TWENTY-FOURTH ANNUAL

TestConX™

Archive

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Mesa, Arizona
March 5-8, 2023

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Marketplace Report
Curves & Waves

Ira Feldman
Feldman Engineering Corp.

TestConX
Mesa, Arizona • March 5-8, 2023

FELDMAN ENGINEERING

Outline

- Celebrate the Transistor!
- Moore
- Dennard
- Kondratiev

- Socket Market

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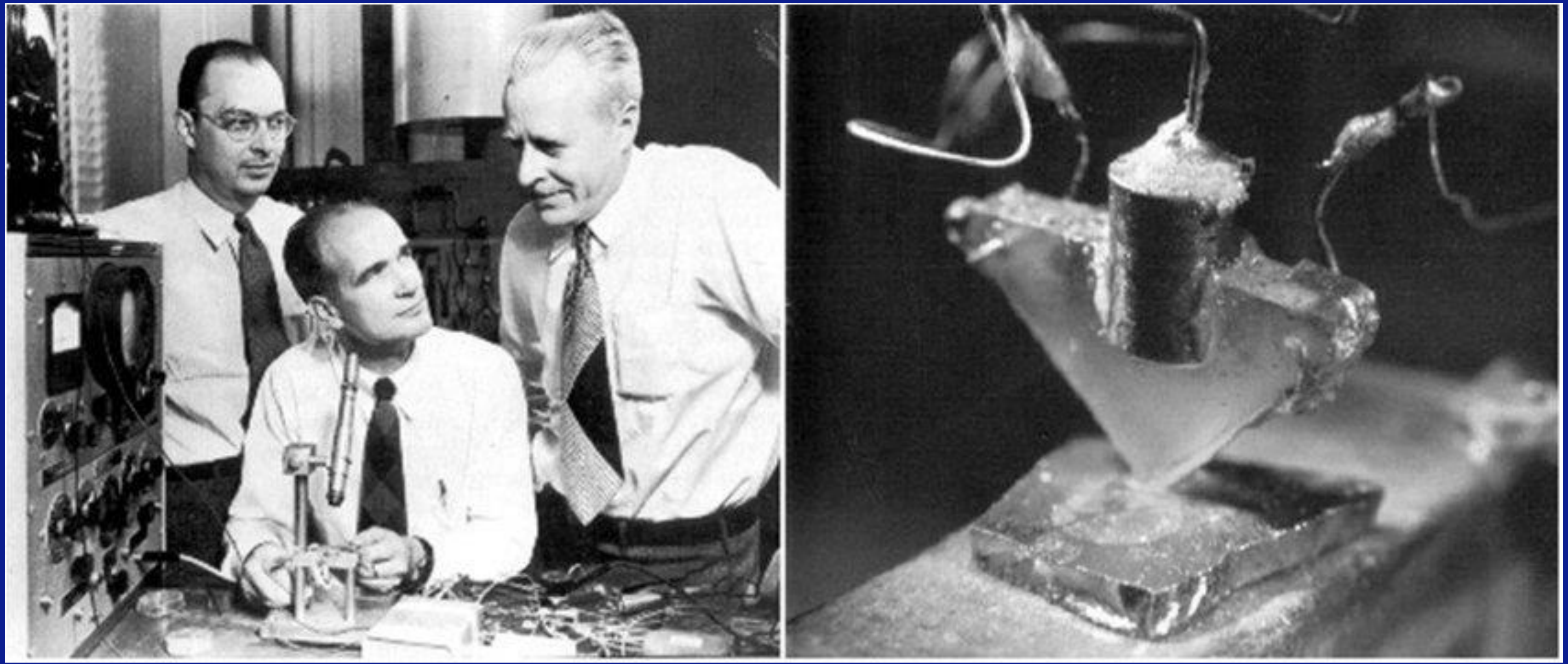
Marketplace Report - Curves & Waves

3 2023

December 23, 1947



John Bardeen, William Shockley, and Walter Brattain from Bell Laboratories (left), and the first germanium point-contact transistor (right) (Riordan, Hoddeson, & Herring, 1999).
Larki, Farhad. (2018). THESIS. 10.13140/RG.2.2.21745.17766.

Traitorous Eight – Fairchild Semiconductor

Gordon Moore, C. Sheldon Roberts, Eugene Kleiner, Robert Noyce, Victor Grinich, Julius Blank, Jean Hoerni and Jay Last (1960)
Wikipedia - Magnum Photos for Fairchild Semiconductor

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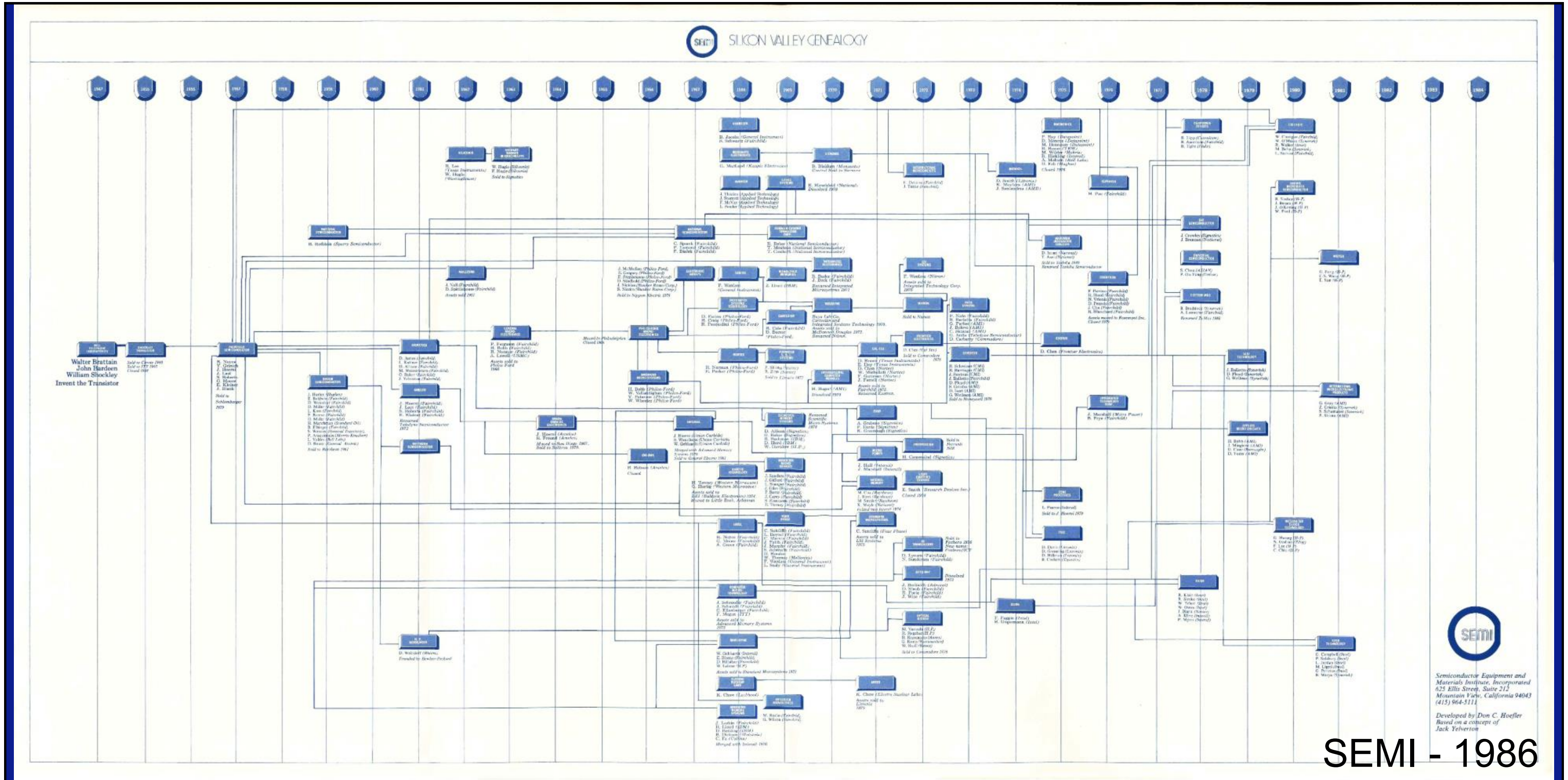

SEMI - 1986

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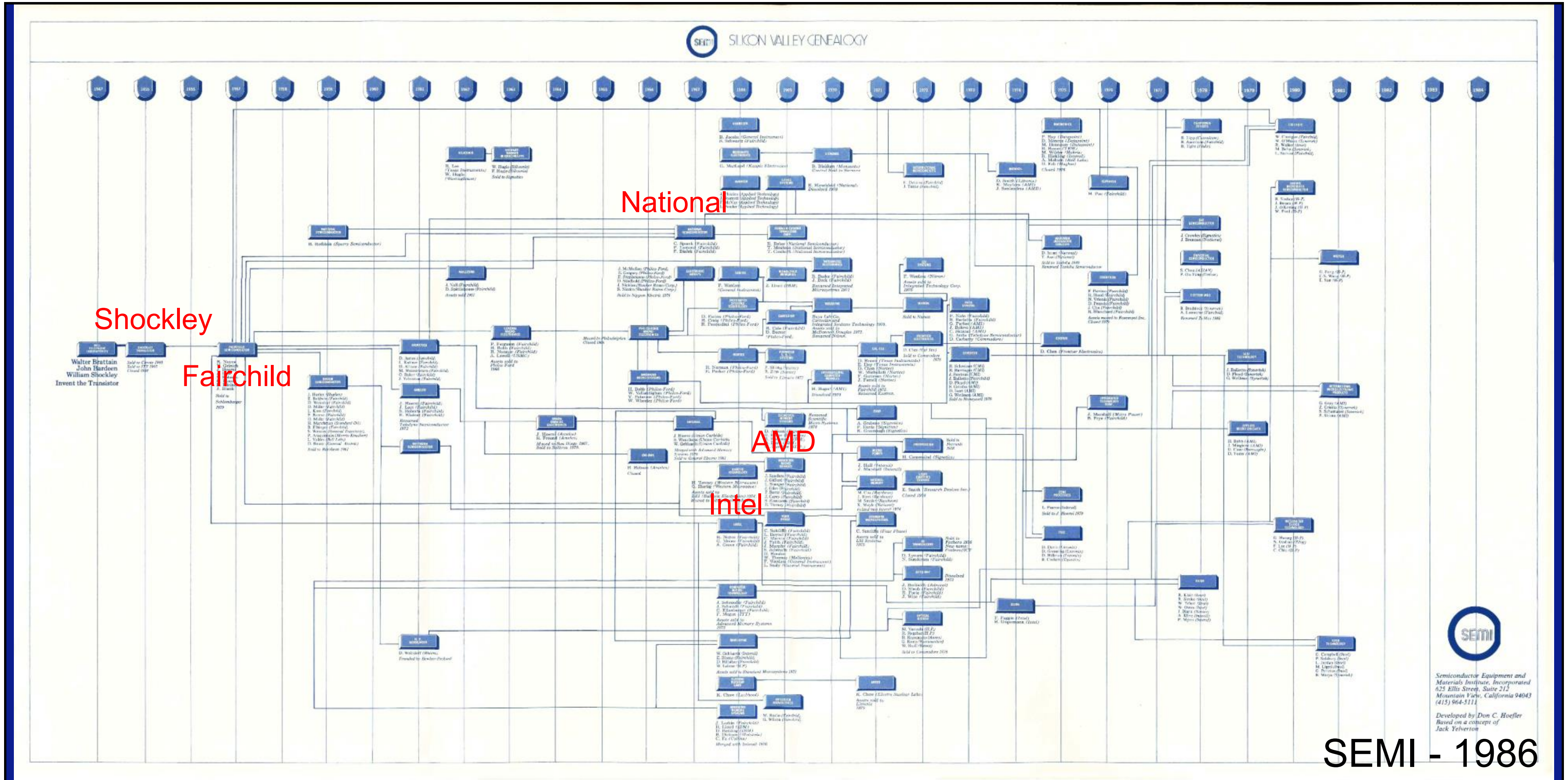
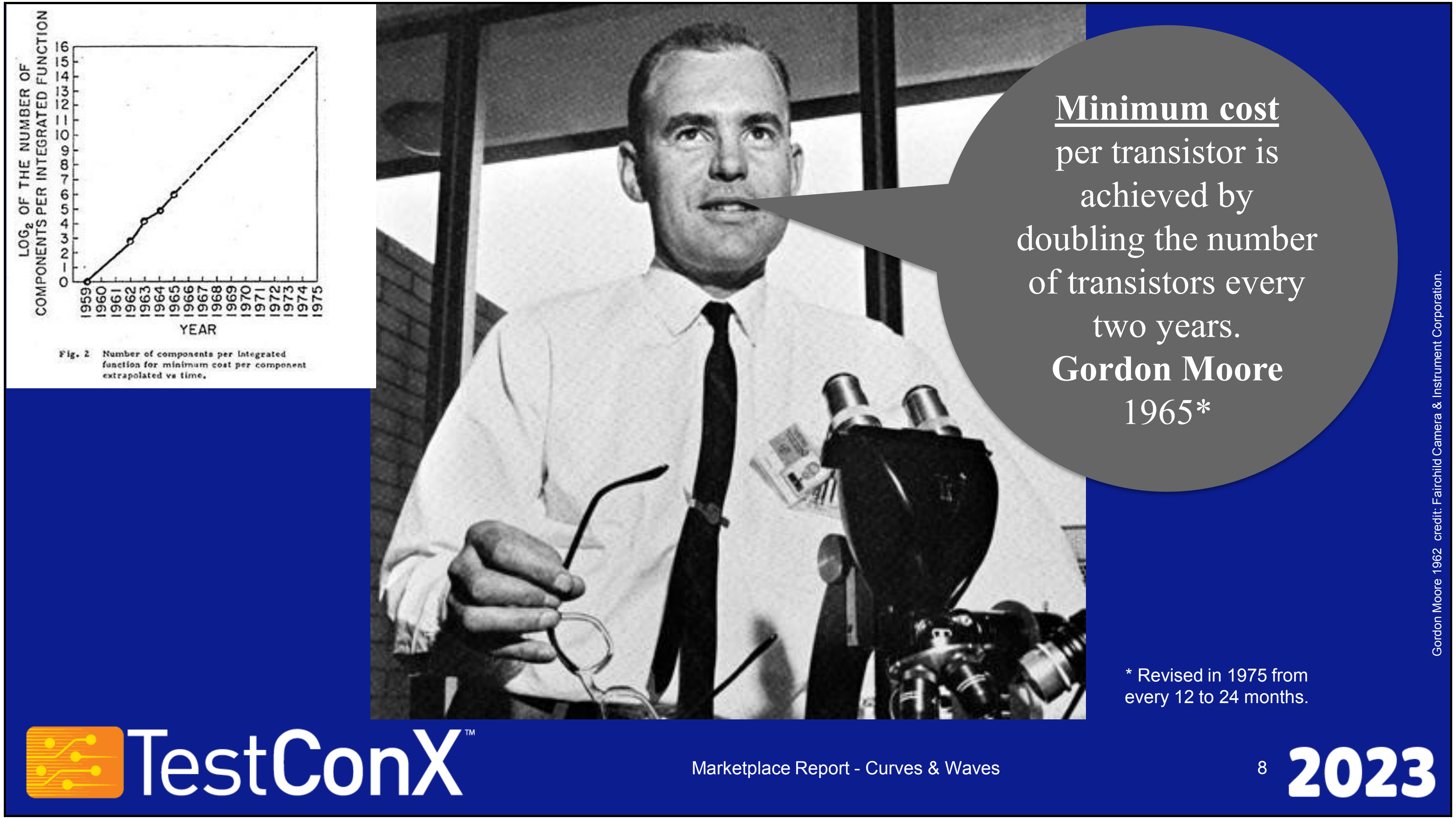
6 2023


SILICON VALLEY GENEALOGY
Shockley
Fairchild
National
AMD
Intel
Walter Brattain
John Bardeen
William Shockley
Invent the Transistor
SEMI - 1986



LOG2 OF THE NUMBER OF COMPONENTS PER INTEGRATED FUNCTION
YEAR
Fig. 2 Number of components per integrated function for minimum cost per component extrapolated vs time.
Minimum cost per transistor is achieved by doubling the number of transistors every two years.
Gordon Moore 1965*
* Revised in 1975 from every 12 to 24 months.
Gordon Moore 1962 credit: Fairchild Camera & Instrument Corporation.
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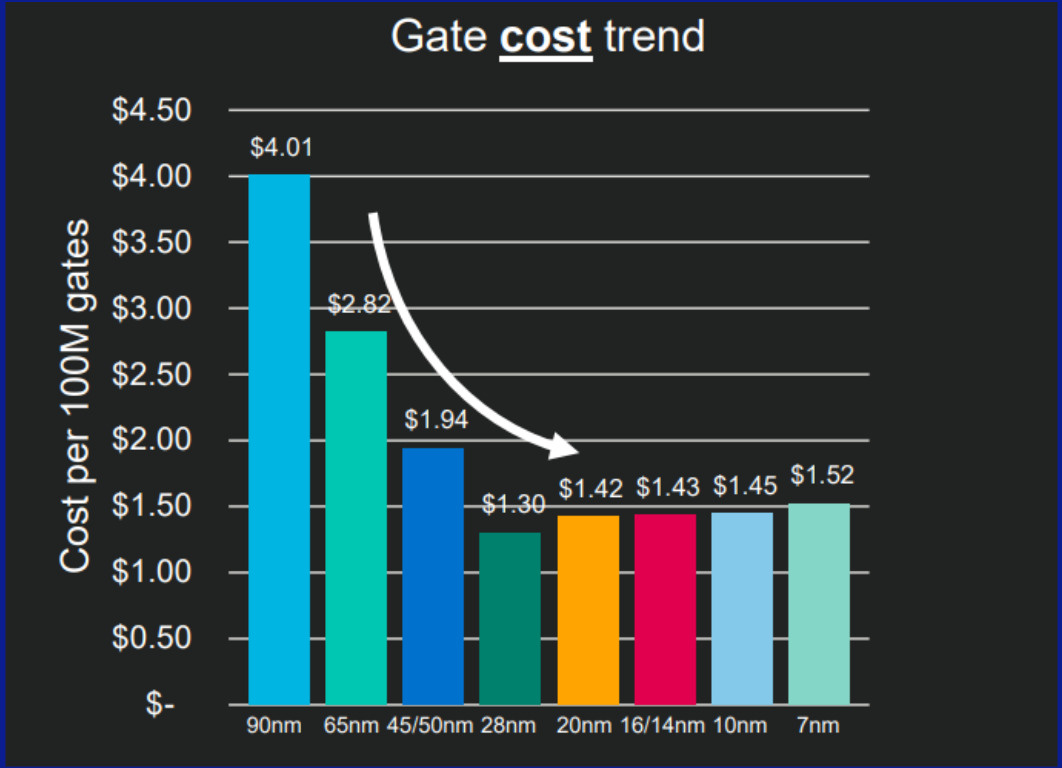
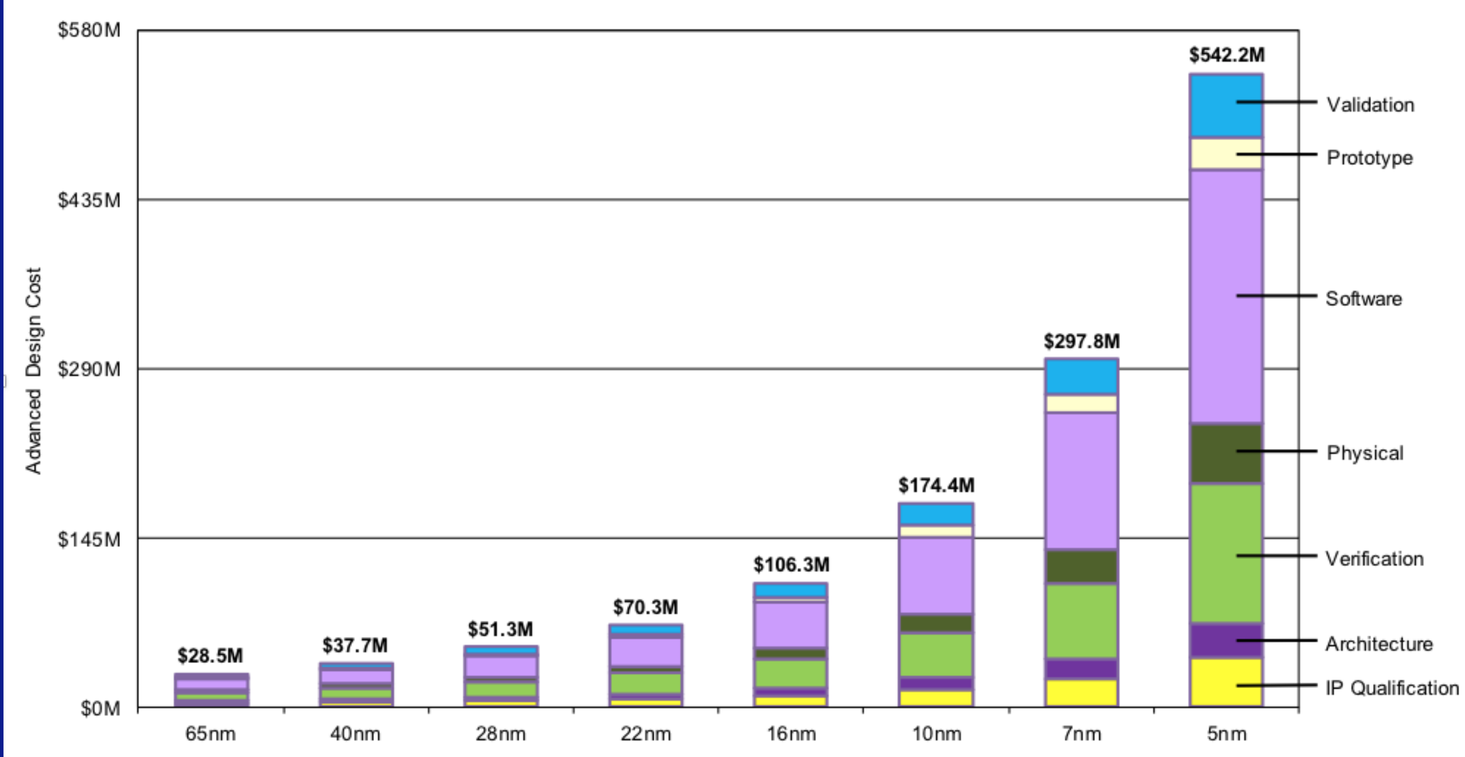
2023

Cost per Transistor

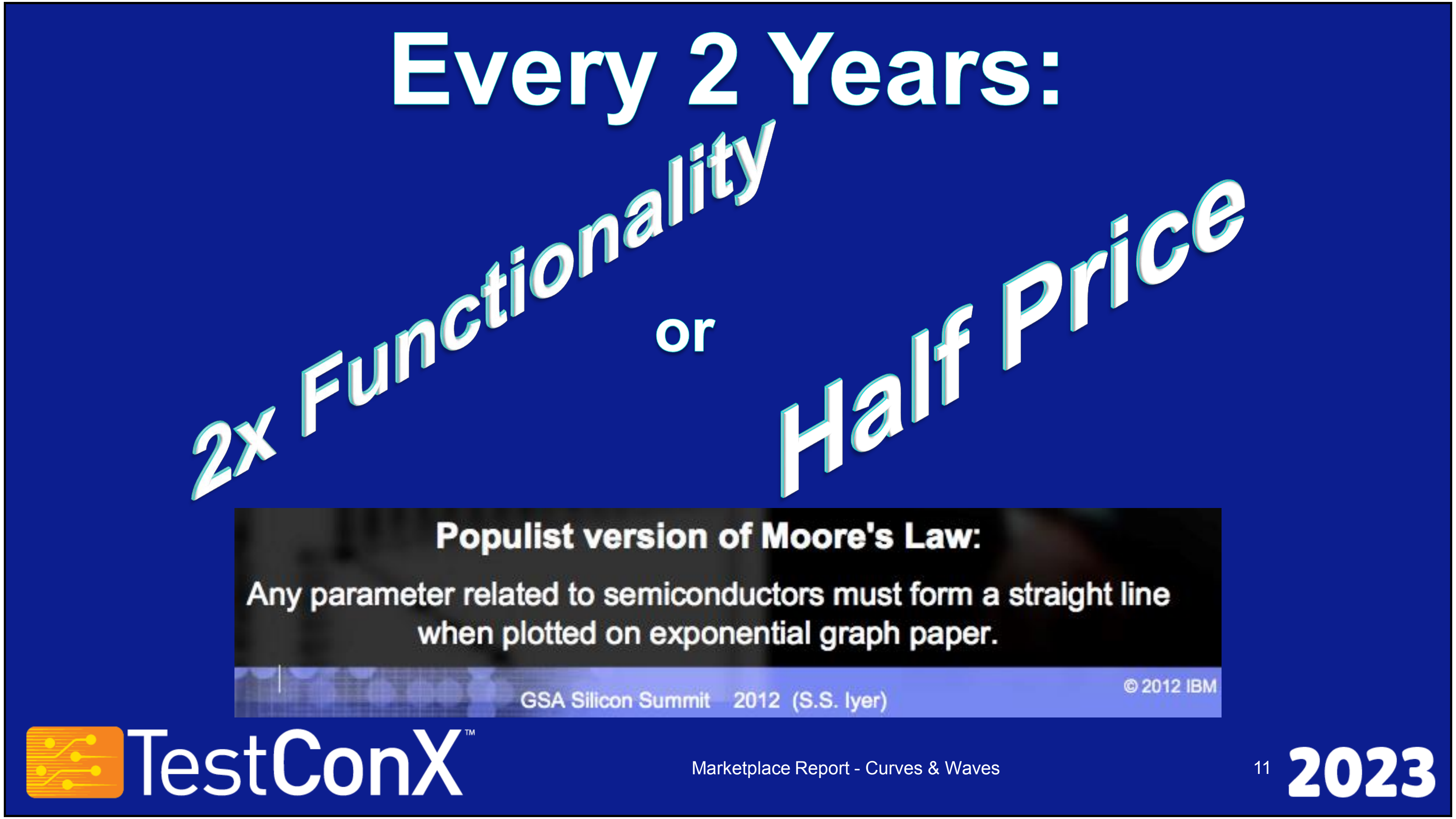


Marvel 2020

Process Node Per Design Costs



IBS / Jones


Every 2 Years:
2x Functionality
or
Half Price
Populist version of Moore's Law:
Any parameter related to semiconductors must form a straight line when plotted on exponential graph paper.
GSA Silicon Summit 2012 (S.S. Iyer)
© 2012 IBM
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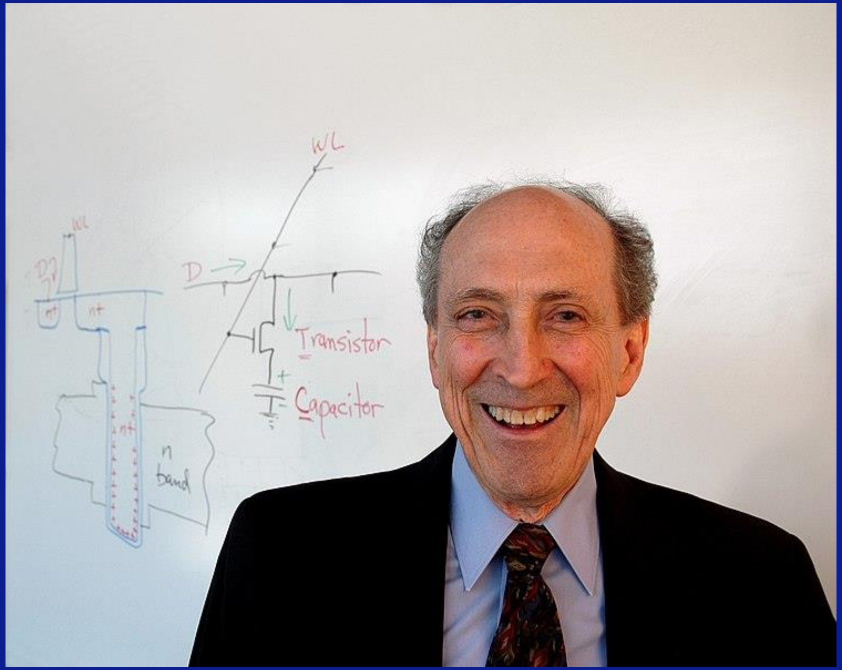
2023

Dennard Scaling

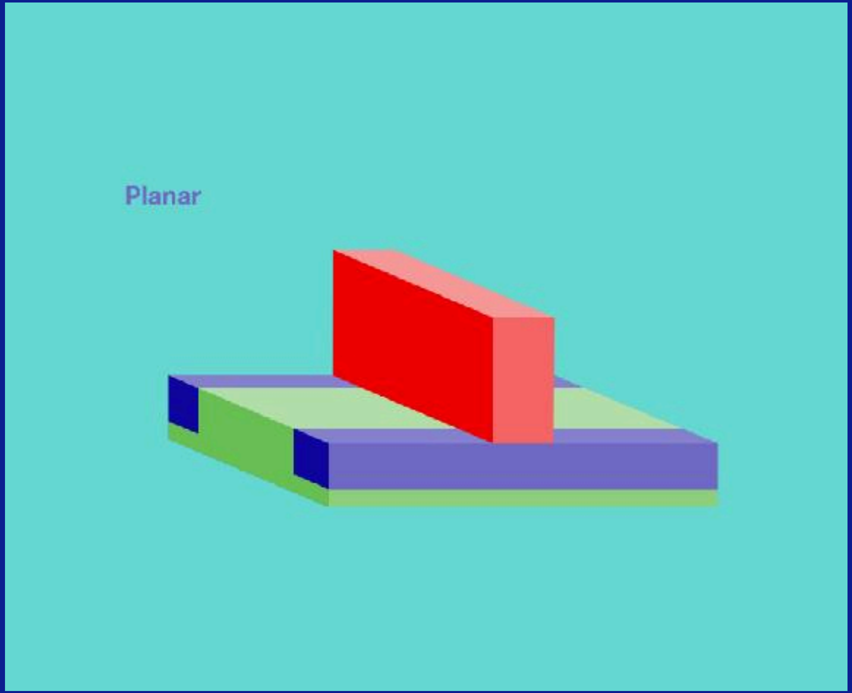


Robert H. Dennard

As transistors get smaller, their power density stays constant, so that the power use stays in proportion with area; both voltage and current scale (downward) with length. (Wikipedia)

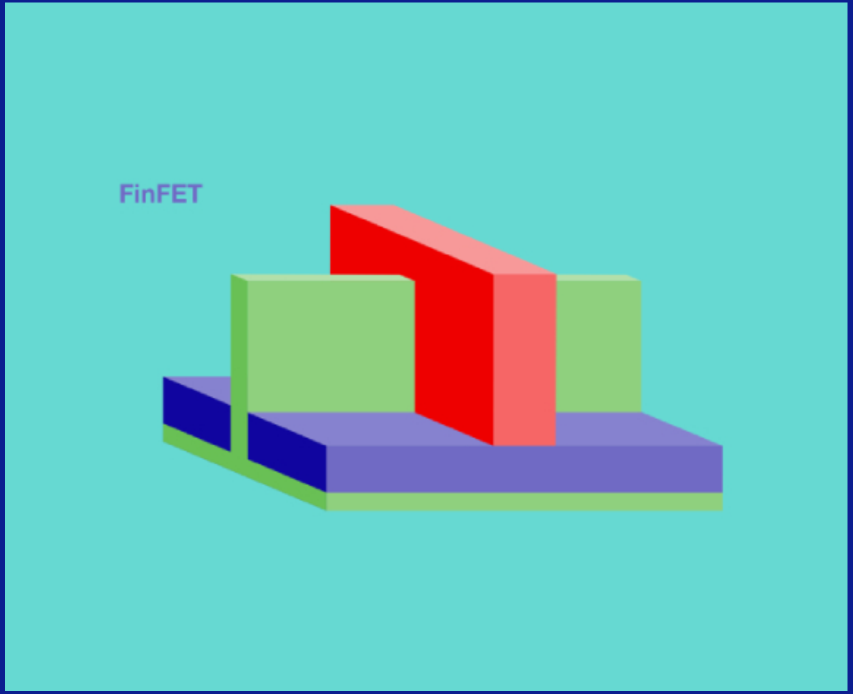
Wikipedia

Planar Transistor



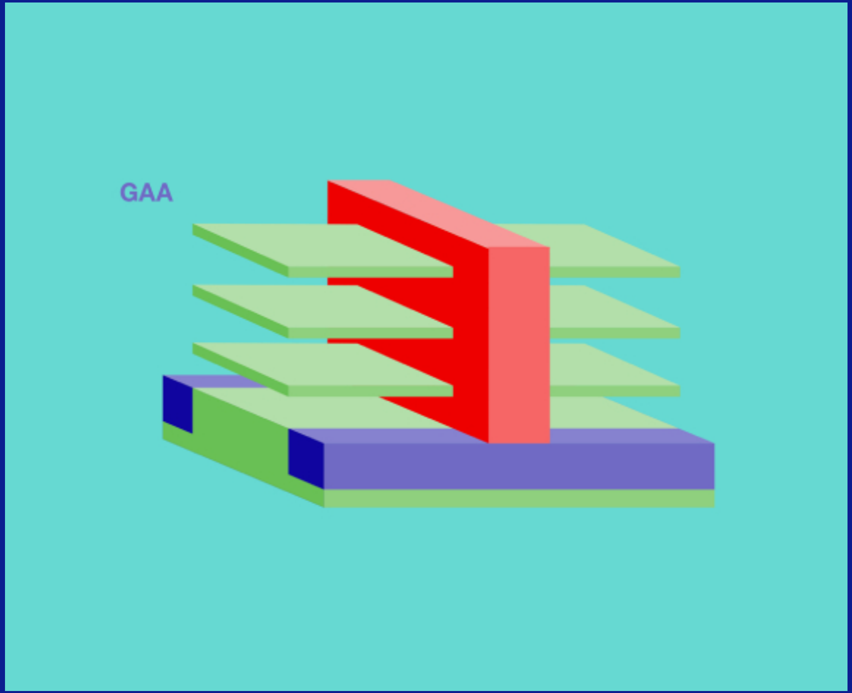
ASML.com

fin field-effect transistor (FinFET) – ca. 1995



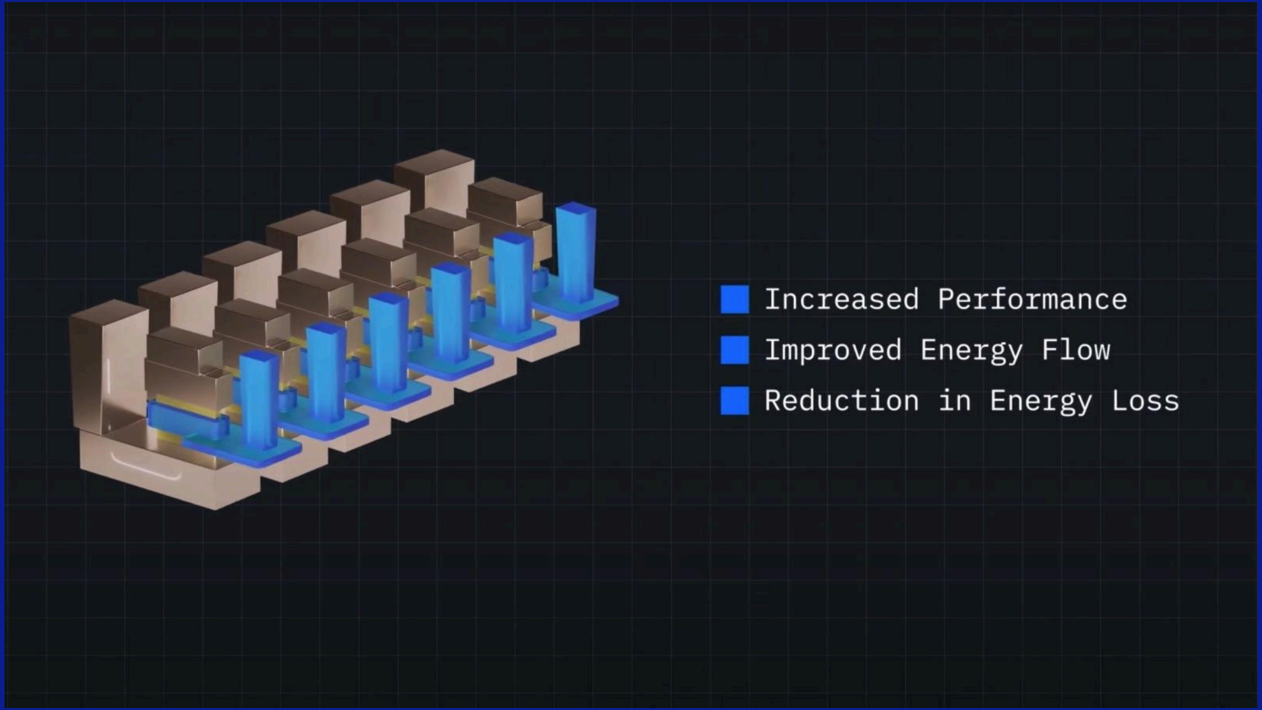
ASML.com

gate-all-around field-effect transistors (GAA) – 2020's



ASML.com

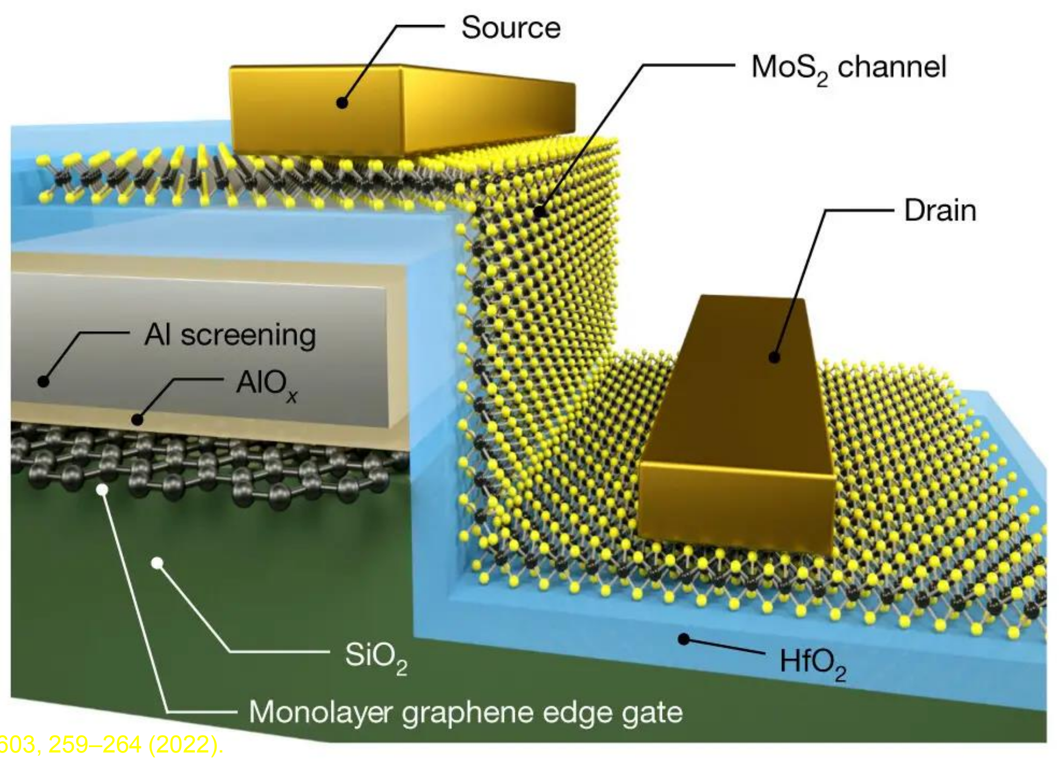
Vertical-Transport Nanosheet Field Effect Transistor (VTFET)



IBM & Samsung - 2021

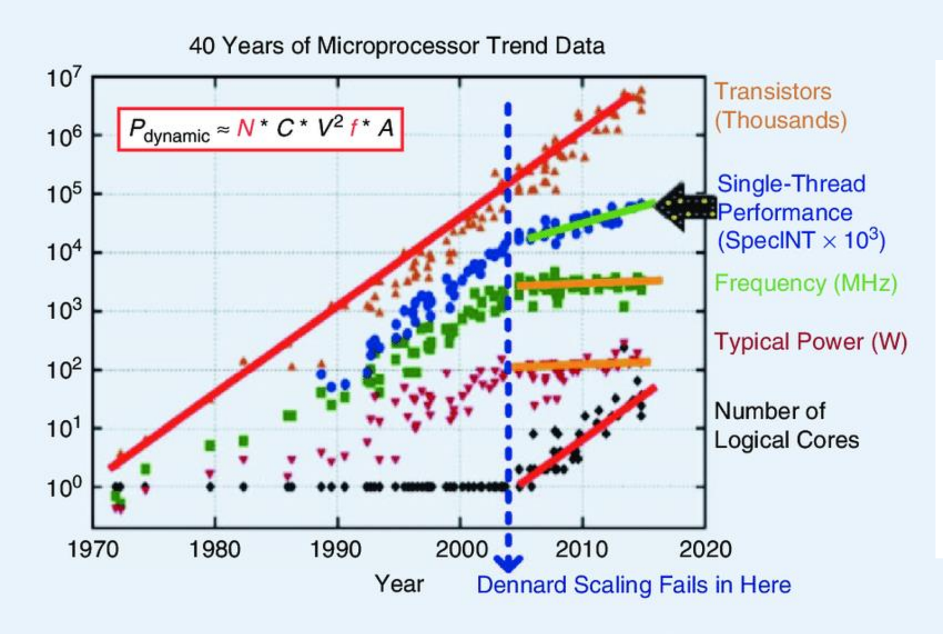
Single atom gate thickness limit?

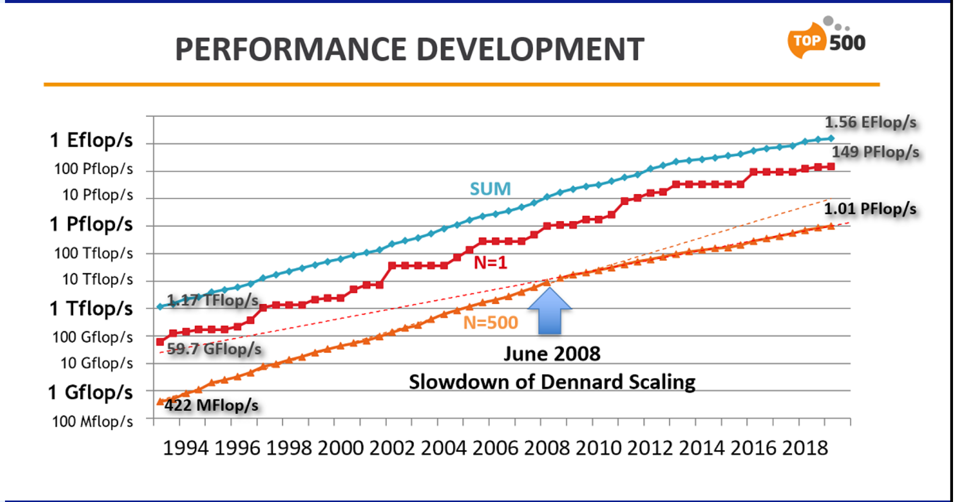
.34 nm
gate length
simulated



Tsinghua University in Beijing
Wu, F., Tian, H., Shen, Y. et al. Nature 603, 259–264 (2022).

End of Dennard Scaling





Top500.org

Xiu, Liming. (2019). IEEE Solid-State Circuits Magazine. 11. 39-55

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"Knobs" to reduce product cost or increase performance

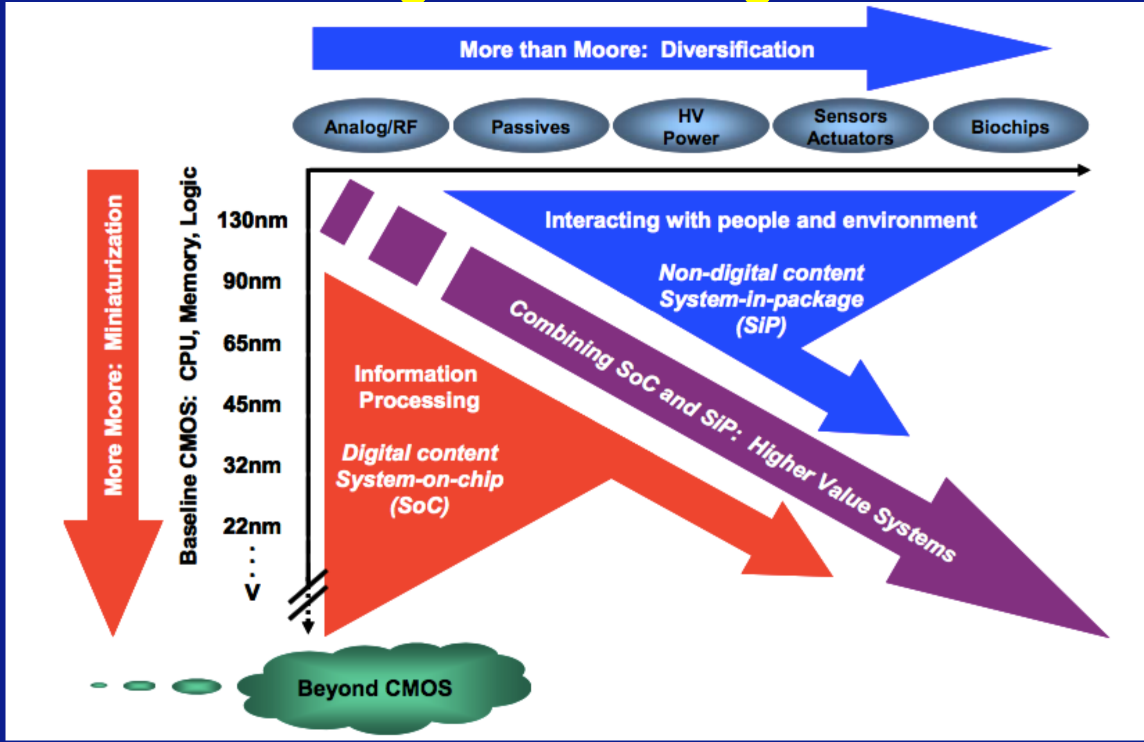
Transistor Scaling
Materials
Device Structure

Substrate Size
cost / area

More than Moore
Architecture
Packaging

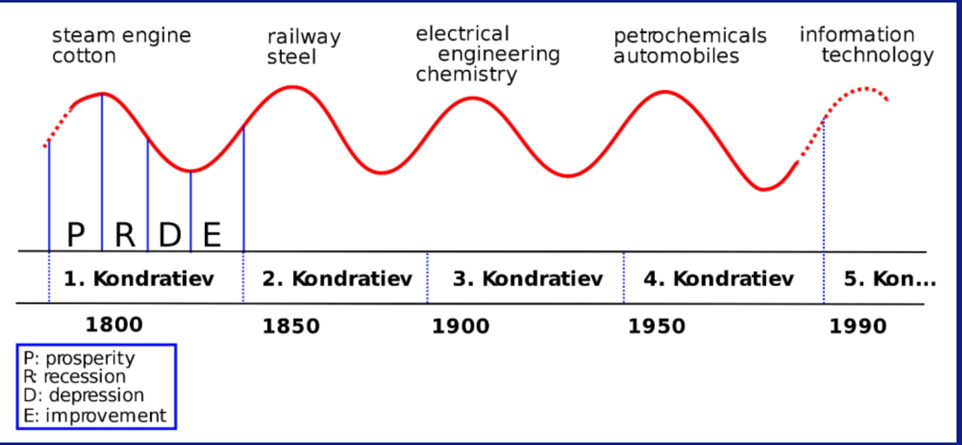
More than Moore (MtM)

Heterogeneous Integration



ITRS "More than Moore" Whitepaper

Soviet New Economic Policy (NEP)

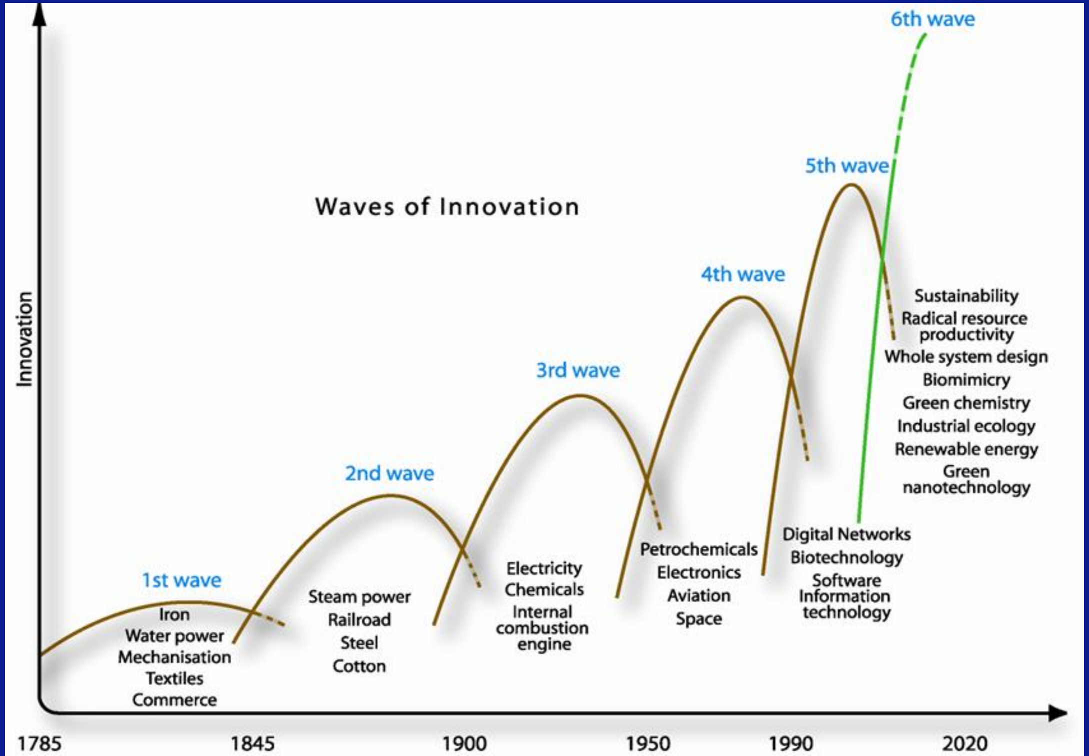


Kondratiev Waves

Николай Дмитриевич Кондратьев
Nikolai Dmitriyevich Kondratiev
1892-1938

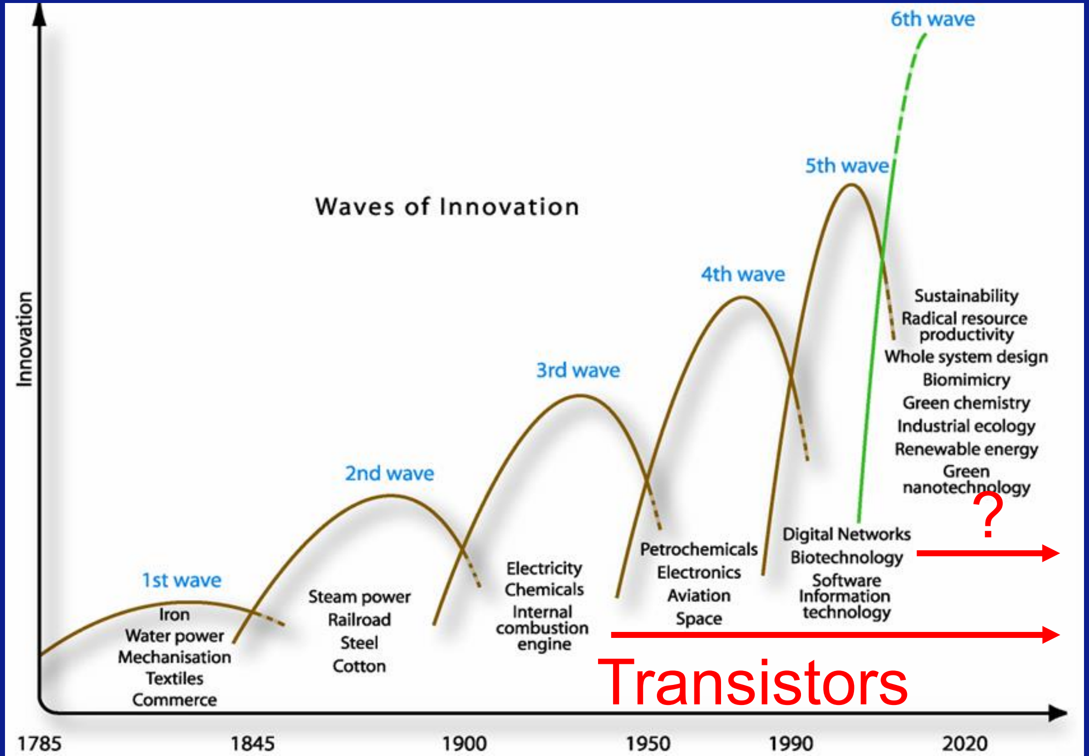
Wikipedia

Waves of Innovation



Almgren & Skobelev - Journal of Open Innovation: Technology, Market, and Complexity. 28 March 2020

Waves of Innovation



Almgren & Skobelev - Journal of Open Innovation: Technology, Market, and Complexity. 28 March 2020

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23 2023

MEPTEC Report Column

COLUMN

COUPLING & CROSSTALK

By Ira Feldman

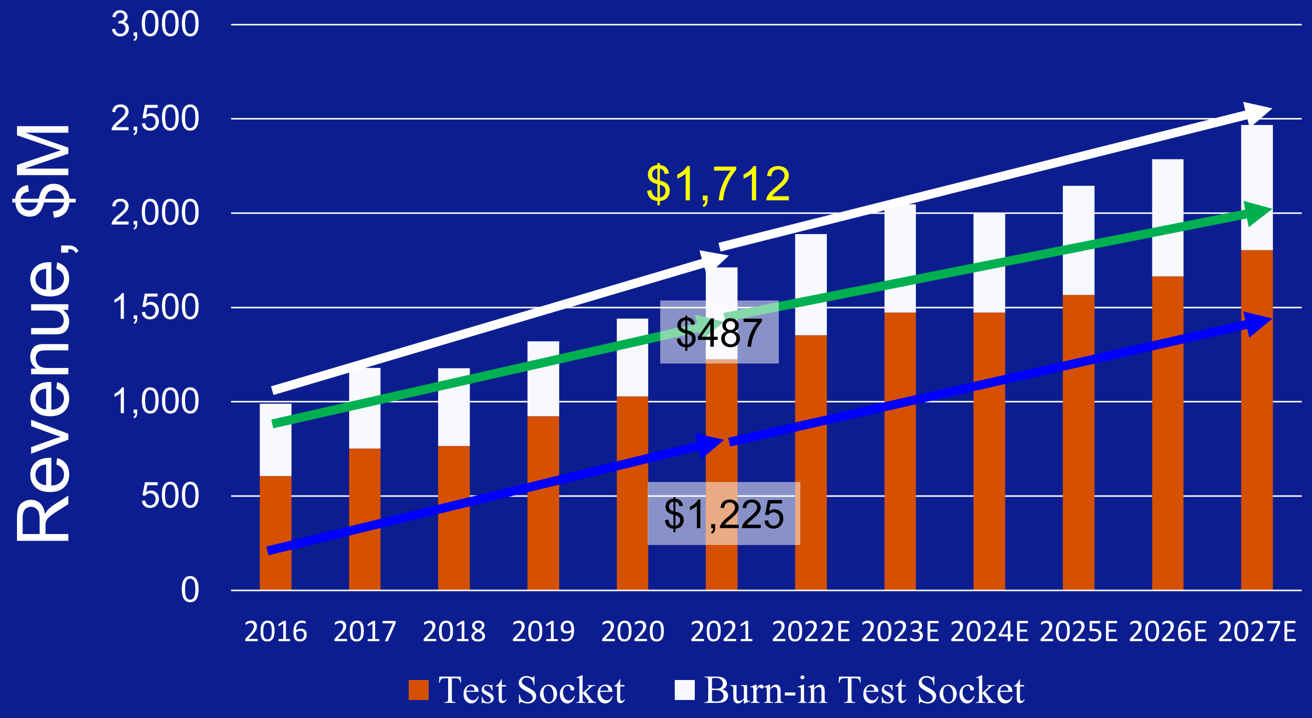
Electronic coupling is the transfer of energy from one circuit or medium to another. Sometimes it is intentional and sometimes not (crosstalk). I hope that this column, by mixing technology and general observations, is thought-provoking and "couples" with your thinking. Most of the time I will stick to technology, but occasional crosstalk diversions may deliver a message closer to home.

Curves & Waves

meptec.org

SOCKET MARKET

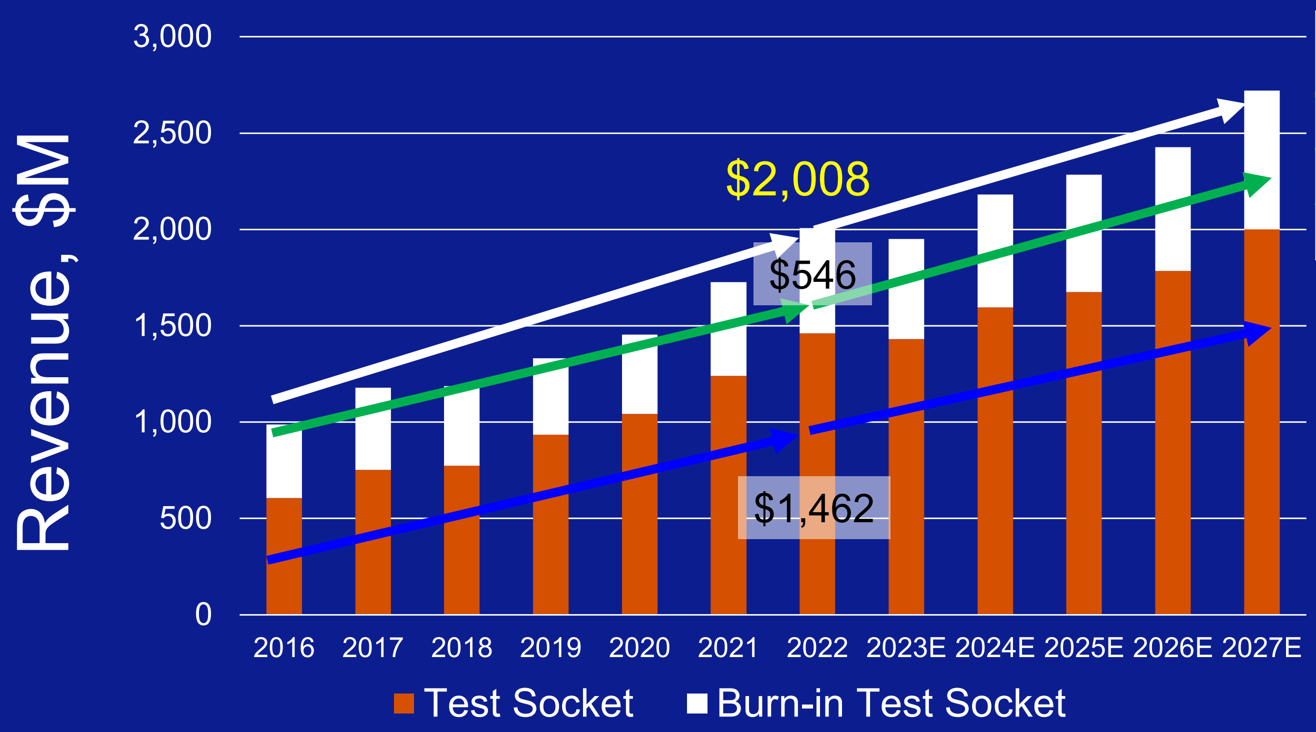
Test and Burn-In Socket Market



	2016-2021 CAGR	2022-2027 CAGR
Overall	11.6%	5.3%
Burn-in	4.9%	4.3%
Test	15.1%	5.9%

Yole Developpement 2021

Test and Burn-In Socket Market



	2016-2022 CAGR	2023-2027 CAGR
Overall	12.5%	8.7%
Burn-in	6.1%	8.5%
Test	15.8%	8.7%

Forecast vs Actual
For 2022:
Test +$110M
Burn-in +$9M

Yole Developpement 2022

TestConX

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27 2023

Segment Revenue ($M)

	2022	2027		2022 - 2027 CAGR
Test Socket	**1,462**	**2,000**		**6.5%**
Package Test	992	1,213		4.1%
System Level Test	349	650		13.2%
Engineering Test Sockets	120	138		2.8%
Burn-in Test Socket	**546**	**720**		**5.7%**
Package Test	474	624		5.7%
System Level Test	33	49		8.4%
Engineering Test Sockets	39	47		3.7%
Total Sockets	**2,008**	**2,721**		**6.3%**

Yole Developpement 2022

Top Test & Burn-in Vendors 2022

Rank	Overall	Test Socket	Burn-in Socket
1	Yamaichi	LEENO	Yamaichi
2	LEENO	Yokowo	Enplas
3	Enplas	Cohu	Boyd
4	Yokowo	ISC	Micro Contact Solution
5	Cohu	Smiths Interconnect	Okins

Yole Developpement 2022

Acknowledgements

- Socket Market Data courtesy of Yole Developpement
  - Thank you John West & Lin Fu