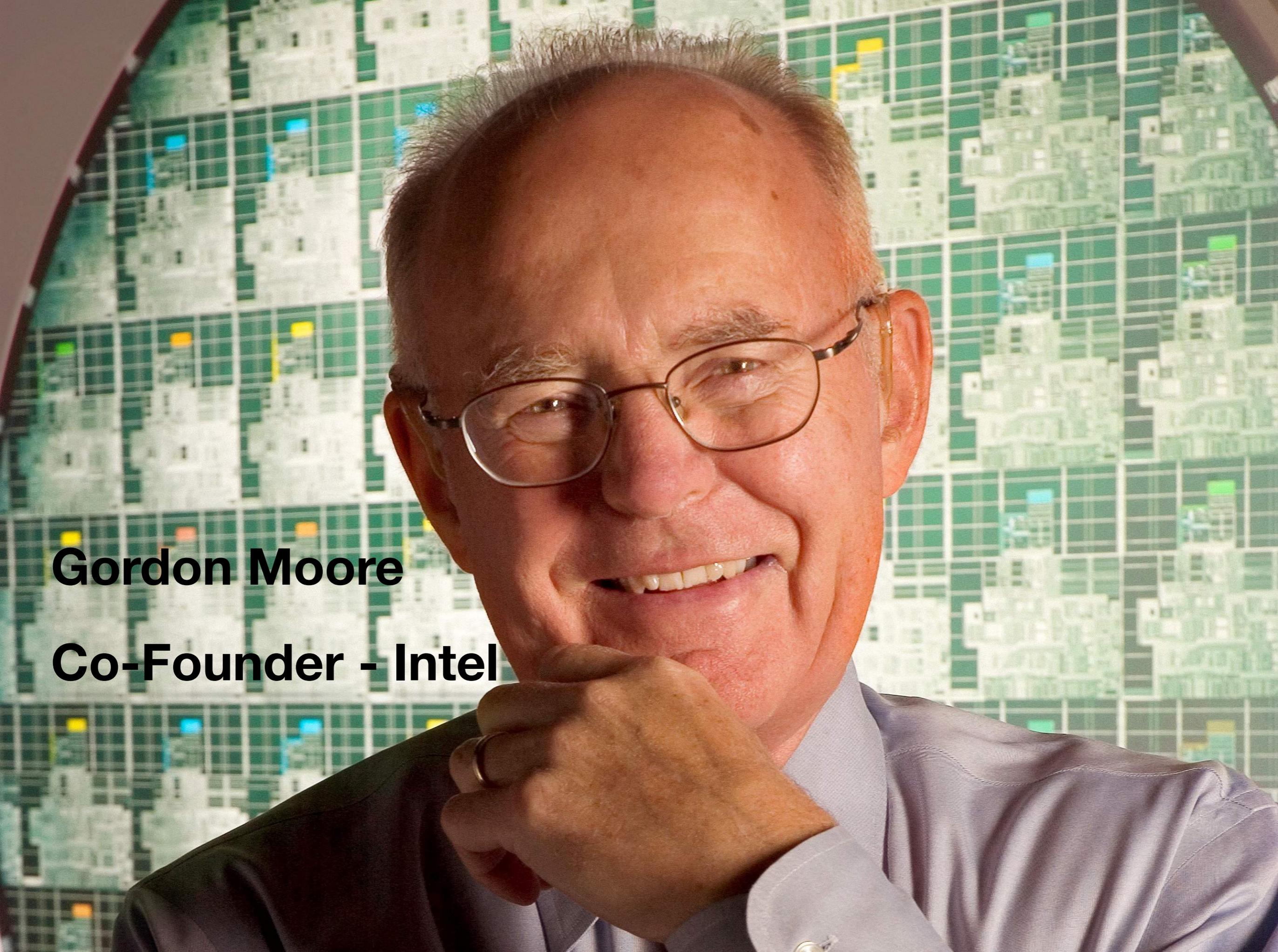


1960's



1970's

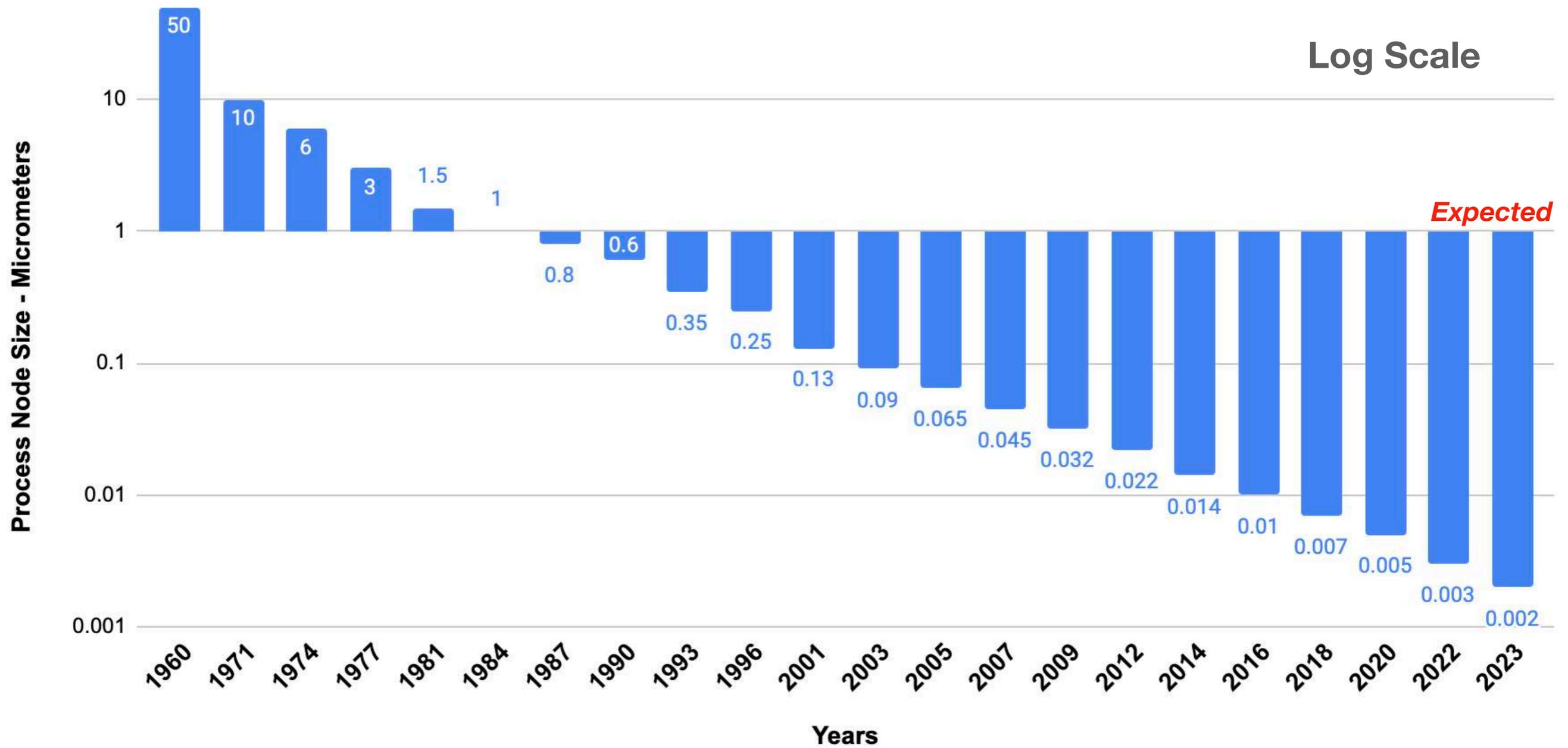
- - - -

A portrait of Gordon Moore, co-founder of Intel. He is an older man with glasses, smiling, and resting his chin on his hand. The background is a close-up of a green printed circuit board (PCB) with various components and traces. The text "Gordon Moore" and "Co-Founder - Intel" is overlaid on the left side of the image.

Gordon Moore
Co-Founder - Intel

More Transistors Compressed on a single chip over time

1 CM = 1000 Micrometers



Source: wikichip.org

Zooming in on Smartphone Chip Transistors

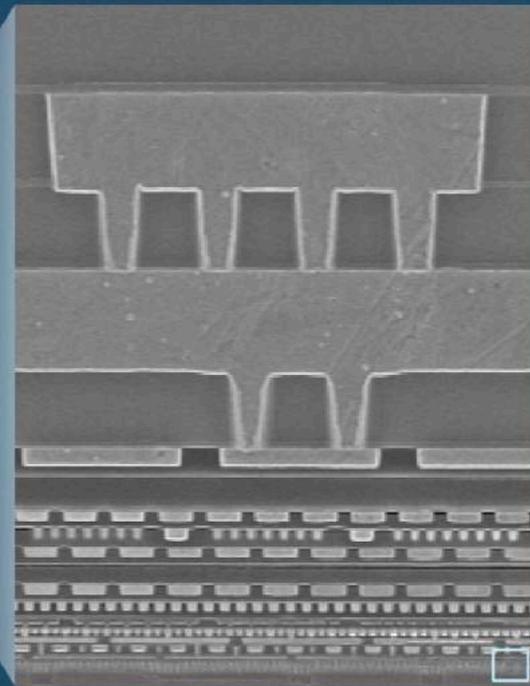


Source: Apple



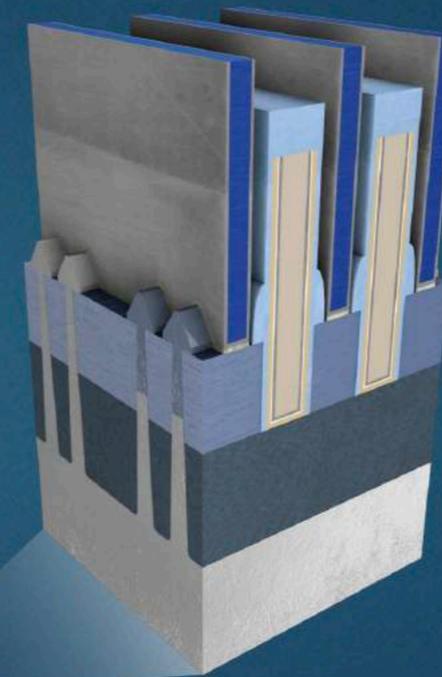
Source: Apple

Processor chip: 88mm² size
8.57 mm x 10.23 mm



Source: Technisights

Microscope cross section view of chip



3D model of a transistor and contacts

5nm
technology node

>11.8 billion
transistors

>24 billion
contacts

7 threshold voltages
HPC and mobile compute

• V_T Threshold voltage

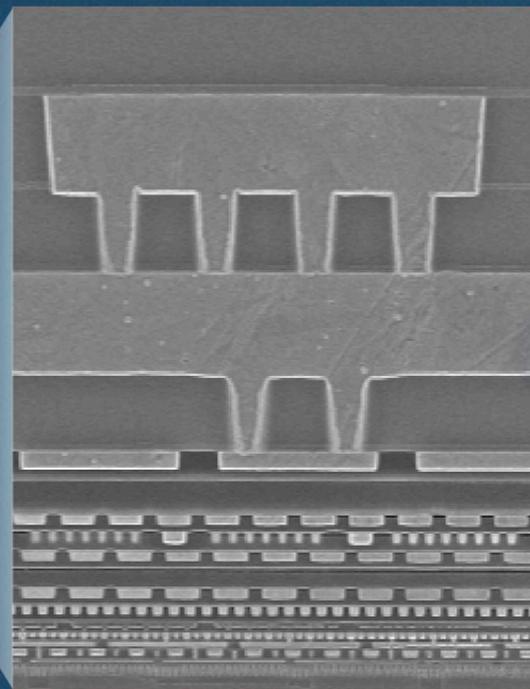
Zooming in on Smartphone Chip Interconnects



Source: Apple

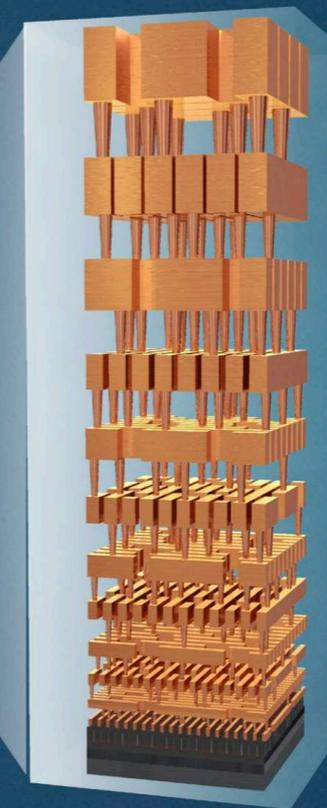


Source: Apple
Processor chip: 88mm² size
8.57 mm x 10.23 mm



Source: TechInsights

Microscope cross section view of chip



3D model of a chip

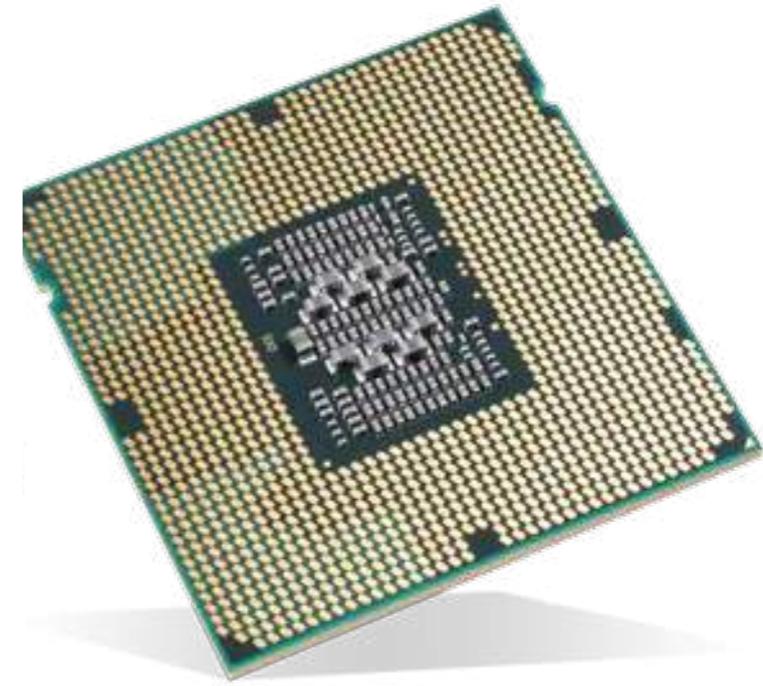
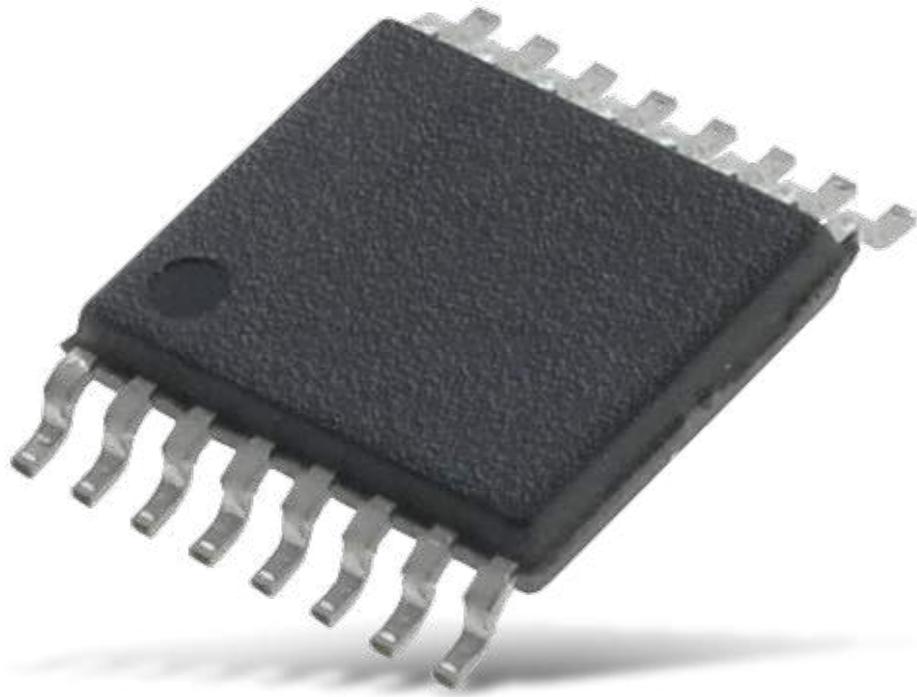
> 15 layers
stacked copper interconnects

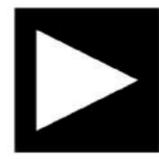
> 24 billion
contact trench and via connections

> 11.8 billion
transistors

\$

\$\$\$\$



 ANALOG
DEVICES

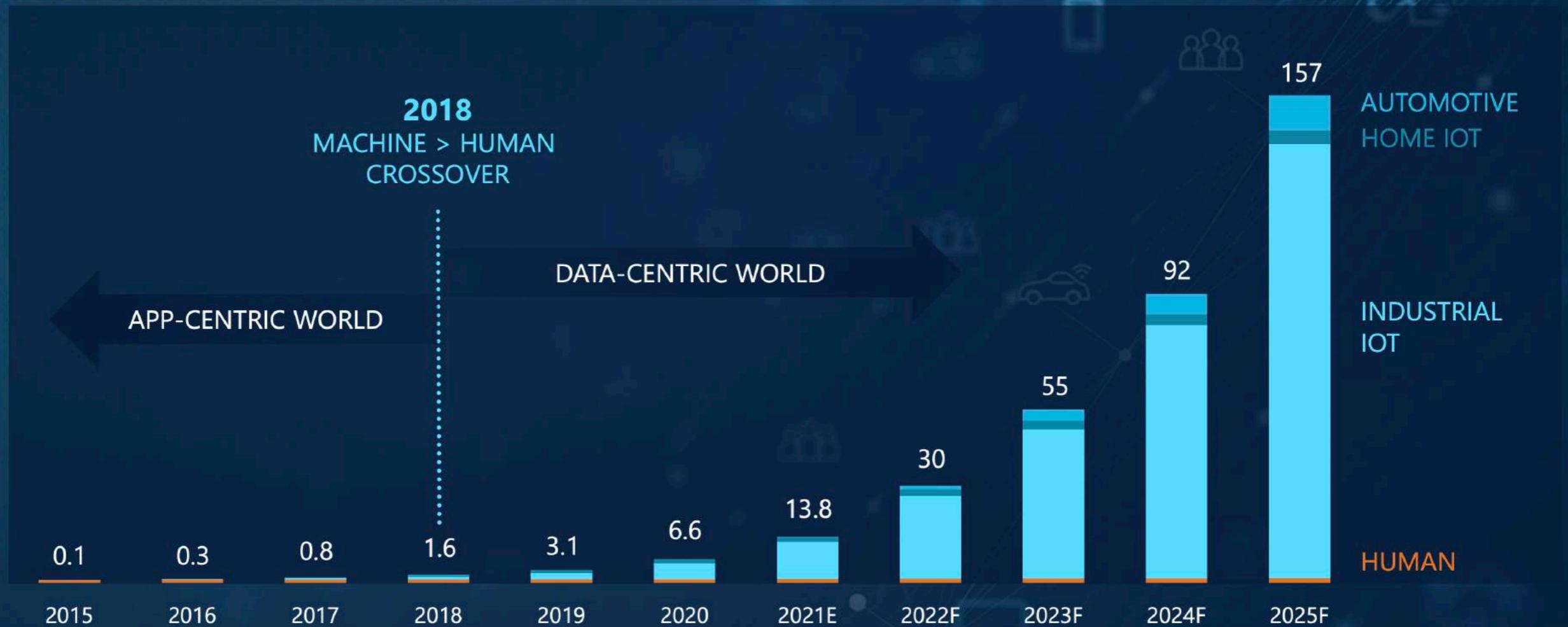


ANALOG

MIXED

DIGITAL

Data Generation By Category (ZB)



SEMI GROWTH NO LONGER LIMITED BY HUMAN CONSUMPTION

Source: Applied Materials

Applied Materials External Use



Source: Applied Materials

Semi content per unit		2015	2020	2025F	
	HIGH END SMARTPHONE	\$100	\$170	\$275	+62%
	AUTO (GLOBAL AVERAGE)	\$310	\$460	\$690	+50%
	DATACENTER SERVER (CPU + ACCELERATOR)	\$1,620	\$2,810	\$5,600	+99%
	SMARTHOME (GLOBAL AVERAGE)	\$2	\$4	\$9	

SILICON CONTENT GROWING AS EVERYTHING GETS SMARTER

Source: Applied Materials

Applied Materials External Use



Source: Applied Materials

Technologies Involved In Chip Making...

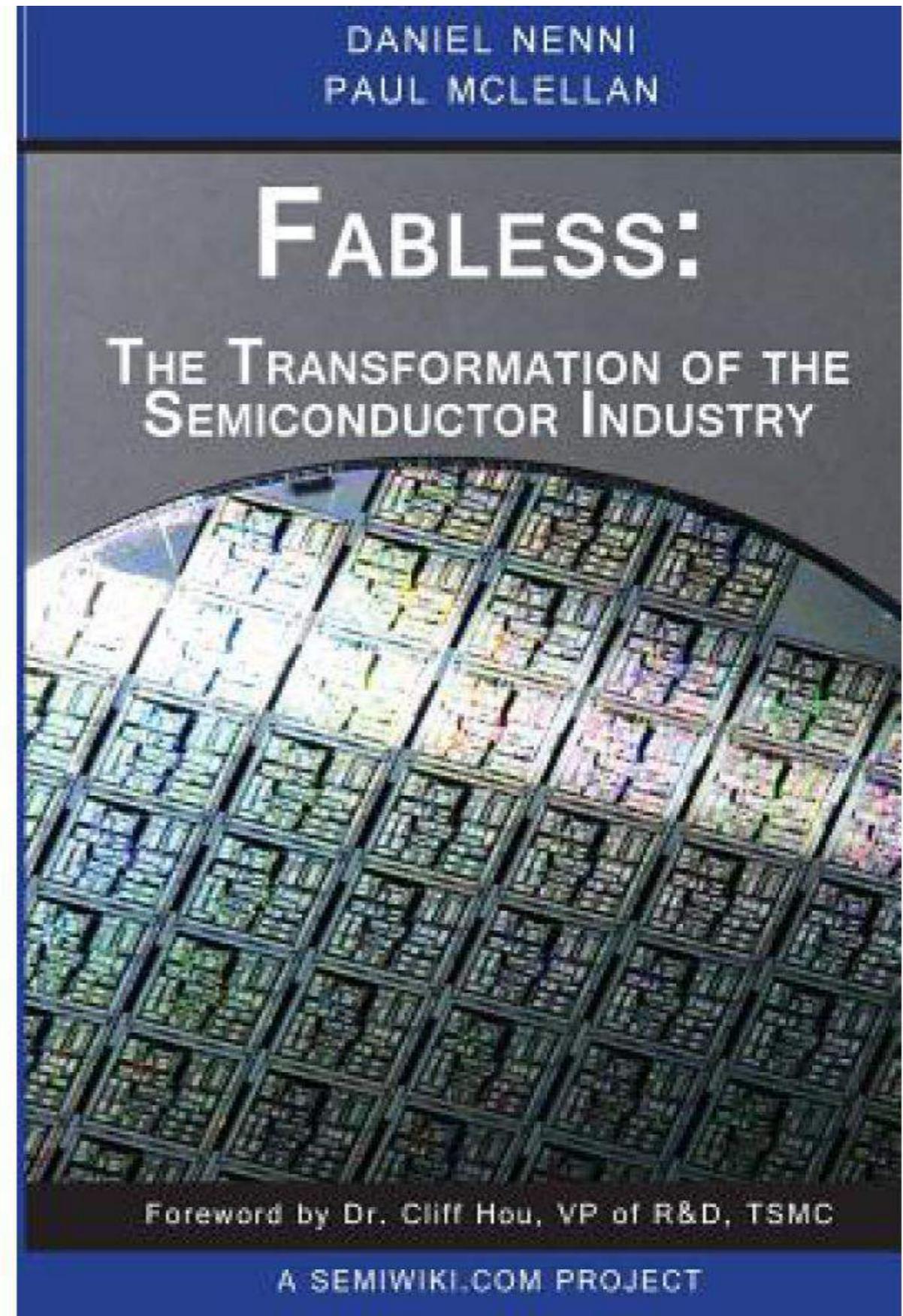
- Material Science
- Optics
- Microelectronics
- Computer Aided Design & Manufacturing
- Extreme Air Filtration HVAC
- Seismic Technology
- Advanced Packaging & Testing

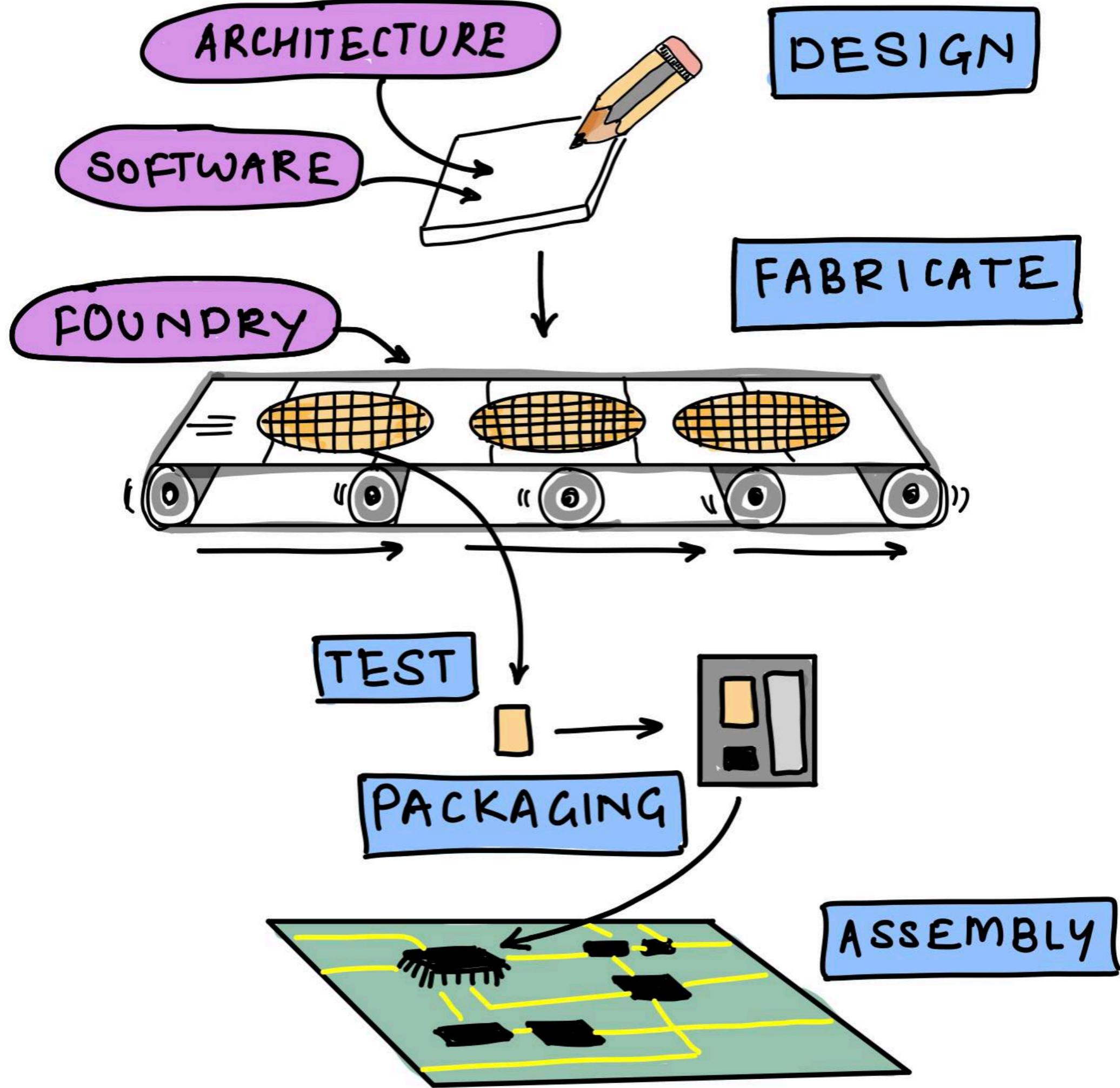
The Semiconductor Ecosystem

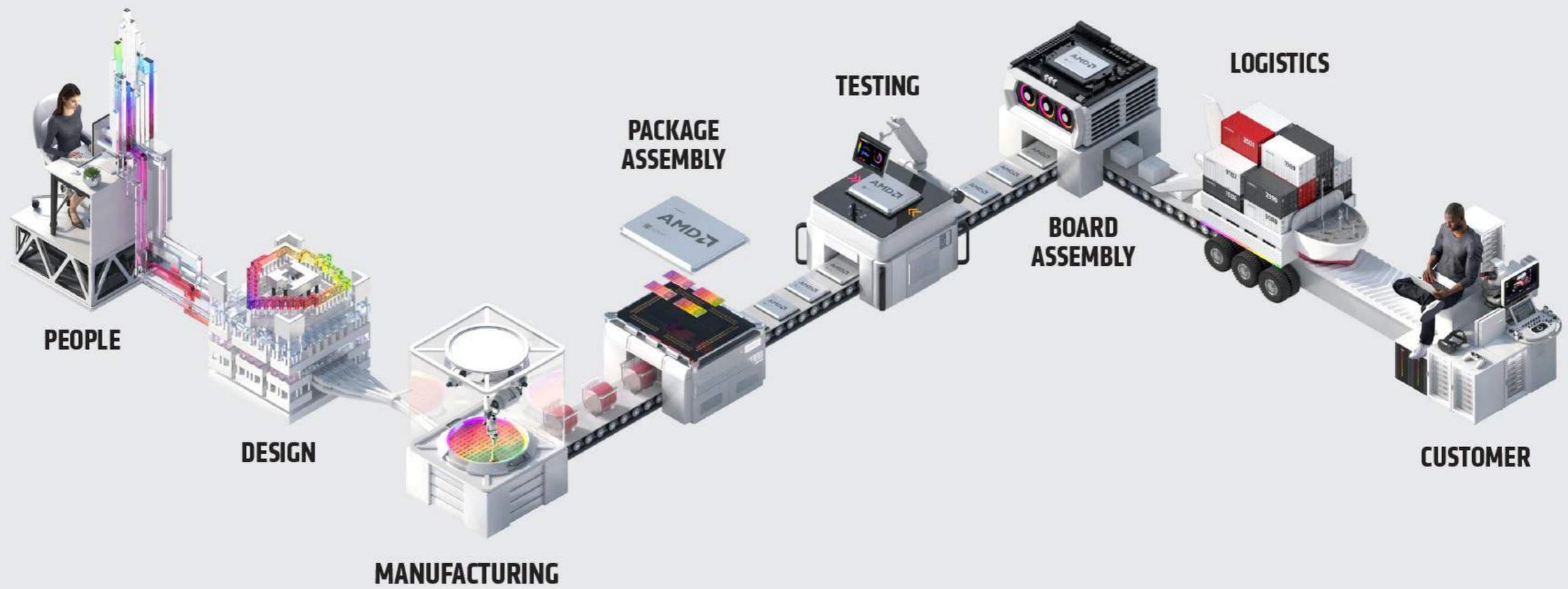
Fabless

The Transformation of the Semiconductor Industry

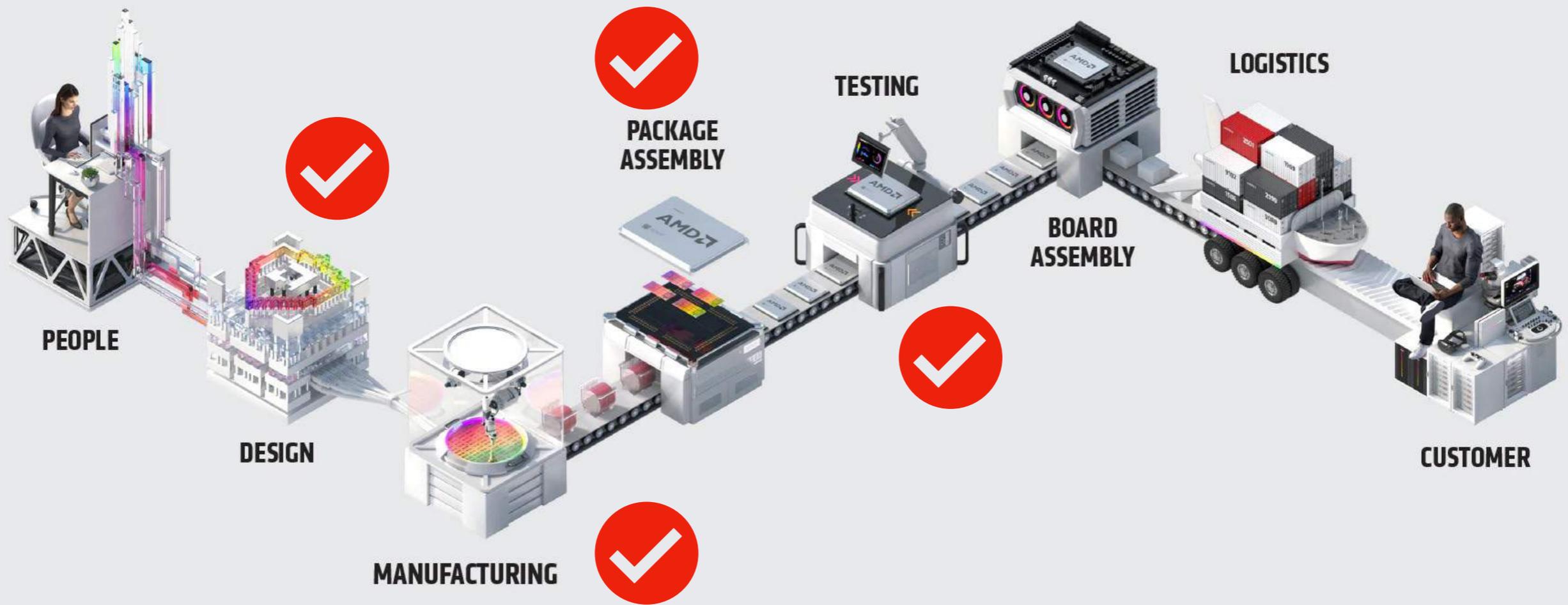
- Daniel Nenni
- Paul Mclellan
- <https://semiwiki.com/>







Source: AMD



Source: AMD

Integrated Device Manufacturer

Design



Source: AMD

**Who are the Chip
Designers?**

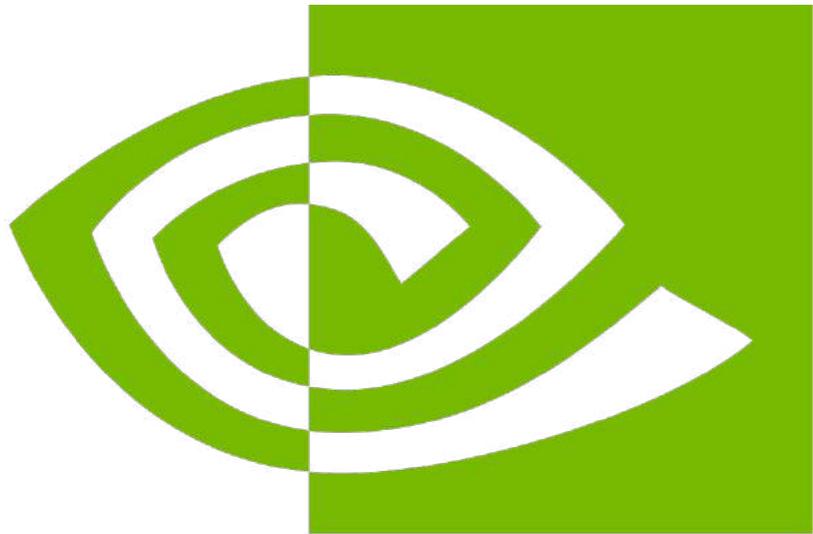
intel[®]

Qualcomm

MEDIATEK

AMD

BROADCOM[®]



NVIDIA[®]





ARCHITECTURE

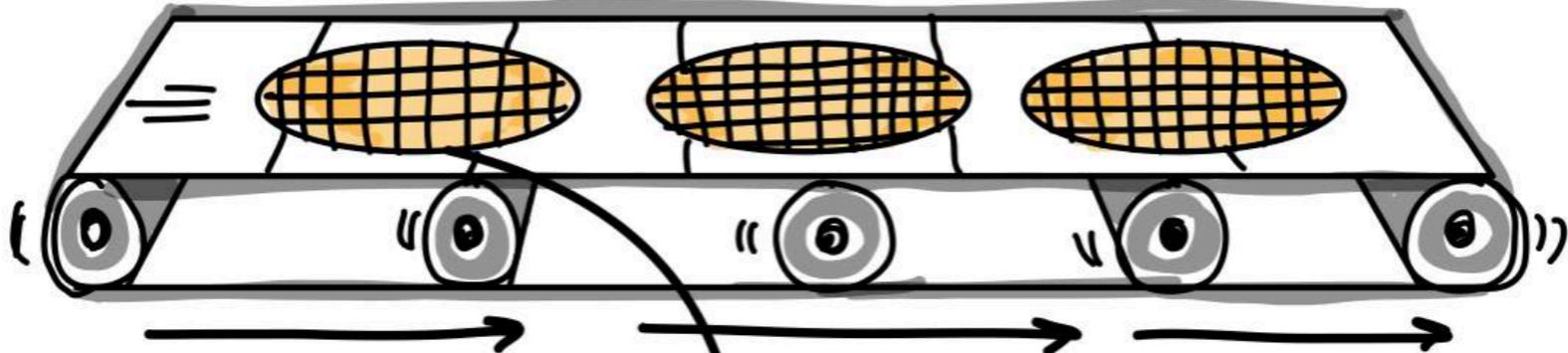
DESIGN

SOFTWARE

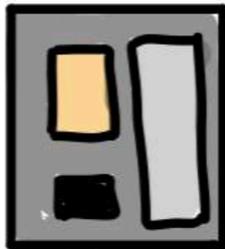


FABRICATE

FOUNDRY

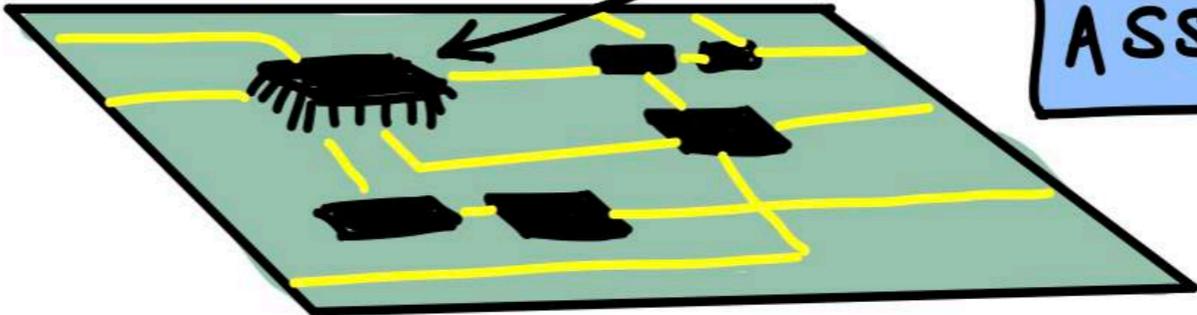


TEST



PACKAGING

ASSEMBLY



How do they Design?



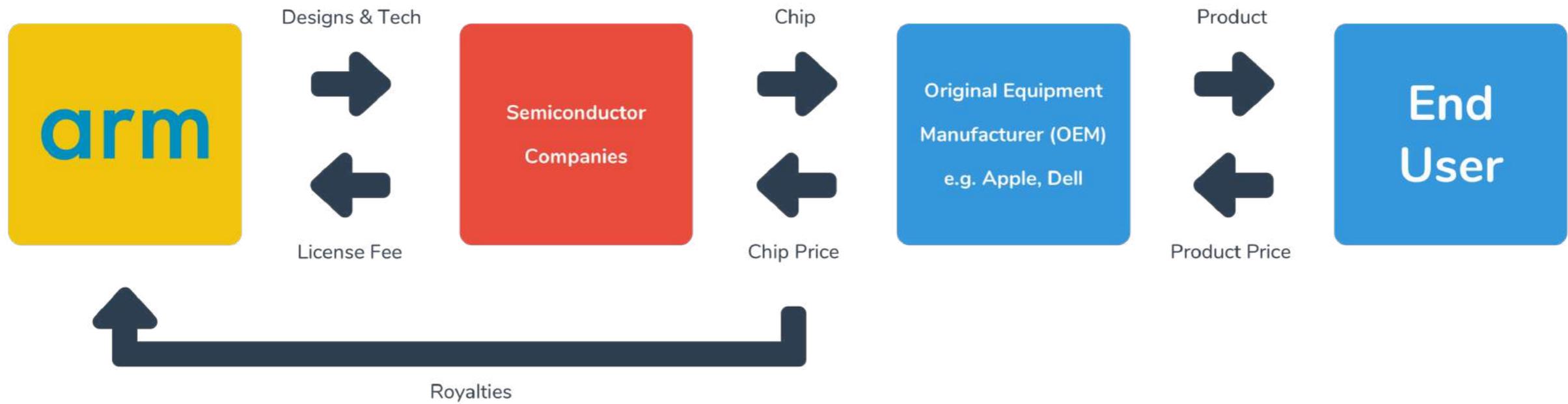
Source: AMD

1 - Architecture

Types of CPU

RISC vs CISC





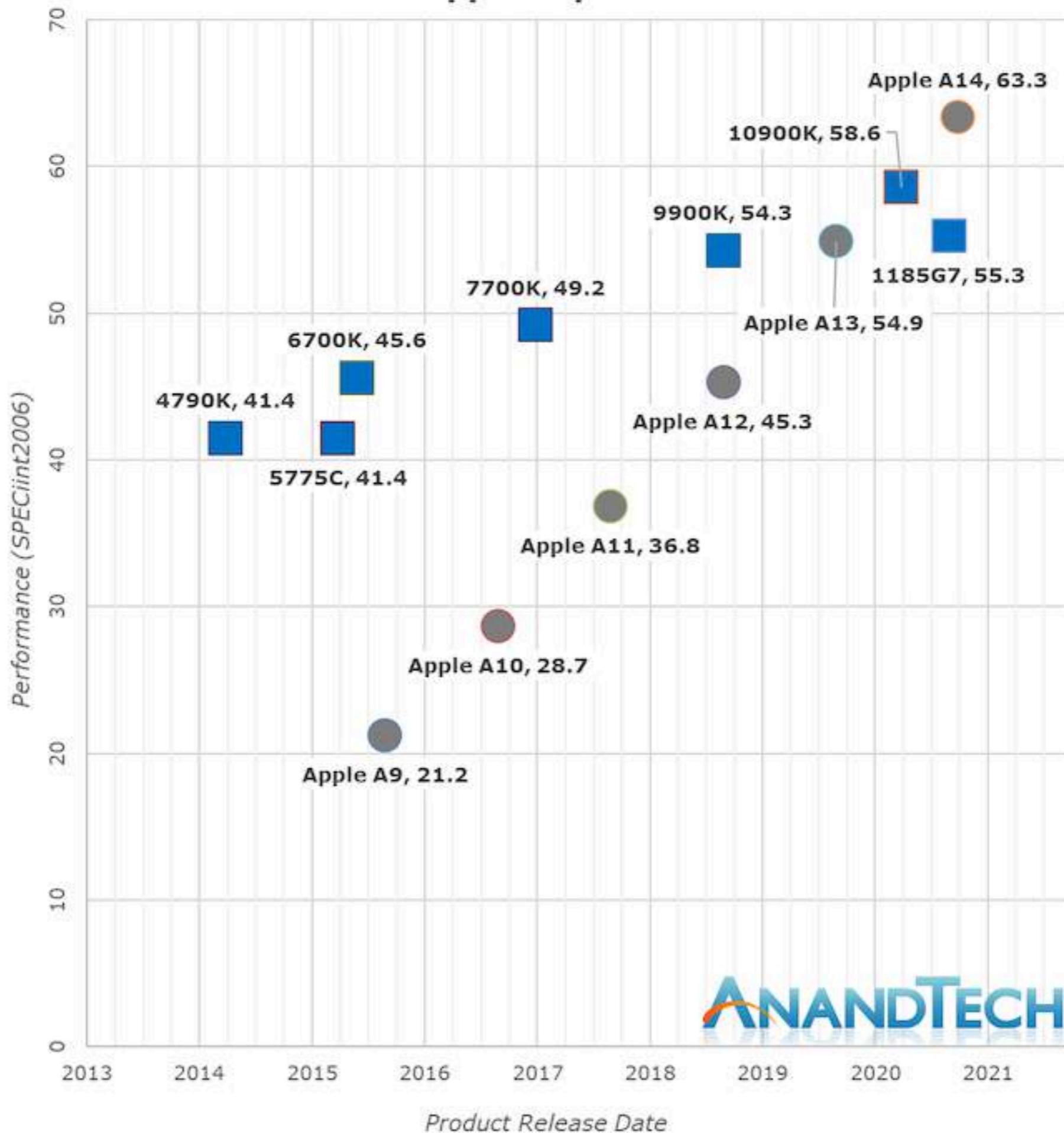
= SoftBank
 \$25 Bn + 2016
ARM

\$40 Bn

NVIDIA®

 202X?

Intel vs Apple Top Performance

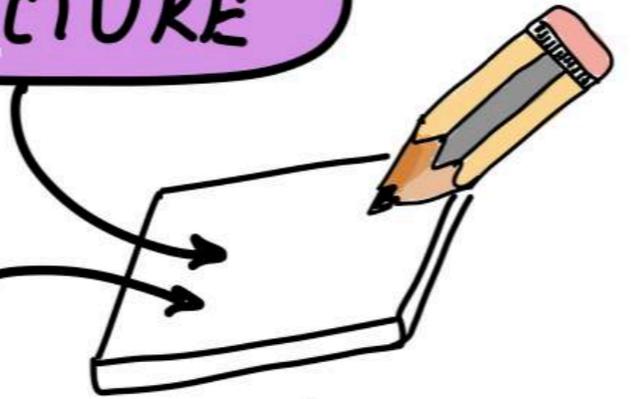




ARCHITECTURE

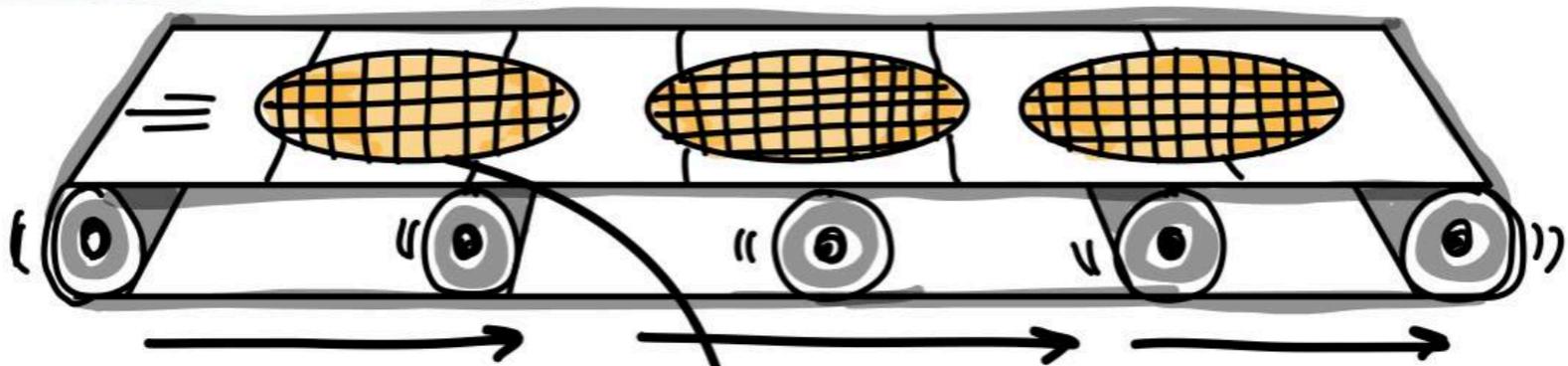
SOFTWARE

DESIGN

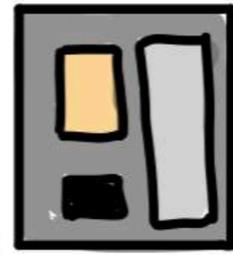


FOUNDRY

FABRICATE

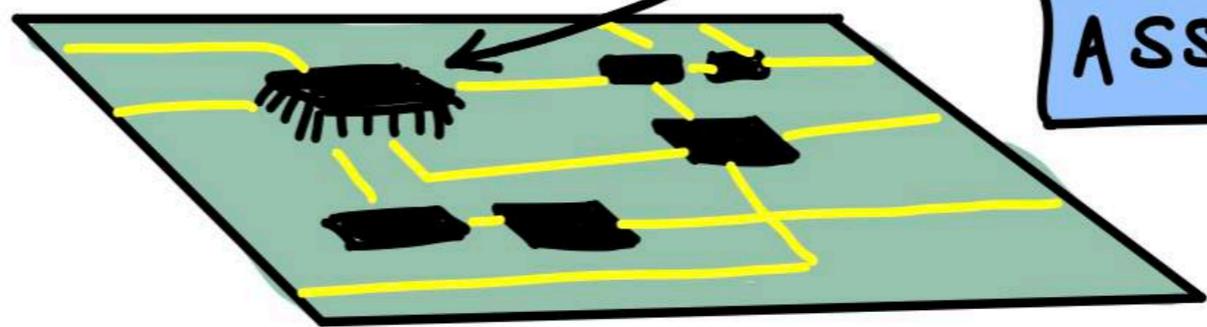


TEST



PACKAGING

ASSEMBLY



How do they Design?

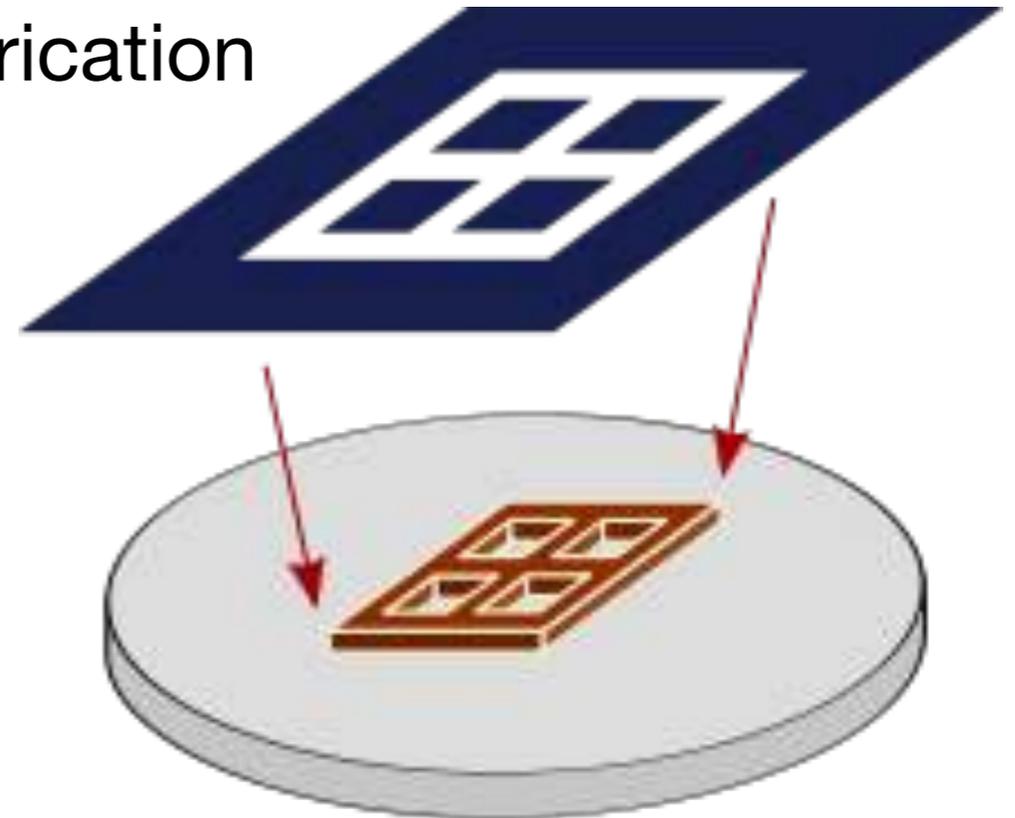


Source: AMD

2 - Electronic Design Automation (EDA)

What do Design Companies do?

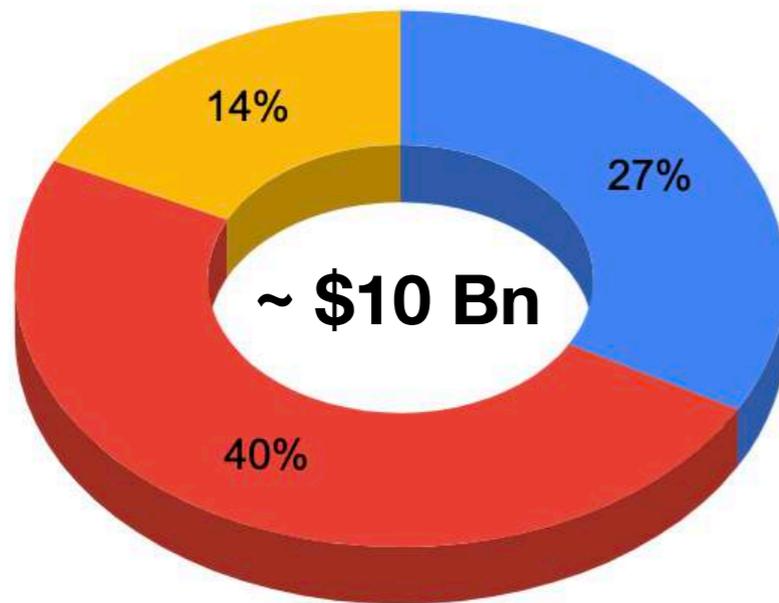
- Softwares help in Designing the chip
- Simulate the behaviour & performance of the chip
- Analyse & Verify if chip performance is optimal
- Prepare a ***photomask*** to send for fabrication



cādence

SYNOPSYS®

Siemens EDA, Cadence & Synopsys Market Share

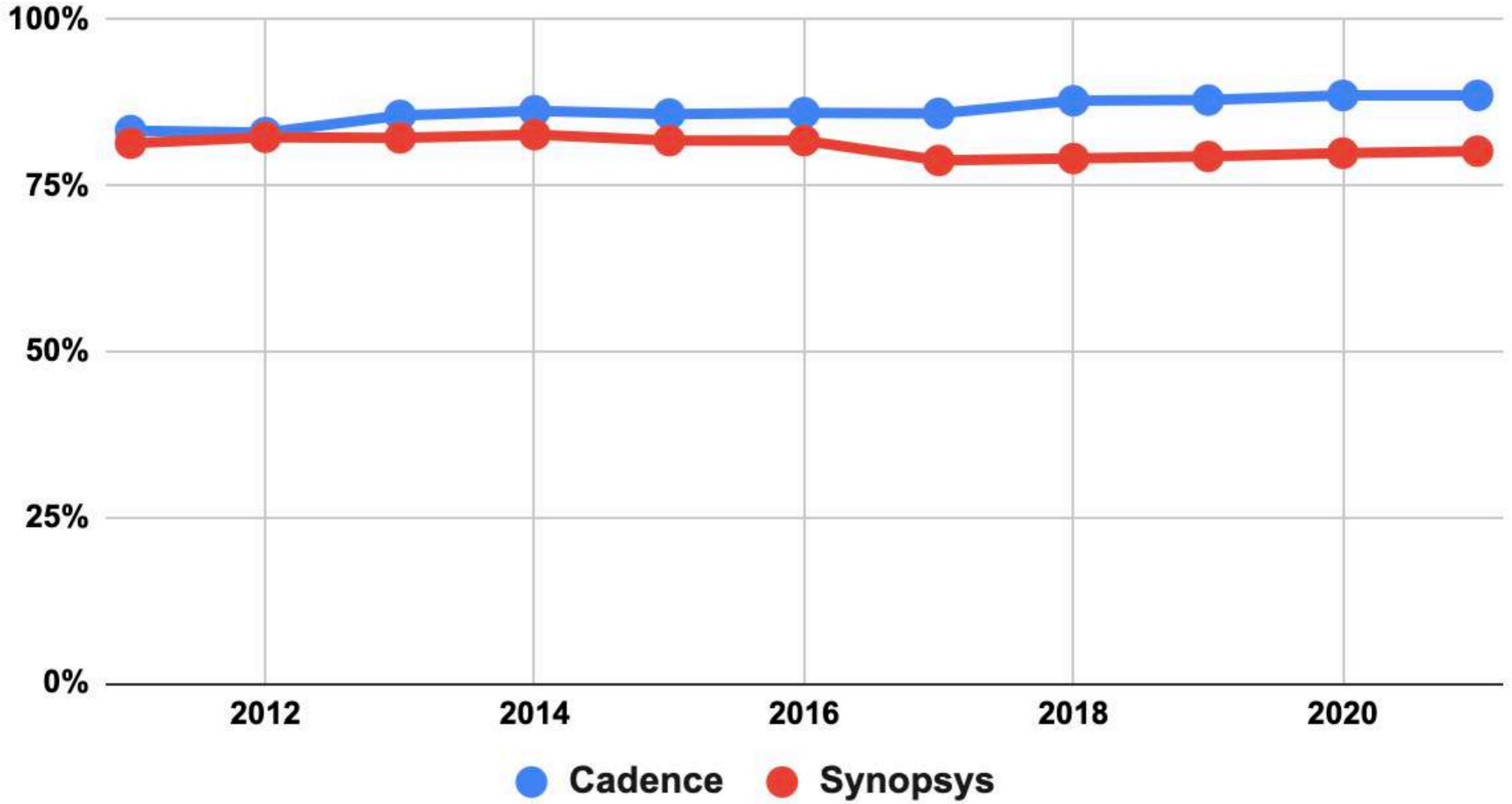


Mentor
Graphics®

SIEMENS

Source: Company Financials & Siemens EDA (estimates)

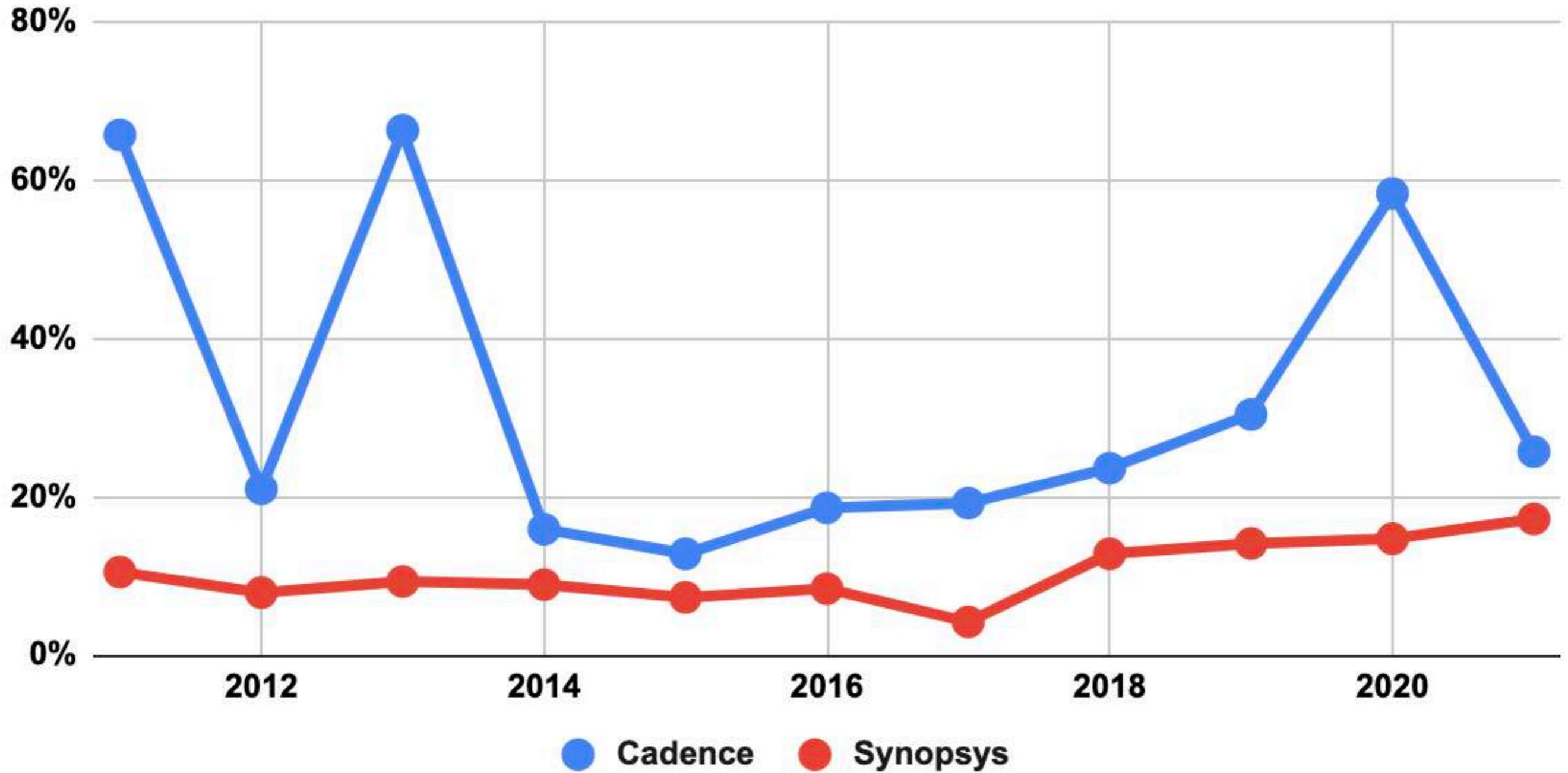
EDA Gross Margins (%)



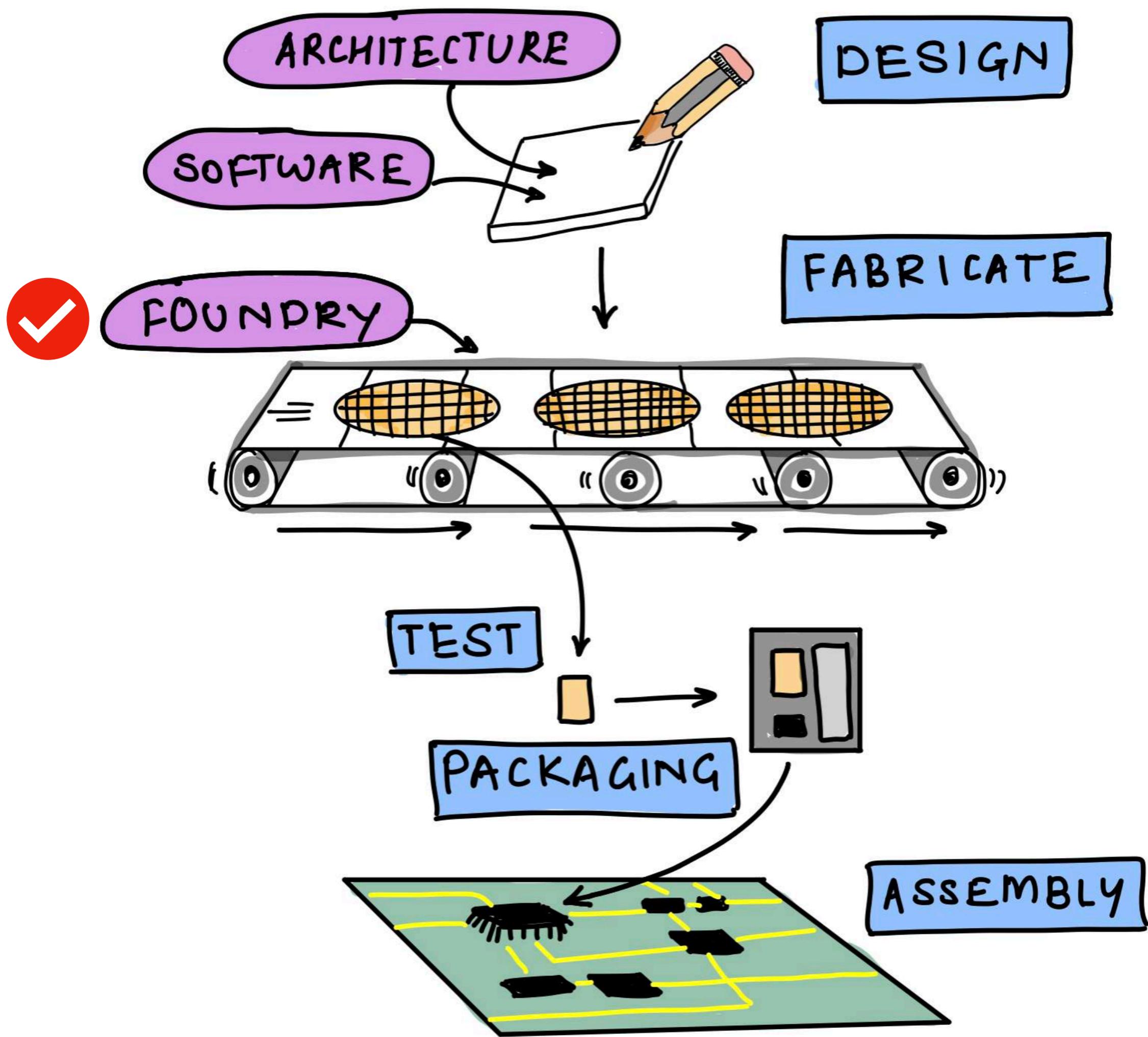
Source: Company Filings

EDA RoE (%)

Low Debt, Hi Margins, Hi Asset Turns



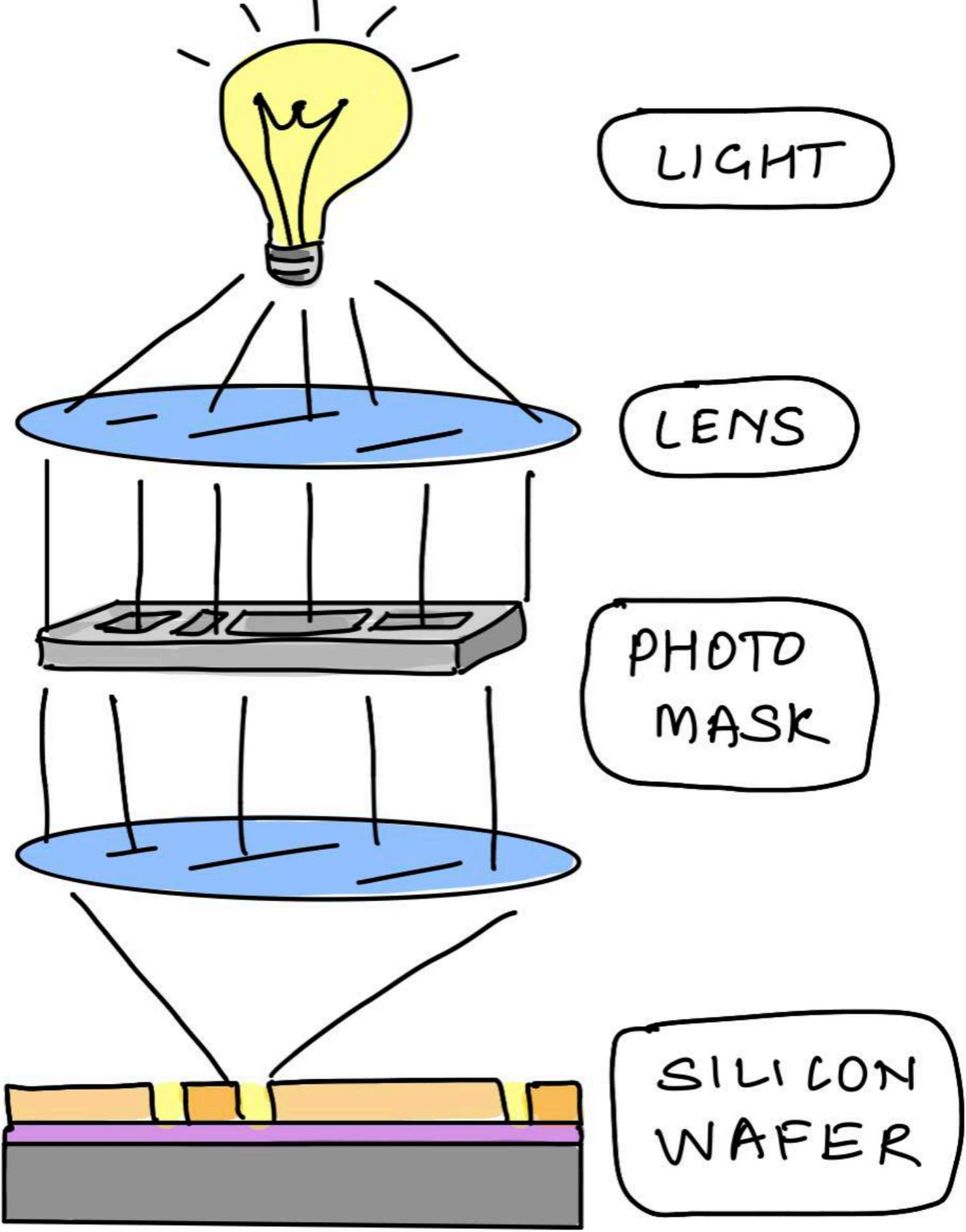
Source: Company Filings



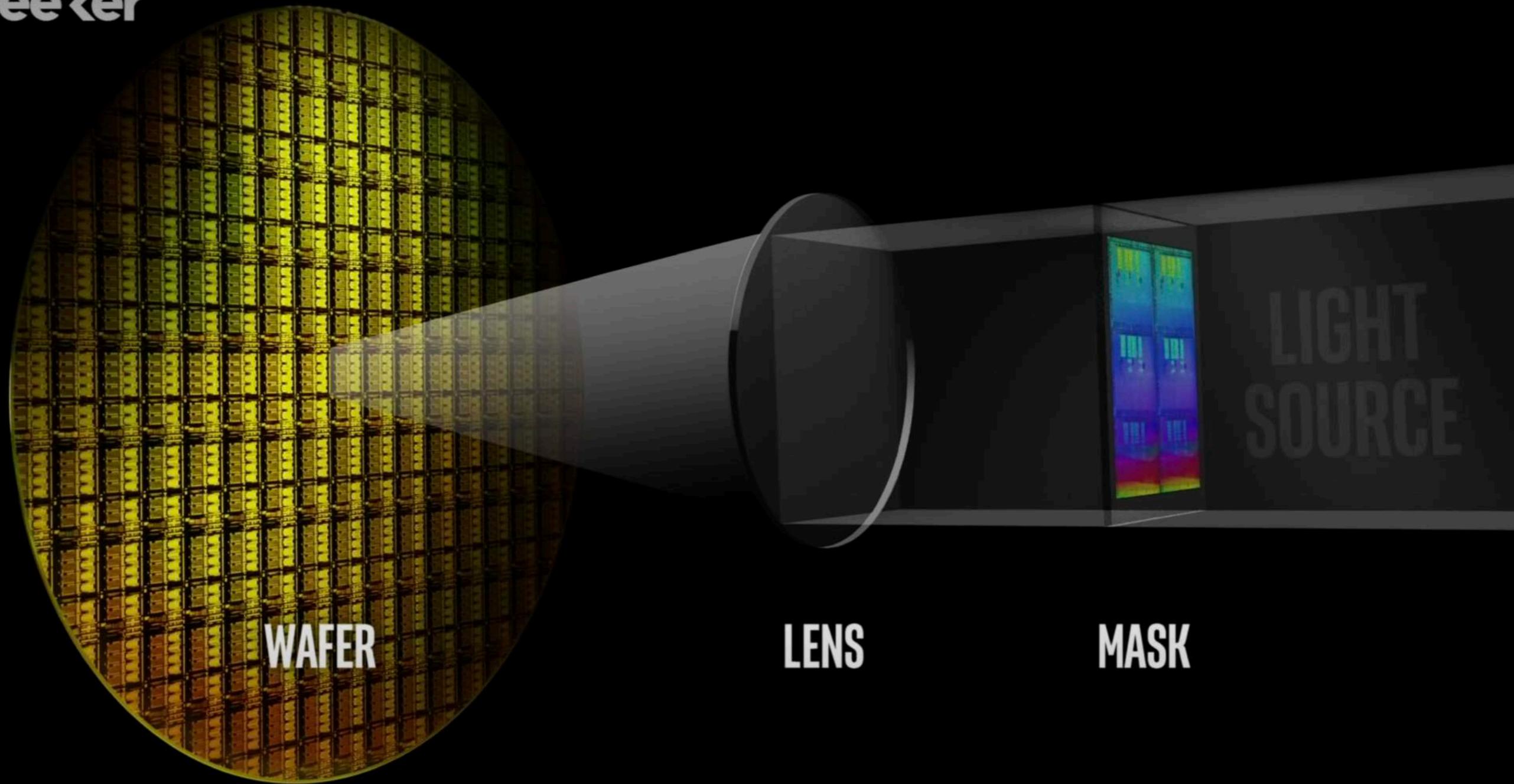




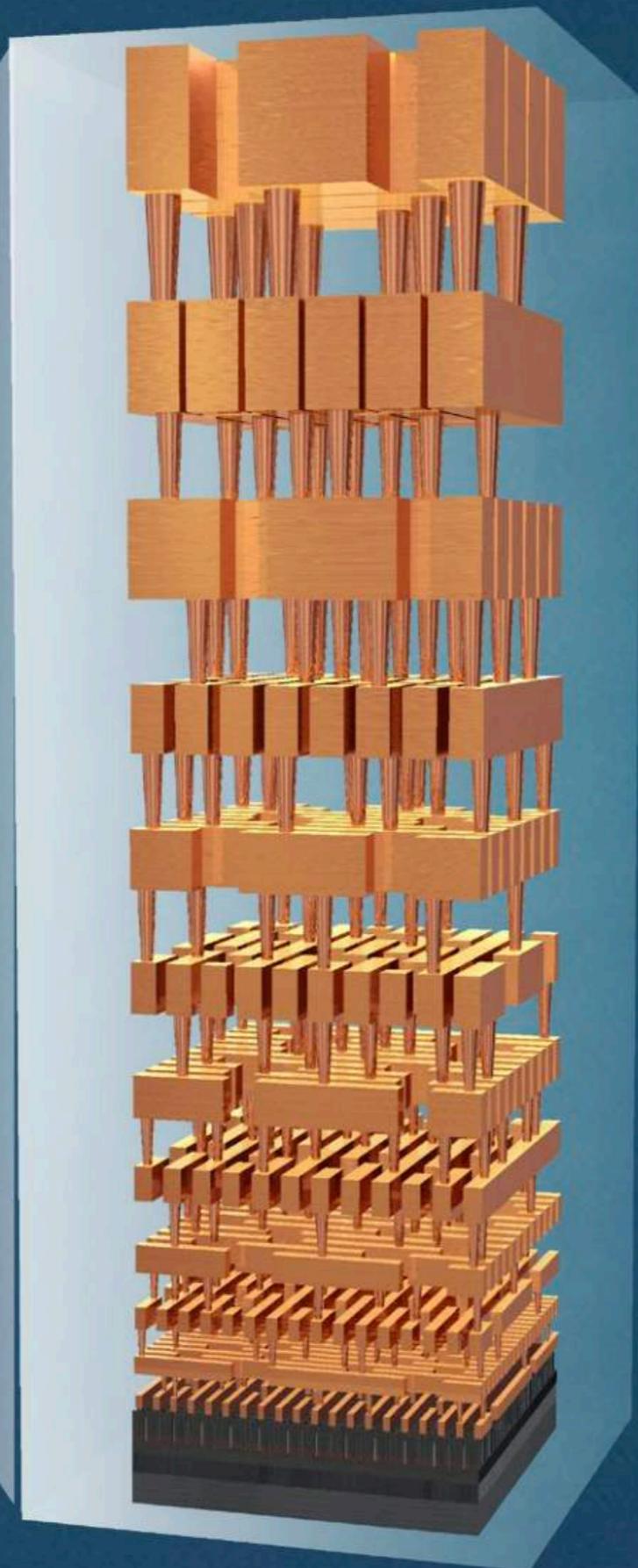
Photolithography



See ker



Photolithography



3D model of a chip

> 15 layers
stacked copper interconnects

> 24 billion
contact trench and via connections

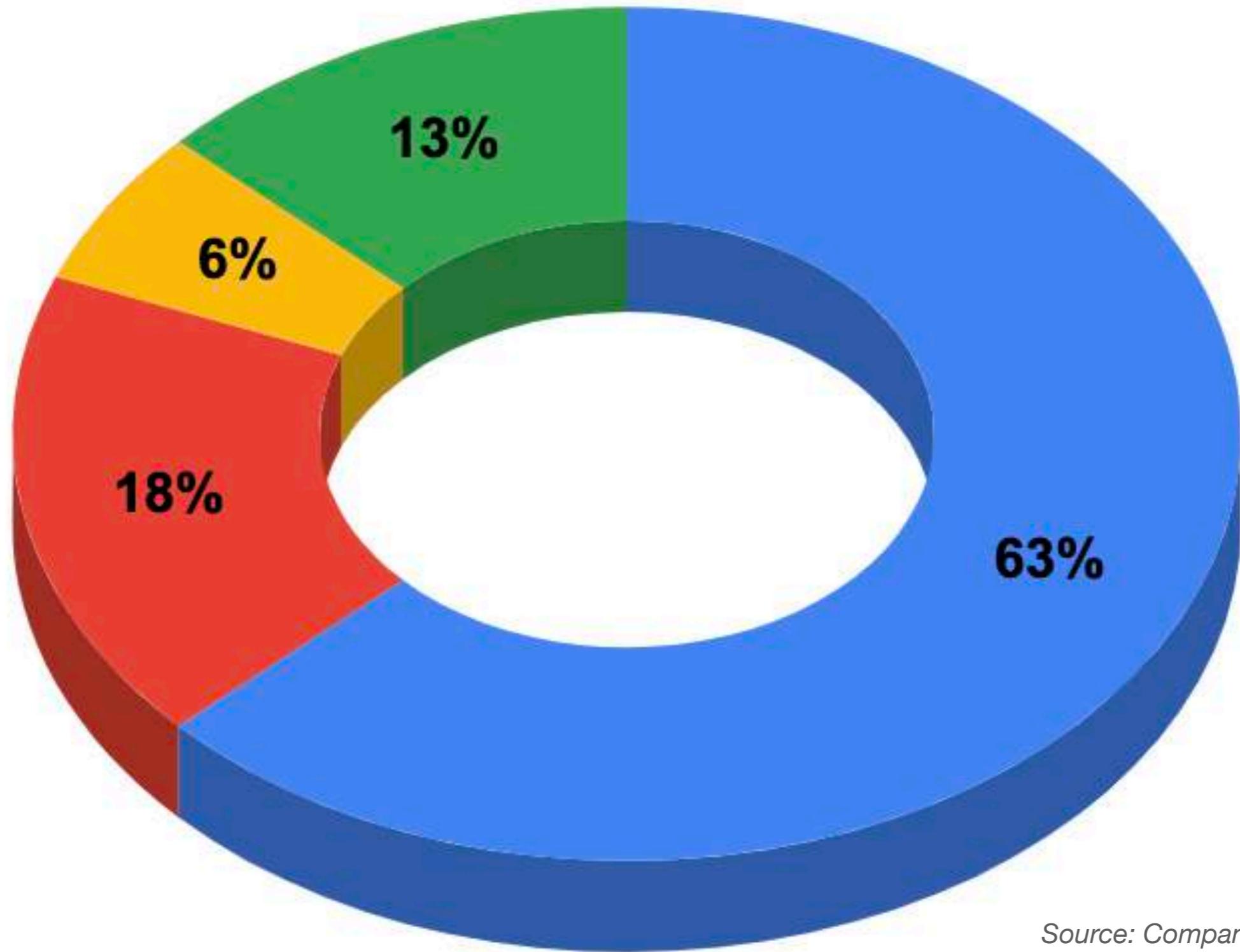
> 11.8 billion
transistors



Foundry Economics

Not for the faint hearted

- Heavy Capital Expenditure
 - Machines & other ancillary equipment
- Land
- Good quality power supply
- Large quantity of fresh water supply
- Skilled Labour
- Intense competition
- Pace of Technology Change
- Wild Capital Cycles in Commodity Semiconductors

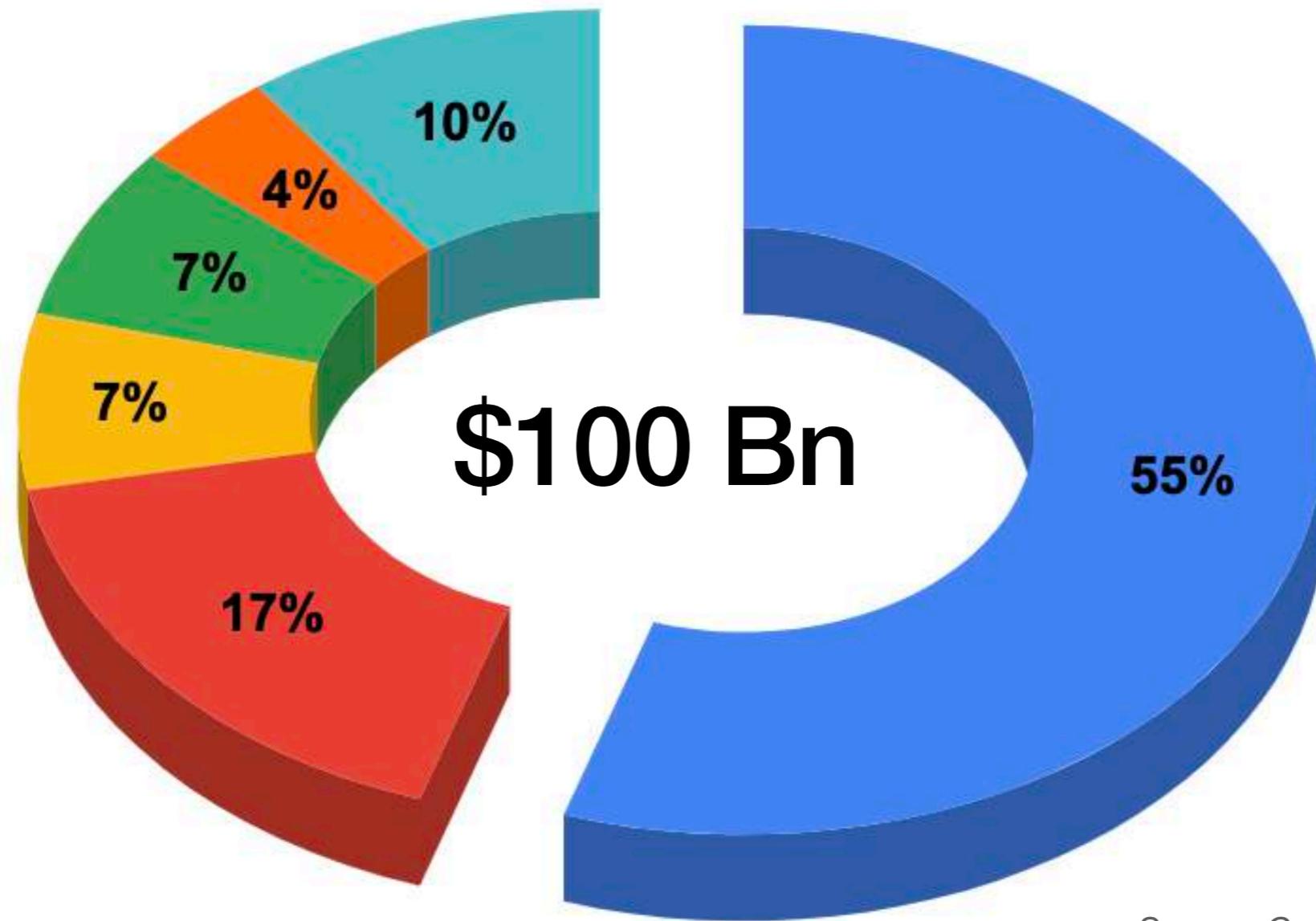


Source: Company Filings

Foundry by Country

- Taiwan
- South Korea
- China
- Others

Foundry Company Market Share



Source: Company Filings

● TSMC ● Samsung ● UMC ● Global Foundries ● SMIC ● Others





Any sufficiently advanced
technology is indistinguishable from
magic.

— *Arthur C. Clarke* —

AZ QUOTES

Must Watch



Seeker ✓

4.84M subscribers

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FOCAL POINT S1 • E2

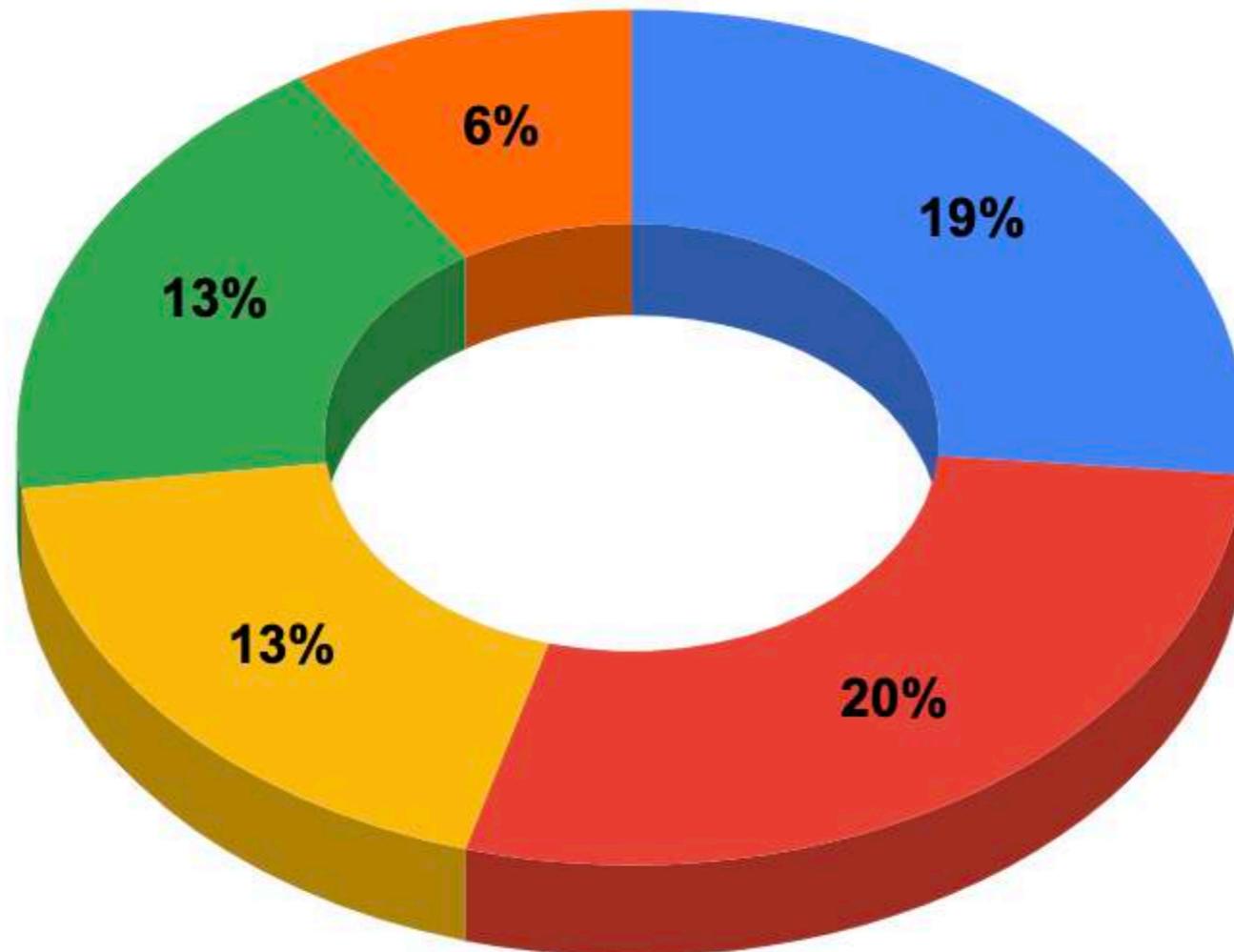
The Extreme Physics Pushing Moore's Law to the Next Level

Seeker ✓ 4M views • 1 year ago

A look inside a new precision machine that wants to reinvent the chip making industry. Seeker! <http://bit.ly/subscribeseeker> » Watch more Focal Point | <https://bit.ly/31Ms6mj..>

Subtitles

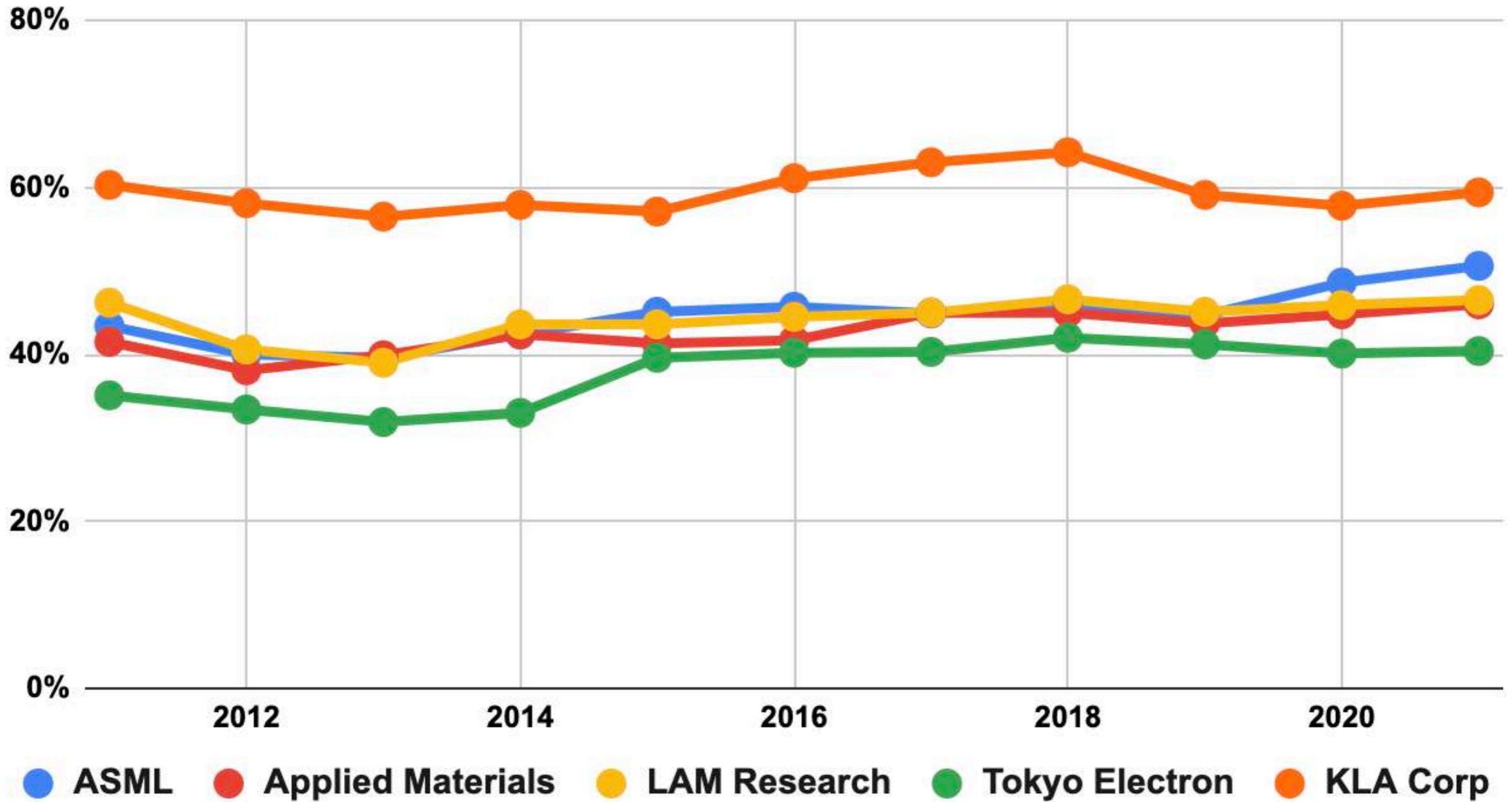
Equipment Makers - Market Share



Source: Company Filings

● ASML ● Applied Material ● LAM Research ● Tokyo Electron ● KLA Corporation

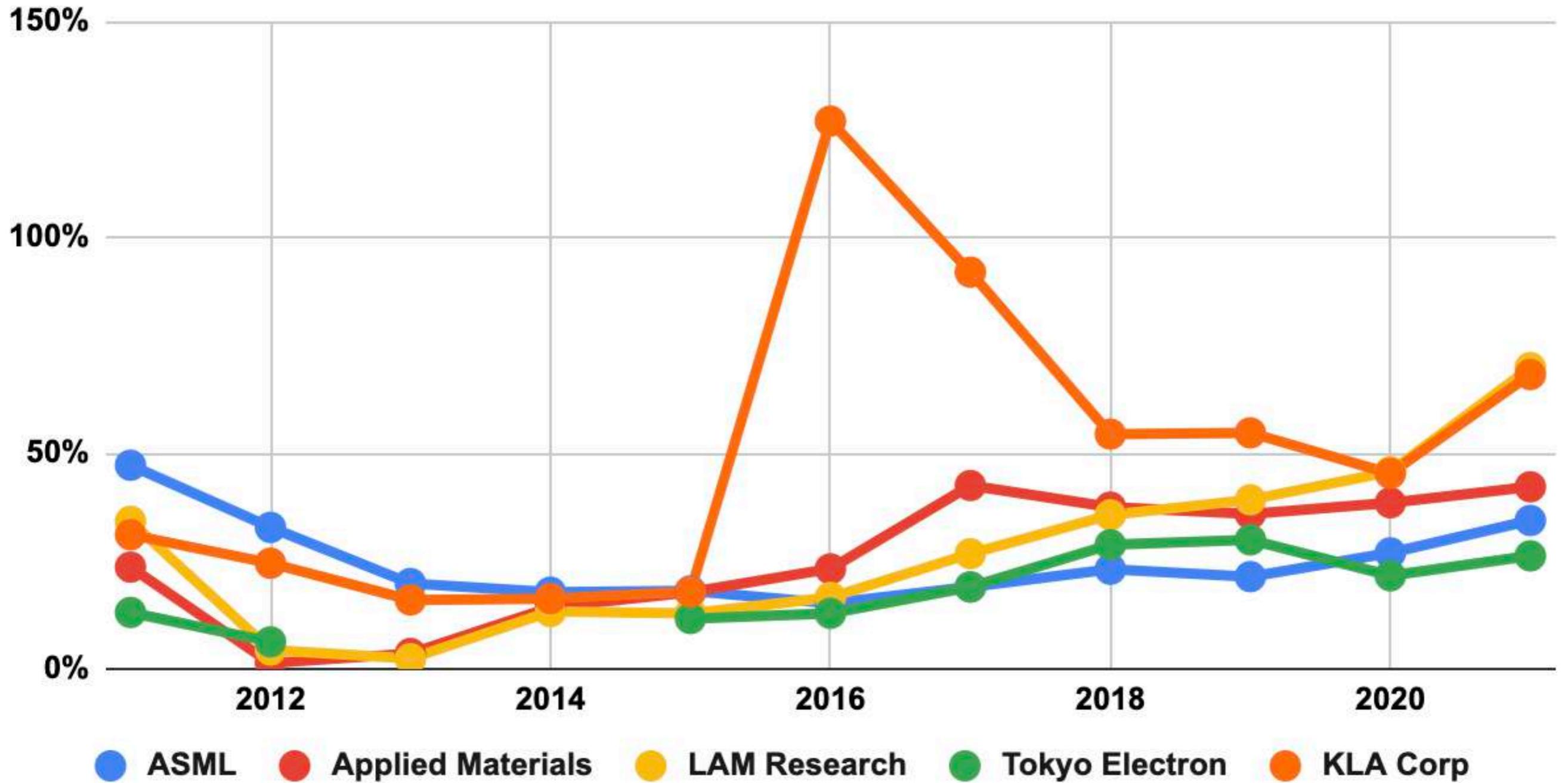
Equipment Makers Gross Margins (%)



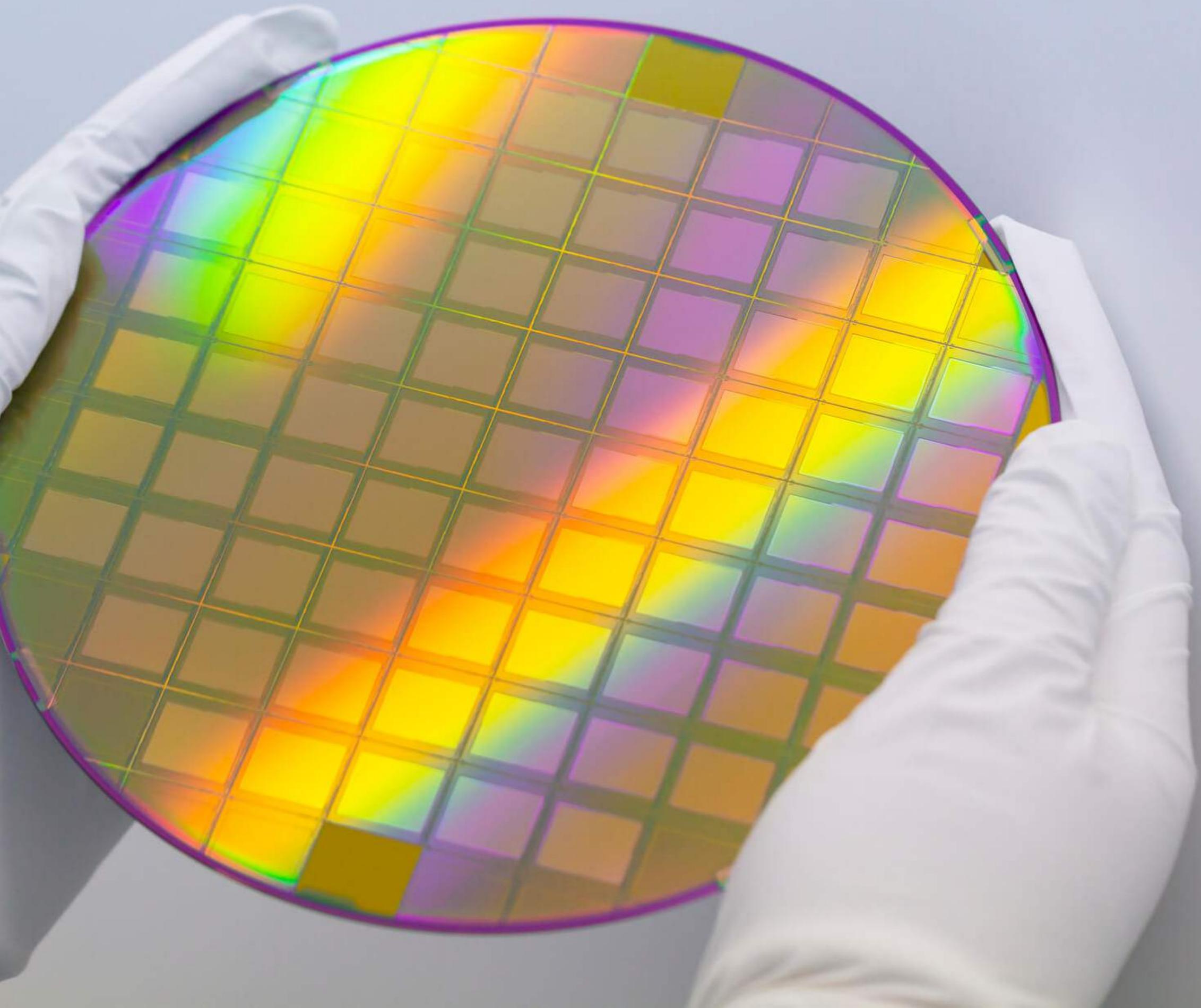
Source: Company Filings

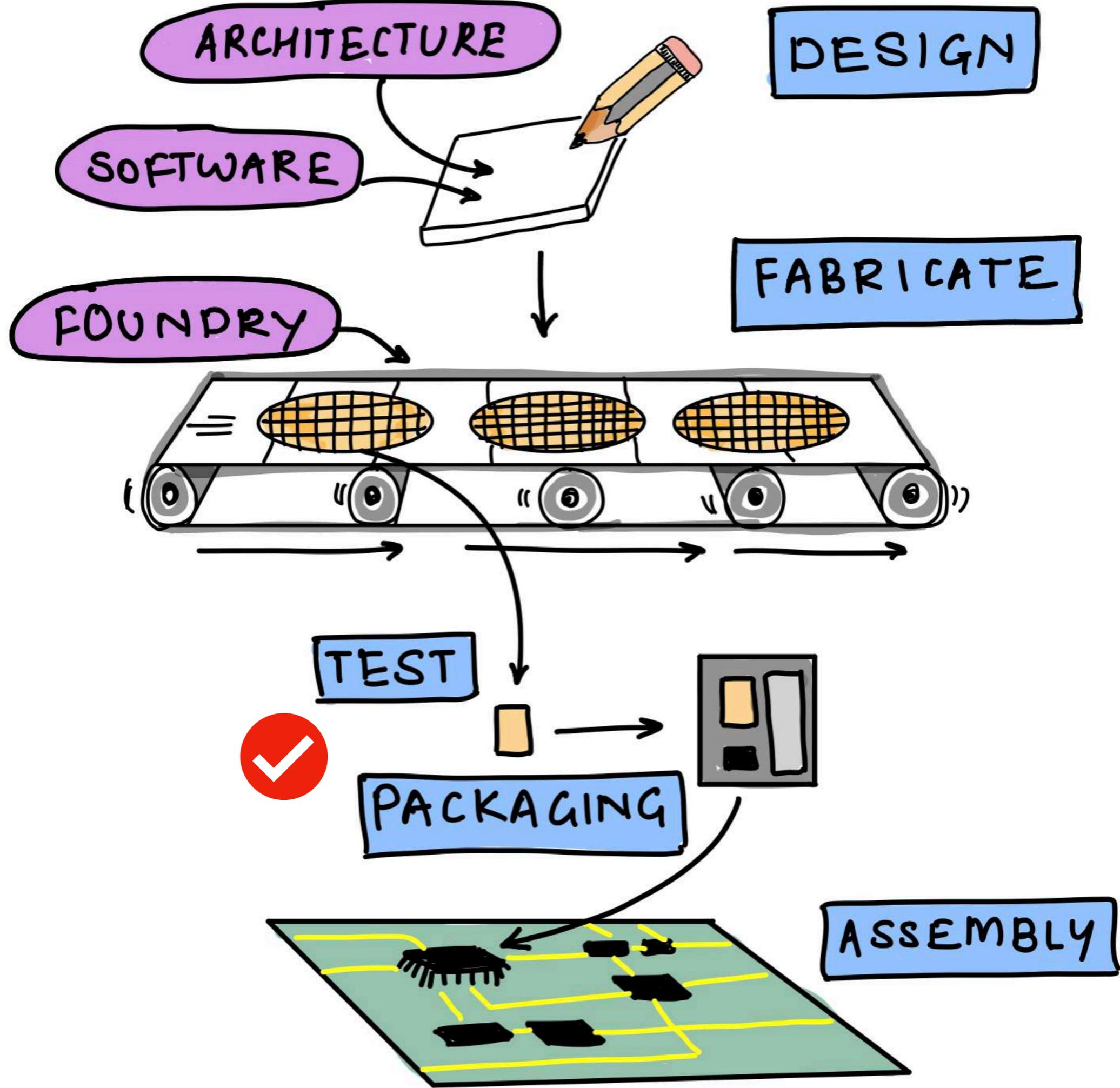
Equipment Makers RoE (%)

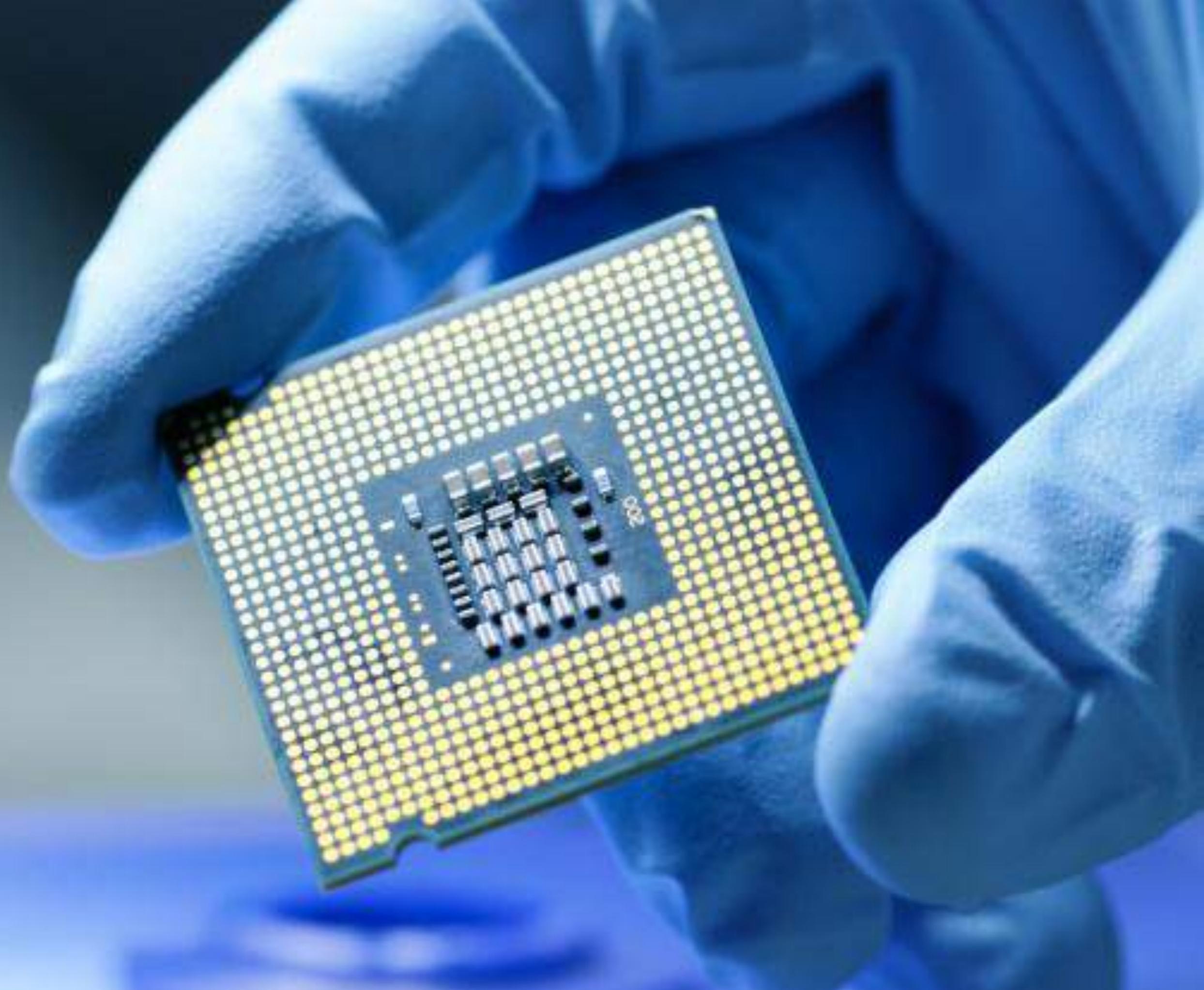
Hi Margin, Hi Asset Turns, Lo Debt



Source: Company Filings

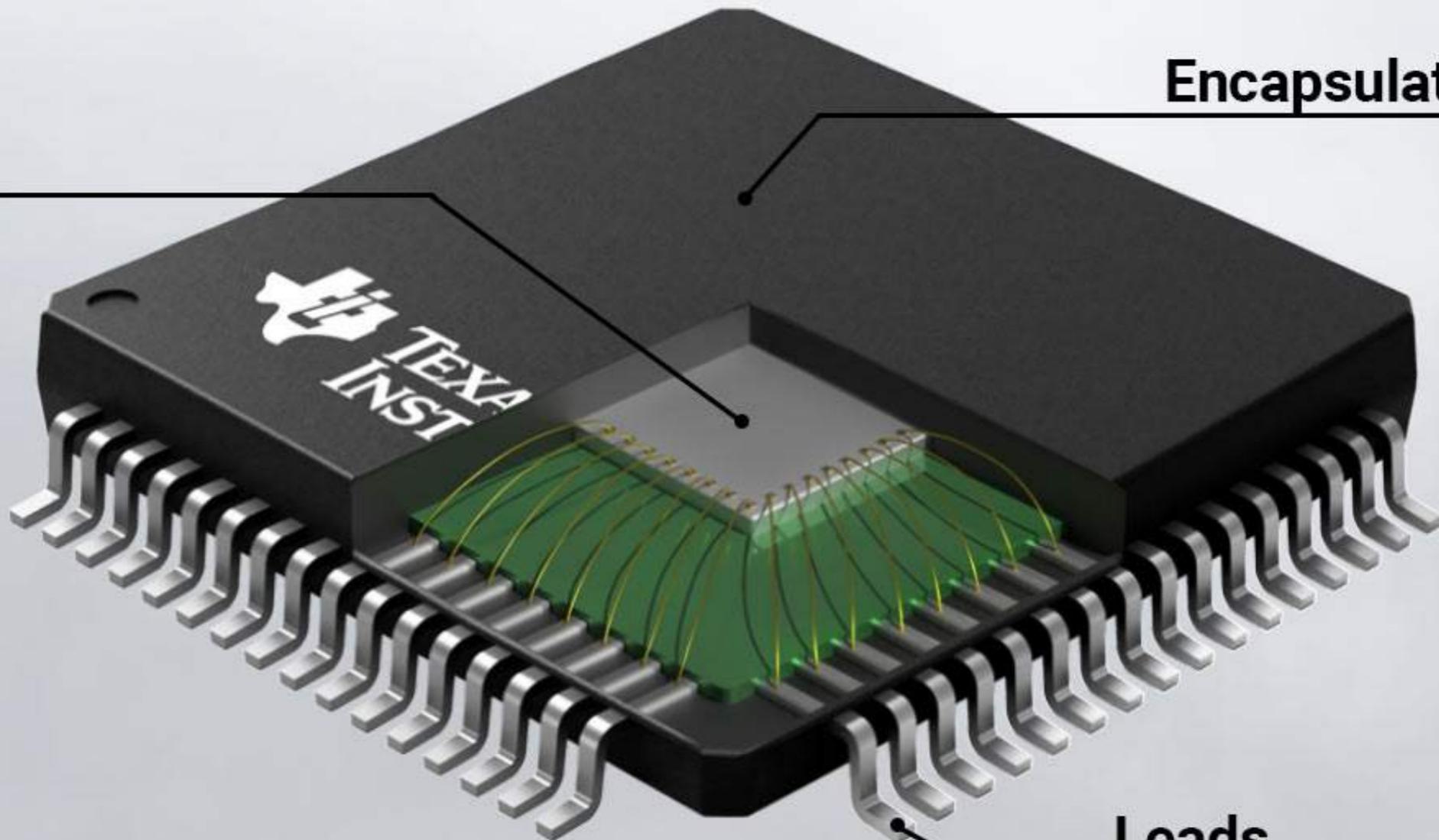




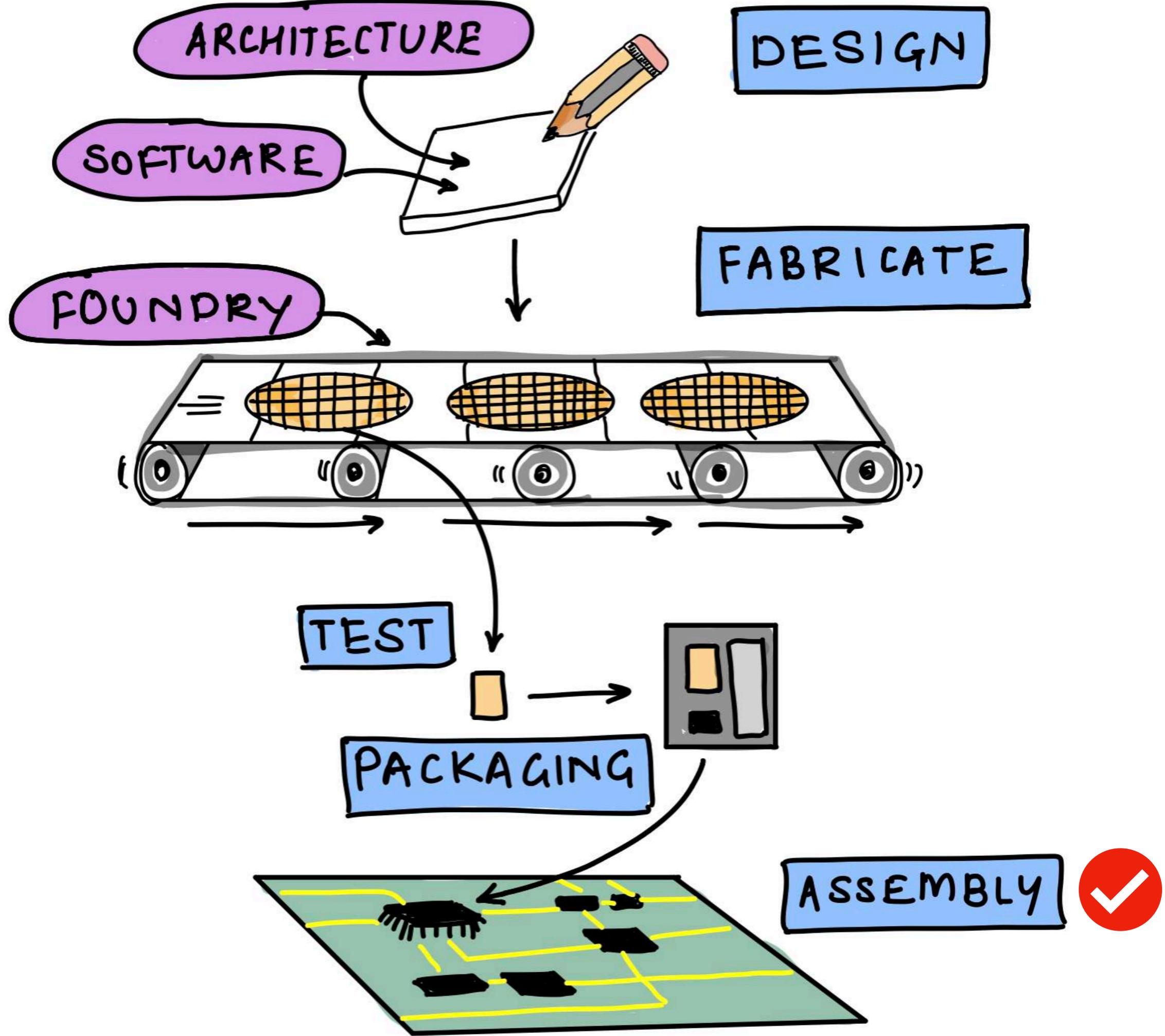


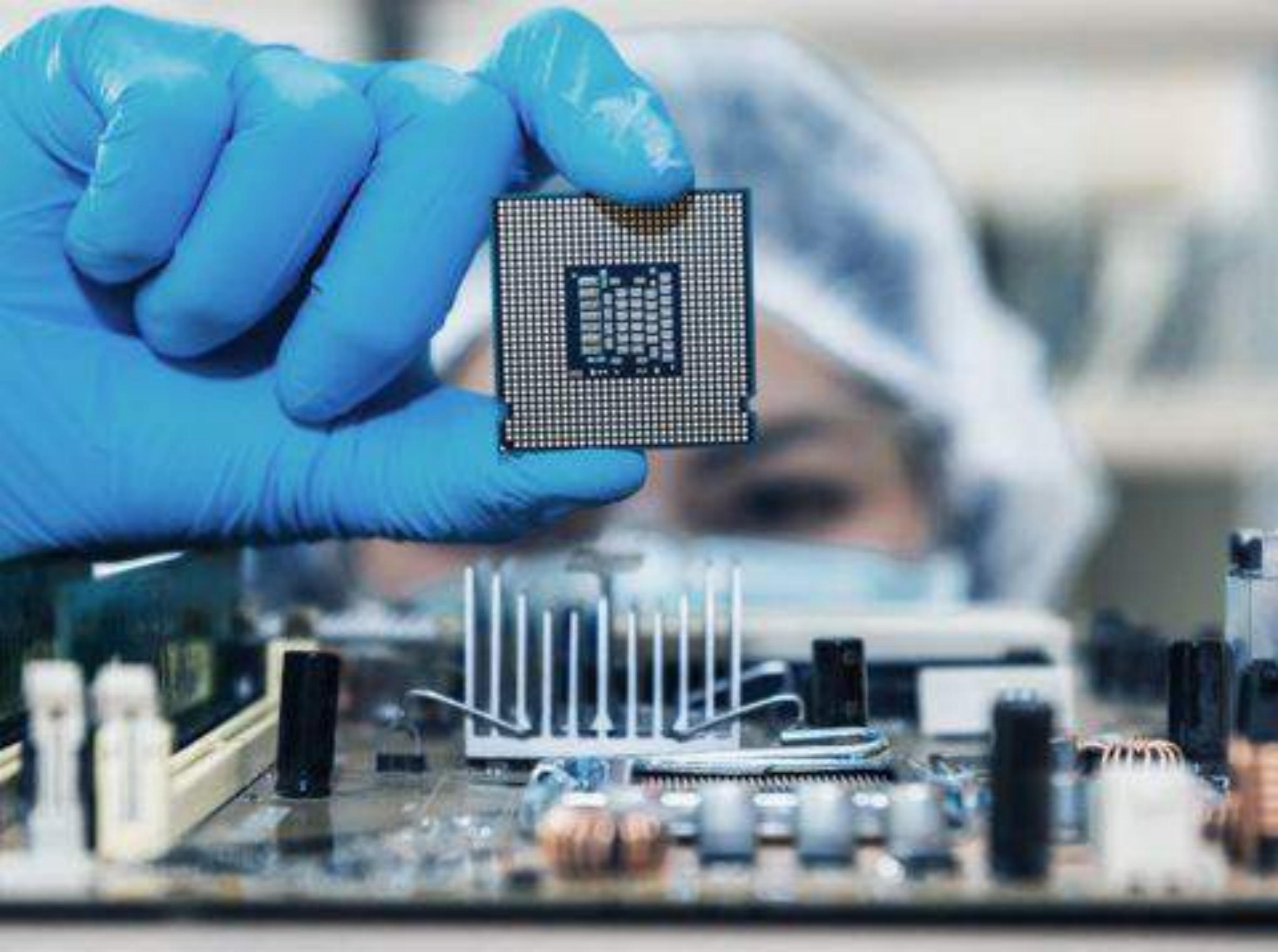
IC chip

Encapsulation



Leads





Why Chip Shortage?

On Infrastructure

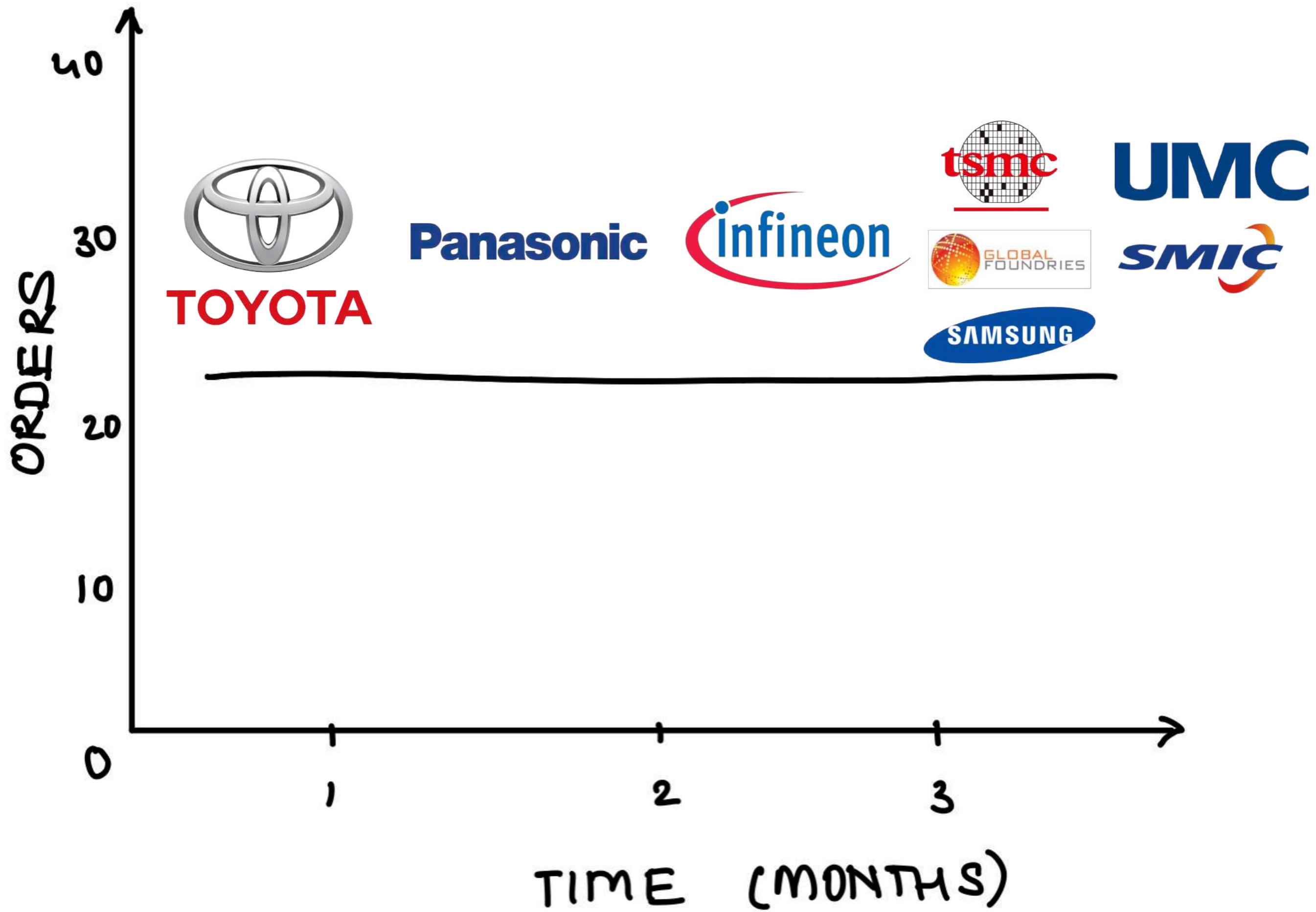
*“Becomes visible
upon Breakdown”*

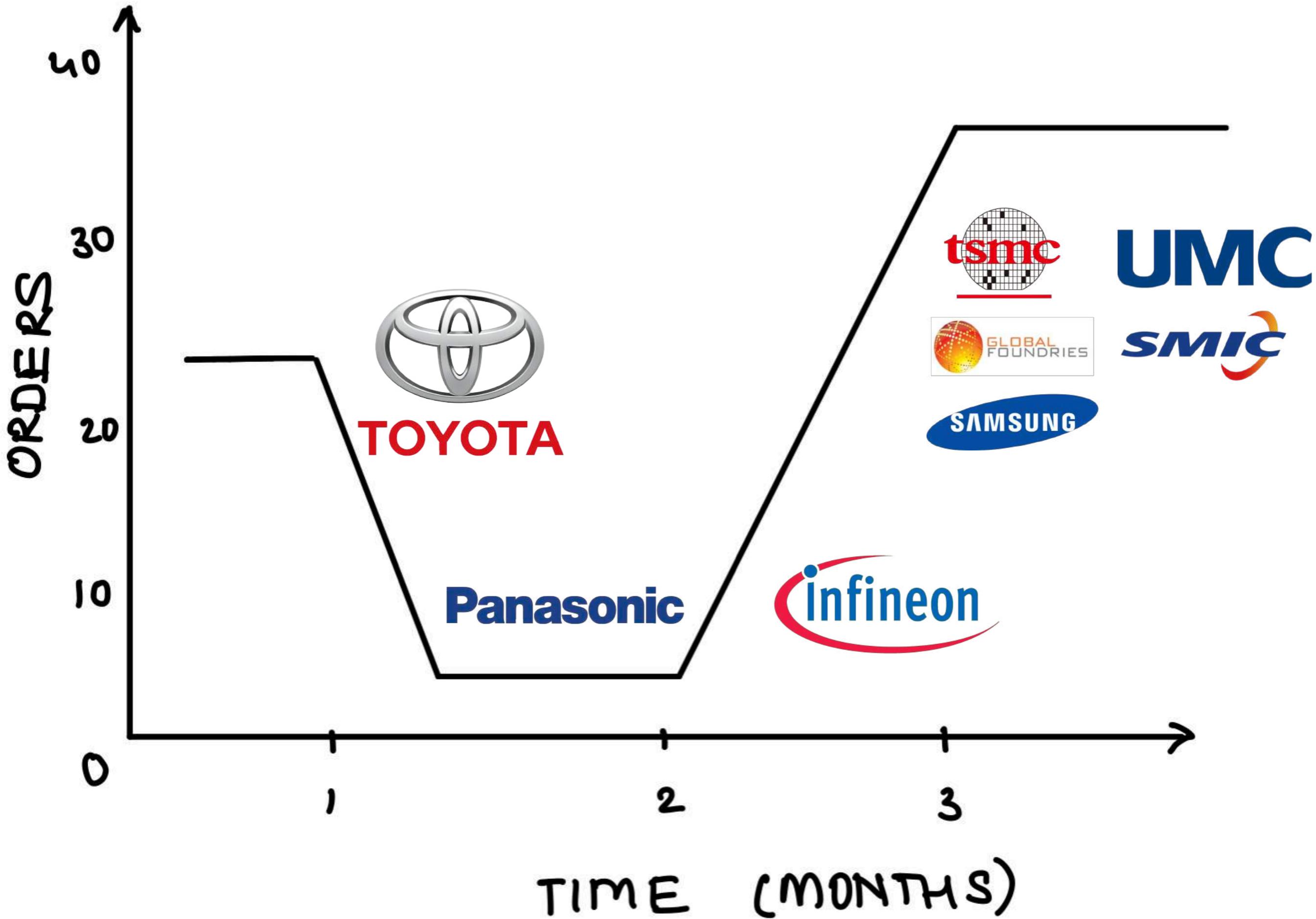


SORTING THINGS OUT

CLASSIFICATION AND ITS CONSEQUENCES

GEOFFREY C. BOWKER AND SUSAN LEIGH STAR





Semi content per unit		2015	2020	2025F	
	HIGH END SMARTPHONE	\$100	\$170	\$275	+62%
	AUTO (GLOBAL AVERAGE)	\$310	\$460	\$690	+50%
	DATACENTER SERVER (CPU + ACCELERATOR)	\$1,620	\$2,810	\$5,600	+99%
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SILICON CONTENT GROWING AS EVERYTHING GETS SMARTER

Source: Applied Materials

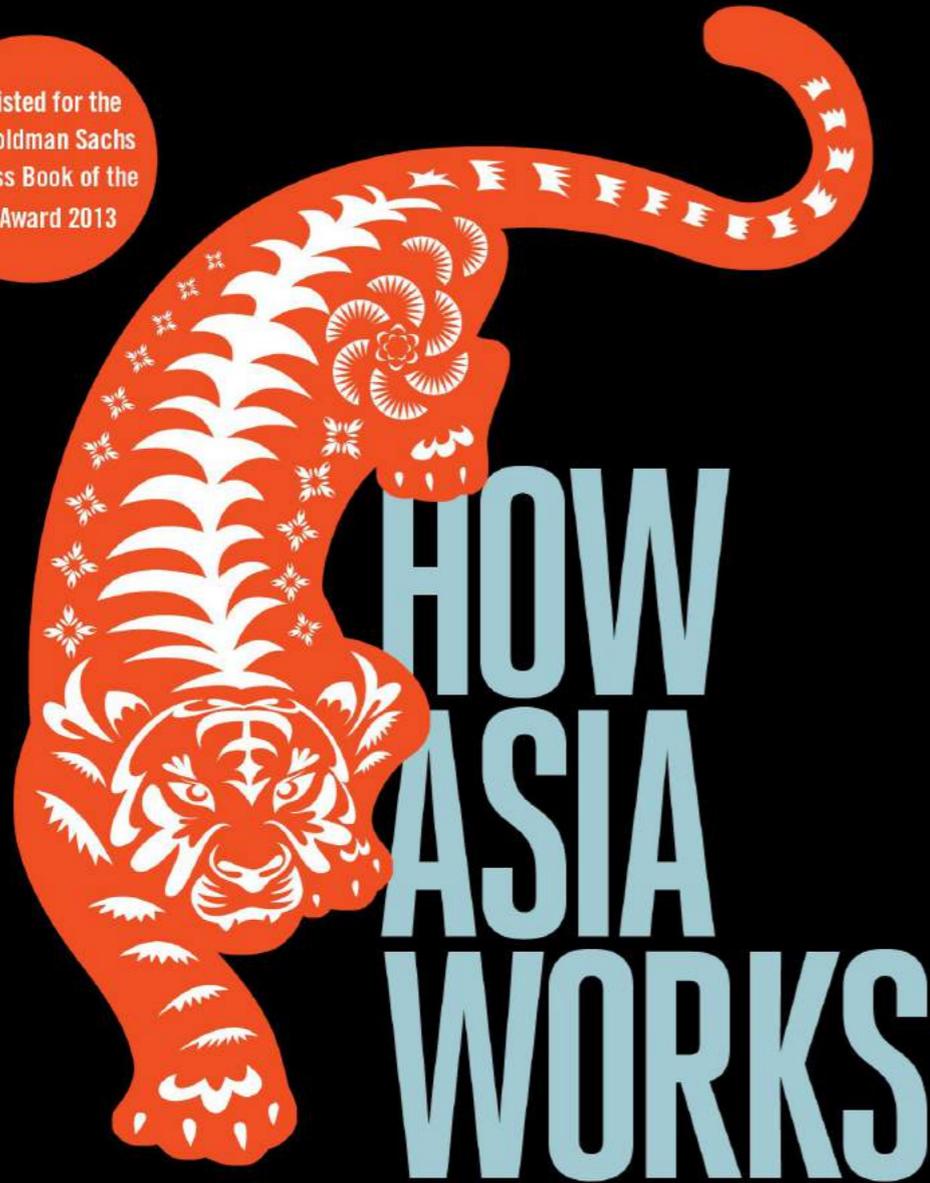
Applied Materials External Use



Source: Applied Materials

Geopolitics

Longlisted for the
FT & Goldman Sachs
Business Book of the
Year Award 2013



Success and Failure
in the World's Most
Dynamic Region
JOE STUDWELL

'Pithy, well-written and intellectually vigorous'
FINANCIAL TIMES

How Asia Works

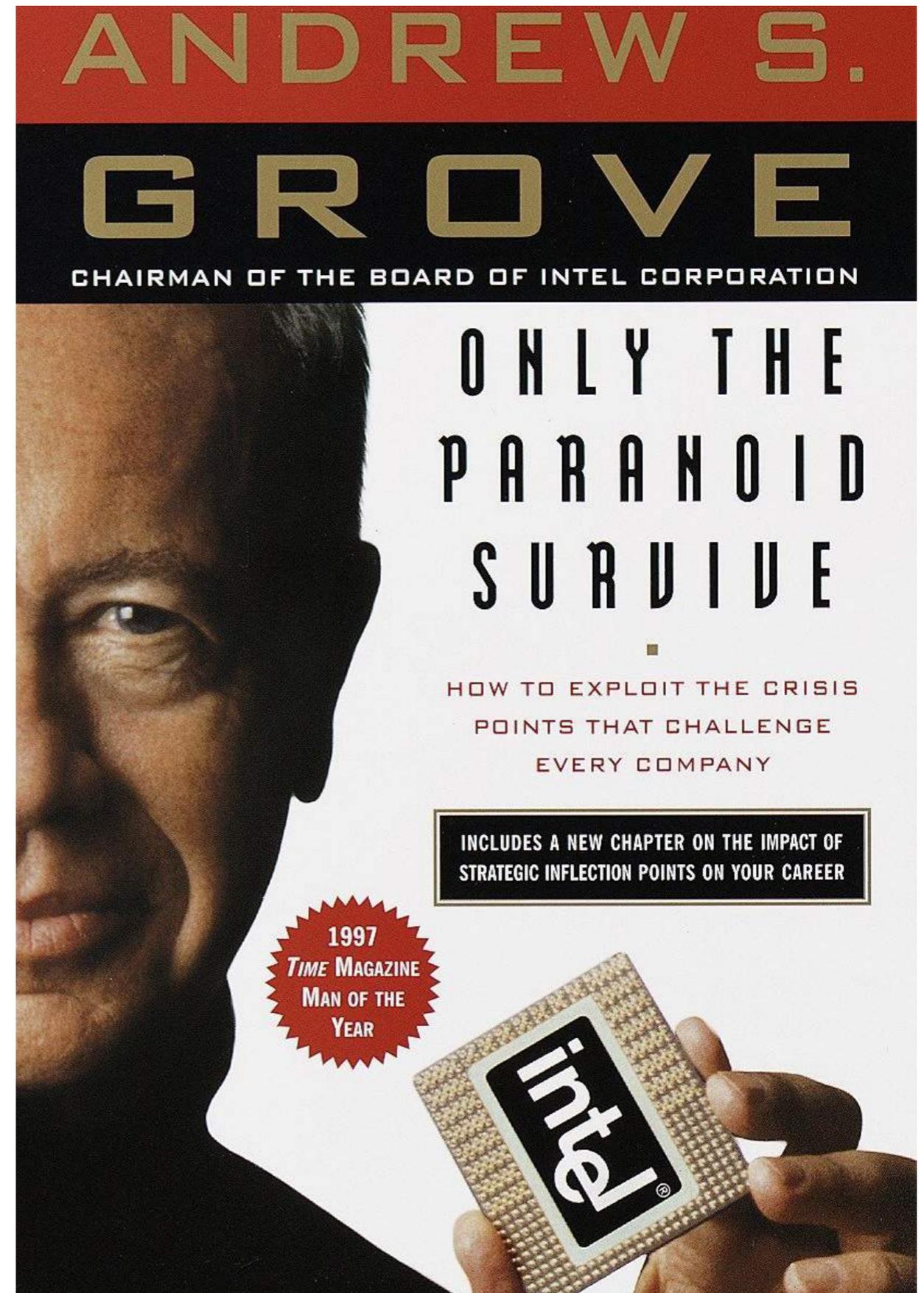
Joe Studwell

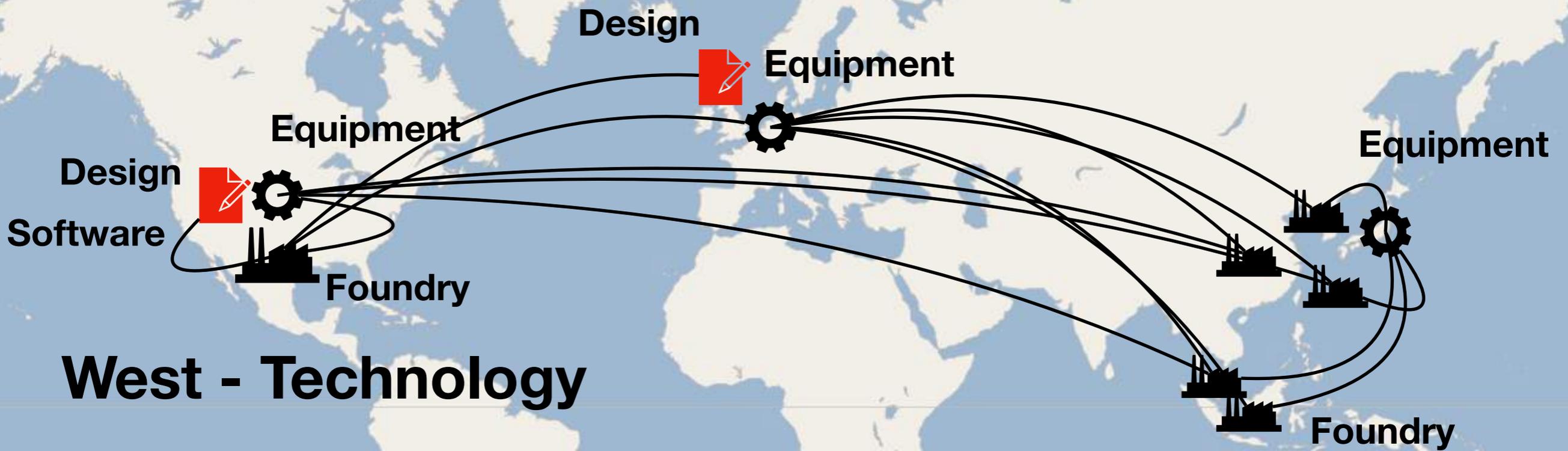
Historical context of
Asian Economies
(ex-India)

Andy Grove

Former CEO - Intel

- Intel's survival
- Intel's revival





West - Technology

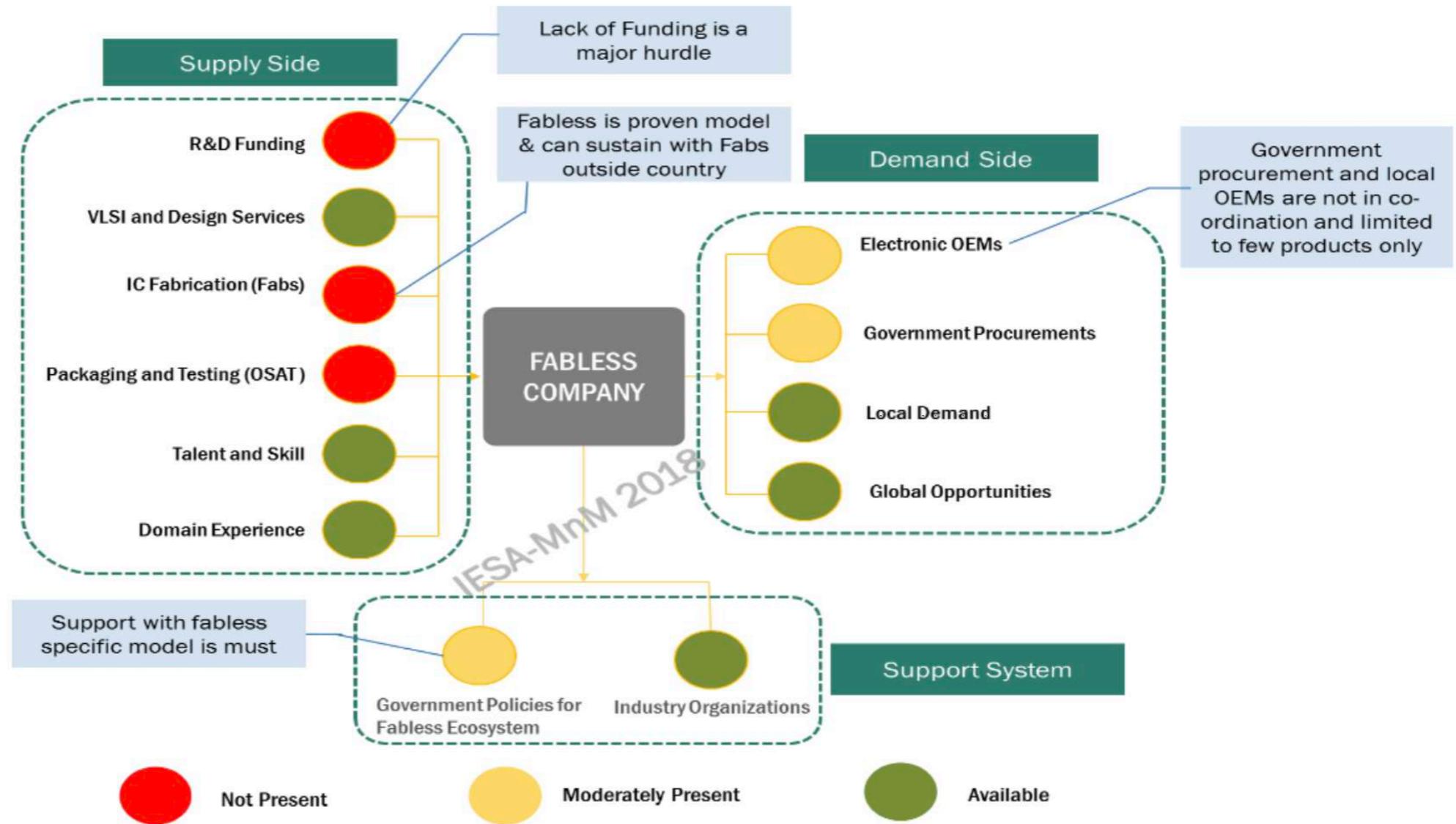
East - Manufacturing

- Who controls software?
- Who controls the architecture?
- Who controls manufacturing equipment?
- Who controls the manufacturing facilities?

India Semiconductor Opportunity

Indian Electronics & Semiconductor Association

FIGURE 1 STATUS OF INDIAN FABLESS ECOSYSTEM



Source: Secondary, Company Websites, and IESA-MarketsandMarkets Analysis

Indian Electronics & Semiconductor Association

TABLE 1 KEY OPPORTUNITIES FOR SEMICONDUCTOR COMPANIES IN INDIA

Key Trends	Key Products	Driving Factors
Smart Industrial Automation	<ul style="list-style-type: none"> • PLC • DSC • Transmitters • Sensors 	<ul style="list-style-type: none"> • Need for mass production and connected monitoring • Government initiatives toward pollution control
Defense	<ul style="list-style-type: none"> • Weapons • Munitions 	<ul style="list-style-type: none"> • Need for more efficient arms and armaments, and military weapons
Rural Broadband	<ul style="list-style-type: none"> • Modem • Fiber optic components 	<ul style="list-style-type: none"> • Encourage telecommunication spread in rural areas and increase literacy

Source: IESA-MarketsandMarkets Analysis

Scheme for Promotion of Manufacturing of Electronic Components and Semiconductors (SPECS)

Incentives
(INR 3,285 crore)

Financial Incentive of 25% on Capital Expenditure, on reimbursement basis

Tenure

3 Years for Filing Applications, 5 Years for Investment

Coverage

Electronic components, semiconductor/ display fabrication units, ATMP units, specialized sub-assemblies and capital goods for manufacture of aforesaid goods. **(Electronics Products such as Mobiles and Consumer Goods excluded)**

Eligible Capex

Plant, Machinery, Equipment, Associated Utilities and Technology including R&D **(Land and Building excluded)**

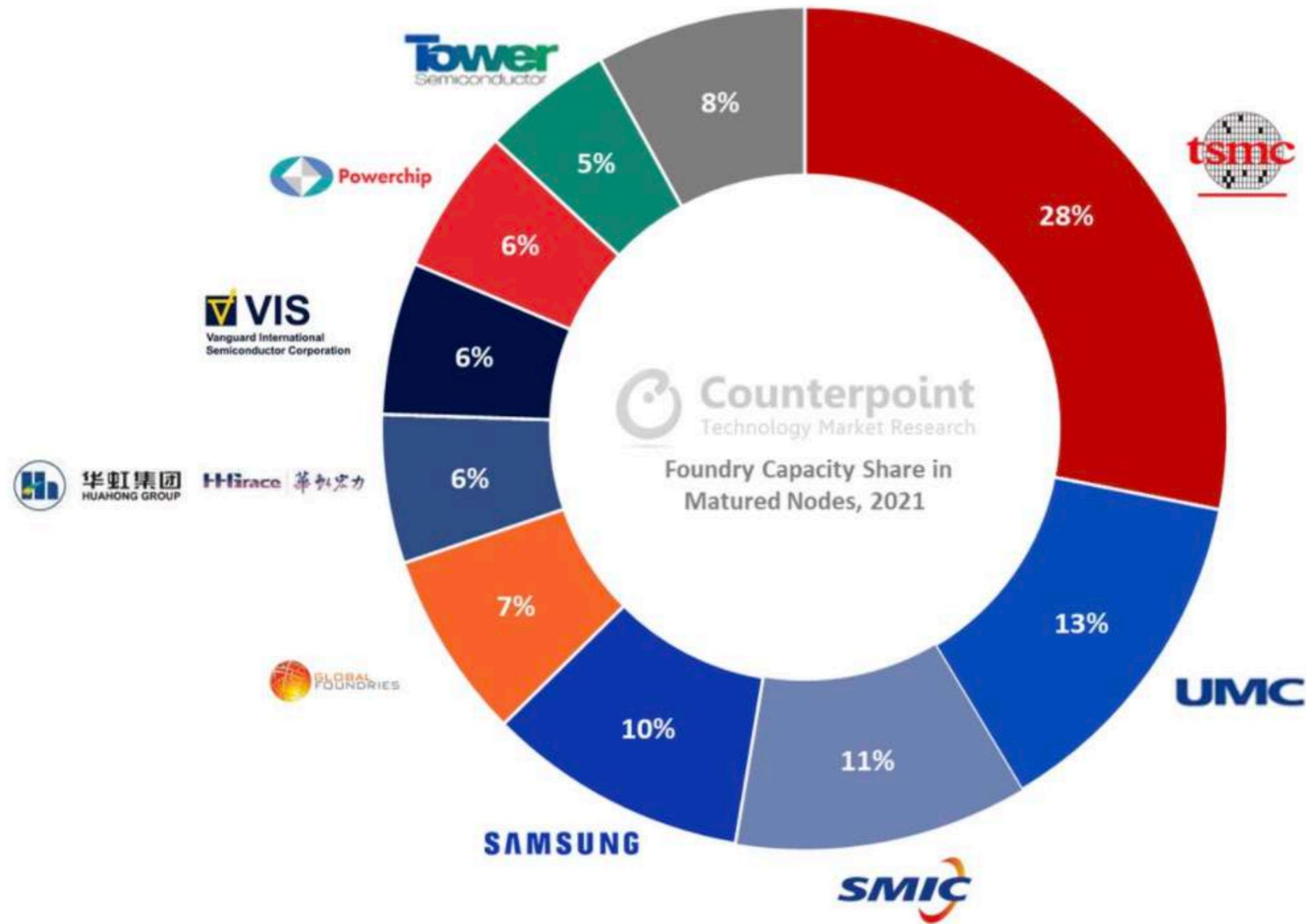
Eligibility

Investments in new and expansion of capacity / modernization and diversification of existing units

Minimum Investment Threshold

Ranges from INR 5 crore to 1,000 crore (Will encourage Domestic Players)

Exhibit 2: Foundry Capacity Share in Matured Nodes (40-nanometer and below, including 8-inch), 2021



Source: Counterpoint Research

Conclusion

A very interesting space to track

- Delicately Balanced Supply Chain
- Close integration between vendors
- Winners Take Most
- Profitable but Intensely Competitive
- Economies of Scale Matter
- Organic Growth of Digital Products & Semi Penetration
- Engineering and R&D Services Growth
- Directly Enables Software & Technology Services Businesses

Helpful Sources

- Books mentioned
- Youtube for everything to get a visual context
- Podcast & Youtube interviews with Company Managements
- Whitepapers from NZS Capital & Jon Bathgate Interview
- Asianometry Youtube Channel & Substack
- Long listing history & good quality filings & disclosures

Thank You