

TWENTY-FOURTH ANNUAL



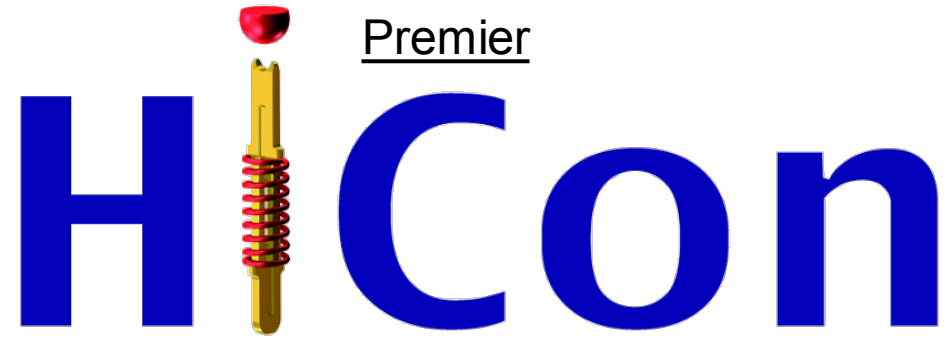
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DoubleTree by Hilton  
Mesa, Arizona  
March 5-8, 2023

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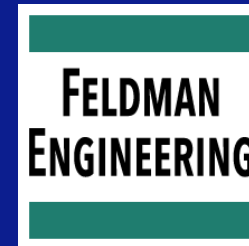
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# Marketplace Report

## Curves & Waves

**Ira Feldman**  
**Feldman Engineering Corp.**



## Outline

- Celebrate the Transistor!
- Moore
- Dennard
- Kondratiev
  
- Socket Market



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2 **2023**



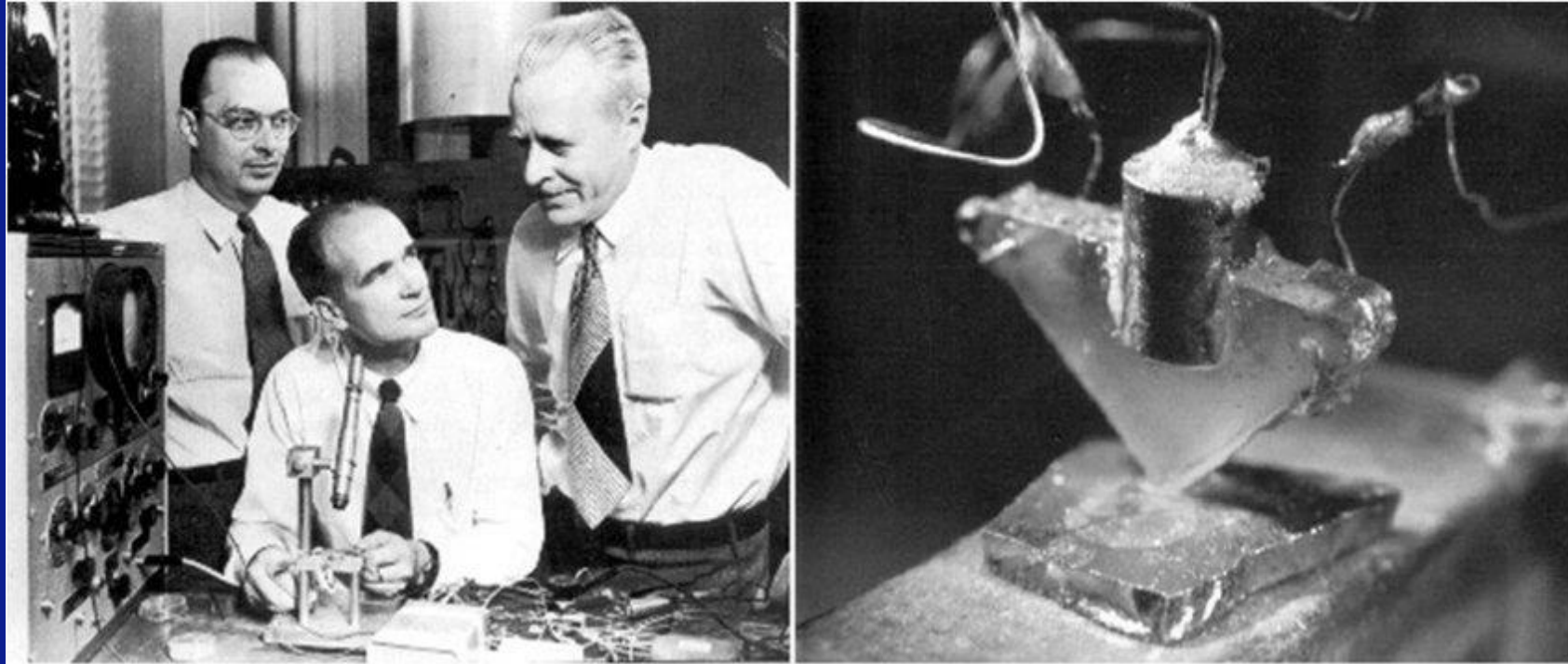
The collage features two main elements. On the left, a tilted image of an IEEE Spectrum magazine cover. The cover has a teal and white color scheme. At the top, it reads 'IEEE Spectrum FOR THE TECHNOLOGY INSIDER'. Below that, 'FEATURE SEMICONDUCTORS' is written. The main title is 'THE TRANSISTOR AT 75' in large, bold, black letters. Underneath the title, it says 'The past, present, and future of the modern world's most important invention'. On the right, a 3D-rendered birthday cake with white frosting and blue and red decorations. The cake is on a silver platter. A large, lit candle in the shape of the number '75' is on top of the cake. The background of the collage is a solid dark blue.

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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.



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4 **2023**



## Traitorous Eight – Fairchild Semiconductor

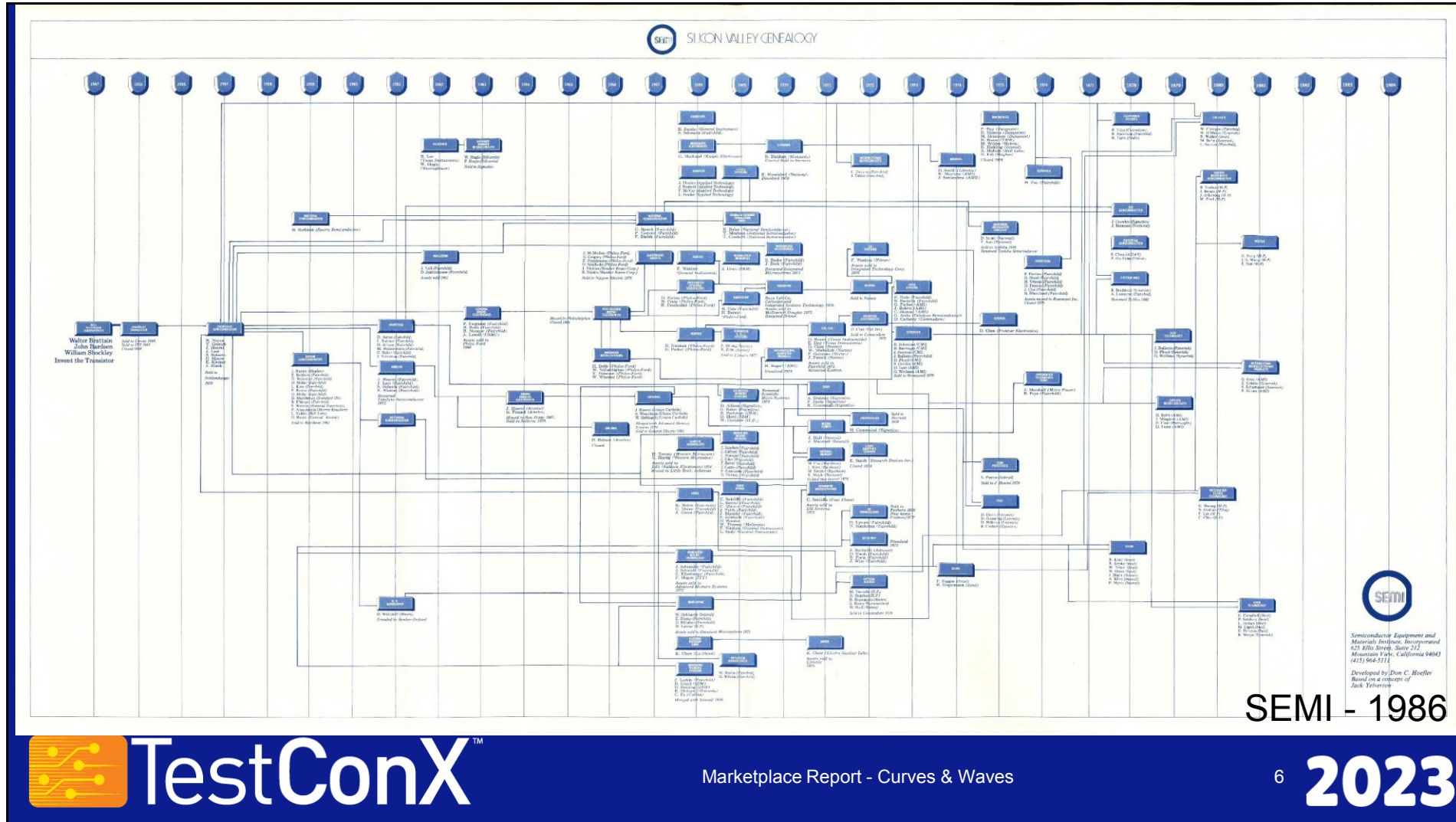


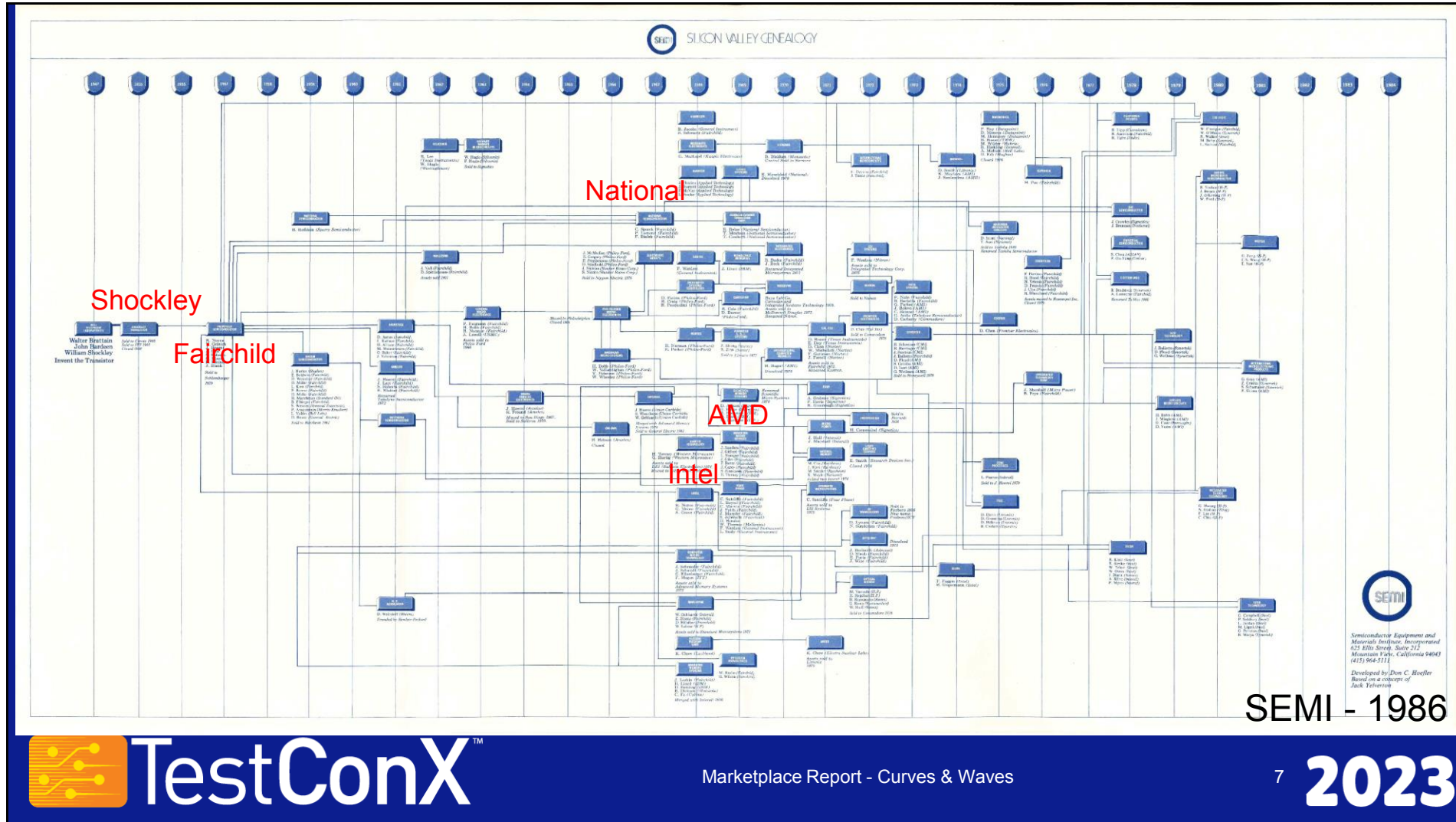
Gordon Moore, C. Sheldon Roberts, Eugene Kleiner, Robert Noyce, Victor Grinich, Julius Blank, Jean Hoerni and Jay Last (1960)  
Wikipedia - Magnum Photos for Fairchild Semiconductor



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5 **2023**





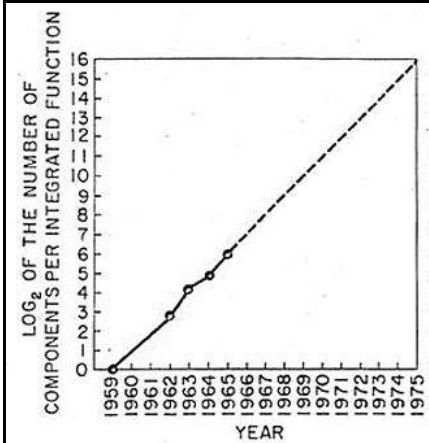
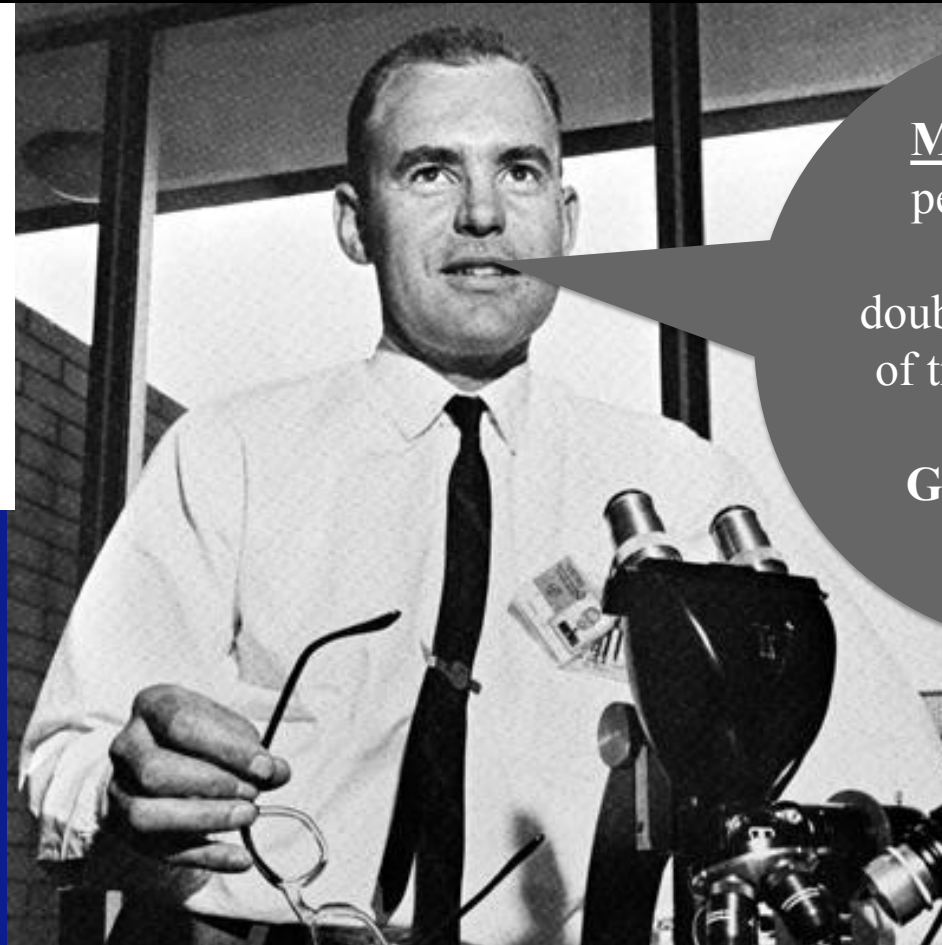


Fig. 2 Number of components per integrated function for minimum cost per component extrapolated vs time.

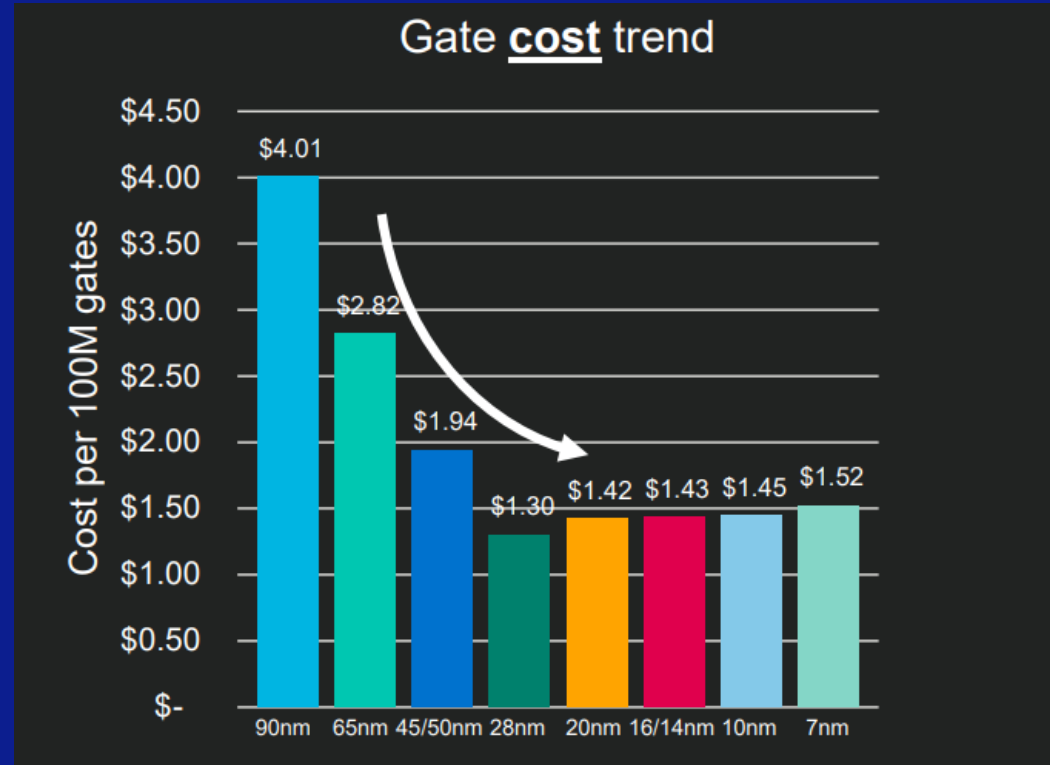


Minimum cost  
per transistor is  
achieved by  
doubling the number  
of transistors every  
two years.  
**Gordon Moore**  
1965\*

\* Revised in 1975 from every 12 to 24 months.

Gordon Moore 1962 credit: Fairchild Camera & Instrument Corporation.

## Cost per Transistor



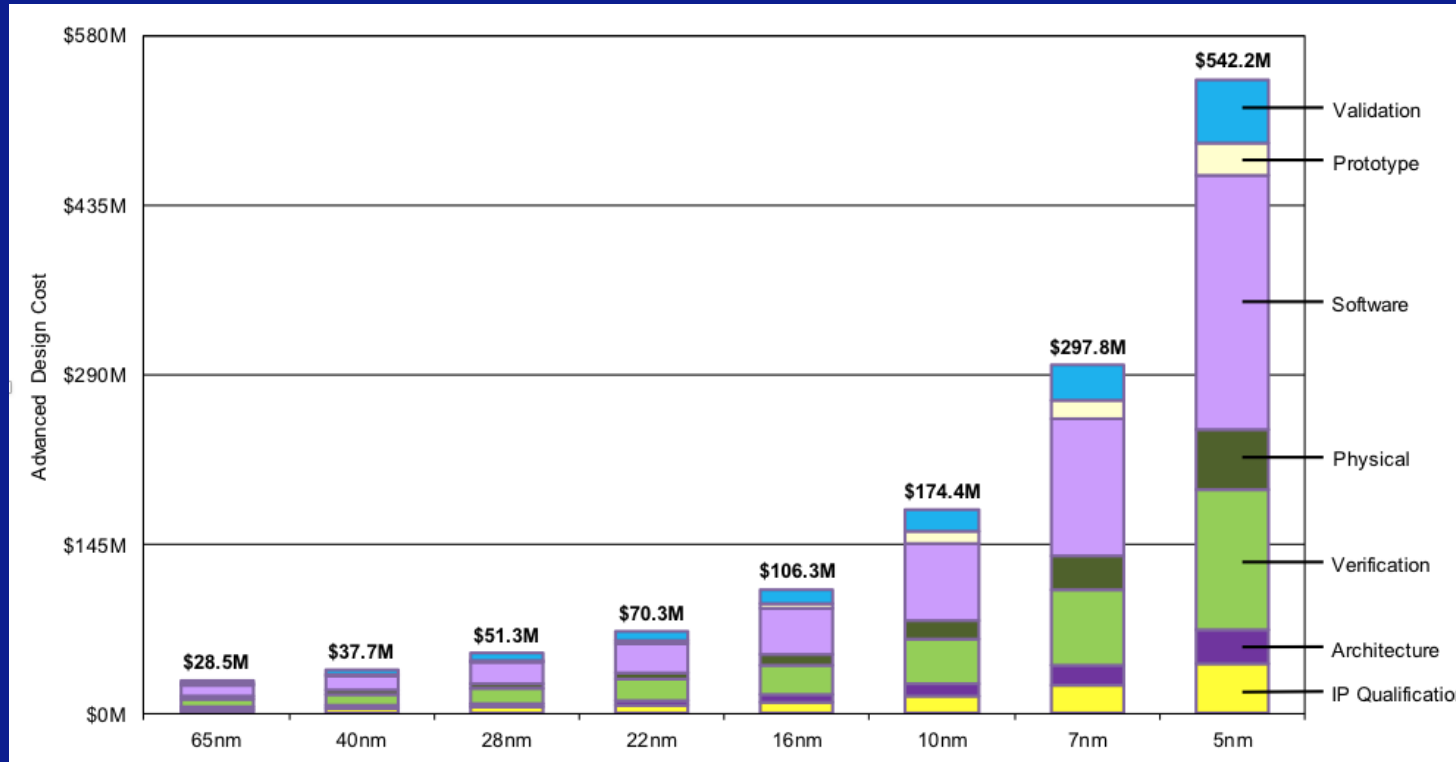
Marvel 2020



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## Process Node Per Design Costs



IBS / Jones




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**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.

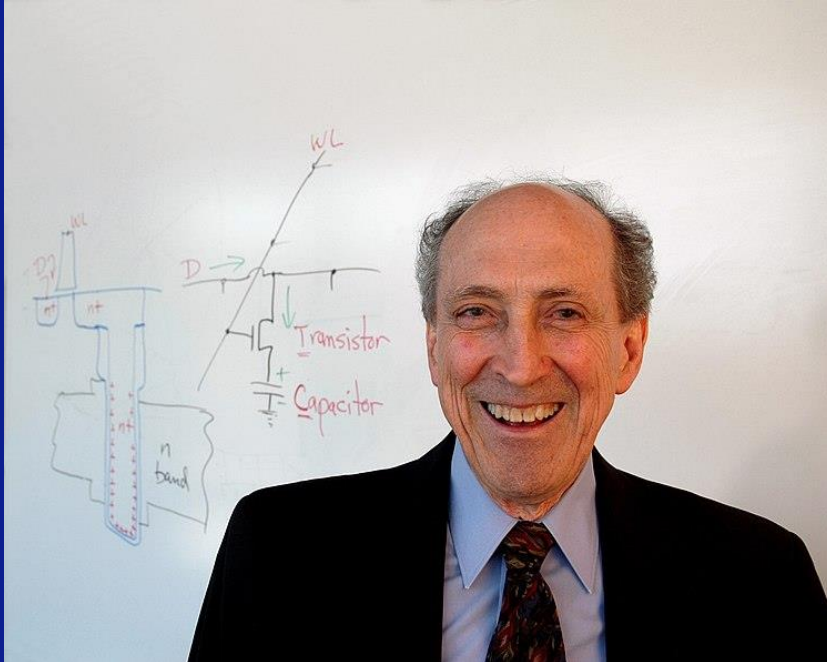
GSA Silicon Summit 2012 (S.S. Iyer) © 2012 IBM

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## 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

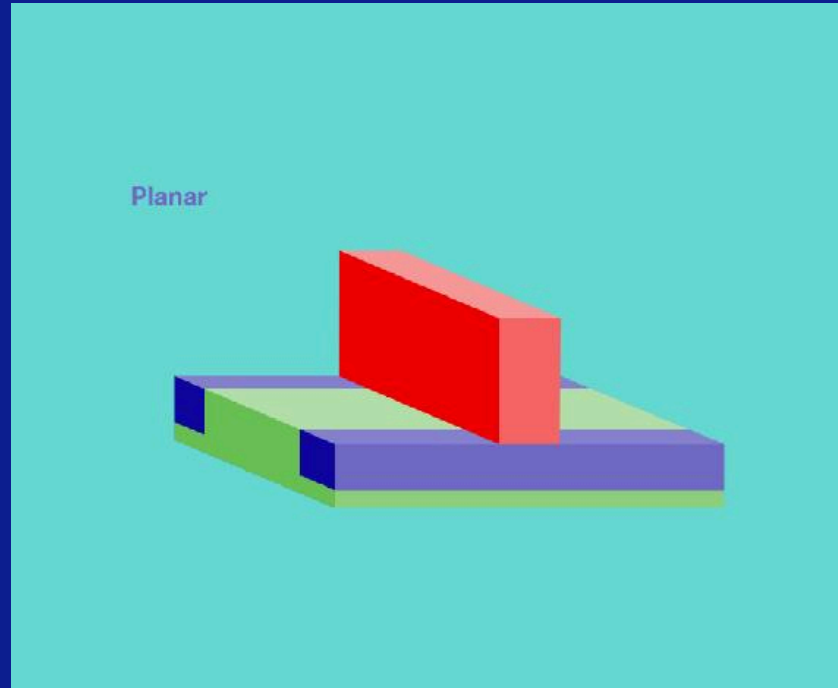


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12 **2023**



## Planar Transistor



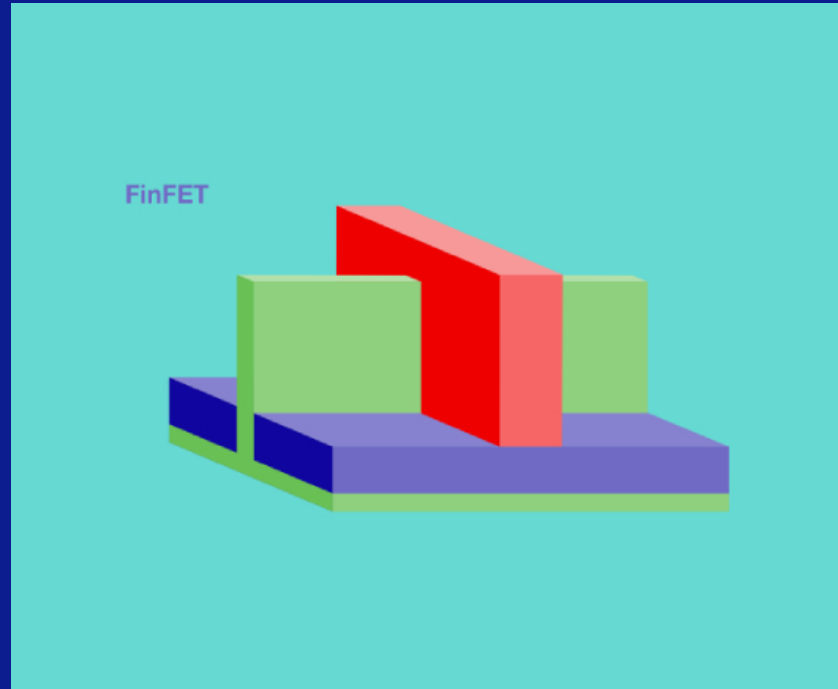
ASML.com



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



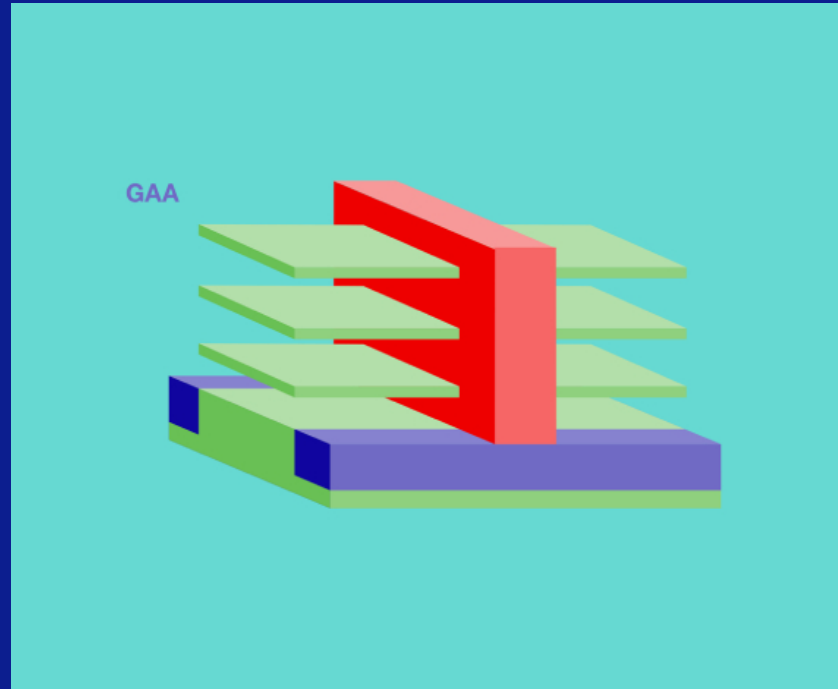
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## gate-all-around field-effect transistors (GAA) – 2020's



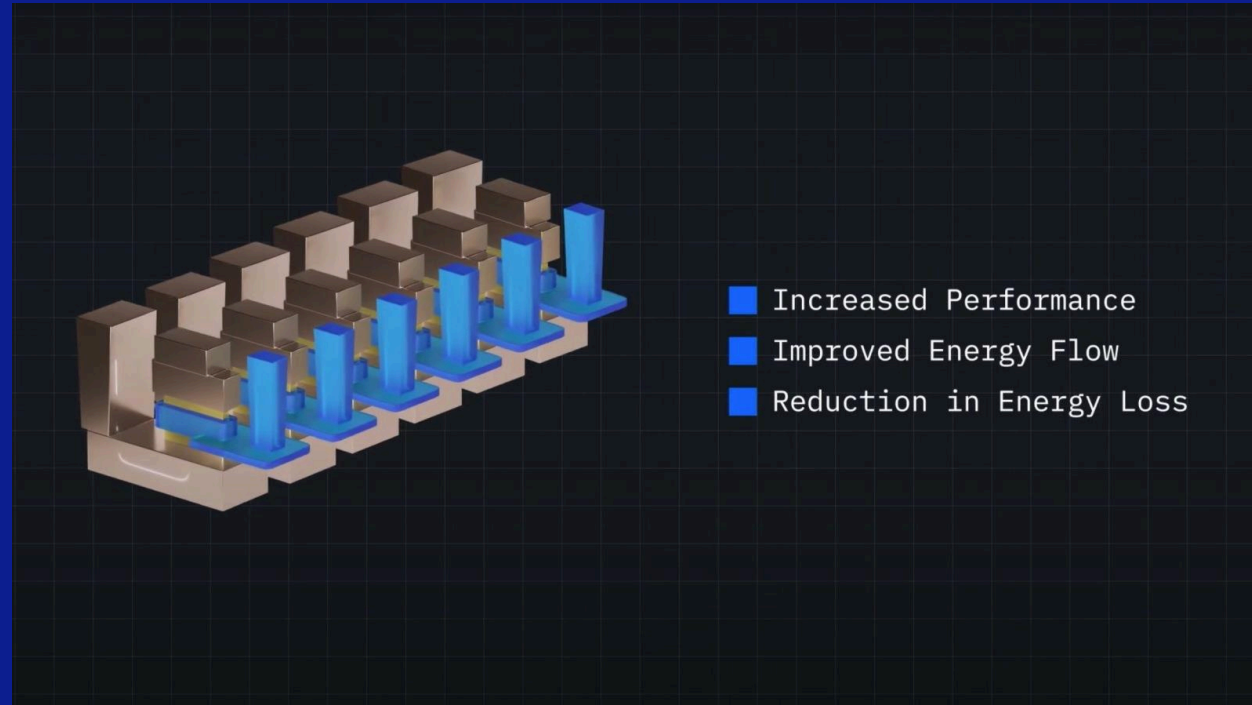
ASML.com



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## Vertical-Transport Nanosheet Field Effect Transistor (VTFET)



IBM & Samsung - 2021

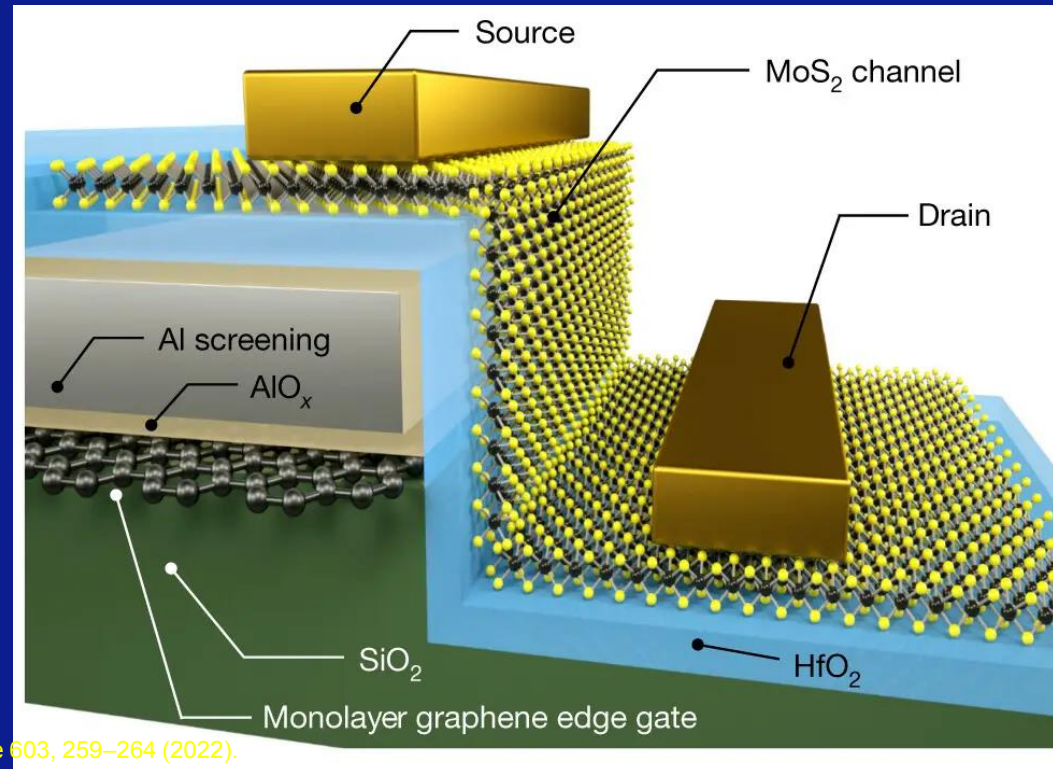


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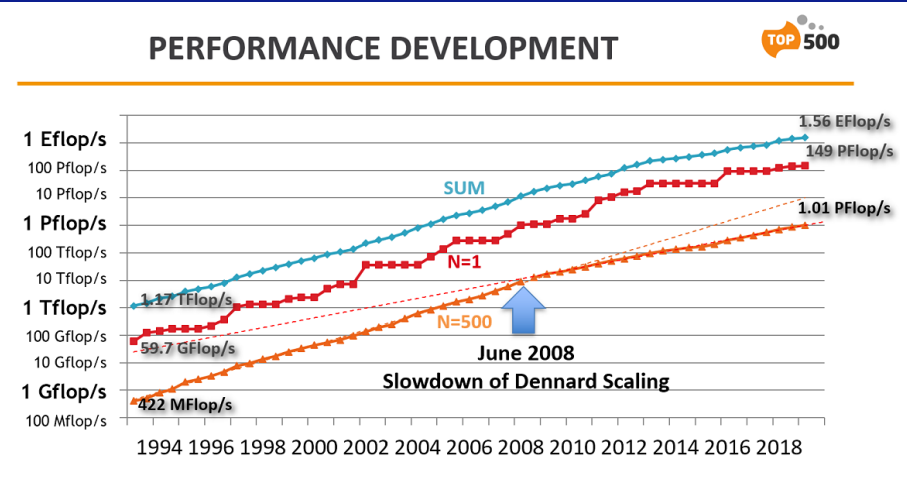
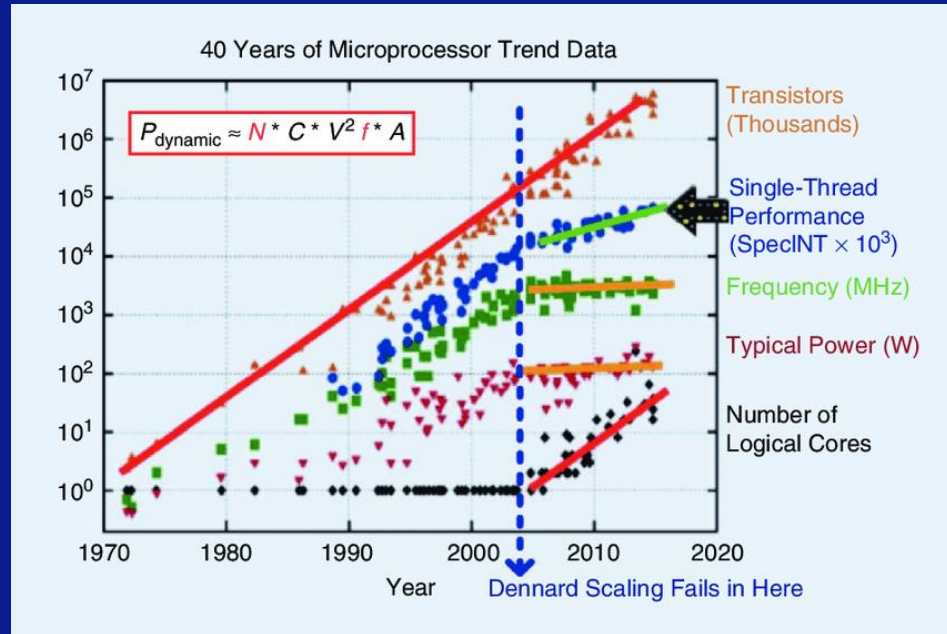
## Single atom gate thickness limit?

.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

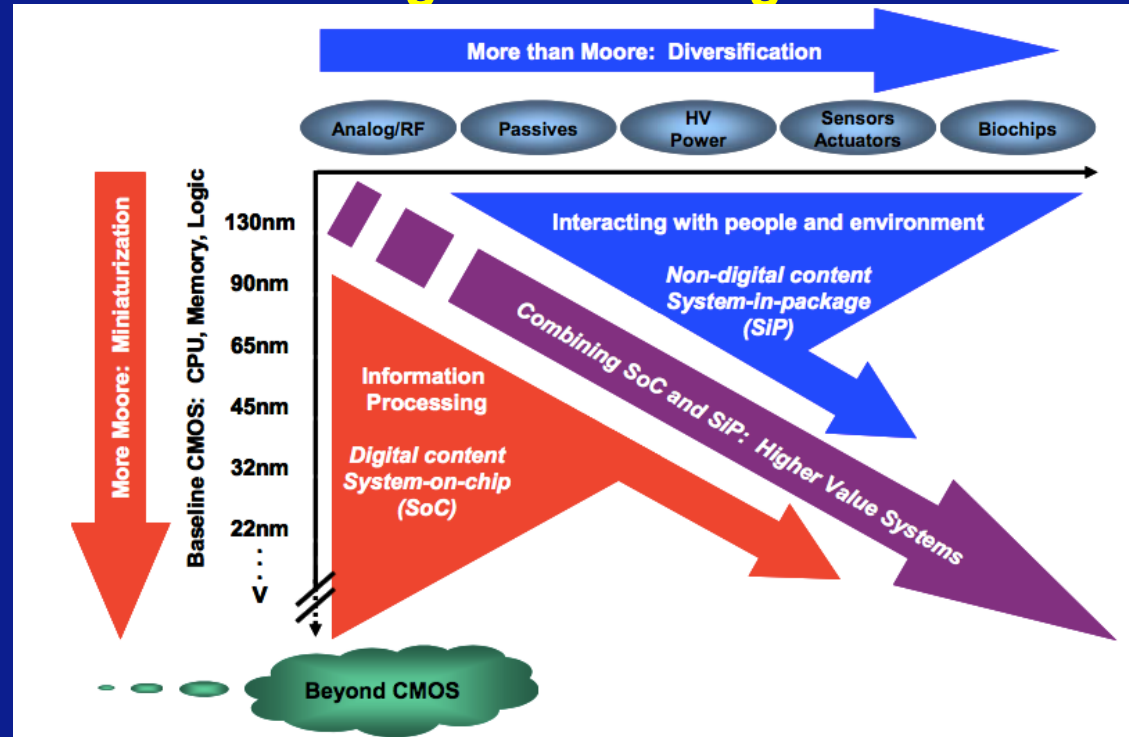
Substrate Size  
cost / area

More than Moore  
Architecture  
Packaging

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19 **2023**

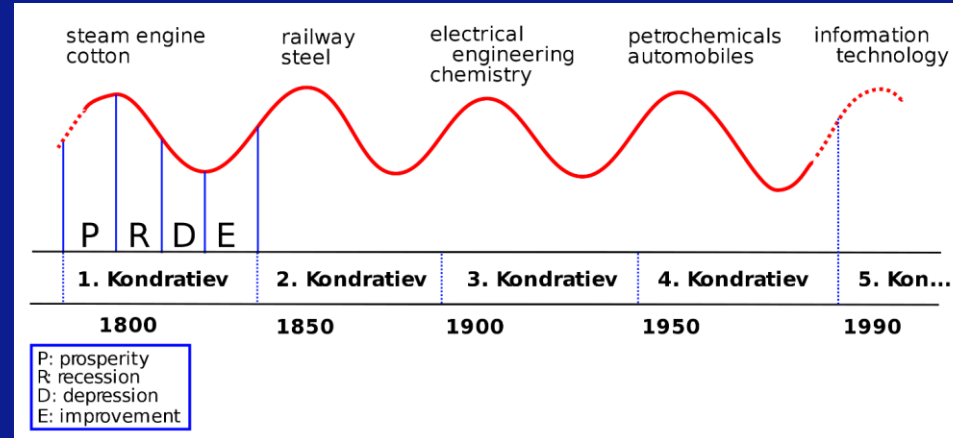
## More than Moore (MtM) Heterogeneous Integration



ITRS "More than Moore" Whitepaper



## Soviet New Economic Policy (NEP)



## Kondratiev Waves

Николай Дмитриевич Кондратьев

Nikolai Dmitriyevich Kondratiev

1892-1938



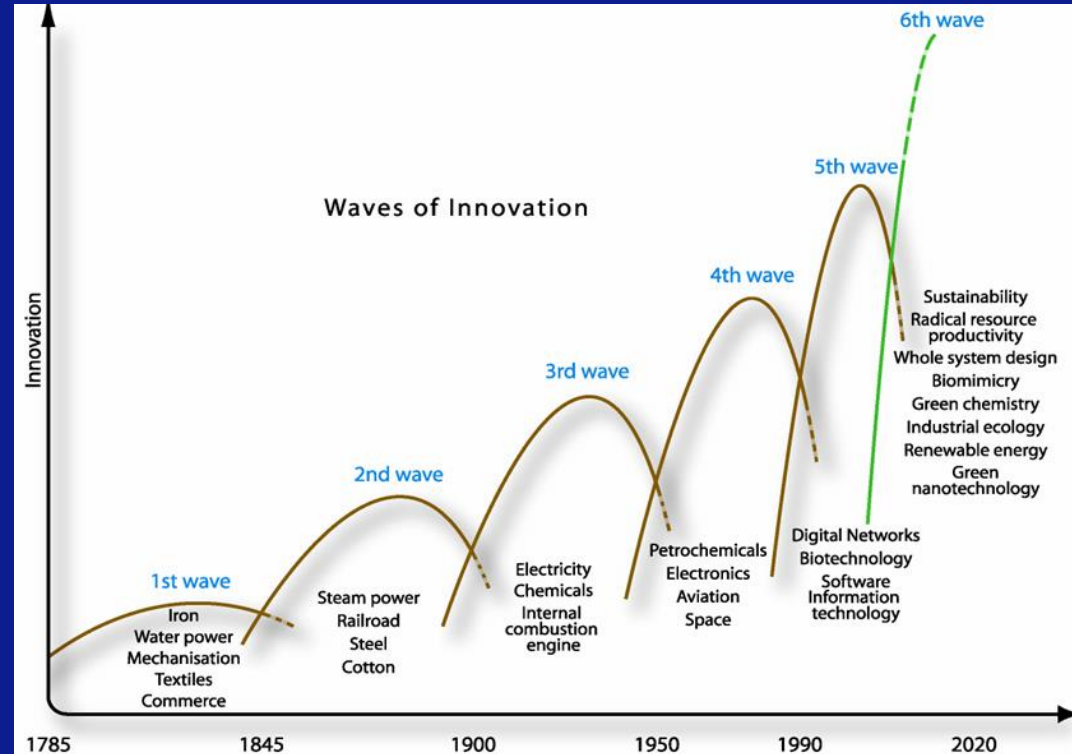
Wikipedia

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21

**2023**

## Waves of Innovation



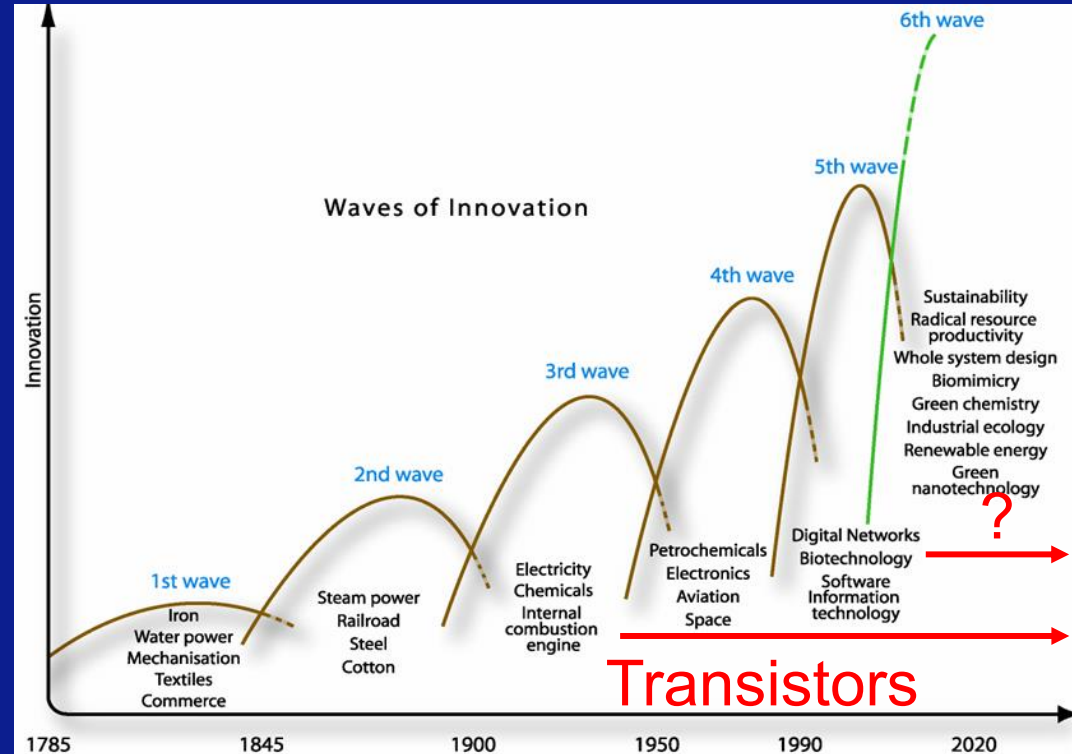
Almgren & Skobelev - Journal of Open Innovation: Technology, Market, and Complexity. 28 March 2020



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22 **2023**

## 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](http://meptec.org)

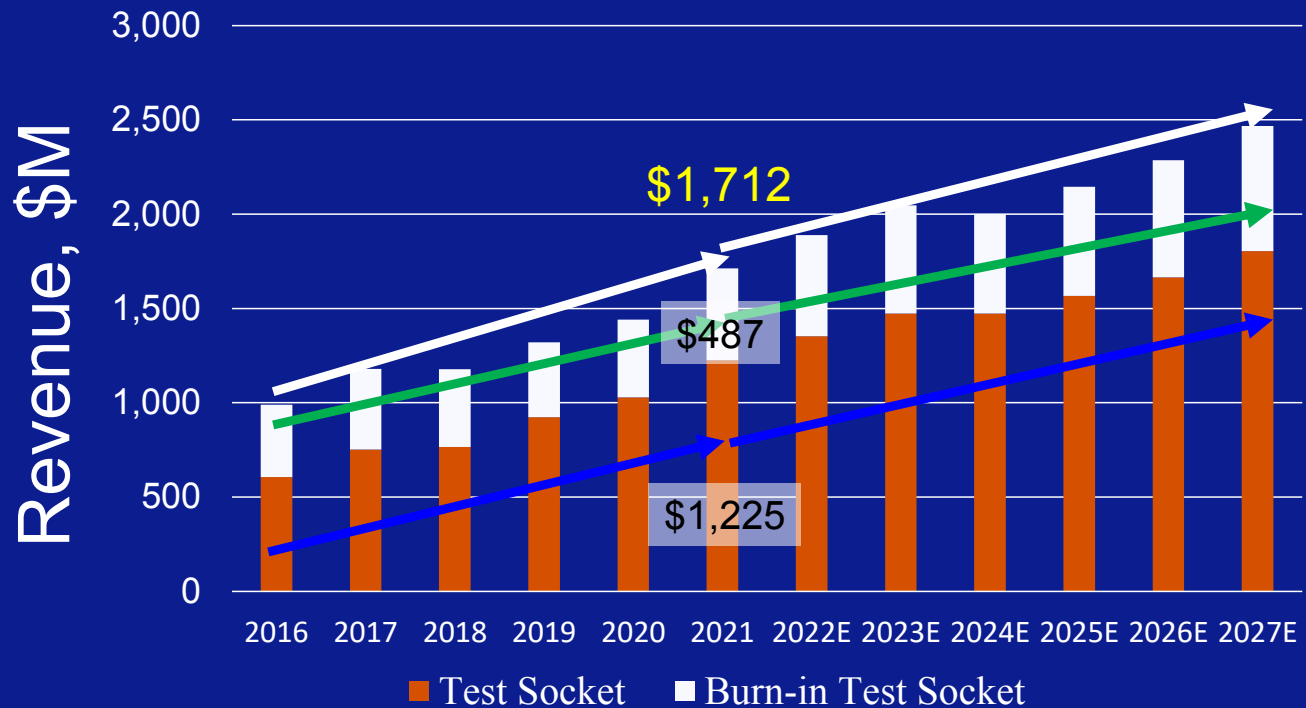
## SOCKET MARKET



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25 **2023**

## 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%

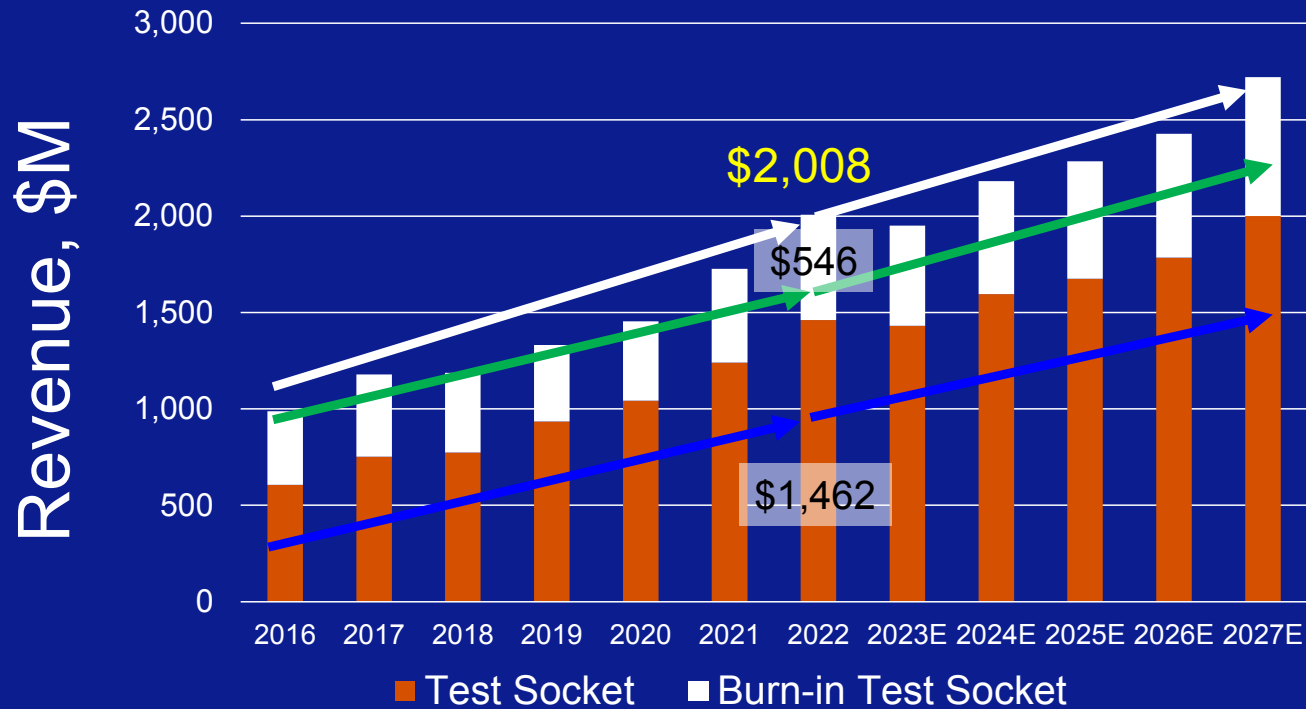
Yole Developpement 2021



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26 **2023**

## 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



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27 **2023**

## Segment Revenue (\$M)

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



Yole Developpement 2022

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28 **2023**



## 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

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29 **2023**

## Acknowledgements

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

