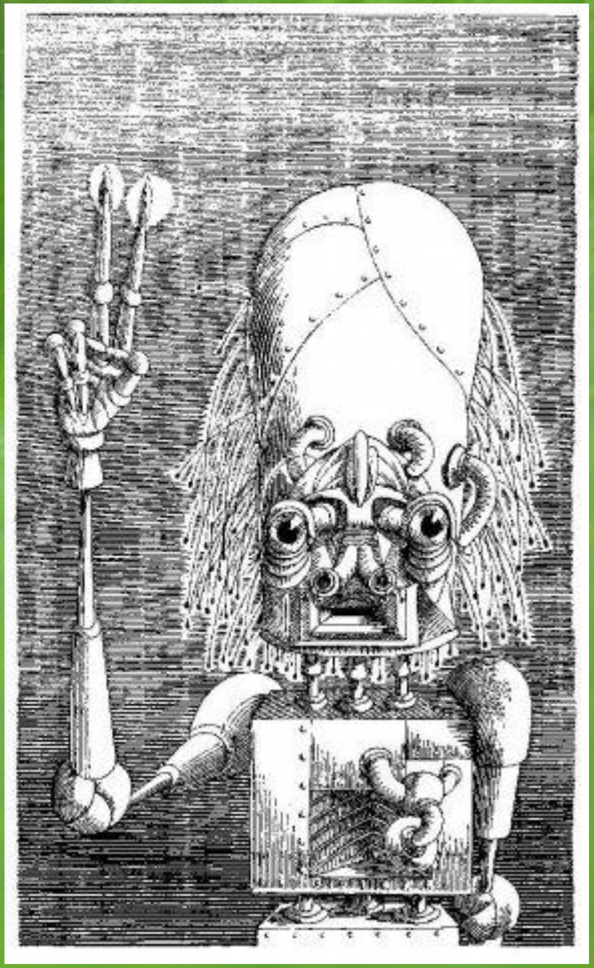
Jak działa komputer?
Logika bramek logicznych.



Jacek.Szczytko@fuw.edu.pl Wydział Fizyki UW

Jak TO działa? http://www.fuw.edu.pl/~szczytko/

Google: **Jacek Szczytko**

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Polski (pl) Jacek Szczytko

Strona główna » 1100-JTD-OG, 1100-3JTD_2020/21Z

Włącz tryb edycji

Jak TO działa? Urządzenia kwantowe (1100-JTD-OG, 1100-3JTD) (semestr zimowy 2020/21)

Forum aktualności

Wykłady środy 17:15-18:45 na platformie Zoom

https://us02web.zoom.us/j/83742912392?pwd=SEhySm5ZbU1nTUU5QmNNNW9UVEp4UT09

Meeting ID: 837 4291 2392

hasło: jtd

Wykład 1 - Technologie 'disruptive', czyli ciężkie życie futurologa

- Wykład 1 - Technologie 'disruptive', czyli ciężkie życie futurologa
- Test 1 - Disruptive technologies
- Wykład 1 - Czat
- Wykład 1 - Nagranie

ADMINISTRACJA

- Administracja kursem
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  - Reset
  - Baza pytań
  - Repozytoria
  - Kosz
  - Ustawienia dodatkowe
- Zmień rolę na...

NAJNOWSZE WIADOMOŚCI

Dodaj nowy temat...

Zoom do wykładu
21 paź, 00:35 Jacek Szczytko

Wykład 1 - Technologie 'disruptive', czyli ciężkie życie futurologa
21 paź, 00:34 Jacek Szczytko

Starsze tematy ...

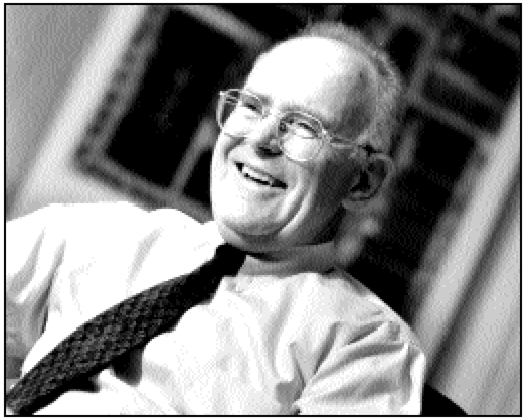
Jak TO działa? http://www.fuw.edu.pl/~szczytko/

W przyszłym tygodniu ŚRODA jest we CZWARTEK!

12 listopada (też) jest środa!

Prawo Moora i jego konsekwencje.

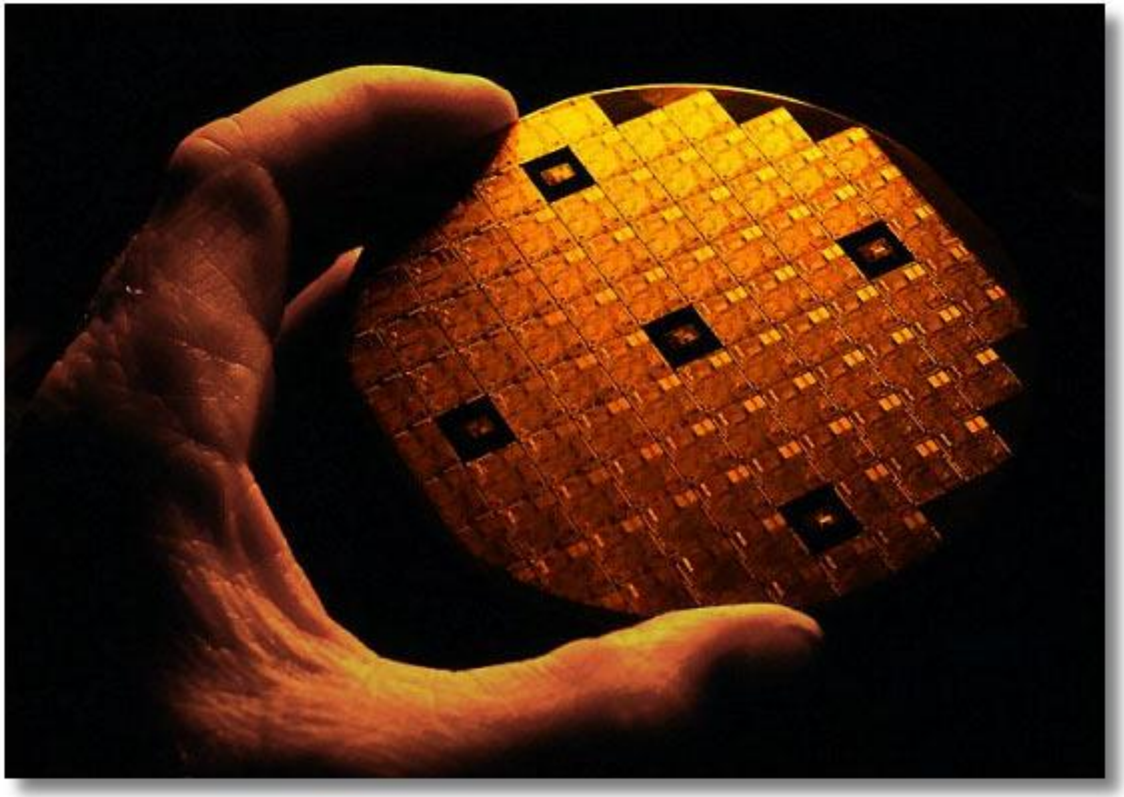
a. Trochę historii
b. Jak to działa
   i. Trochę logiki
   ii. Od bramki do bramki
   iii. Jak działa tranzystor
c. Prawo Moora
   i. Nanotechnologia
   ii. Domieszki – koncentracja i statystyka
   iii. Tunelowanie
   iv. Chłodzenie



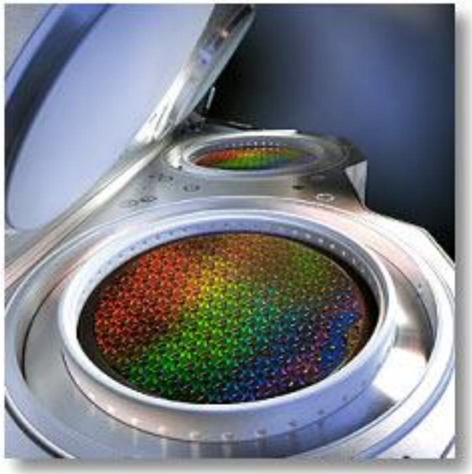
Amara's law is a maxim stating:
We tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run.

Koniec technologii krzemowej?

Prescot, Intel



Nanotechnologia
Litografia
Udoskonalenia
Galeria



Jan Czochralski

Urodzony w 1885 roku jako ósmy syn ubogiego stolarza.
Nie jest pewne czy zdał maturę.
Nie stać go było na opłacenie studiów.
Odkrywca metody wzrostu kryształów - *"metody Czochralskiego"*.
Uznawany za *"praojca elektroniki"*
Polski uczony **najczęściej wymieniany w literaturze światowej**.
W Polsce prawie nieznany...

Jan Czochralski

http://www.ptwk.org.pl/pol/patron.html

STANOWISKO SENACKIEJ KOMISJI HISTORII I TRADYCJI SZKOŁY PW W SPRAWIE UCHWAŁY SENATU Z DNIA 19 GRUDNIA 1945 R. DOTYCZĄCEJ PROF. DR. H.C. JANA CZOCHRALSKIEGO

Jak wynika z zeznań świadków, w tym mgr. inż. Ludwika Szenderowskiego, b. kierownika warsztatu i odlewni w Zakładzie Badań Materiałów, a jednocześnie członka ruchu oporu, w r. 1942 na terenie ZBM rozpoczęła swą potajemną działalność komórka organizacyjna AK w zakresie produkcji odlewów żeliwnych skorup do granatów, elementów drukarń polowych i części do pistoletów. Prof. Czochralski wiedział o tym i nie tylko tolerował, ale i ochraniał działalność konspiracyjną w swym zakładzie wobec władz niemieckich i gestapo.

Na korzyść prof. Czochralskiego należy również zaliczyć jego działalność poza ZBM. Wykorzystując swe rozległe znajomości, interweniował wielokrotnie i dość skutecznie u władz okupacyjnych w celu uwolnienia różnych osób z obozów niemieckich, więzień i obozów koncentracyjnych. Wśród osób uwolnionych można znaleźć m.in. nazwisko dr. Mariana Świderka, późniejszego profesora PW, wnuka Ludwika Solskiego.

Znamienna jest tu wypowiedź b. asystentki prof. Czochralskiego prof. dr Zofii Wendorff, że "nie zna ona przypadku, aby prof. Czochralski odmówił pomocy Polakom, którzy się do niego zwrócili".

Jan Czochralski

http://www.ptwk.org.pl/pol/patron.html

Uzasadnienie Sądu i decyzja o zwolnieniu z zarzutów, Łódź , dnia 13.sierpnia 1945r

U z a s a d n i e n i e

Jan Czochralski, Mieczysław Wojciechowski i Leonia z Czochralskich Wojciechowska podejrzani są o współpracę z niemieckimi władzami okupacyjnymi na szkodę osób spośród ludności cywilnej względnie Państwa Polskiego.

W toku przeprowadzonego dochodzenia ustalono, że Jan Czochralski przybył do kraju w roku 1928 r. z Niemiec na wezwanie władz państwowych, jako fachowiec w dziedzinie metalurgii i otrzymał katedrę metalurgii na Politechnice Warszawskiej. Następnie zostało mu również powierzone kierownictwo Instytutu Metalurgii i Metaloznawstwa w Warszawie /k.32/.

Wskutek działań wojennych we wrześniu 1939 r. Instytut ten zawiesił swą pracę. Na początku 1940 r. Instytut, za zezwoleniem niemieckich władz okupacyjnych wznowił swą pracę, lecz już jako przedsiębiorstwo przemysłowo-handlowe /k.8,33-34,43,46,58/. Między innymi przedsiębiorstwo to produkowało panewki i tłoki dla wojskowych reperacyjnych warsztatów samochodowych. W związku z tym Czochralski wszedł w kontakt z niemieckimi władzami okupacyjnymi, co było niewątpliwie asumptem do przypuszczeń, że Czochralski uprawia działalność, szkodliwą dla Państwa Polskiego względnie osób spośród ludności cywilnej. Jednakże materiał zebrany w dochodzeniu nie potwierdził tych przypuszczeń. Przeciwnie z akt dochodzenia wynika, że dzięki stosunkom Czochralskiego udało się wydostać szereg osób z obozów koncentracyjnych względnie więzień /k.25,35,36,39,46,58/.

Dochodzenie nie dostarczyło również żadnych konkretnych faktów szkodliwej działalności ze strony innych członków rodziny Jana Czochralskiego, a w szczególności ze strony Mieczysława i Leonii Wojciechowskich. Zaznaczyć przy tym należy, że Leonia Wojciechowska w szeregu wypadków skutecznie interweniowała u władz niemieckich na rzecz osób, aresztowanych przez władze okupacyjne /k.12,13,15,19-23/.

W świetle tych ustaleń brak jest podstaw do ścigania Jana Czochralskiego oraz Mieczysława i Leonii Wojciechowskich przed Specjalnym Sądem Karnym w kierunku jednego z przestępstw, przewidzianych w dekrecie P.K.W.N. z dnia 31.8.1944 r. w brzmieniu dekretu z dnia 16.2.1945 r./Dz.U.R.P. Nr.7/45, poz.29/.

p.o. Wiceprokurator
/St. Walczak /

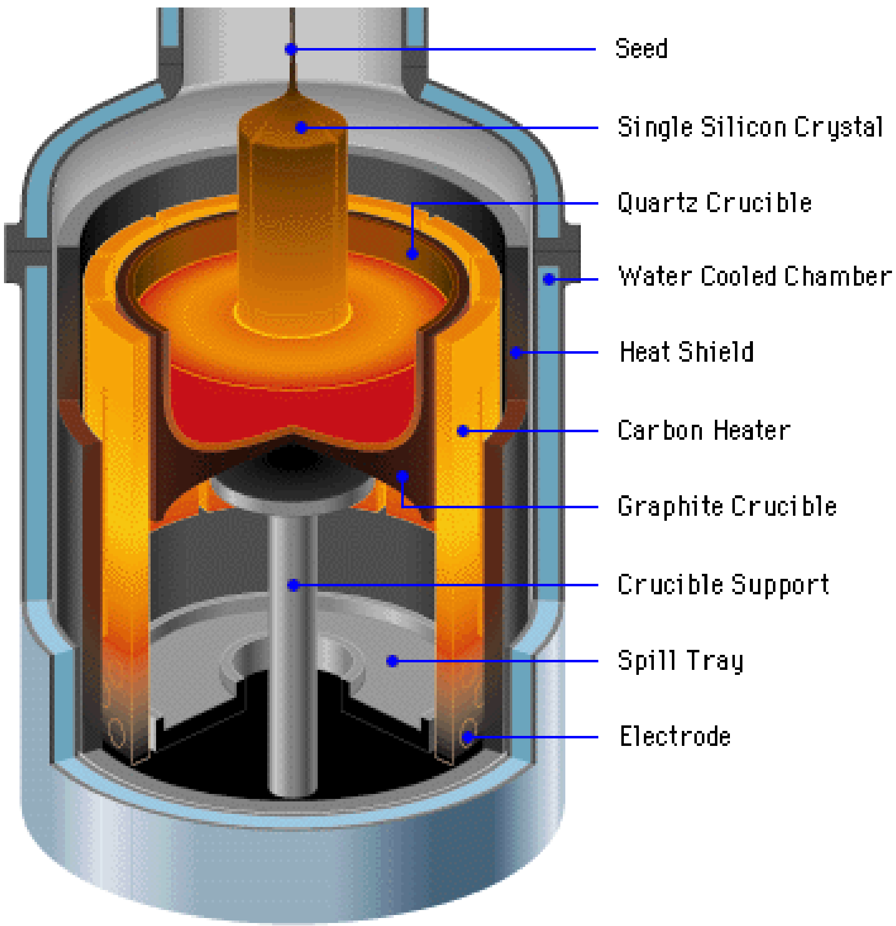
P o s t a n o w i e n i e

Postanawiam zgodnie z wnioskiem Wiceprokuratora rejonowego.

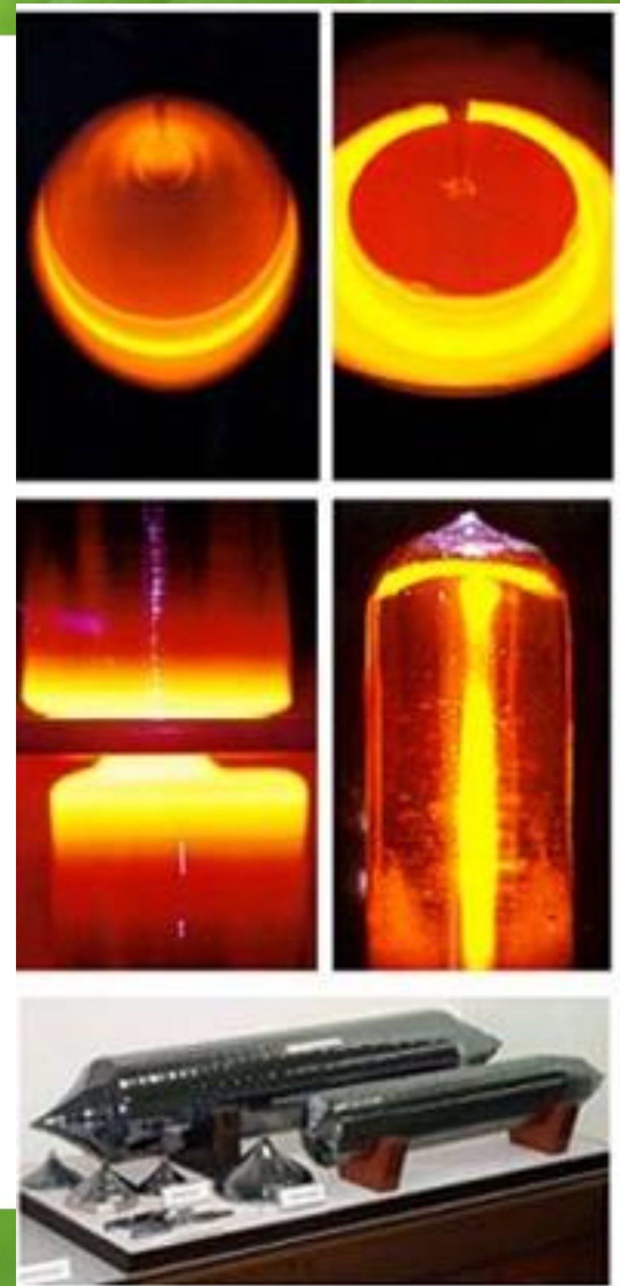
Odnotowano   Prokurator

Łódź, dnia 13 sierpnia 1945 r.

Metoda Czochralskiego



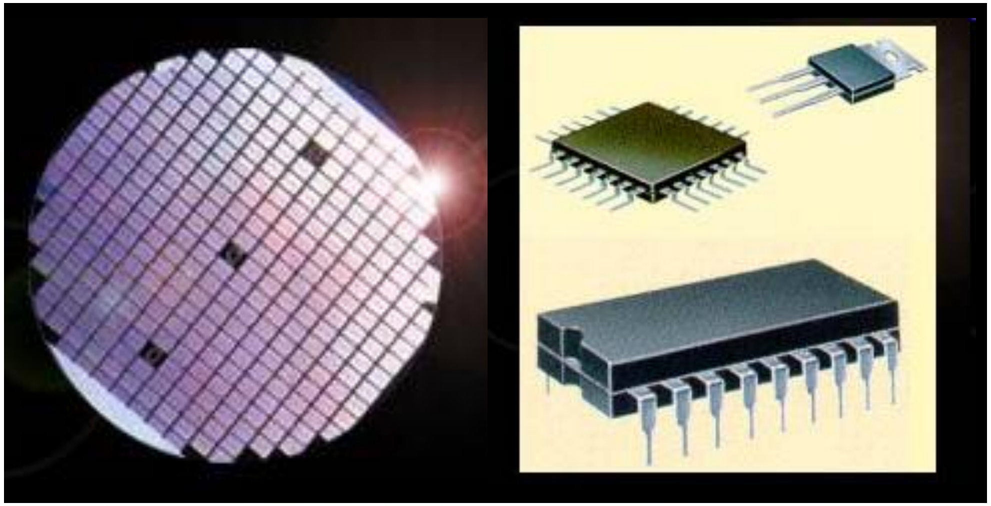
http://people.seas.harvard.edu/~jones/es154/lectures/lecture_2/materials/materials.html



http://www.sehmy.com/Product/abtWafers.htm

Metoda Czochralskiego

http://www.sehmy.com/Product/abtWafers.htm

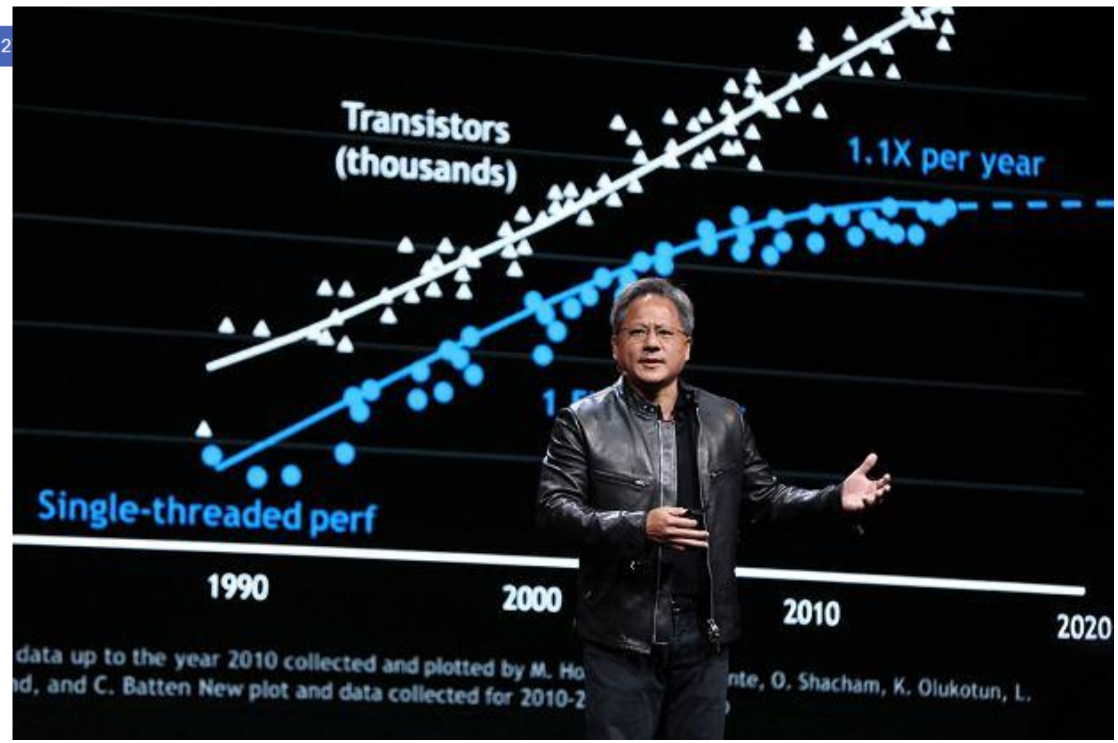


Koniec?

Koniec podstawowego prawa rządzącego światem komputerów? "Dotarliśmy do ściany"

Robert Kędzierski
02.10.2017 13:30

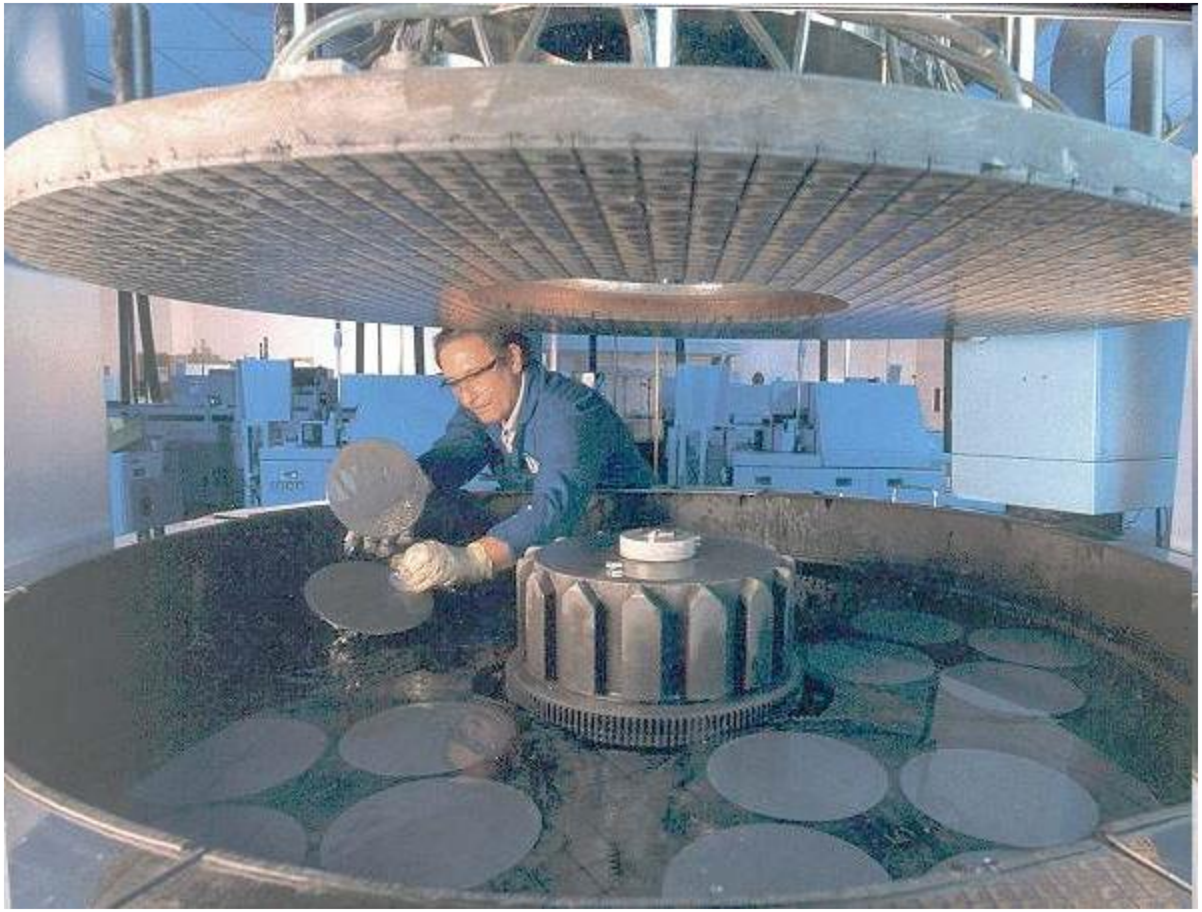
Podziel się 2



Jen-Hsun Huang, szef NVIDII oznajmił, że prawo Moore'a jest w zasadzie martwe. […] Przepowiednia sprawdzała się przez kilka dekad, ale w ostatnich latach w zasadzie przestała obowiązywać. Proces technologiczny wytwarzania układów jest co prawda imponujący - 5 nanometrów jest już osiągalne. Pomimo imponującej minimalizacji przyrost wydajności nie jest już tak wielki - nie podwaja się. Według szefa Nvidii zwiększa się realnie o ok. 10 proc - informuje PC Gamer.

http://next.gazeta.pl/next/7,151243,22456101,szef-nvidii-doszlismy-do-sciany-procesory-nie-beda-juz-rozwijac.html#BoxBizImg

Metoda Czochralskiego



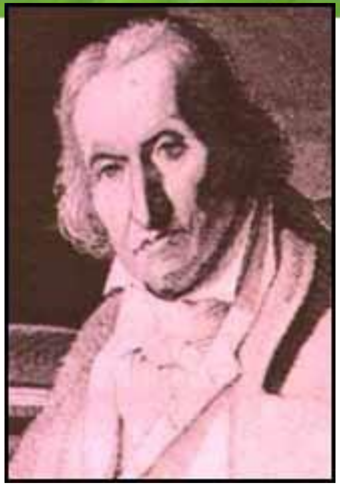
© "Smithsonian", Jan 2000, Vol 30, No. 10

http://www.tf.uni-kiel.de/matwis/amat/elmat_en/kap_6/backbone/r6_1_2.html

Trochę historii

Trochę historii

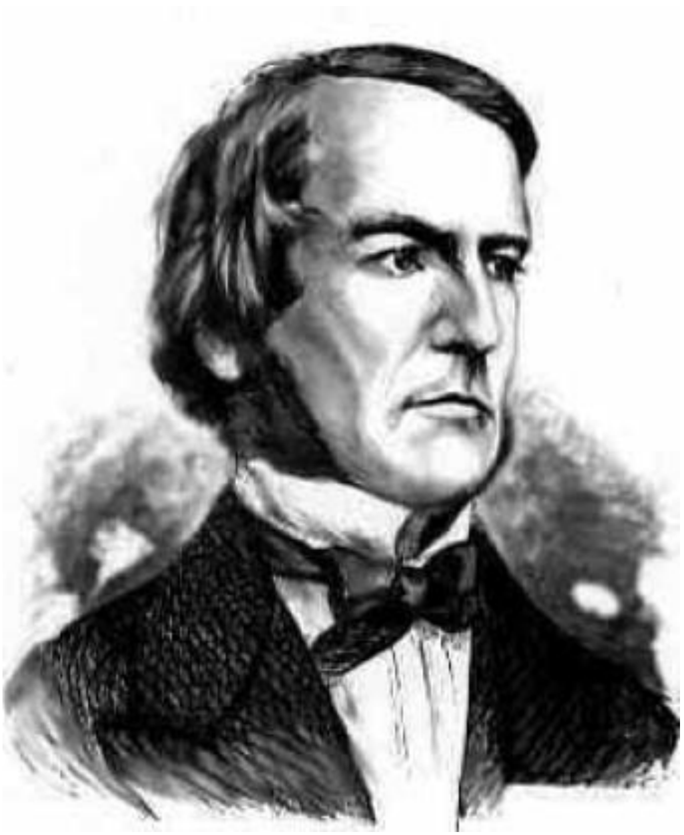
1. Początek XIX w. ok.. 1800 Francuz Joseph Jacquard i jego krosna (sprzeciw w Lyonie)



Źródło: http://en.wikipedia.org/wiki/Jacquard_loom

Trochę historii

1. George Boole (1815-1865)



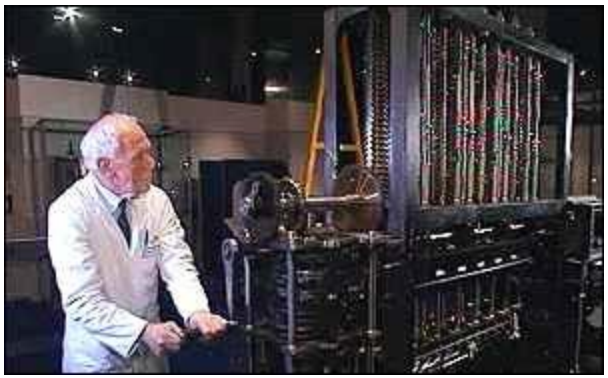
Prof.. Ryszard Tanas http://zon8.physd.amu.edu.pl/~tanas/

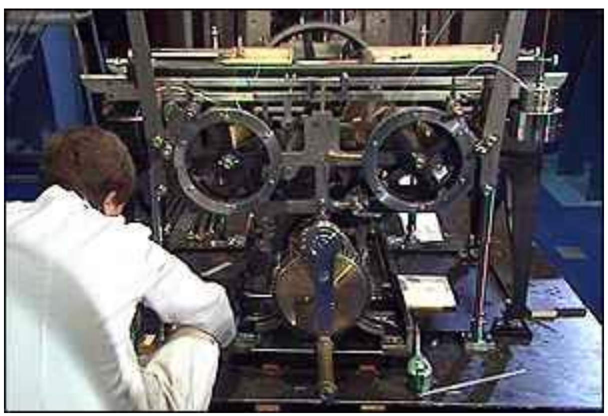
Trochę historii

2. Połowa XIX w. Anglik Charles Babbage i jego „maszyna analityczna".

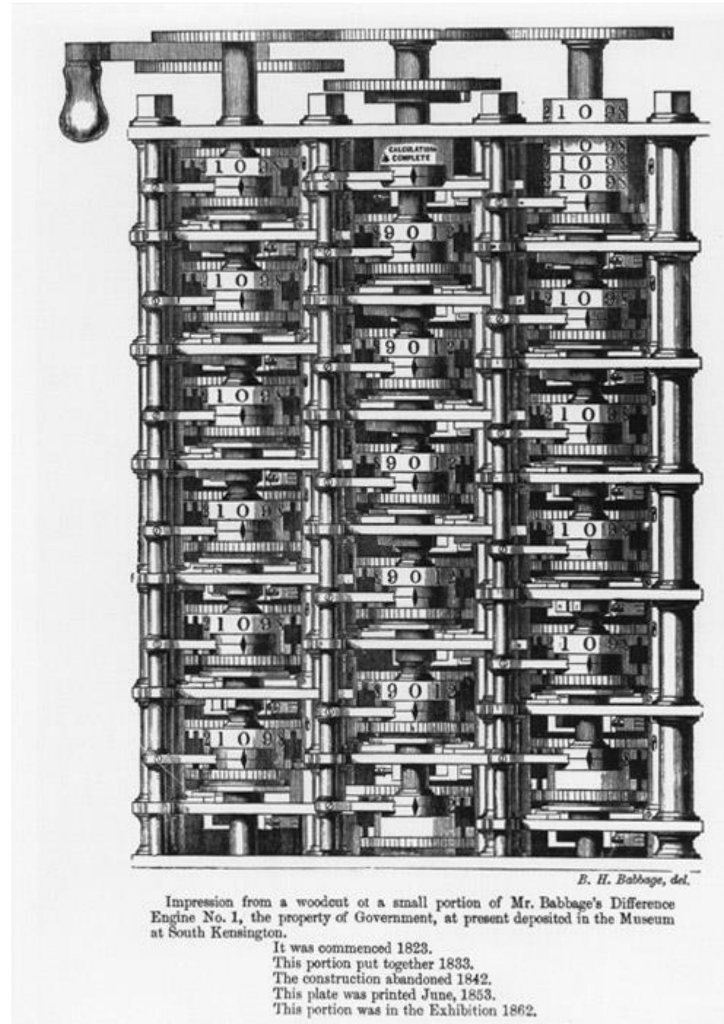
Skonstruowana w 1985 –1991 r. w Science Museum w Londynie. Urządzenie składa się z 4000 części i waży ponad 3 tony. Podobnie jak i drukarka.

„komputer"





drukarka



Źródło: http://www.cbi.umn.edu/exhibits/cb.html , http://www.sciencemuseum.org.uk/galleryguide/E2052.asp
http://news.bbc.co.uk/1/hi/sci/tech/710950.stm

Trochę historii

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„komputer”

drukarka

Źródło: http://www.cbi.umn.edu/exhibits/cb.html , http://www.sciencemuseum.org.uk/galleryguide/E2052.asp
http://news.bbc.co.uk/1/hi/sci/tech/710950.stm

Trochę historii

3. Koniec XIX w. Herman Hollerith wynalazł maszynę liczącą, którą można było „programować” przy pomocy kart. Wykorzystano ją w 1890 r w spisie powszechnym w USA.

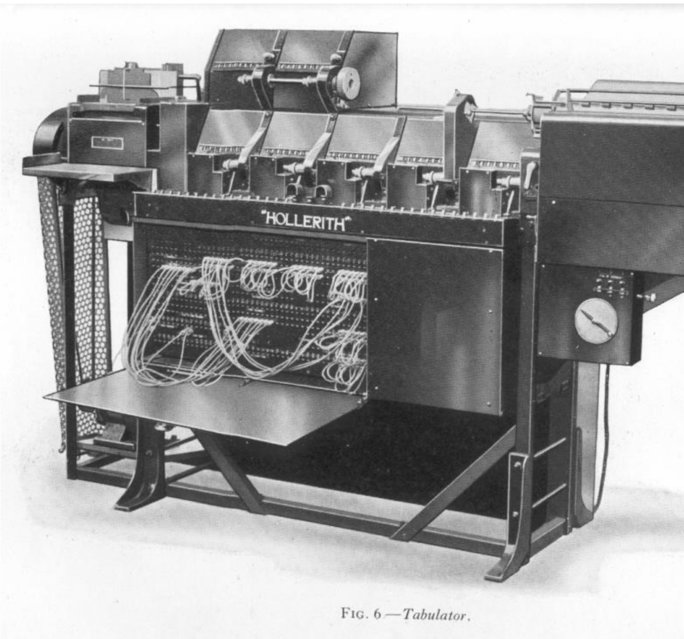
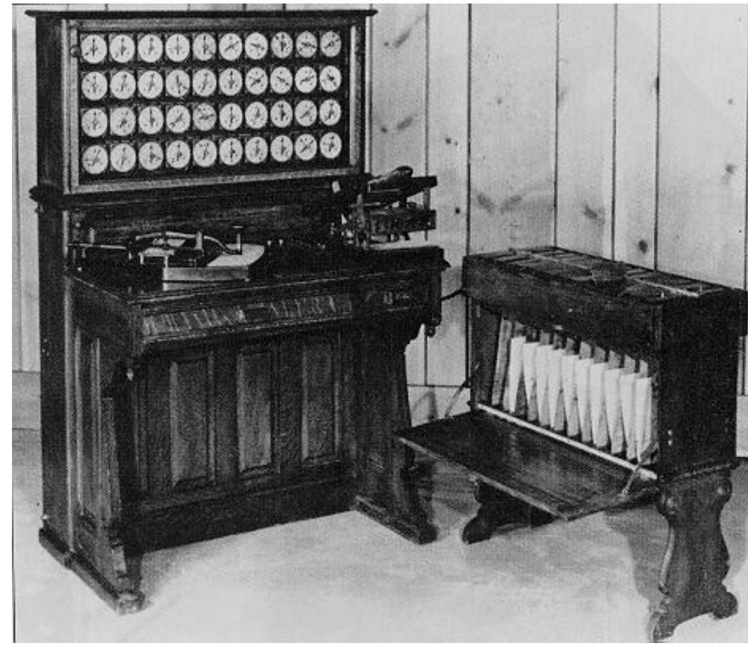


Fig. 6—*Tabulator*.

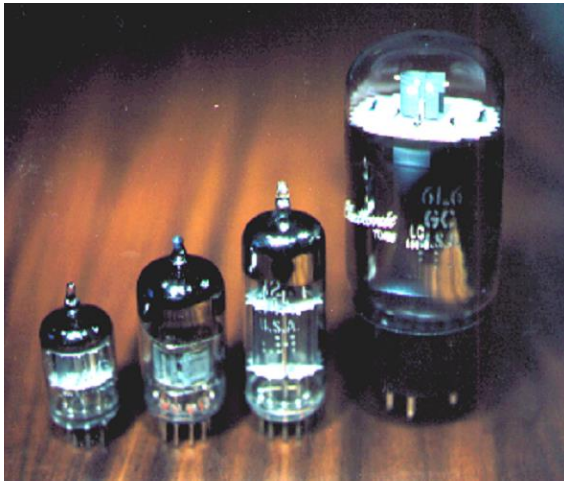


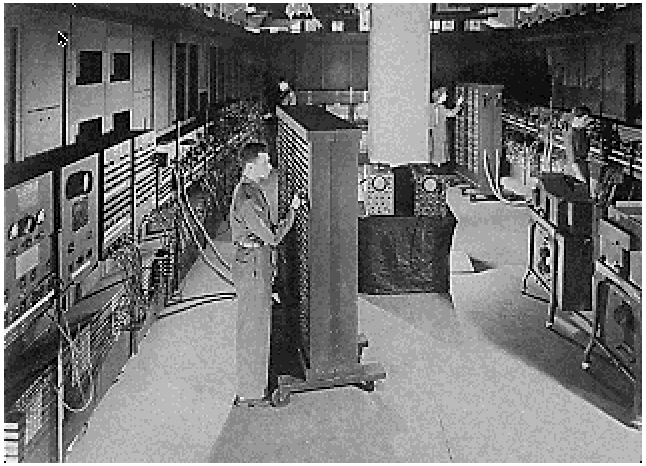
W 1911 r. Hollerith's Tabulating Machine Company łączy się z dwoma innymi Computing Scale Company of America oraz International Time Recording Company. Powstaje Computing-Tabulating-Recording Company (C-T-R) . W 1924 r. zmienia nazwę na **International Business Machines Corporation** – IBM.

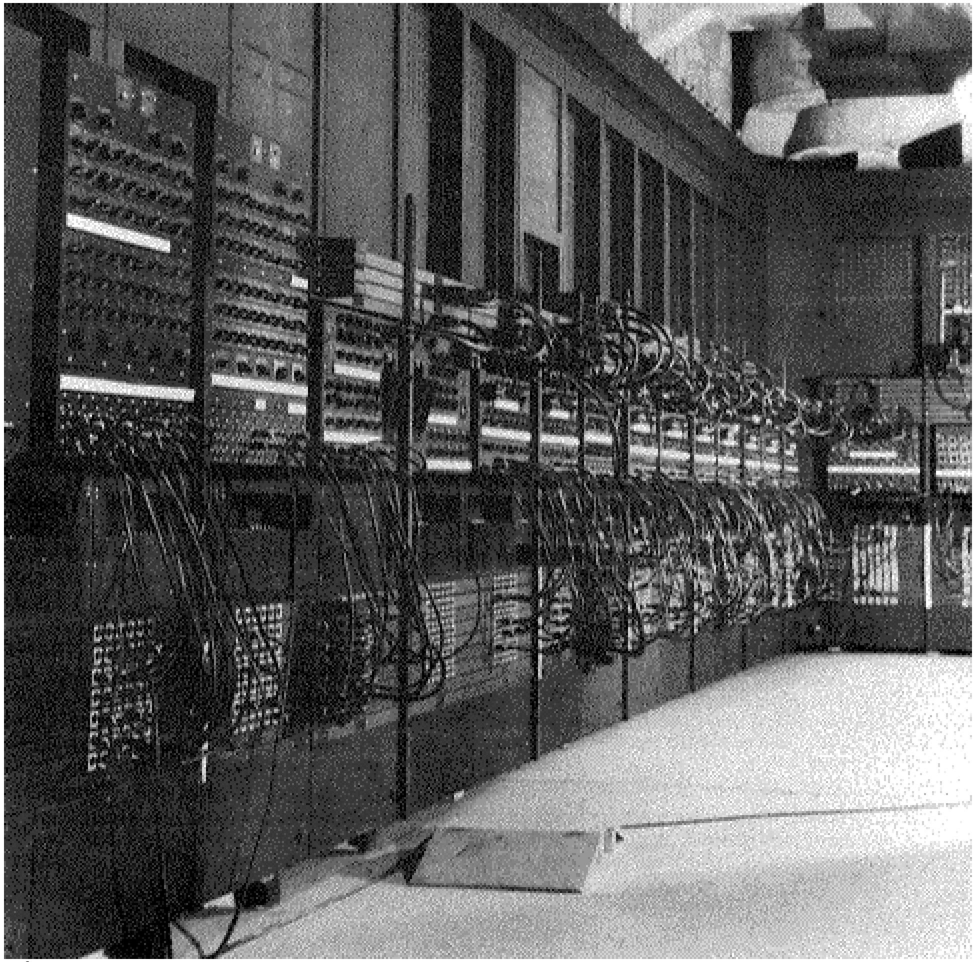
Źródło: http://www.columbia.edu/acis/history/census-tabulator.html, IBM

Trochę historii

1945 ENIAC – lampowa maszyna licząca, zawierała 18 000 lamp próżniowych, 70 000 oporników oraz 5 milionów połączeń. Zużywała 160 kilowatów energii. Zaprojektowana przez Jouna Prospera Eckerta (1919-1995) i Johna Mauchly'ego (1907-1980). Ważyła 27 ton, zajmowała 460 m^3, i mogła dodać 5,000 numerów/s.







Źródło: http://ei.cs.vt.edu/~history/ENIAC.Richey.HTML

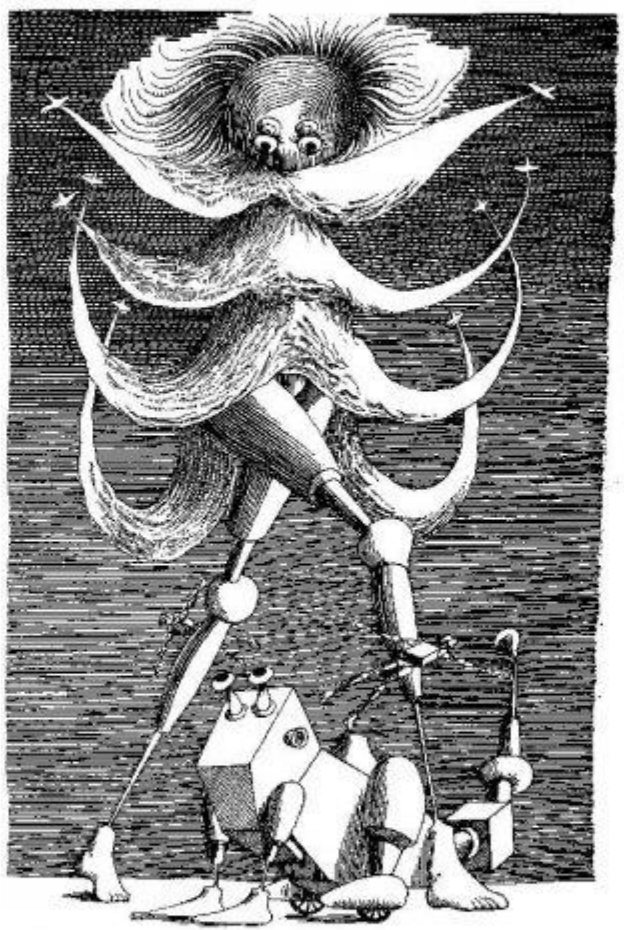
Eniac - max. 116h

Trochę historii

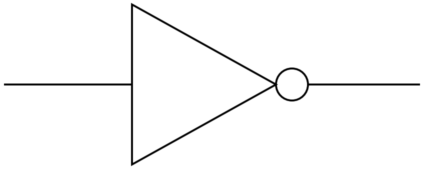
5. W połowie lat 40-tych John von Neuman wymyślił projekt maszyny EDVAC (Electronic Discrete Variable Automatic Computer) – z pamięcią do przechowywania danych i programów oraz z centralną jednostką procesorową
6. 1948 – William Schockley, John Bardeen oraz Walter Brattain z Bell Labs wymyślają tranzystor (Nobel 1956)
7. Rok 1955
   - 2 października komputer ENIAC zostaje ostatecznie wyłączony i zdemontowany.
   - Firma Semiconductor Laboratory, założona przez Williama Shockley'a, jest pierwszą założoną w Dolinie Krzemowej.
7. Lata 50 XX w. – „superkomputer" IBM 360
8. Lata 60 XX w. – minikomputer Digital Equipment Corporation
9. W 1969 r. Intel Corporation dostaje zamówienie na układ do japońskiego kalkulatora...

J. Von Neuman, źródło Wikipedia

Jak TO działa? Trochę logiki.



Jak TO działa? Trochę logiki.



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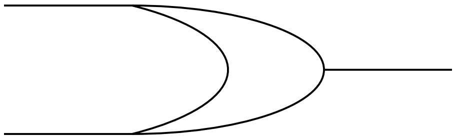

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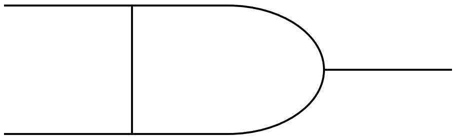

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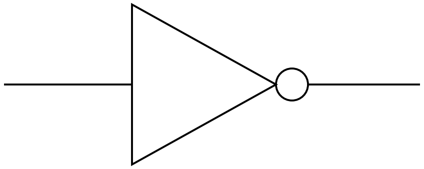
Jak TO działa? Trochę logiki.



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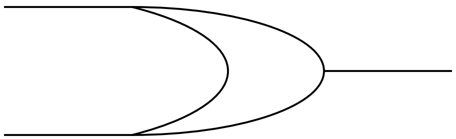

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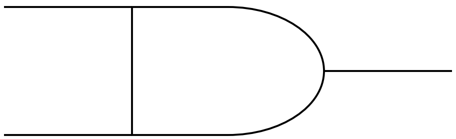

AND	0	1
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WEJŚCIE

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Sumator: 8 4 2 1

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1 + 1 + 1 = 3 = - - 1 1

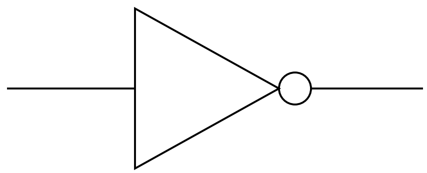
1 + 1 + 1 + 1 = 4 = - 1 0 0

WYJŚCIE

2 1

0 0

Jak TO działa? Trochę logiki.



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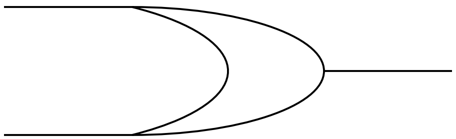

OR	0	1
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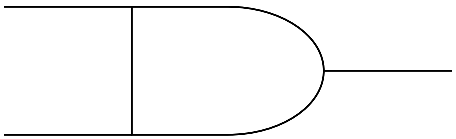

AND	0	1
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WEJŚCIE

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Sumator: 8 4 2 1

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WYJŚCIE

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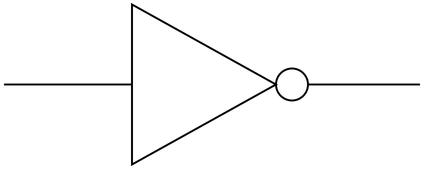
Jak TO działa? Trochę logiki.



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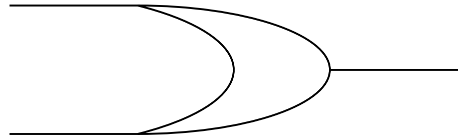
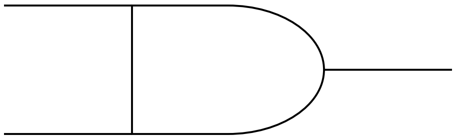


OR	0	1
0	0	1
1	1	1



AND	0	1
0	0	0
1	0	1

WEJŚCIE

0

+

1

Sumator: 8 4 2 1

= 0 = - - - 0

1 = 1 = - - - 1

1 + 1 = 2 = - - 1 0

1 + 1 + 1 = 3 = - - 1 1

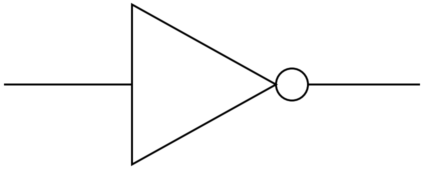
1 + 1 + 1 + 1 = 4 = - 1 0 0

WYJŚCIE

2 1

0 1

Jak TO działa? Trochę logiki.



NOT	
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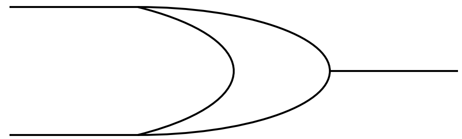
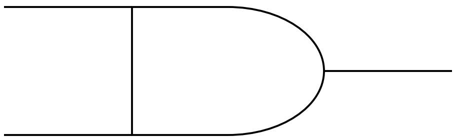
1	0



OR	0	1
0	0	1
1	1	1



AND	0	1
0	0	0
1	0	1

WEJŚCIE

1

+

1

Sumator: 8 4 2 1

= 0 = - - - 0

1 = 1 = - - - 1

1 + 1 = 2 = - - 1 0

1 + 1 + 1 = 3 = - - 1 1

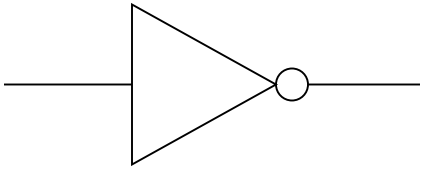
1 + 1 + 1 + 1 = 4 = - 1 0 0

WYJŚCIE

2 1

1 0

Jak TO działa? Trochę logiki.



NOT	
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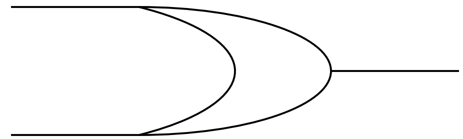
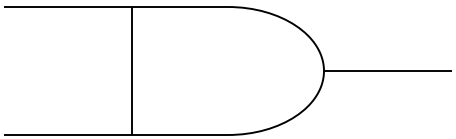
1	0



OR	0	1
0	0	1
1	1	1



AND	0	1
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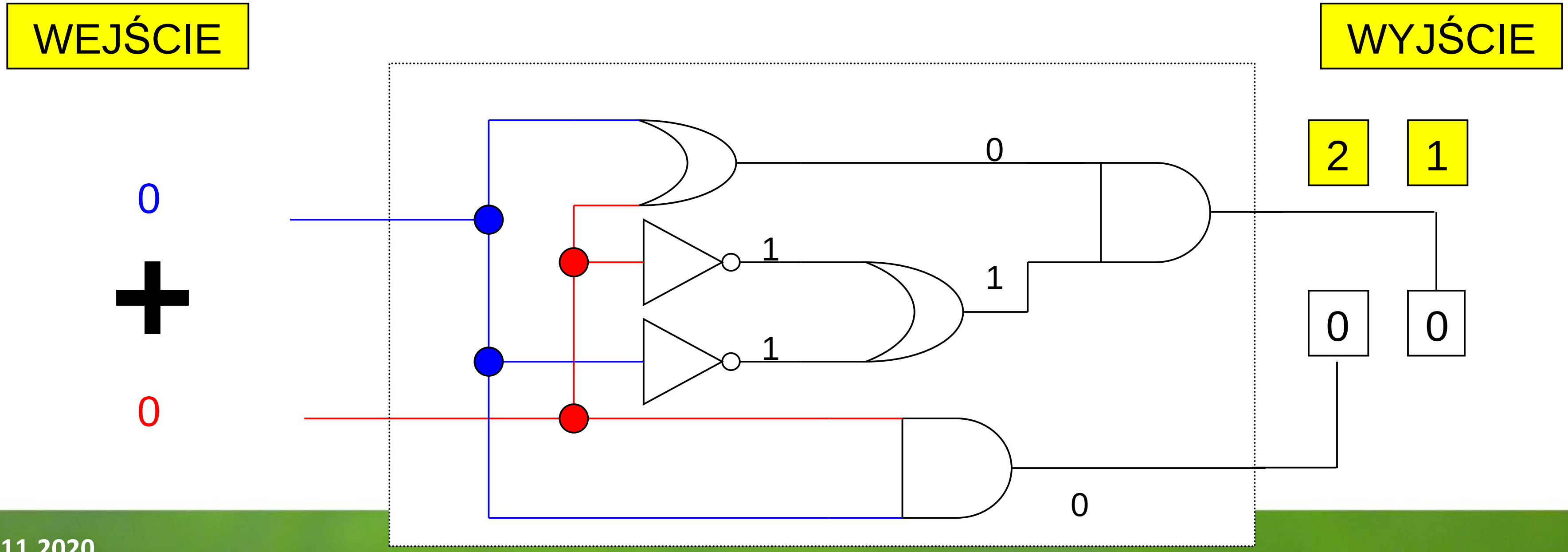
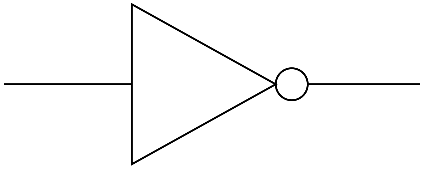
1	0	1



Jak TO działa? Trochę logiki.



NOT	
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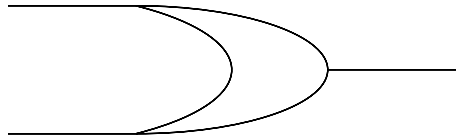

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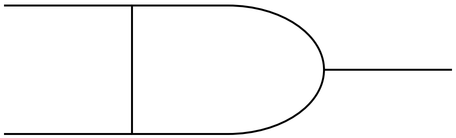

AND	0	1
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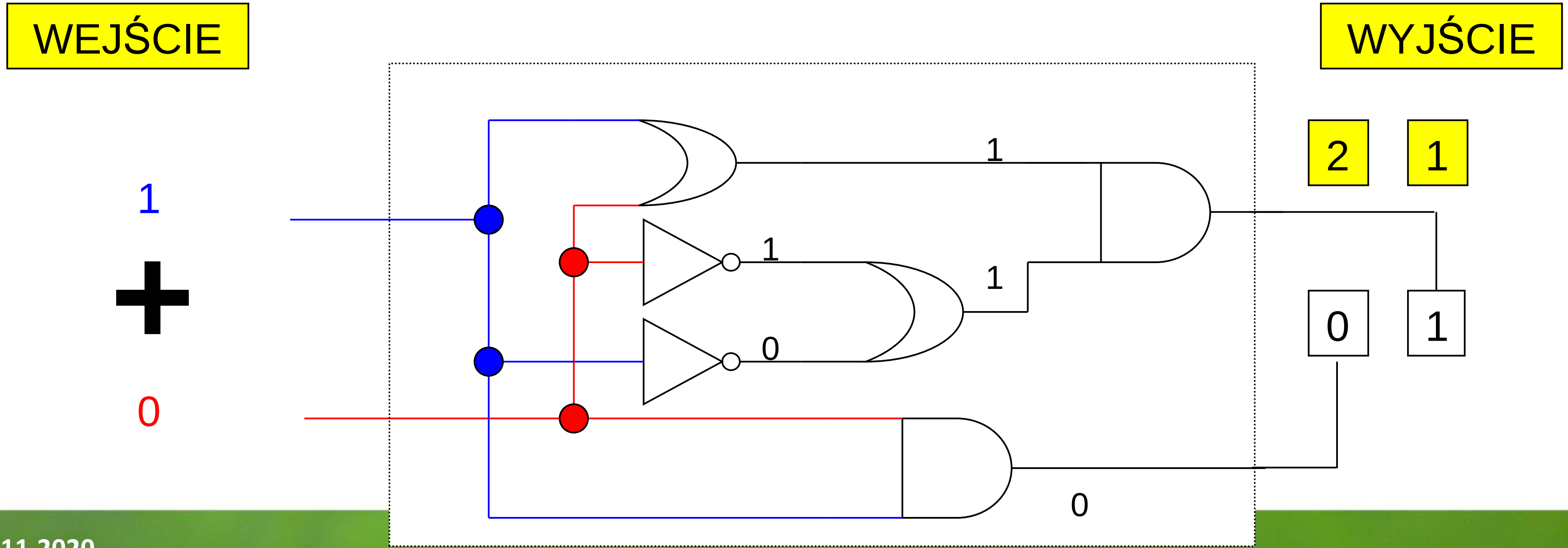
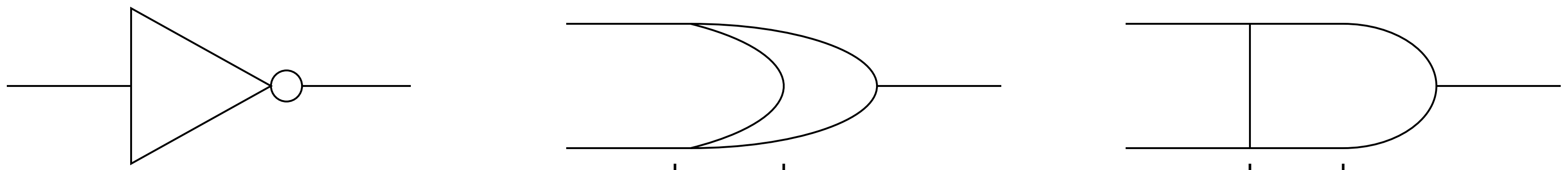
1	0	1



Jak TO działa? Trochę logiki.



NOT	
0	1
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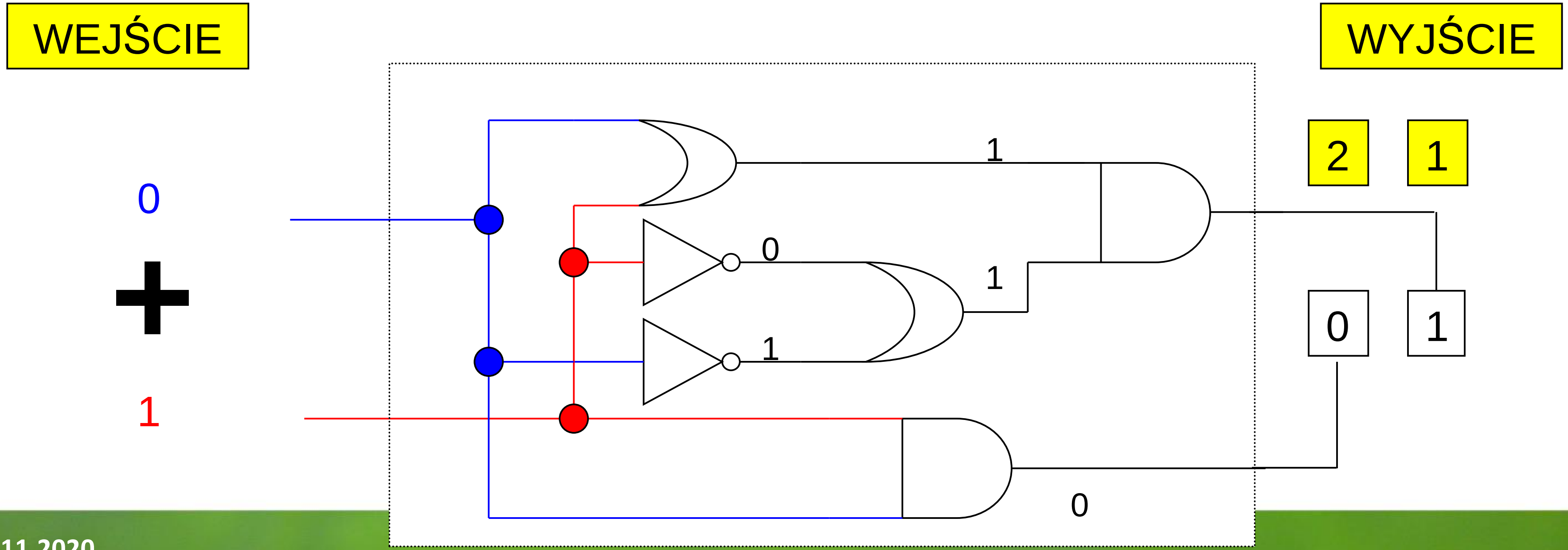
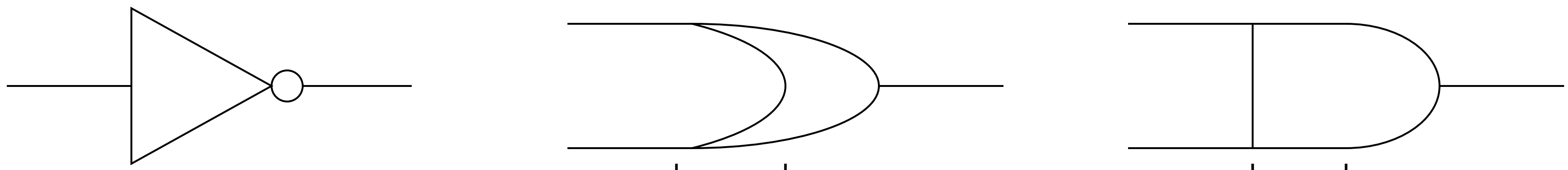
OR	0	1
0	0	1
1	1	1

AND	0	1
0	0	0
1	0	1



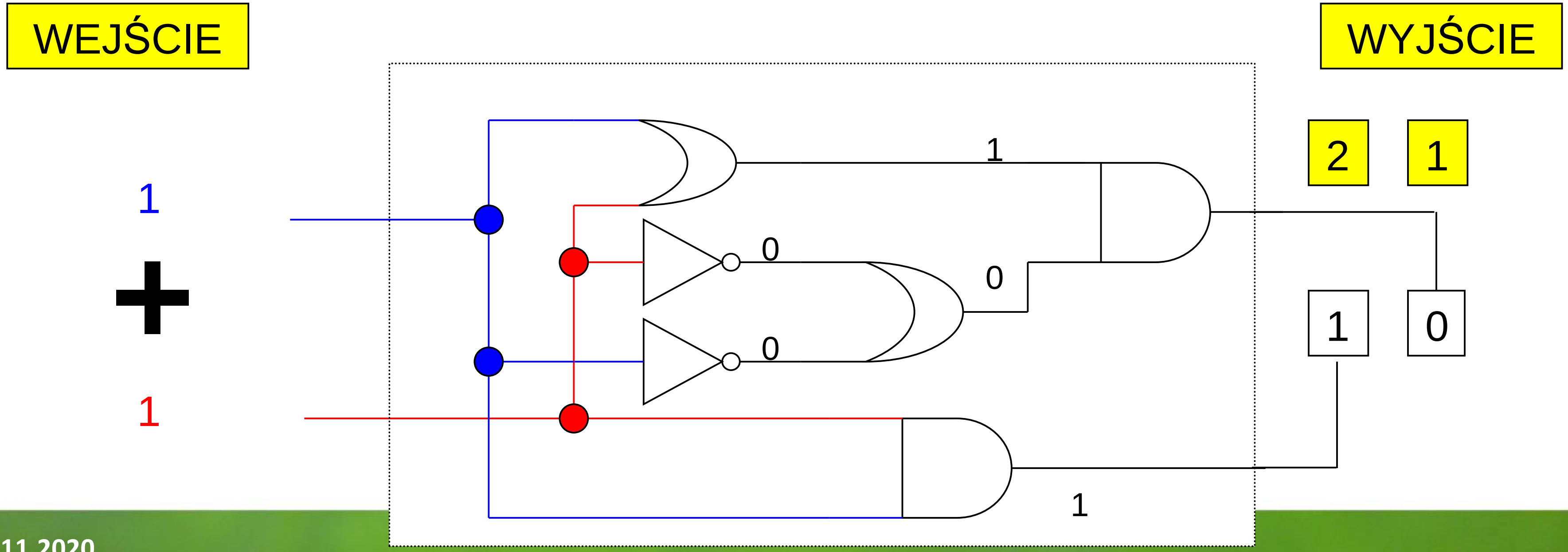
Jak TO działa? Trochę logiki.



NOT	
0	1
1	0

OR	0	1
0	0	1
1	1	1

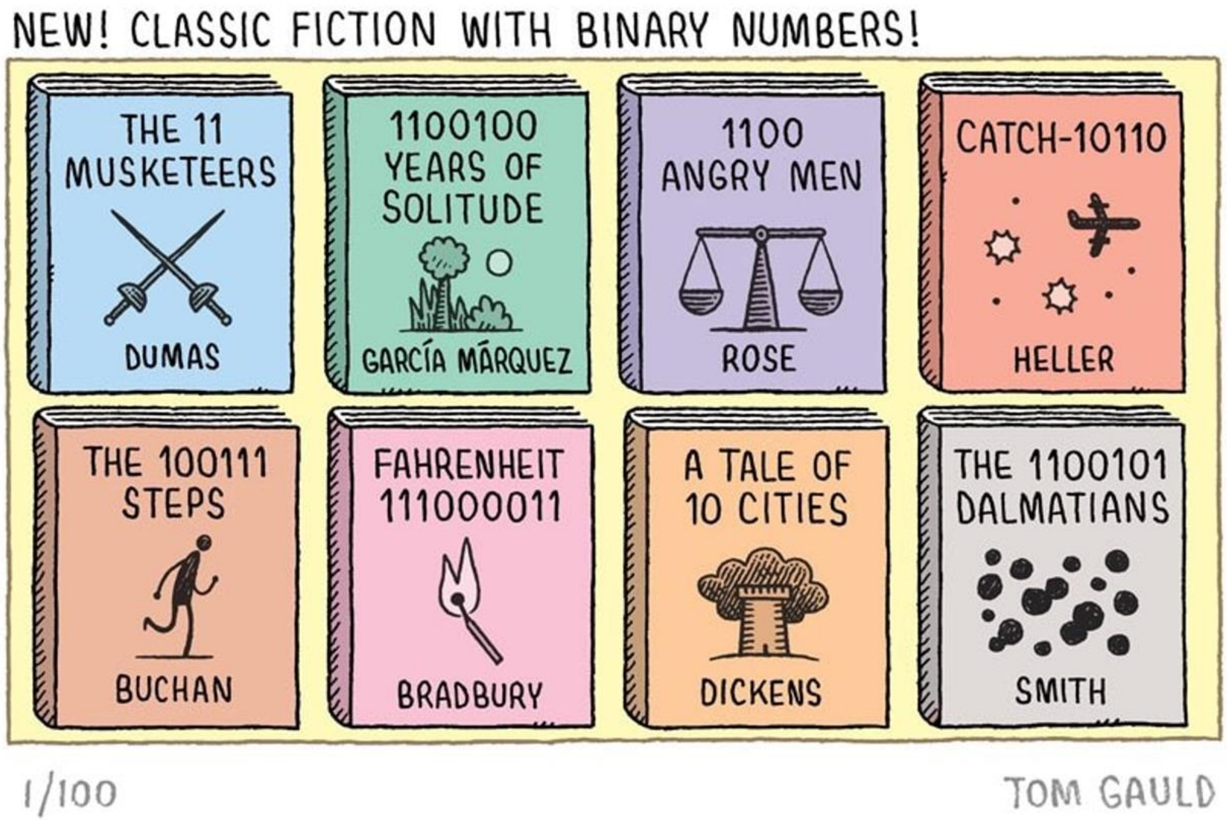
AND	0	1
0	0	0
1	0	1



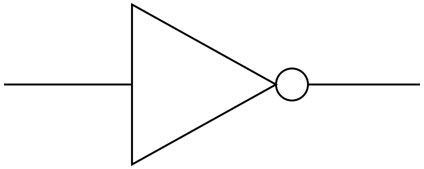
Jak TO działa? Trochę logiki.

Jak TO działa? Trochę logiki.

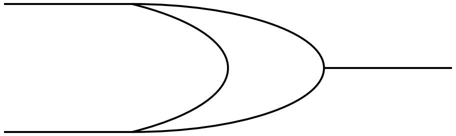
https://docs.google.com/document/d/1I-yd_Qs65z39IxUaGy7w8tqBHc745q47NB3fjnGXaQI/edit?usp=sharing



Jak TO działa? Trochę logiki.



NOT	
0	1
1	0



OR	0	1
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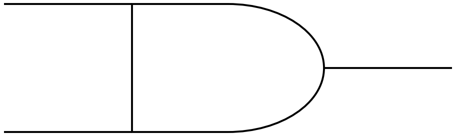
1	1	1



AND	0	1
0	0	0
1	0	1

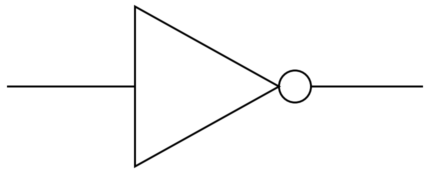
XOR	0	1
0	0	1
1	1	0

NOR	0	1
0	1	0
1	0	0

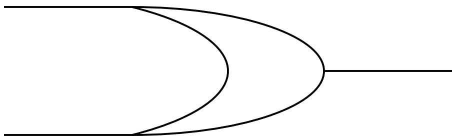
NAND	0	1
0	1	1
1	1	0

XNOR	0	1
0	1	0
1	0	1

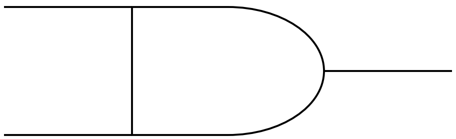
Jak TO działa? Trochę logiki.



NOT	
0	1
1	0



OR	0	1
0	0	1
1	1	1



AND	0	1
0	0	0
1	0	1

XOR	0	1
0	0	1
1	1	0

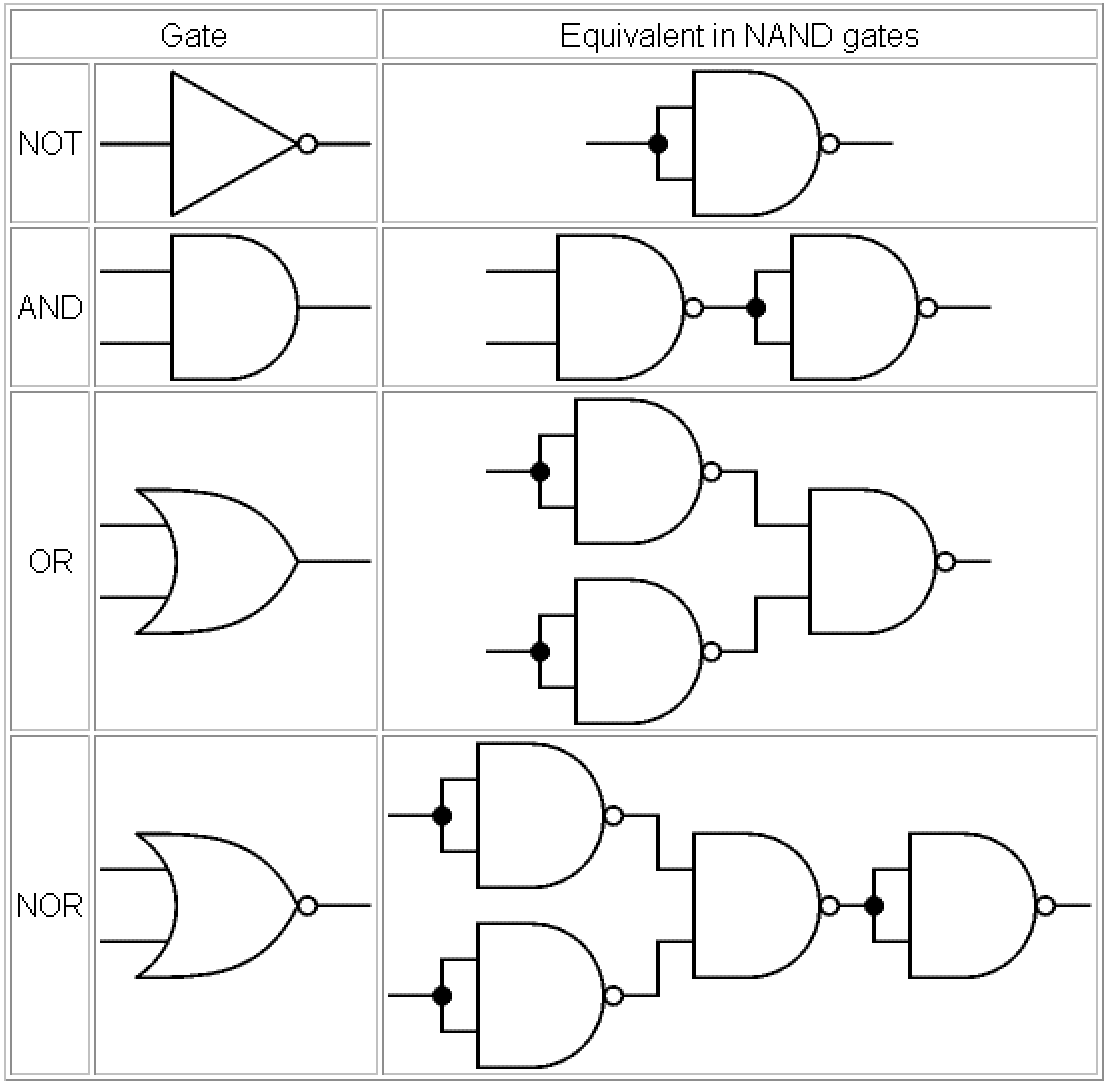
NOR	0	1
0	1	0
1	0	0

NAND	0	1
0	1	1
1	1	0

XNOR	0	1
0	1	0
1	0	1

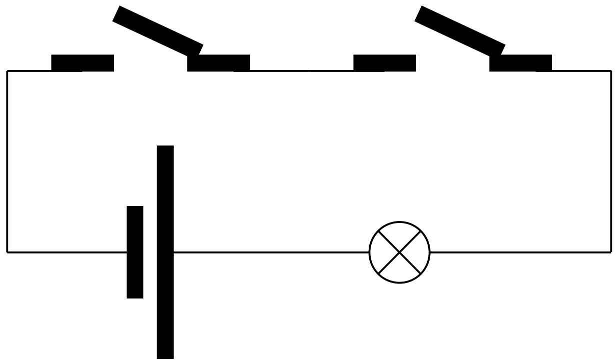
Jak TO działa? Trochę logiki.

NAND	0	1
0	1	1
1	1	0



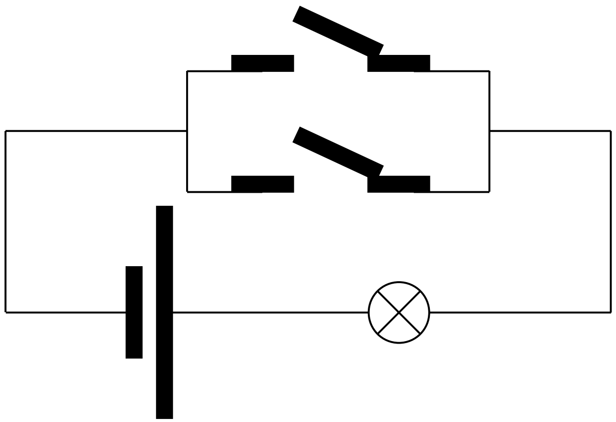
Od bramki do bramki.

AND



AND	0	1
0	0	0
1	0	1

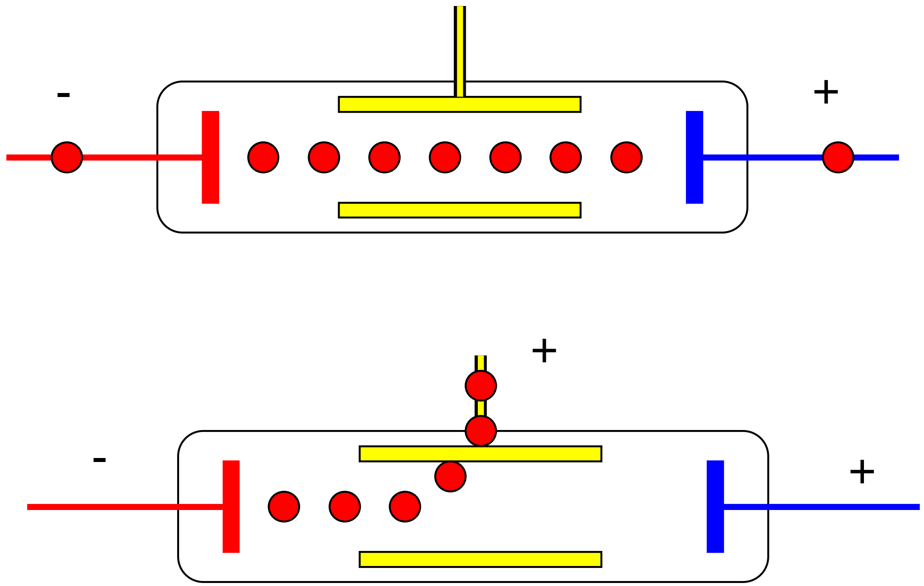
OR



OR	0	1
0	0	1
1	1	1

Od bramki do bramki.

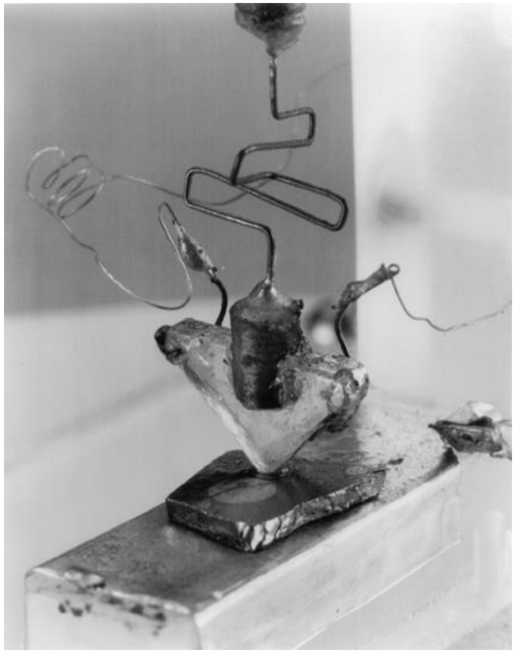
Lampa próżniowa jako przełącznik

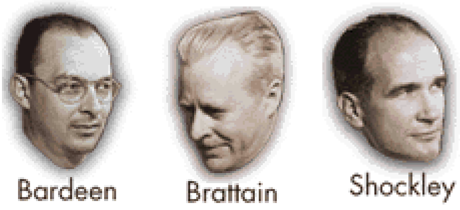


Potrzeba było przełączników: **szybkich i niezawodnych**.
Na początku (r)ewolucji koszty, rozmiar, pobór mocy, łatwość obsługi, uniwersalność, skalowalność, kompatybilność nie miały dużego znaczenia...

Eniac - max. 116h

Jak działa tranzystor?

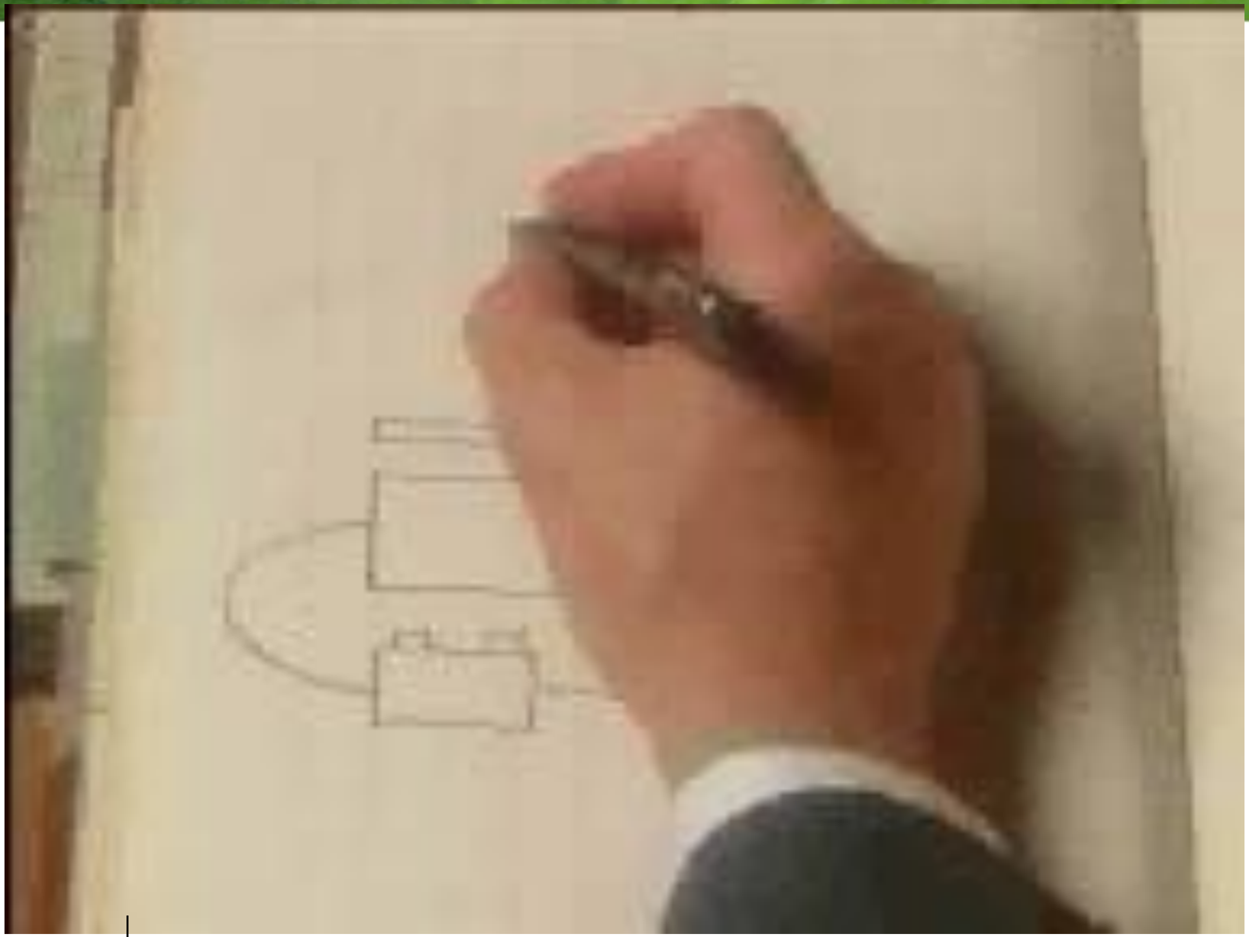


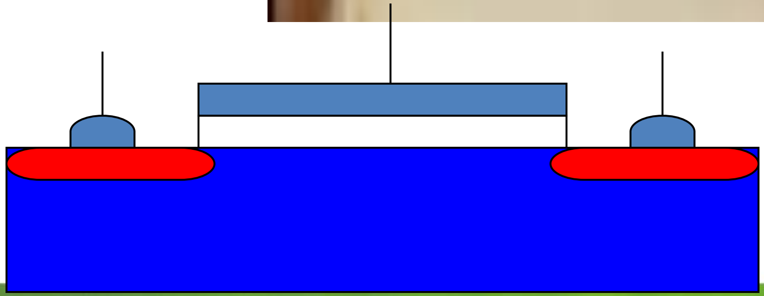


1948 – William Schockley, John Bardeen oraz Walter Brattain z Bell Labs wymyślają tranzystor (Nobel 1956)

Źródło: http://www.facsnet.org/tools/sci_tech/tech/applications/chipsys.php3 http://www.lucent.com/minds/transistor/history.html , http://www.pbs.org/transistor/science/events/pointctrans.html

Jak działa tranzystor?



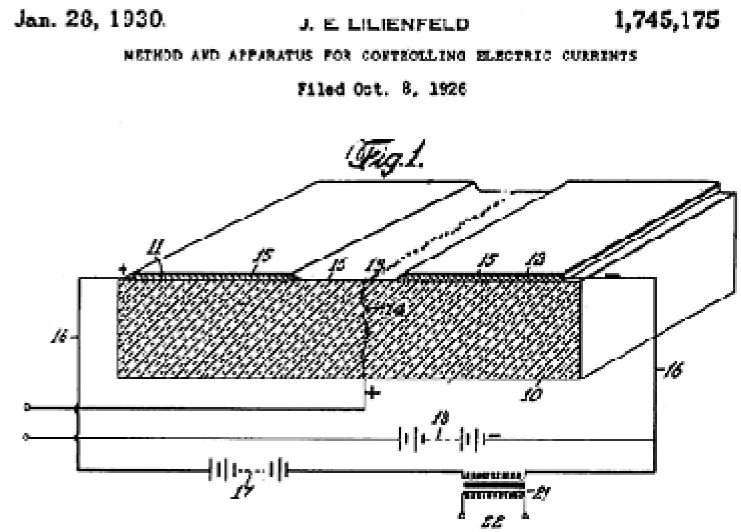


Prof. Juliusz Edgar Lilienfeld
1925 tranzystor polowy Cu_2S (Lipsk)

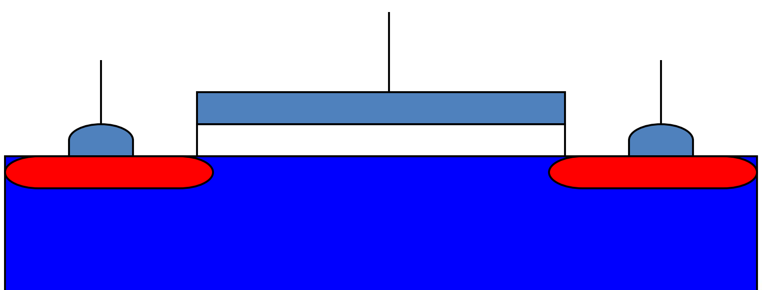
http://www.pbs.org/transistor/science/events/pointctrans.html

Jak działa tranzystor?

18.04.1881, (Lemberg)- 8.08.1963, (Charlotte Amalie, U.S.A.)



U.S. Patent 1,745,175 (MESFET)
U.S. Patent 1,900,018 (MOSFET)



Prof. Juliusz Edgar Lilienfeld
1925 tranzystor polowy Cu_2S (Lipsk)

http://www.computerhistory.org/semiconductor/timeline/1926-field.html

Jak działa tranzystor?

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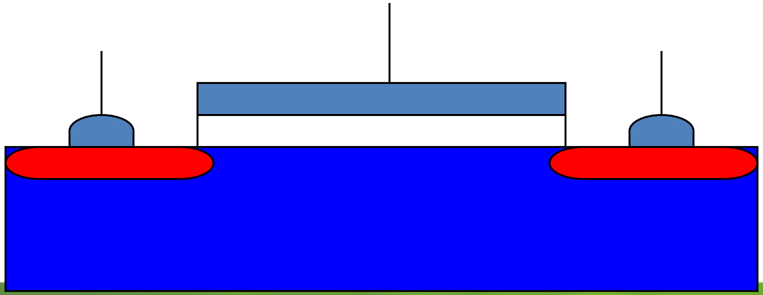
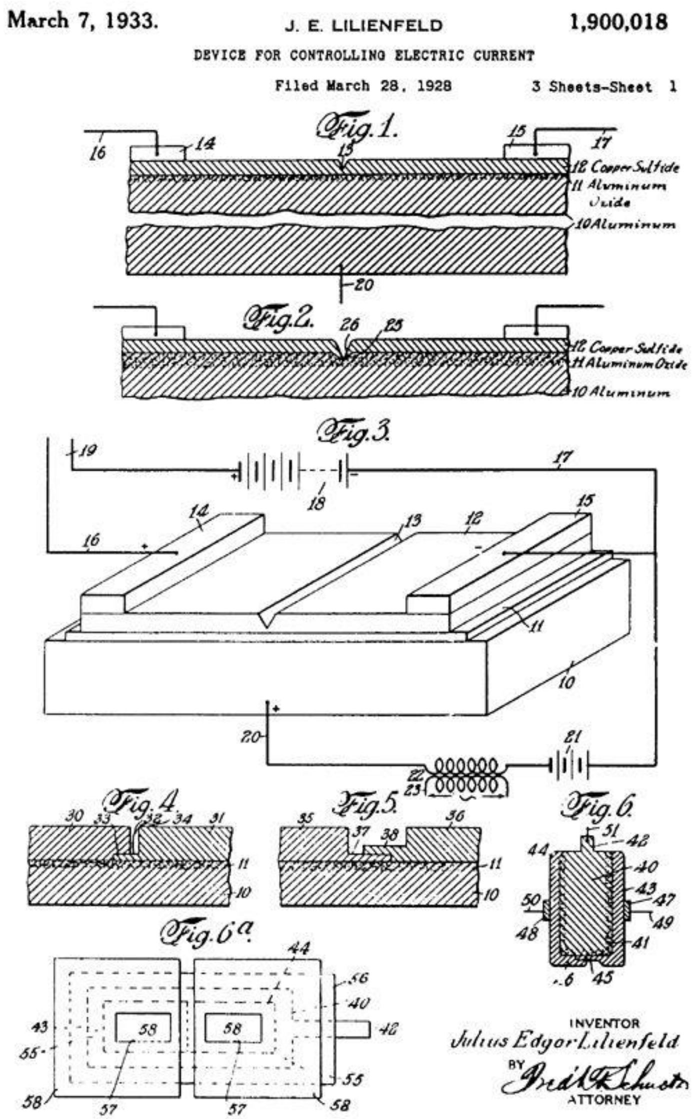
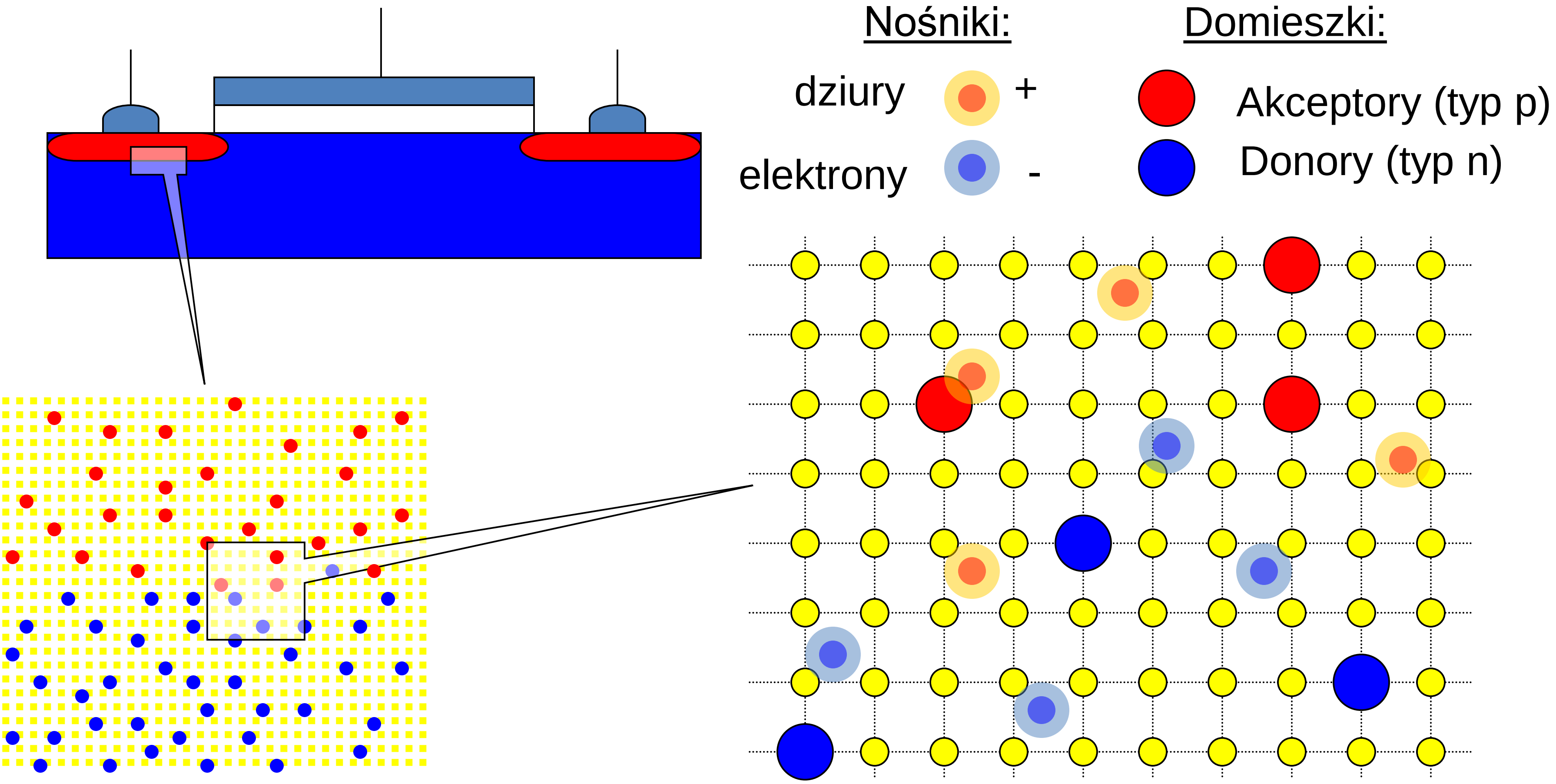




http://chem.ch.huji.ac.il/history/lilienfeld.htm

Półprzewodniki

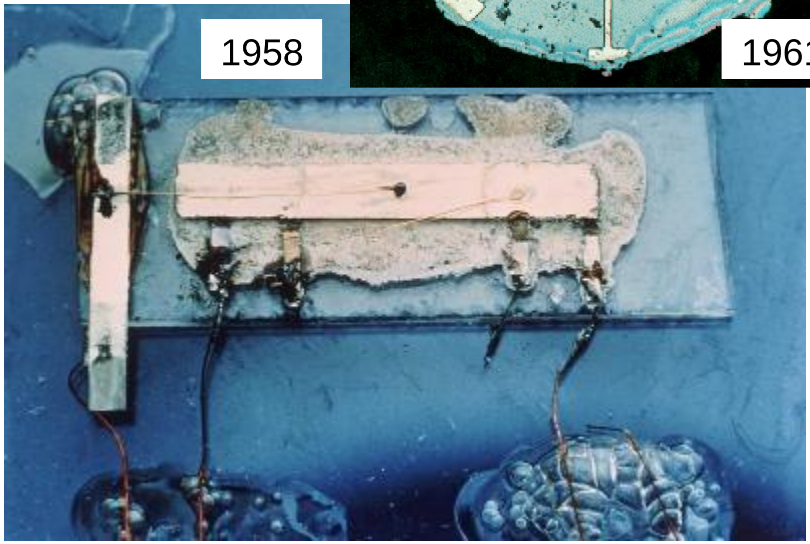


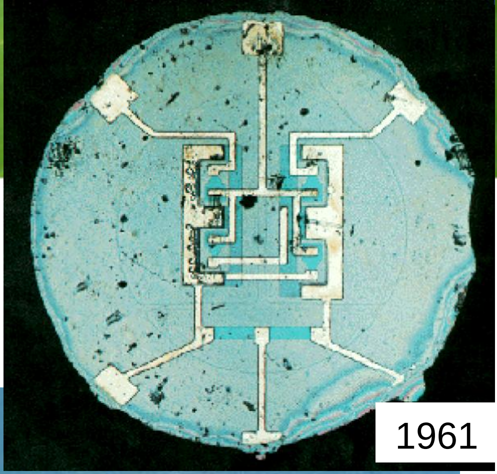
http://jas.eng.buffalo.edu/education/solid/unitCell/home.html
http://jas.eng.buffalo.edu/education/mos/mosfet/mosfet.html

Trochę historii

1955 Shockley Semiconductor – pierwsza firma w Palo Alto (krzemowej dolinie)
Rok 1956
IBM tworzy pierwszy dysk twardy - RAMAC 350. Jego pojemność to 5MB,natomiast cena - milion dolarów.
W laboratoriach MIT ukończony zostaje pierwszy komputer tranzystorowy.
A. Newell, D. Shaw i F. Simon wynajdują IPL (Information Processing Language - język przetwarzania informacji).

1957 Fairchild Semiconductor – na skutek nieporozumień z Shockleyem odchodzą z firmy: Julius Blank, Victor Grinich, Gordon E. Moore, Robert W. Noyce, Jean Hoerni, Gene Kleiner, Jay Last, Sheldon Roberts **(„zdradziecka 8-ka”).**





Ken Olsen i Harlan Anderson zakładają firmę DEC (Digital Equipment Corporation).

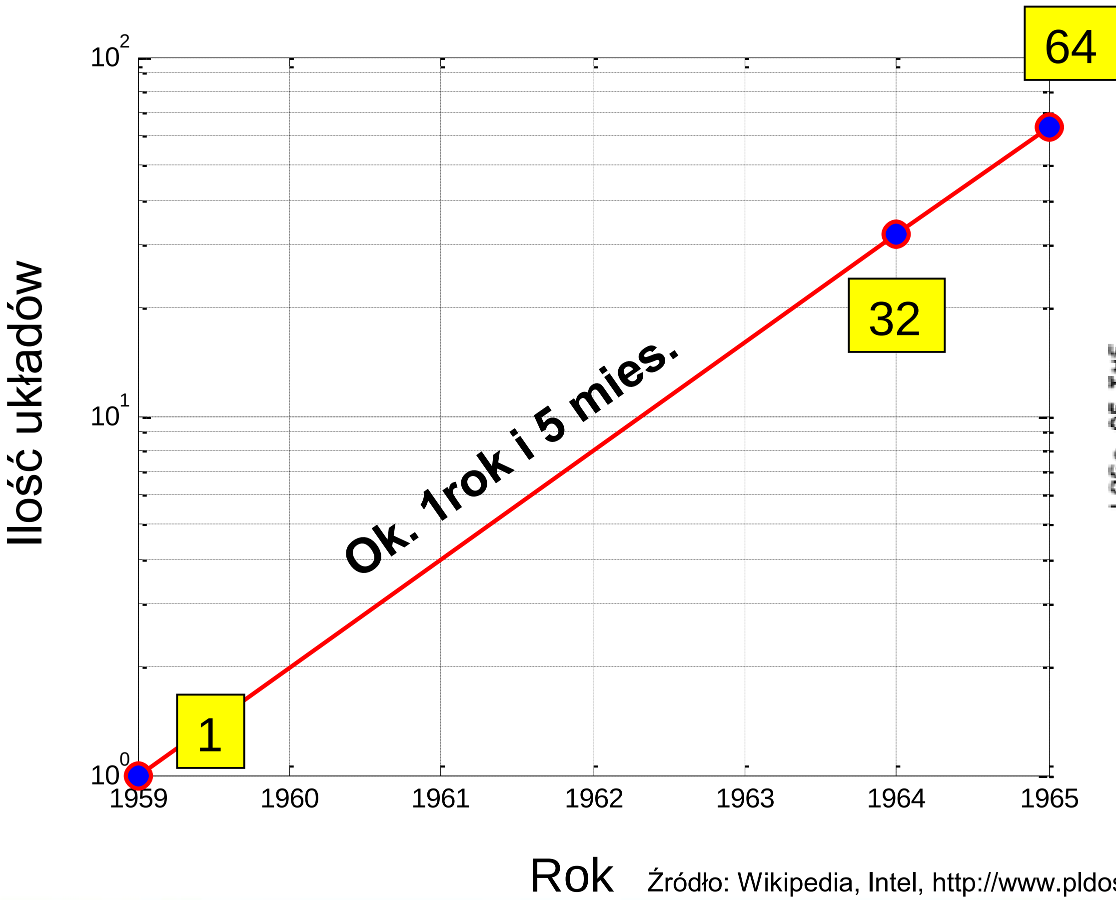
Oficjalnie opublikowany zostaje język FORTRAN-1, stworzony przez Johna Backusa i jego współpracowników z IBM. FORTRAN używa zapisu podobnego do tego z algebry. Dlatego też język ten stanie się popularny, szczególnie wśród naukowców i techników.

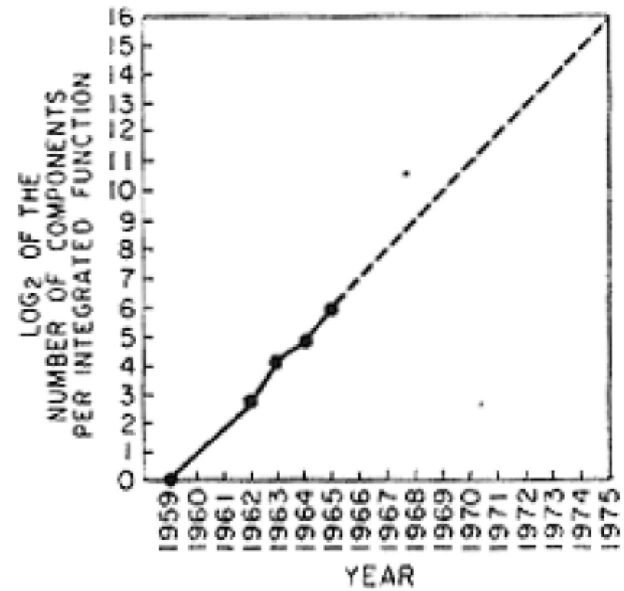
1958 Pierwszy układ scalony (IC – Integrated Circuit) wykonany przez Jack Kilby na germanie w **Texas Instruments** (2000 Nagroda Nobla z fizyki). Niezależnie Robert Noyce (**Fairchild**) zbudował IC na krzemie.

Źródło: http://www.facsnet.org/tools/sci_tech/tech/applications/chipsys.php3 http://www.lucent.com/minds/transistor/history.html

Trochę historii

"The complexity for minimum component costs has increased at a rate of roughly a factor of two per year. Certainly over the short term this rate can be expected to continue, if not to increase. Over the longer term, the rate of increase is a bit more uncertain, although there is no reason to believe it will remain nearly constant for at least 10 years." (Moore, *Electronics* 1965)



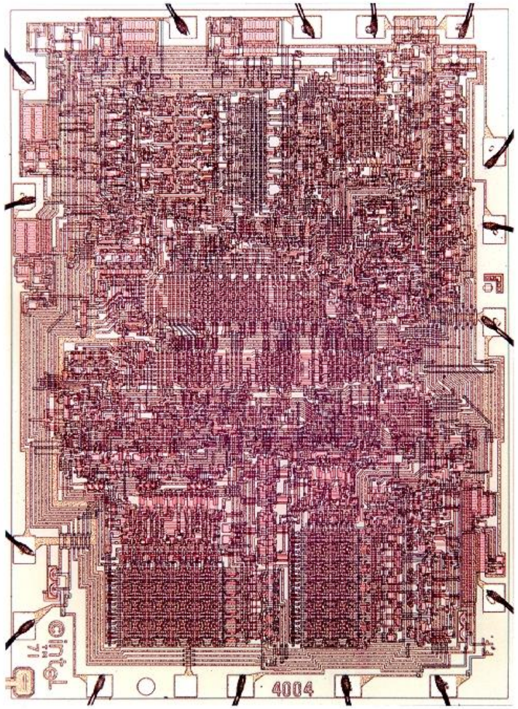


Źródło: Wikipedia, Intel, http://www.pldos.pl/bogus/hardware/procesory/intel/i4004/i4004.htm

Trochę historii

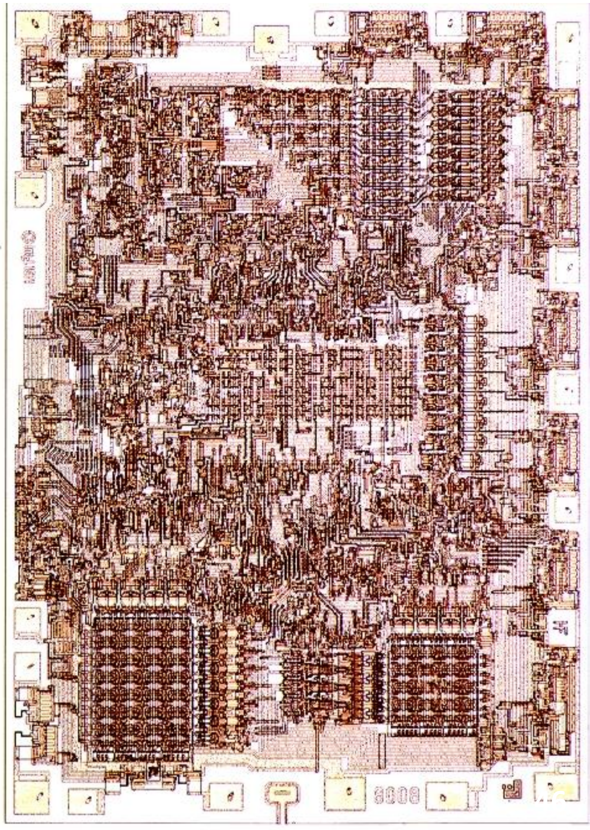
18 lipca **1968** Gordon E. Moore i Robert W. Noyce założyli w kalifornijskim Mountain View w hrabstwie Santa Clara (zaledwie kilka mil od Palo Alto), firmę N M Electronics, wkrótce przemianowaną na Intel (Intel = Integrated Electronics).

1969 r. Intel Corporation dostaje zamówienie na układ do japońskiego kalkulatora...



i4004
Data wprowa
Ilość tranzyst
Technologia:1
Wielkość płyt
Szybkość prac
(0.06 MIPS)
Taktowanie n
Szerokość ma
(adresów 12 l

i8008
Data wprowadzenia:kwiecień 1972
Ilość tranzystorów:3 500
Technologia:10 µm, PMOS
Wielkość płytki krzemu:19 mm^2
Szybkość pracy Taktowanie rdzenia proc.:200 kHz
(0.06 MIPS), magistrali sys.:200 kHz
Szerokość magistrali danych (wewn./zewn.):**8 bitów** Szerokość magistrali adresowej:14 bitów



Źródło: Wikipedia, Intel, http://www.pldos.pl/bogus/hardware/procesory/intel/i4004/i4004.htm

Trochę historii

1975 Altair (i jego klony)

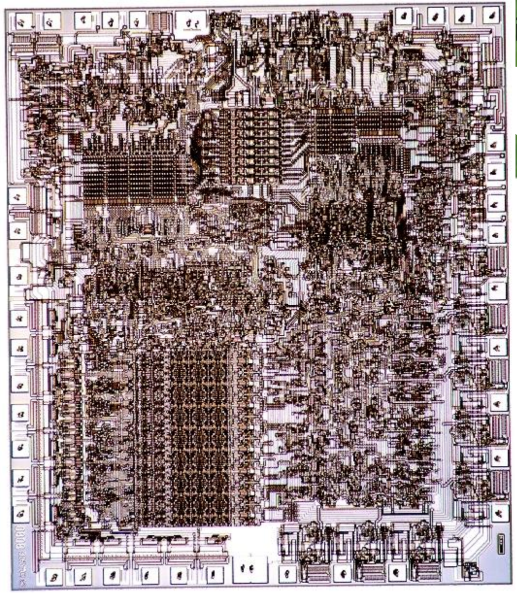
procesor Intel 8080
Bill Gates i Paul Allen piszą wersję BASICa na Altair

A gdzie jest ekran i klawiatura?

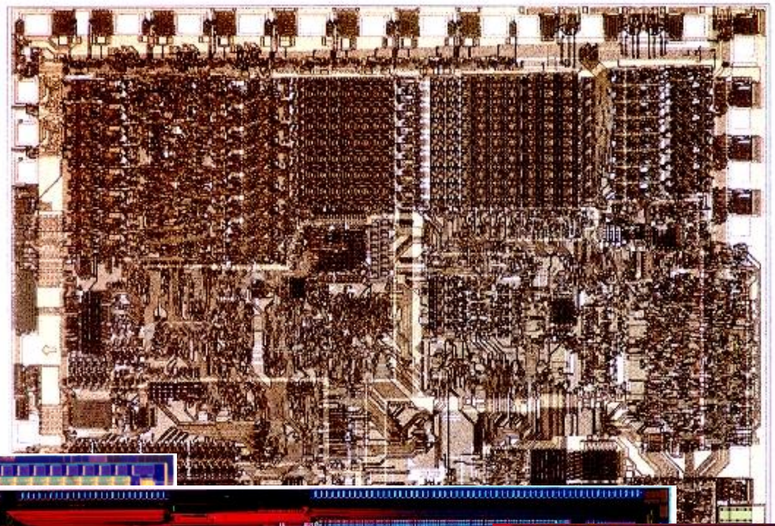
Źródło: http://www.pldos.pl/bogus/spis.htm

Apple I (1976)

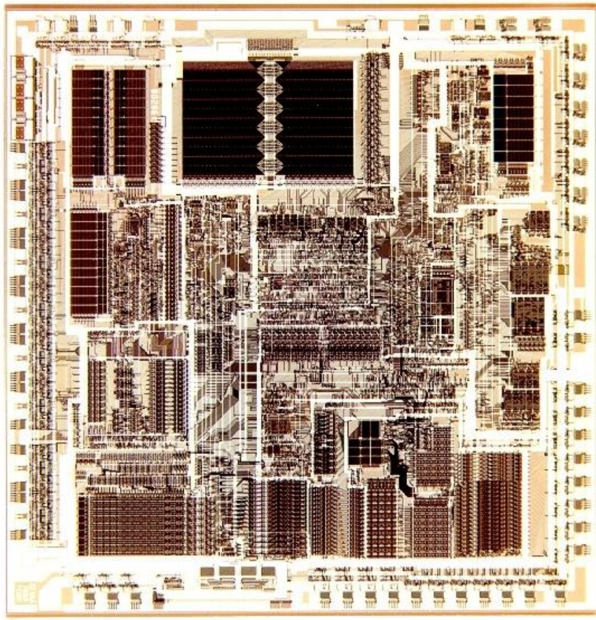
torii



i8080 (1974)

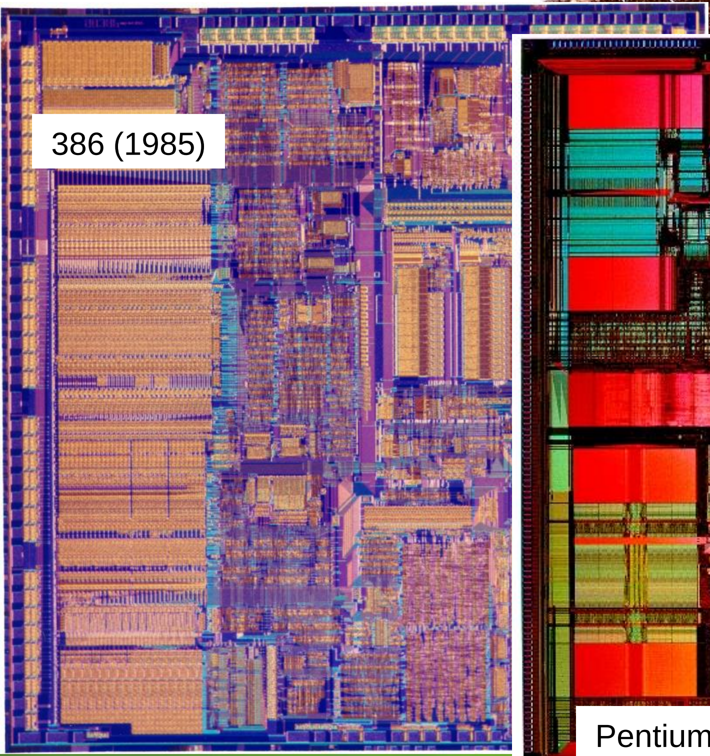


i8088 (1978) IBM PC

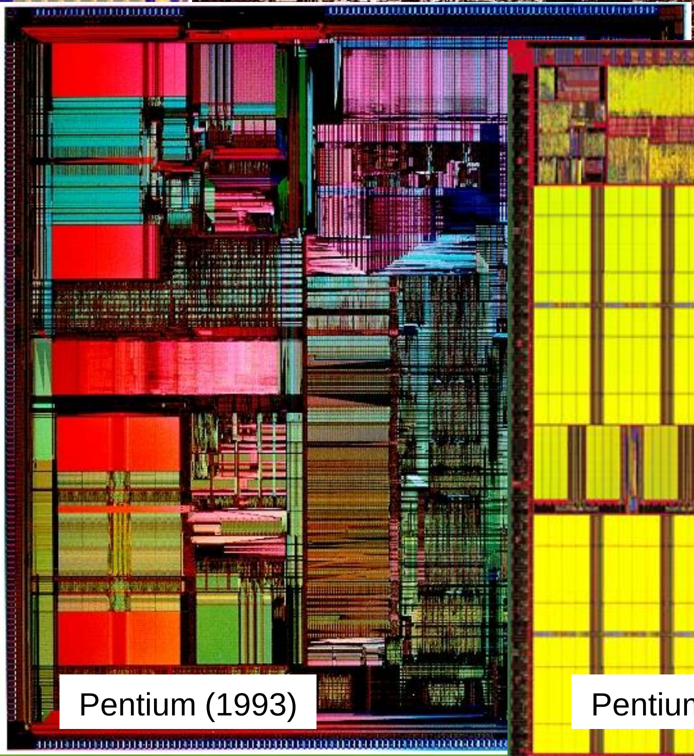


286 (1982)

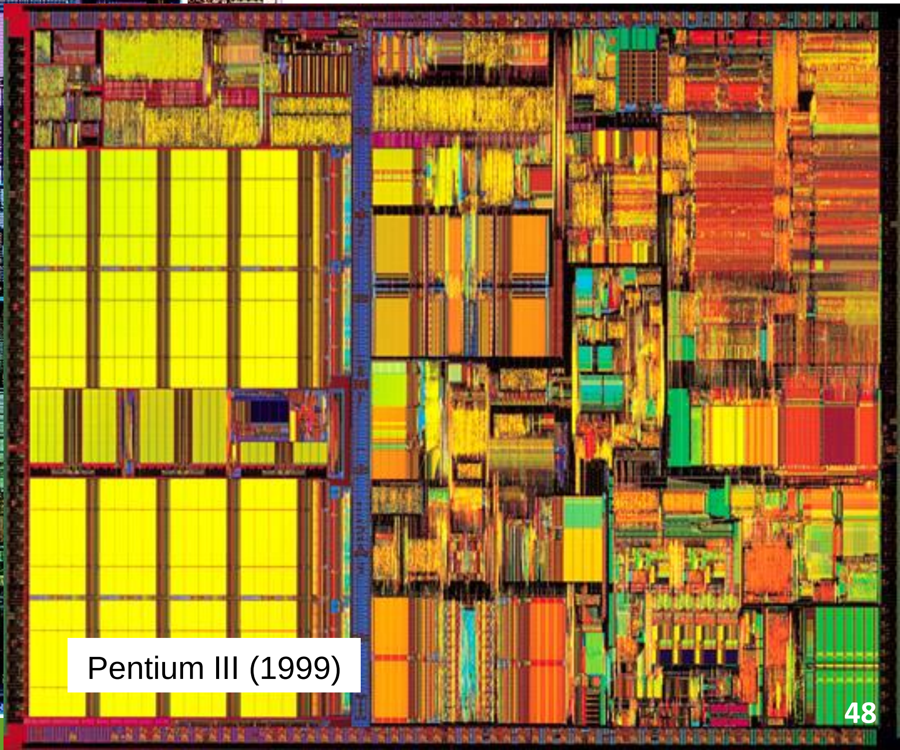
Źródło: Intel



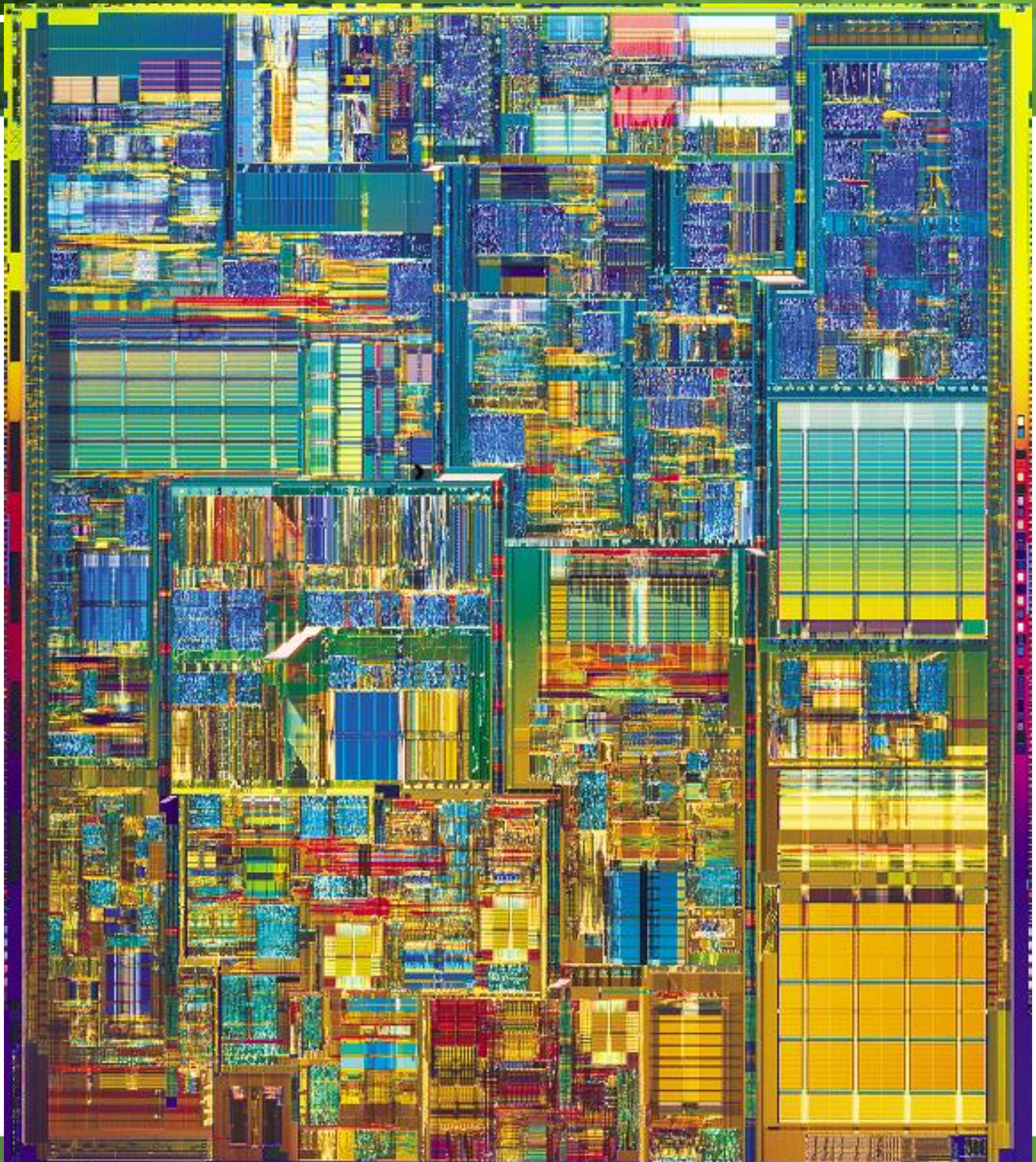
386 (1985)



Pentium (1993)



Pentium III (1999)



Pentium 4 (2000)

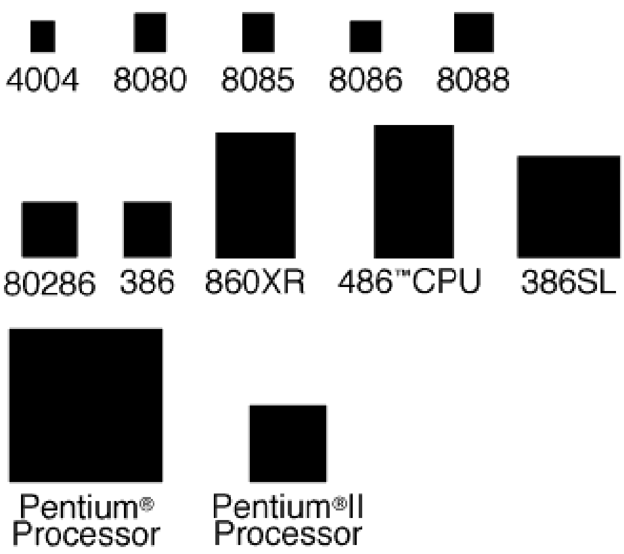
42 000 000 tranzystorów

technologia 0.18 mikrona.

Zegar 1.5 GHz

6 warstw

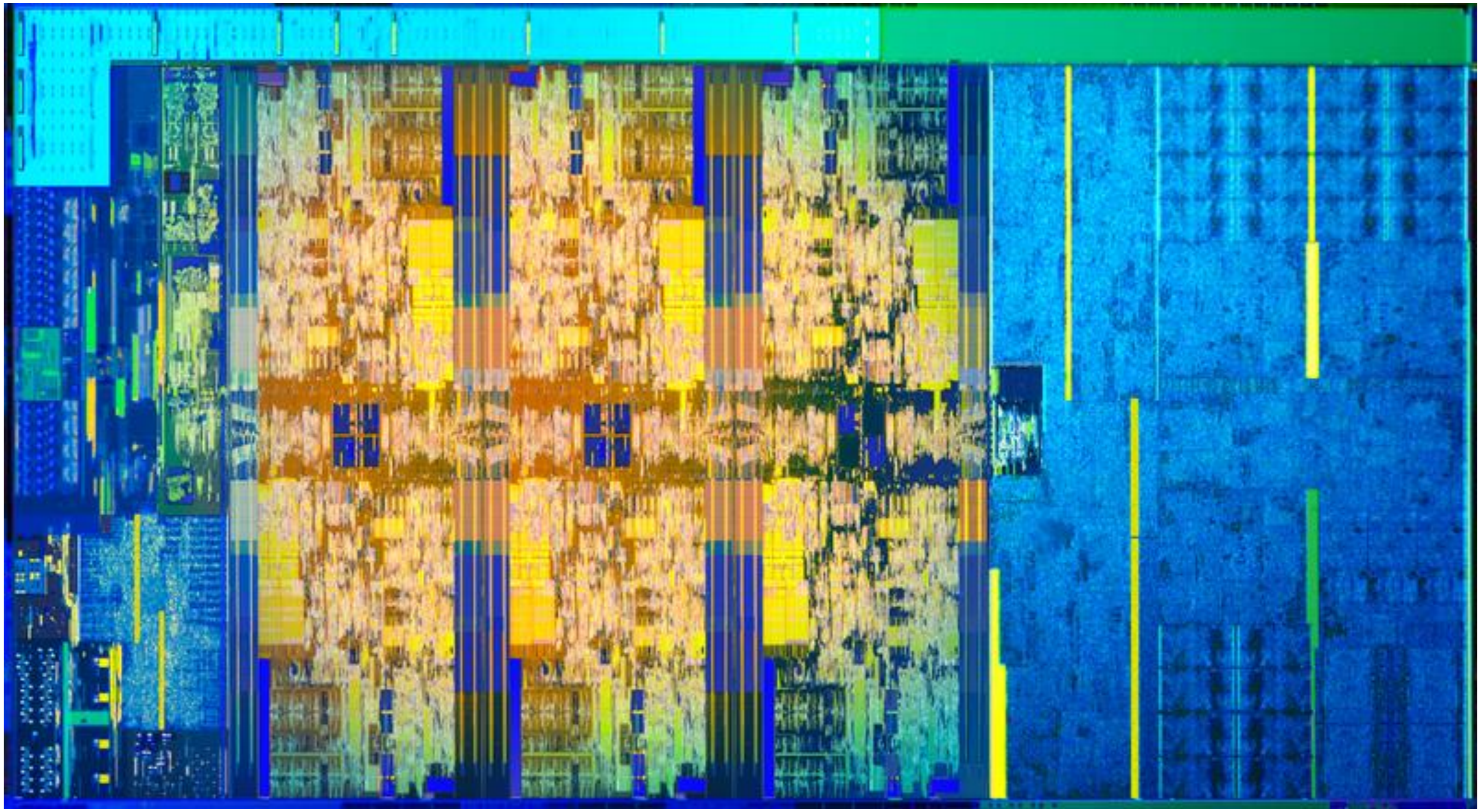
Rozmiar procesorów Intel (w skali)



Źródło: Intel, http://www.facsnet.org/tools/sci_tech/tech/fundaments/mooreslaw.php3

Trochę historii

Intel 9th generation Coffee Lake-S series 6-core die (2018).
14nm, over $1.6 * 10^9$ transistors on 15x15mm die



Źródło: https://en.wikichip.org/wiki/intel/microarchitectures/coffee_lake

Trochę historii

Intel 9th generation Coffee Lake-S series 6-core die (2018).
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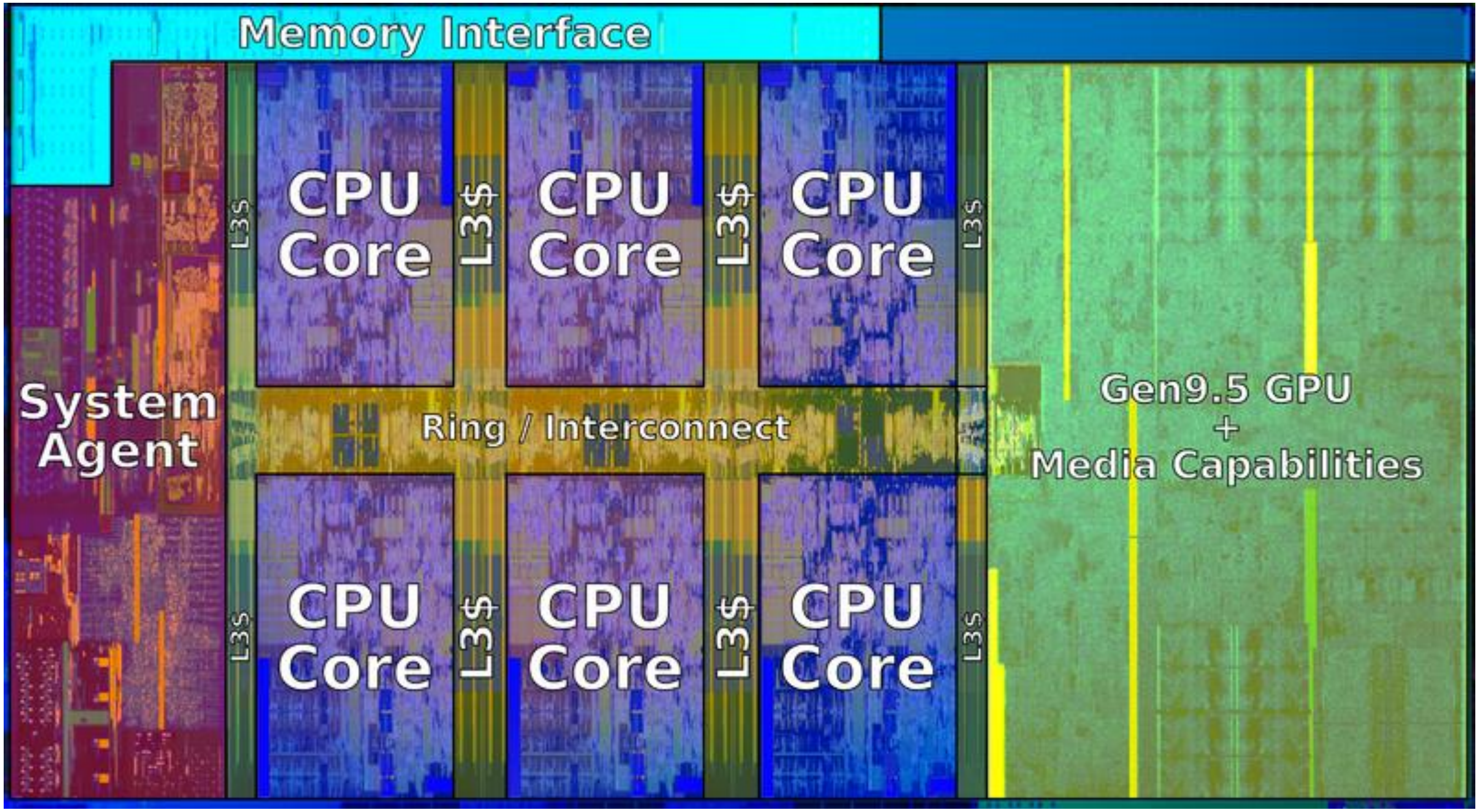
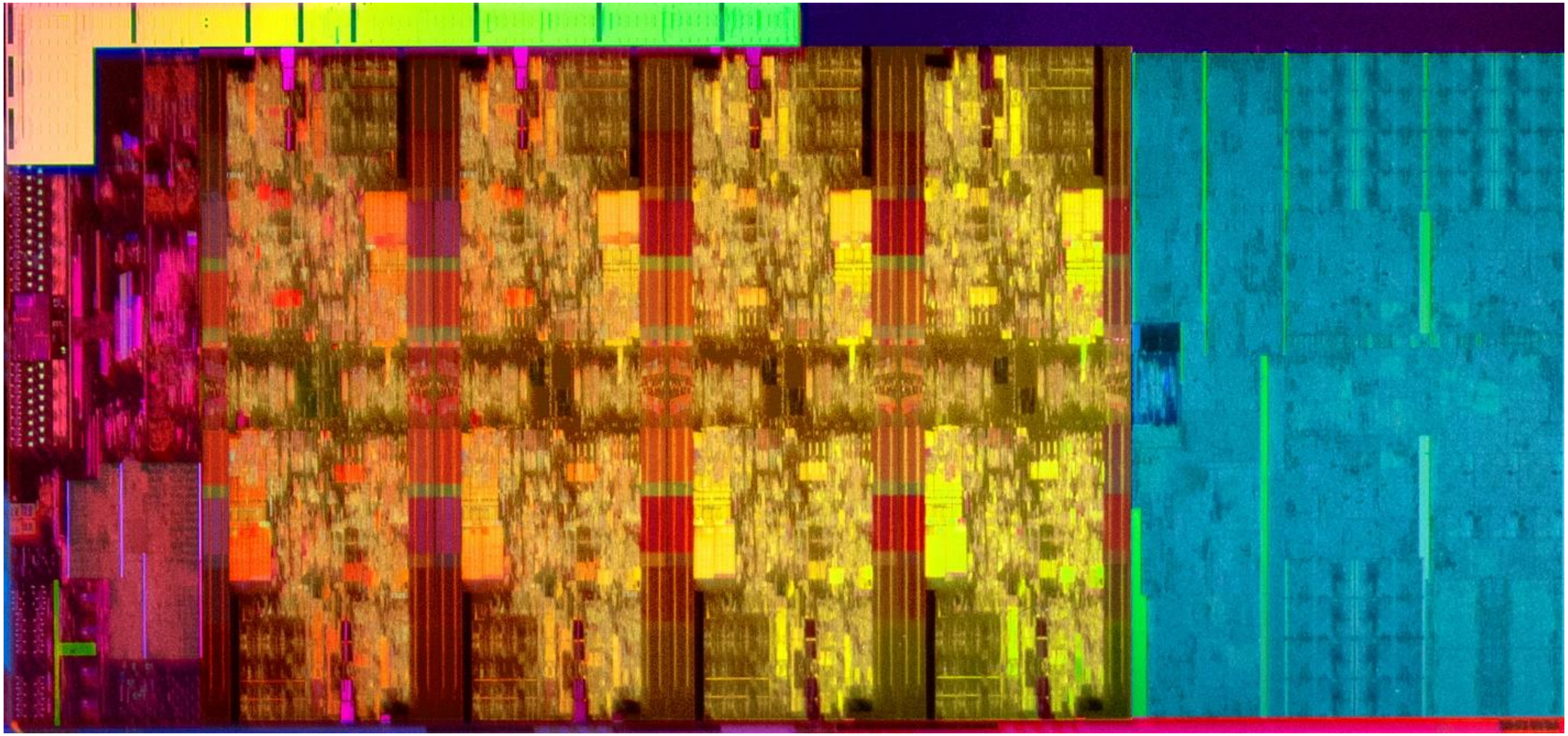


Źródło: https://en.wikichip.org/wiki/intel/microarchitectures/coffee_lake

Trochę historii

Intel 9th generation Coffee Lake-S series 8-core die (2018).
14nm, over $1.6 * 10^9$ transistors on 15x15mm die



Źródło: Intel, https://arstechnica.com/gadgets/2018/10/intels-new-performance-desktop-lineup-an-overclockable-xeon-9th-gen-core/

Trochę historii

Intel - granica 1 mld tranzystorów przekroczona

NetWorld 18-10-2005 , ostatnia aktualizacja

Intel zaczął dostarczać wybranym klientom pierwsze dwurdzeniowe układy Itanium 2 noszące nazwę kodową Montecito, które zawierają ponad miliard tranzystorów. Oznacza to, że jesteśmy świadkami przekroczenia kolejnego progu w dziedzinie technologii produkcji układów scalonych.

Intel zapowiadał już w 2002 roku, że pracuje nad układem CPU zawierającym ponad miliard tranzystorów. Warto przypomnieć, że układ Itanium 2 noszący nazwę kodową Madison zawiera 500 mln tranzystorów.

Kolejną ważną cechą układu Montecito jest to, że każdy rdzeń dysponuje swoim własnym buforem na dane. Dlatego układ ma duże rozmiary (ok. 580 milimetrów kwadratowych). Układy Itanium drugiej generacji, produkowane w 2002 roku, miały powierzchnię 400 do 450 milimetrów kwadratowych.

Intel zwiększał przez ostanie 20 lat sukcesywnie liczbę tranzystorów zagnieżdżanych na układach scalonych. Układ 386, którego produkcję uruchomiono w 1985 roku, miał 275 tys. Tranzystorów. Liczna jednego miliona tranzystorów została przekroczona w 1989 roku, z chwilą podjęcia produkcji układu 486.

Kolejne rekordy padły w 1993 roku (układ Pentium; trzy mln tranzystorów) i następnie w 2002 roku (Pentium 4,42 mln tranzystorów). Pierwszy układ Itanium 2 (2002 rok) zawierał 220 mln tranzystorów.

Janusz Chustecki

: Intel

Nanotechnologia

Core i7-9xx Extreme Edition (2011)

800 000 000 tranzystorów, 2, 4, 8 rdzeni

technologia 45 nm – 32 nm

Zegar max 3,6 GHz

9 warstw

Moc ok. 65 W

AMD Phenom II (2011)

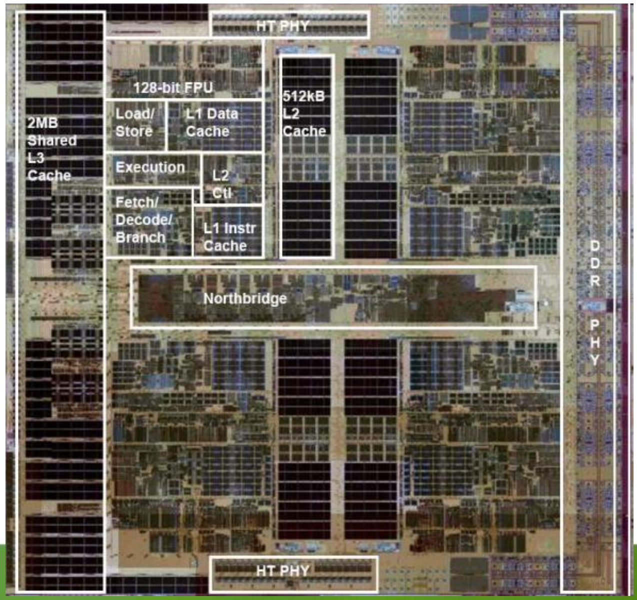
450 000 000 tranzystorów; 2,3,4 rdzenie

technologia 45 nm.

Zegar max 2,8 – 3,1 GHz

11 warstw

Moc 65 W -140 W



Trochę historii

GAZETA.PL TECHNOLOGIE

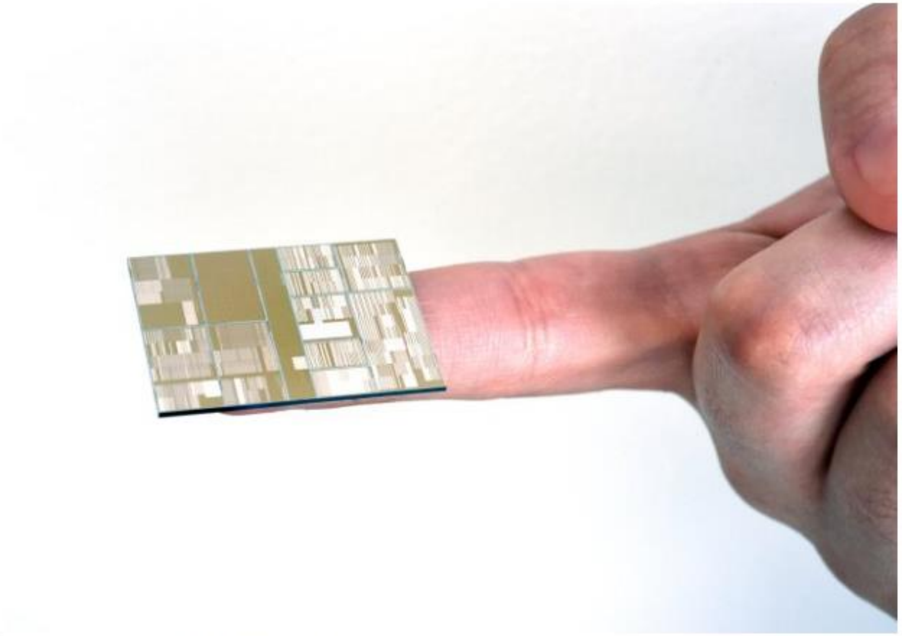
2015-07-11

Wiadomości | Smartfony i tablety | Naszym zdaniem | Nauka | Telewizory | Porady | Mobilnie.gazeta.pl | Forum | Moto

Gazeta.pl > Technologie > Wiadomości

IBM dokonał niemożliwego? Stworzył procesor w technologii 7 nanometrów

Robert Kędzierski 10.07.2015 09:32



Przełomowy procesor IBM i SUNY Polytechnic (Darryl Bautista/ IBM /)

Najczęściej czytane

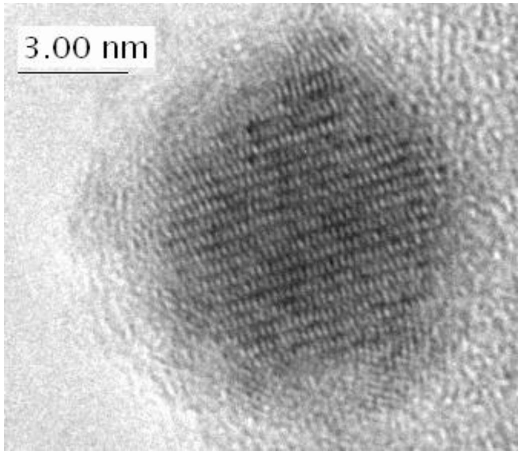
1. IBM dokonał niemożliwego? Stworzył procesor w technologii 7
2. Japończycy reagują na zaczepki Amerykanów. Dwa megaroboty
3. FBI wykryło serwer, z którego korzystało 215 tys. pedofilii.
4. Znajomy z Facebooka nagle zamilkł? Sprawdź, czy cię nie
5. QNAP TS-251C Turbo NAS - chmura całkiem własna

Polecamy

Najpiękniejszy jest dialog przez pracę,

http://technologie.gazeta.pl/internet/1,104530,18332692,ibm-dokonal-niemozliwego-stworzyl-chip-w-technologii-7-nm.html#BoxBizCz

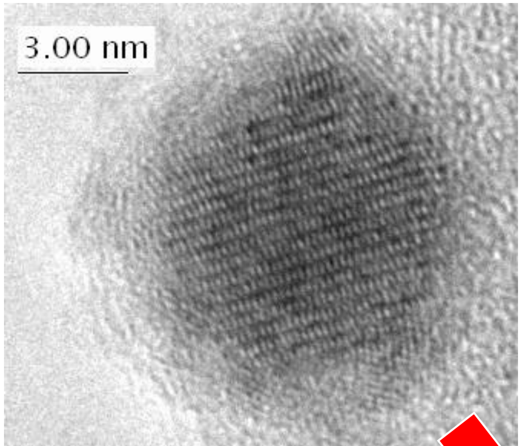
Nanotechnologia



5 nm

Nanotechnologia

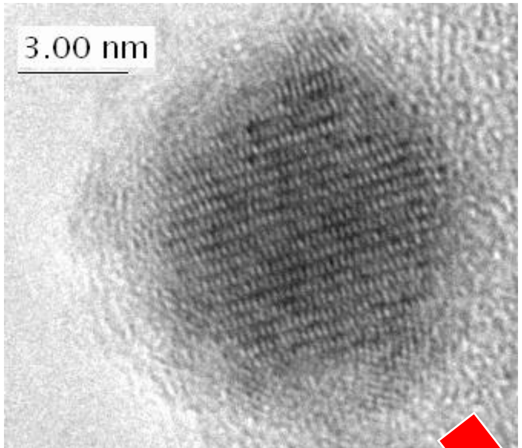
FACULTY OF PHYSICS
UNIVERSITY OF WARSAW



5 nm

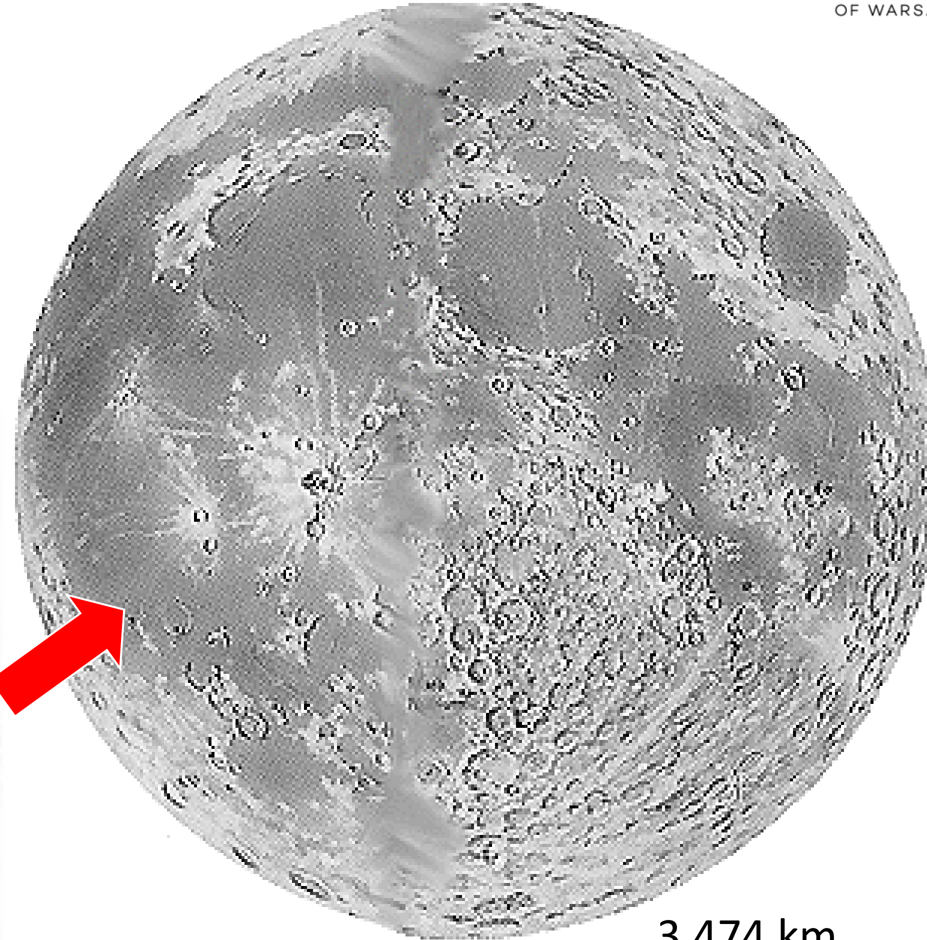
22 cm

Nanotechnologia



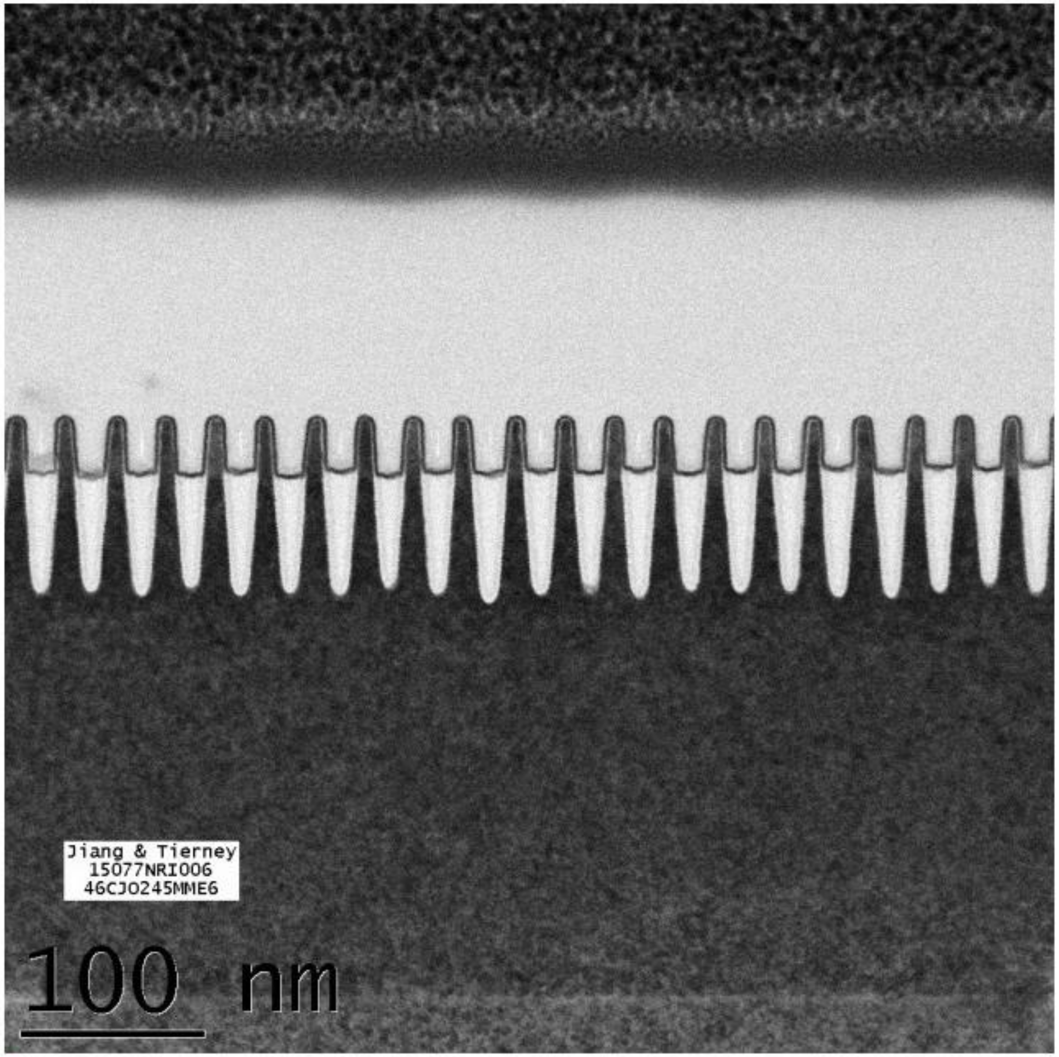
5 nm

22 cm



3,474 km

Trochę historii



Enlarge / Bulk 7nm transistors, with a 30nm pitch (the distance between the front edge of one transistor and the front edge of the next transistor).

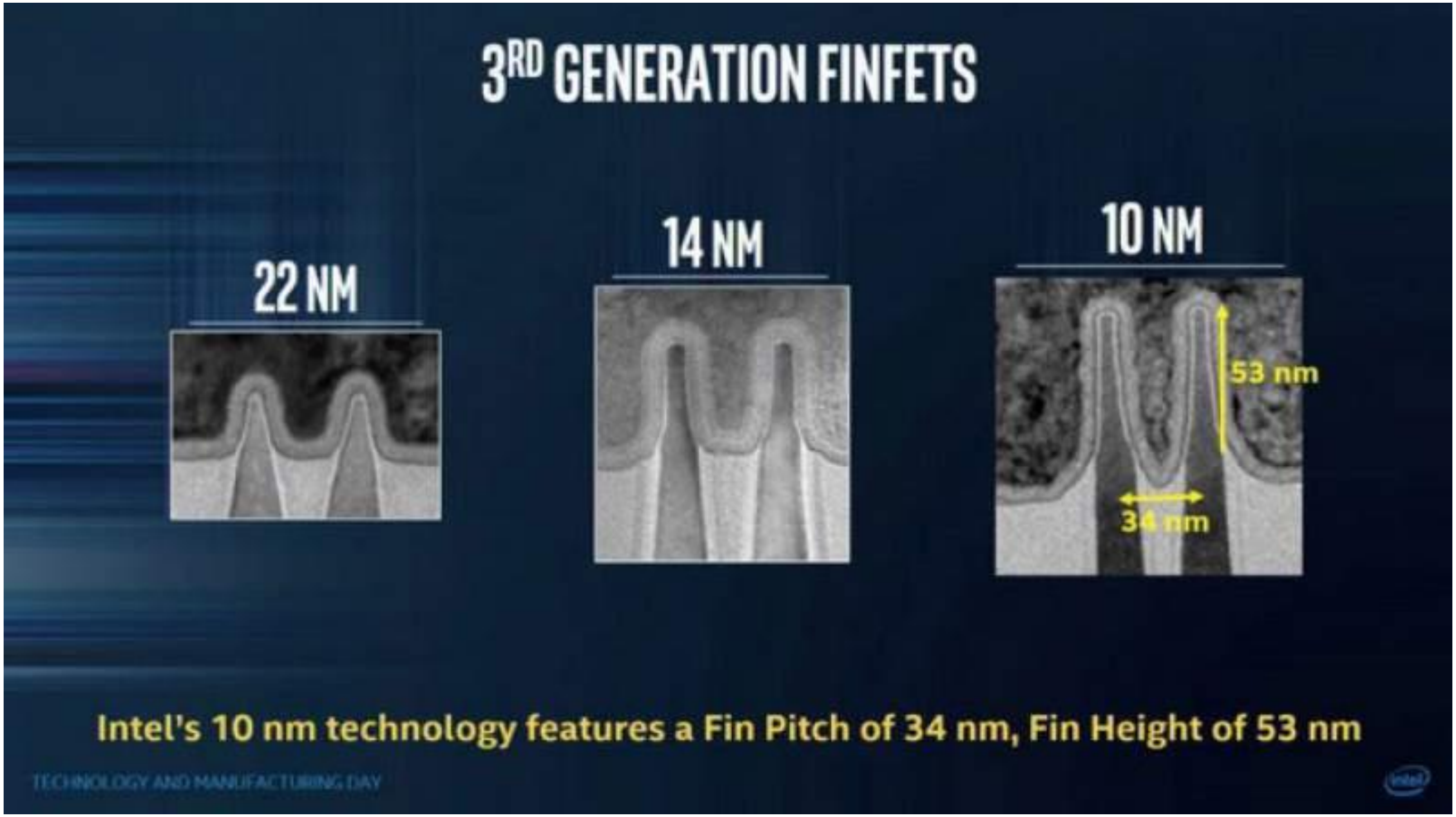
IBM Research

http ... -beyond-silicon/

Źródło: Intel

Trochę historii

Intel 9th generation Coffee Lake-S series 8-core die, 14nm.



https://www.eteknix.com/intel-prepares-cannonlake-i7-9700k-8c16t-cpu-2h-2018/

Trochę historii

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ars technica UK

2015-07-11

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GEAR & GADGETS / PRODUCT NEWS & REVIEWS

Beyond silicon: IBM unveils world's first 7nm chip

With a silicon-germanium channel, and EUV lithography, IBM crosses the 10nm barrier.

by Sebastian Anthony - Jul 9, 2015 11:45am CEST

Share Tweet 89

Enlarge / SUNY's Michael Liehr, left, and IBM's Bala Haranand look at a wafer of 7nm chips.

IBM Research

LATEST FEATURE STORY

FEATURE STORY (5 PAGES)

First look: iOS 9 public beta is the update the iPad deserves

A smallish update for phones is a Mac-sized leap for tablets.

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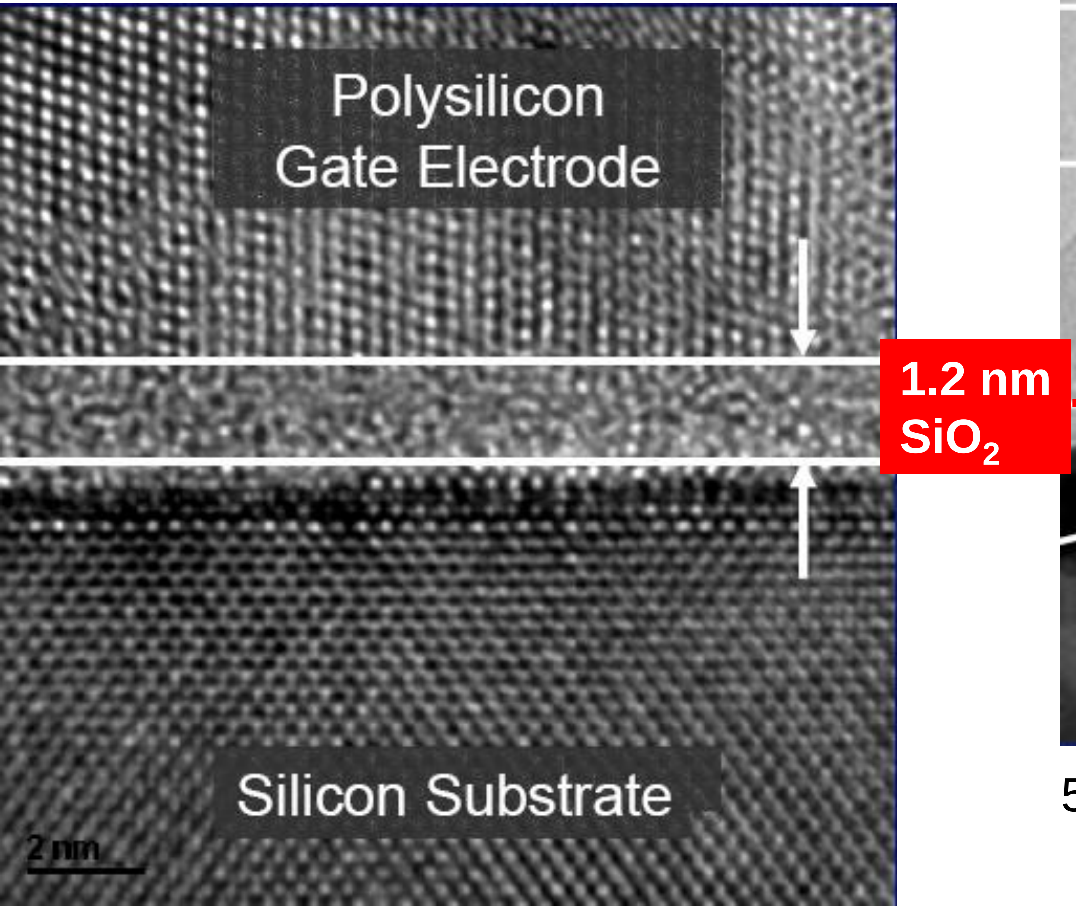
I tried to sign up for Comcast Internet—how hard could it be?

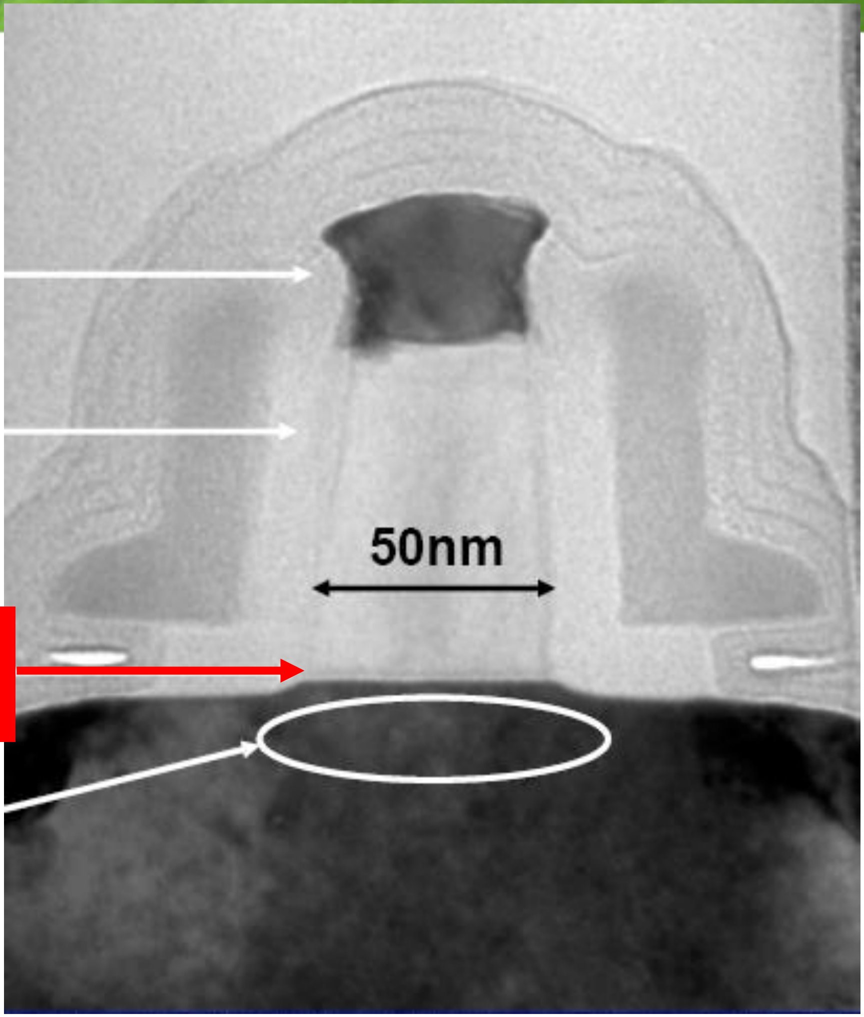
Hacking Team's Flash 0-day: Potent enough to infect actual

http://arstechnica.co.uk/gadgets/2015/07/ibm-unveils-industrys-first-7nm-chip-moving-beyond-silicon/

Źródło: Intel

Nanotechnologia





50 nm generation transistor (Intel 2003)

Źródło: Intel

Nanotechnologia

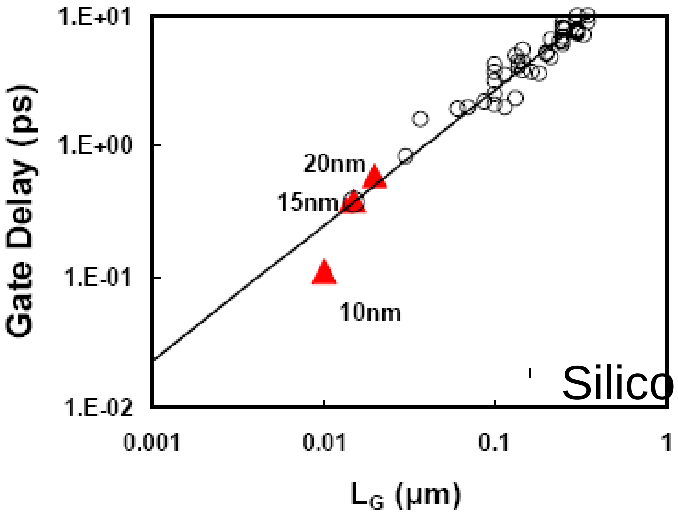


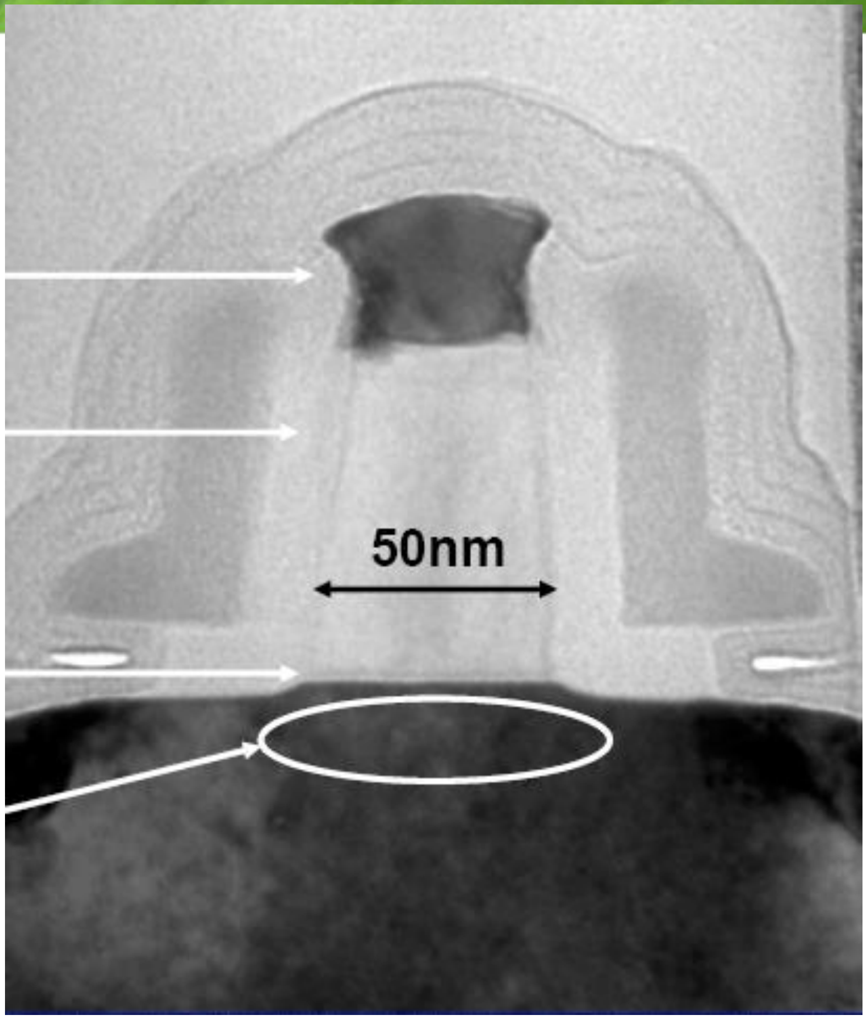
Figure 3: Gate delay vs. transistor physical gate length L_G.

Silicide layer

Silicon gate elctrode

1.2 nm SiO_2 gate oxide

Strained Silicon

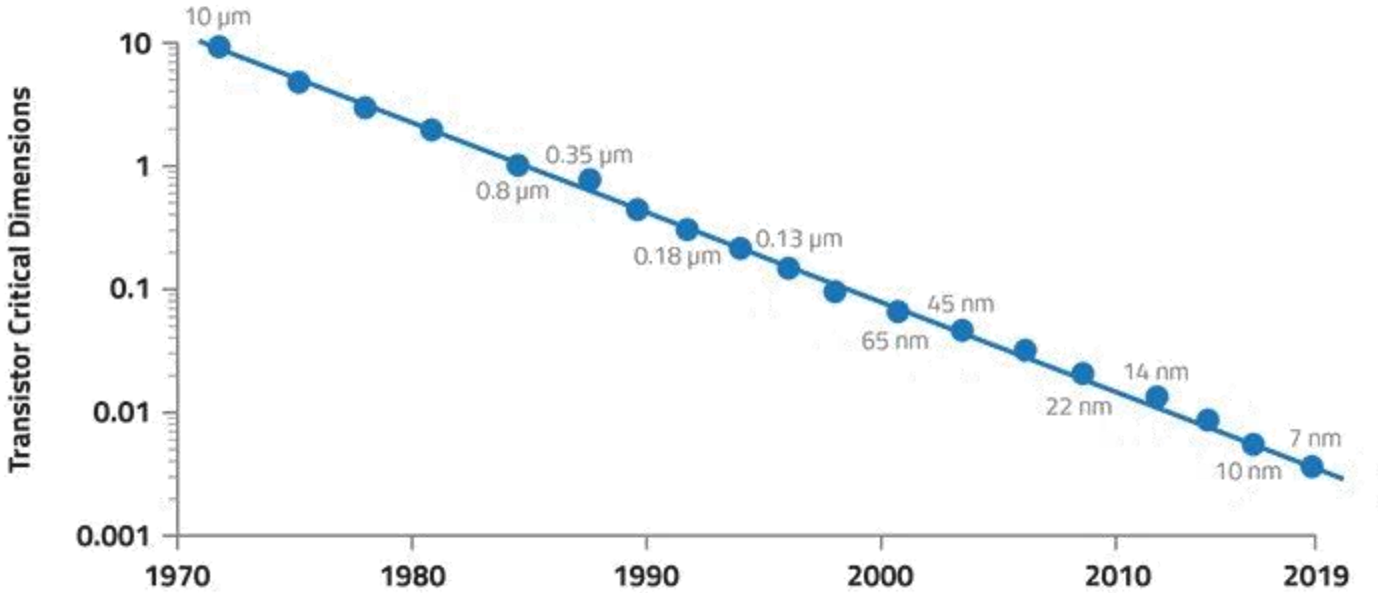


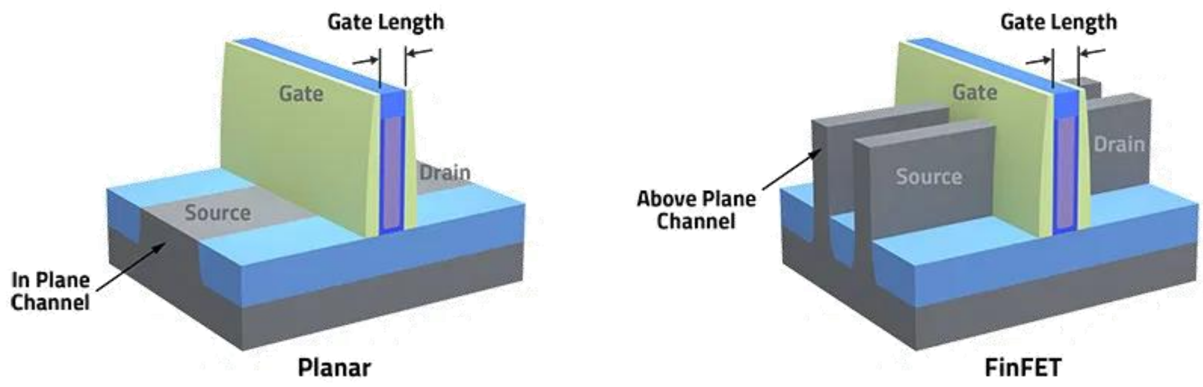
50 nm generation transistor (Intel 2003)

Intel 2Q 2003:
Oxide thickness: ~ 3 nm
Channel length: ~ 90 nm
Gate position: ~ 6 nm (!)
Characteristic time: ~ 1.6 ps
Subthreshold leakage: 0.01 mA/micron
Parasitic *R*SD contribution: < 16%
Energy per switching: 0.35 fJ
Static power dissipation: 5.6 nW

Źródło: Intel

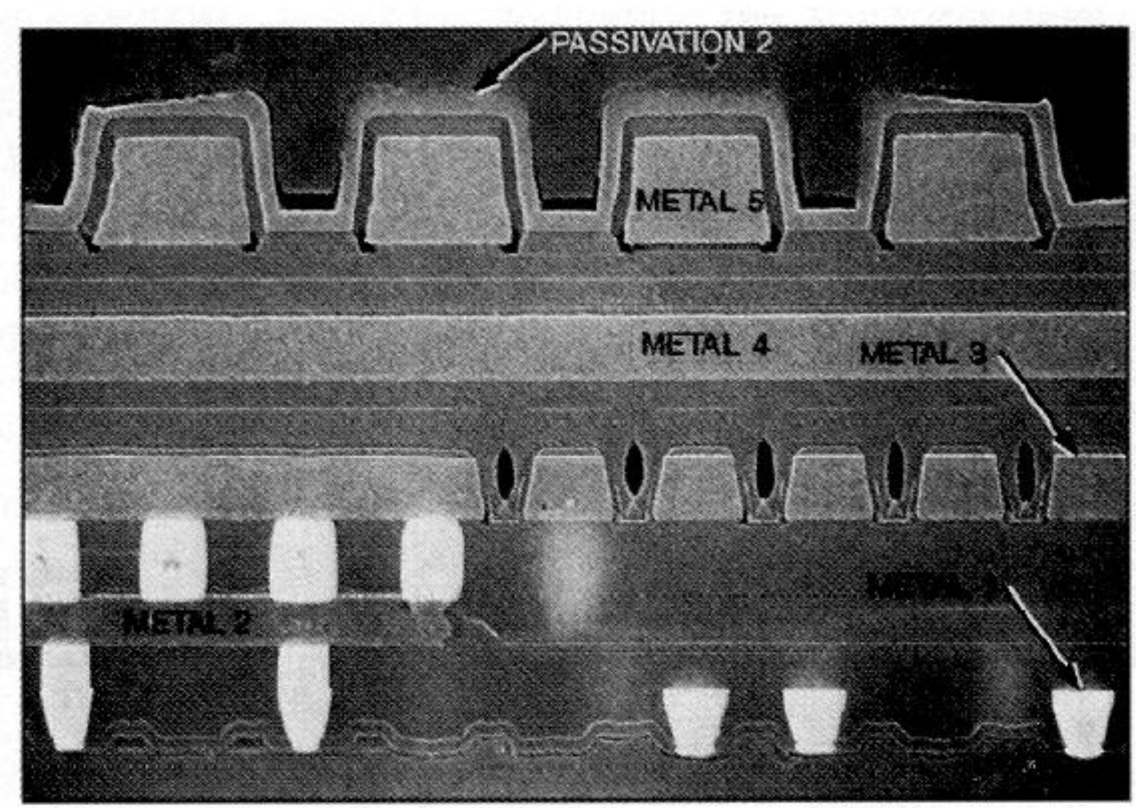
Epoka NANO



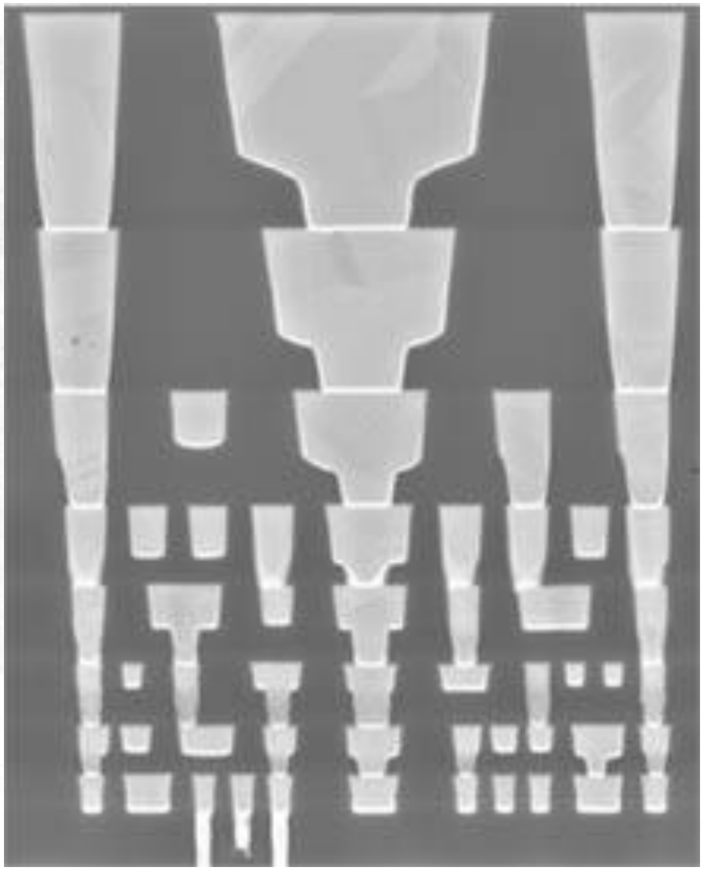


https://semiengineering.com/scaling-up-and-down/

Nanotechnologia



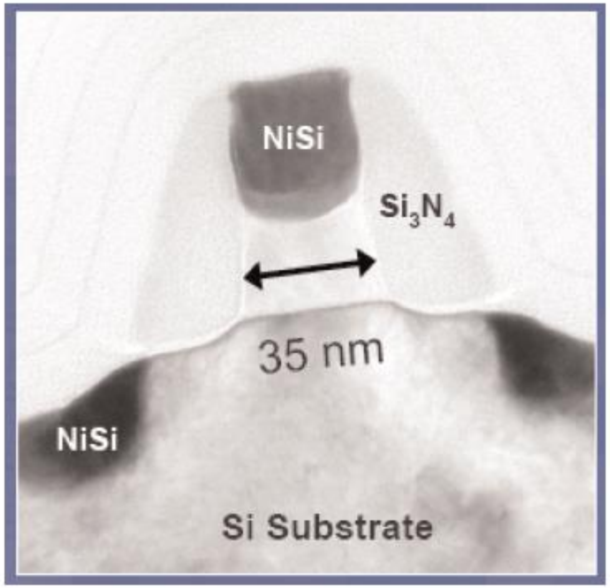
1997

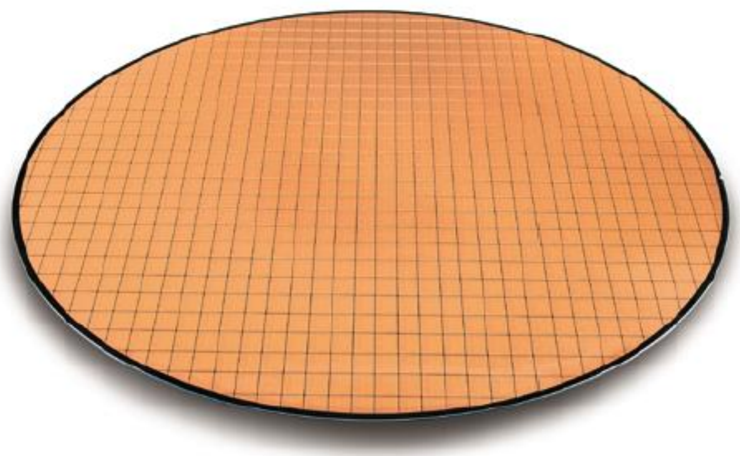


2006

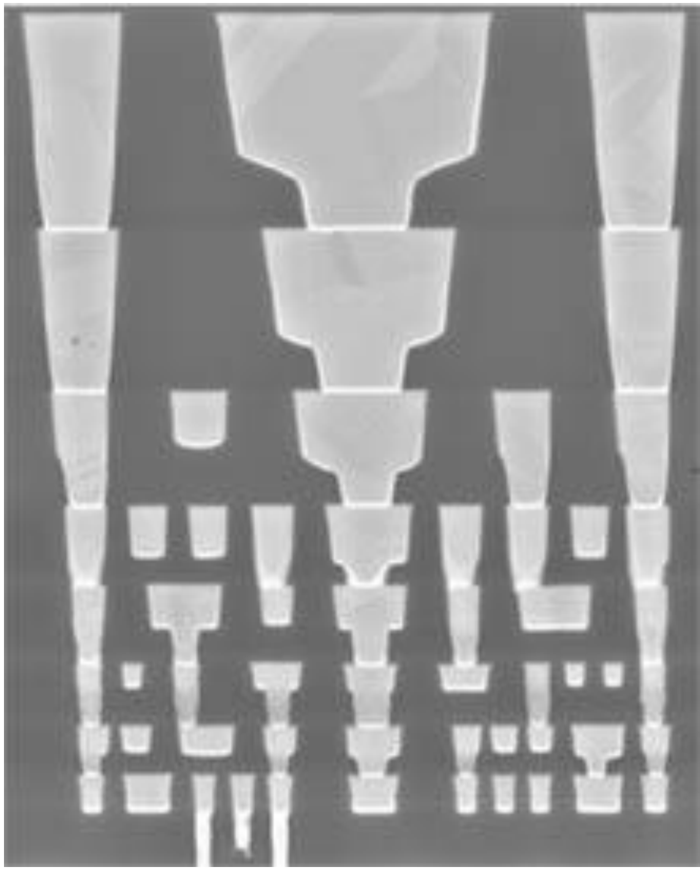
Źródło: www.usna.edu/EE/ee452/LectureNotes/ 05-Processing_Technology

Nanotechnologia





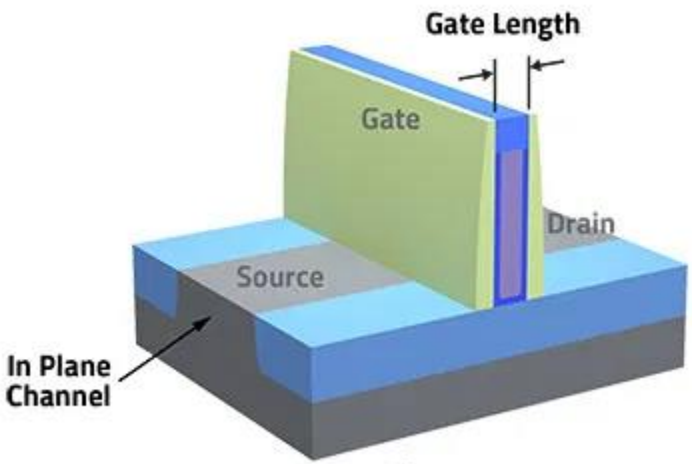
Intel strained silicon (top) and a 65-nm wafer of Intel® Core™ Duo processors (bottom).



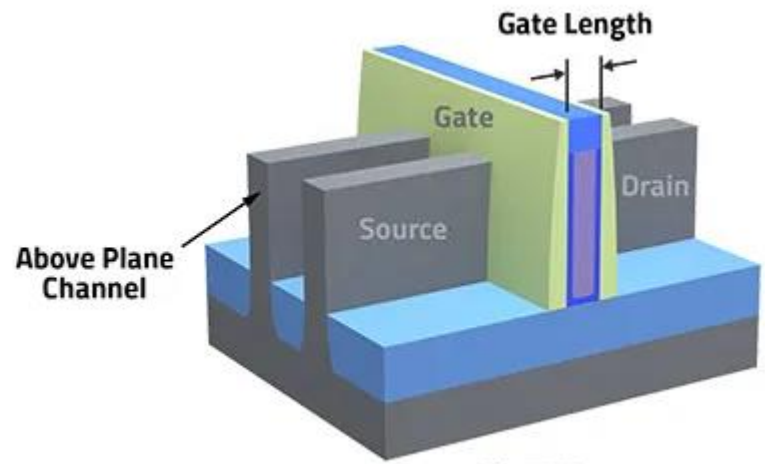
2006

Źródło: www.usna.edu/EE/ee452/LectureNotes/ 05-Processing_Technology

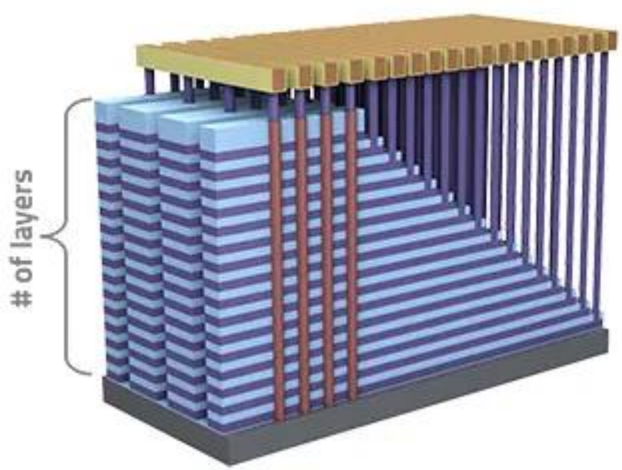
Trochę historii

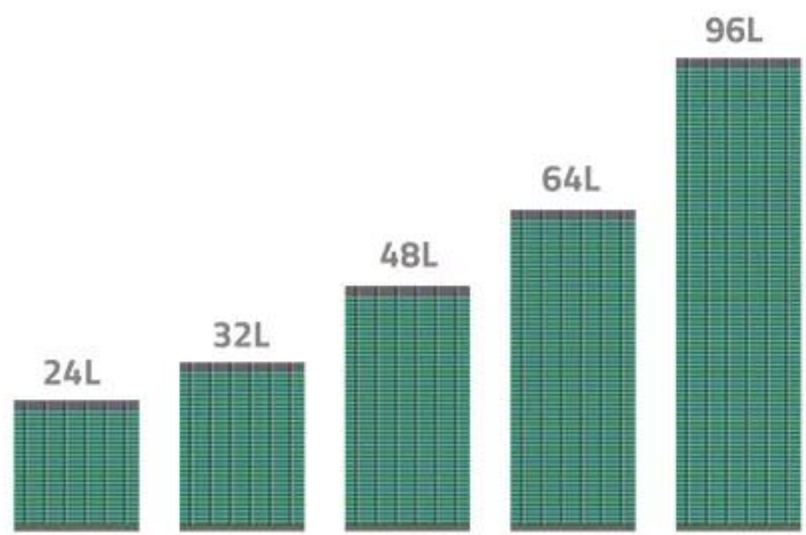


Planar



FinFET

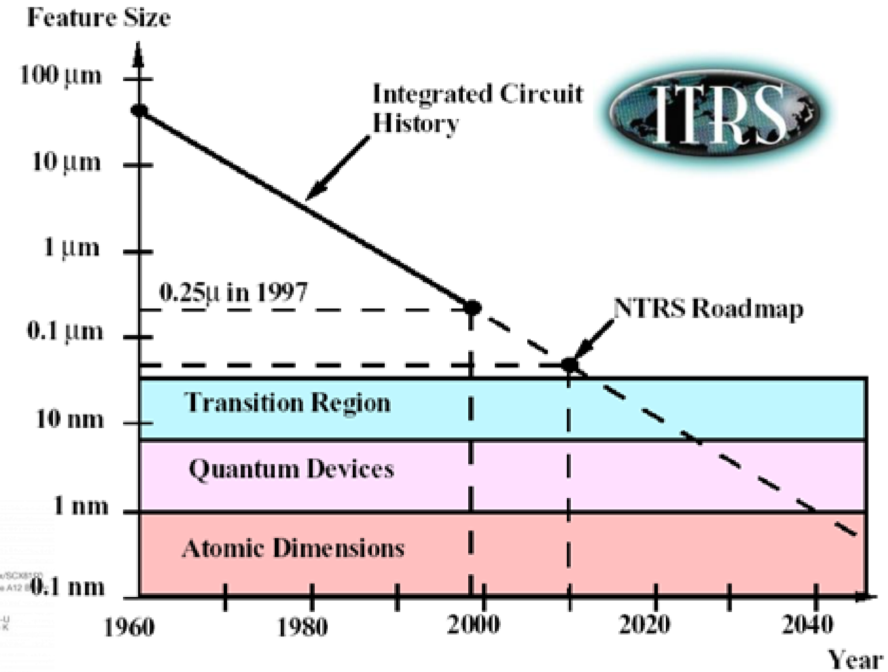


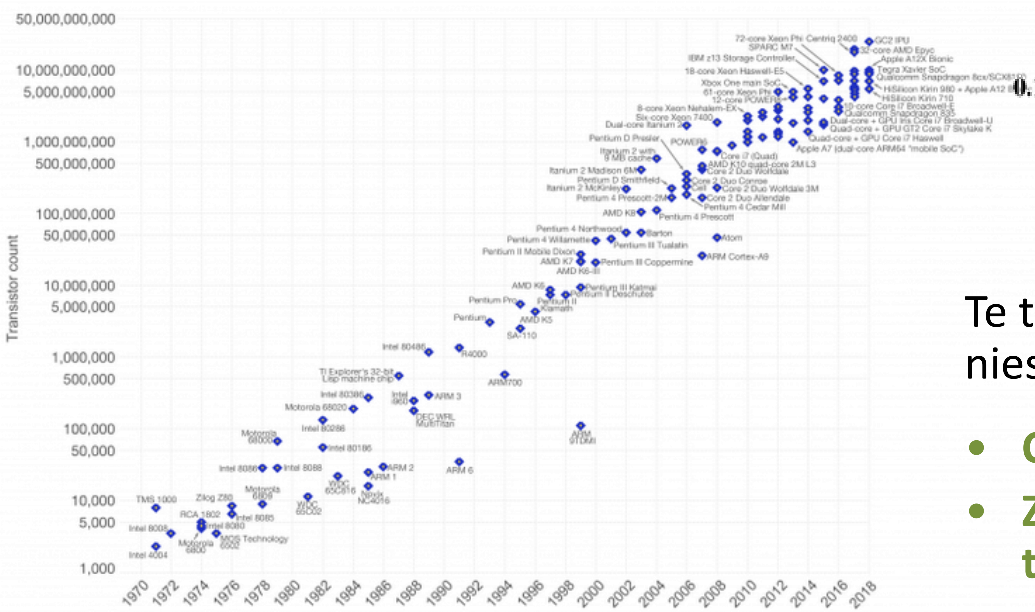


https://semiengineering.com/scaling-up-and-down/

TRENDY: Prawo Moore'a

Ilość komponentów (tranzystory, połączenia, izolacje itd.) w IC podwaja się co około 18 miesięcy. Rozmiar liniowy komponentów również zmniejsza się wykładniczo w czasie.





Te trendy nie mogą być kontynuowane w nieskończoność.

- **Co zastąpi technologię Si?**
- **Z czego będzie wynikała ta zmiana technologii?**

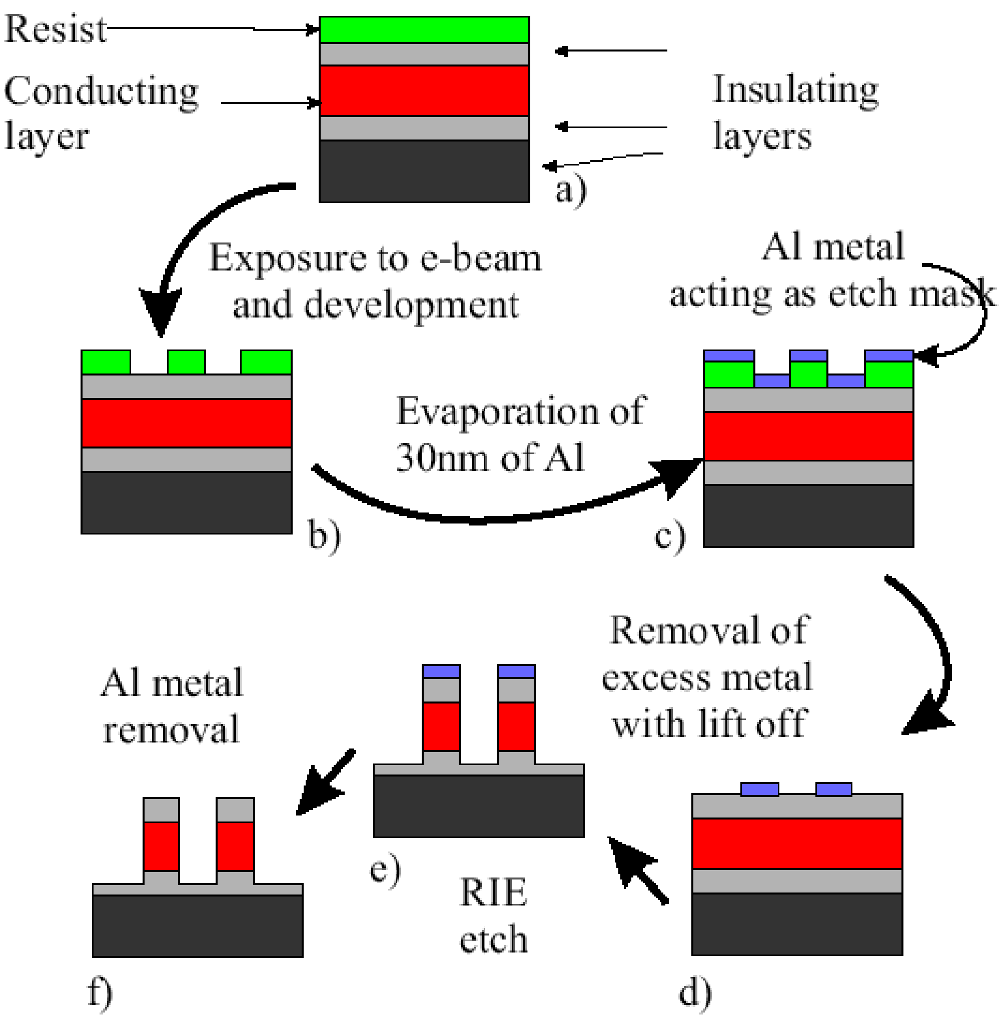
Źródło: Intel

Top-down

Vincent Laforet/The New York Times

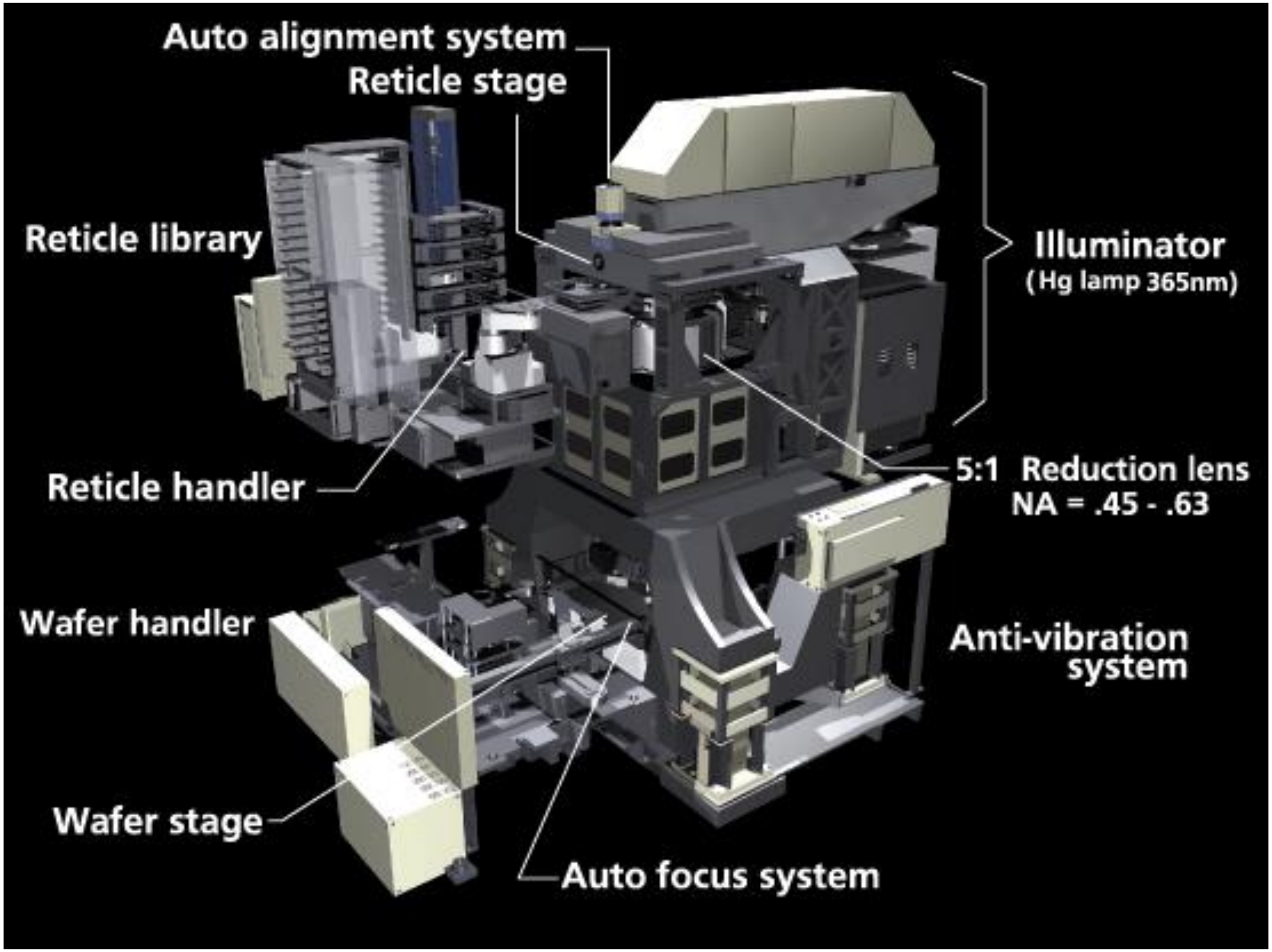
Jak To jest zrobione?

1. **Dominuje technologia krzemowa**
2. **Obecne układy ~ 10^9 - 10^{10} tranzystorów**
3. **Podłoża - 300mm, ~ 10^3 chipów**
4. **Fotolitografia, naświetlanie, trawienie etc**
5. **Typowo ~20 masek, 150 - 200 kroków procesów**



Nanotechnologia

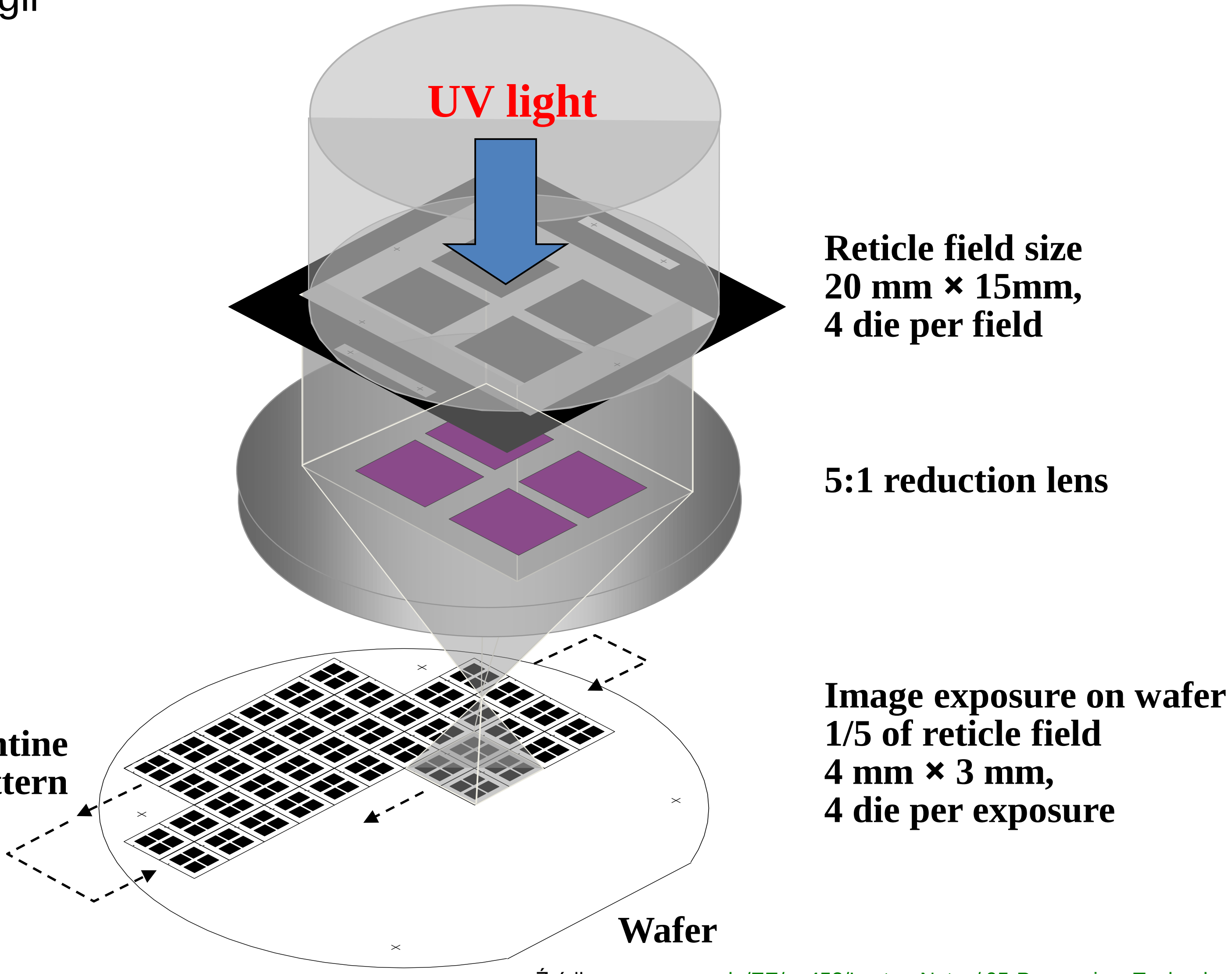
Maszyna do technologii Step-and-Repeat Aligner (Stepper)



Źródło: www.usna.edu/EE/ee452/LectureNotes/ 05-Processing_Technology

Nanotechnologia

Maszyna do technologii



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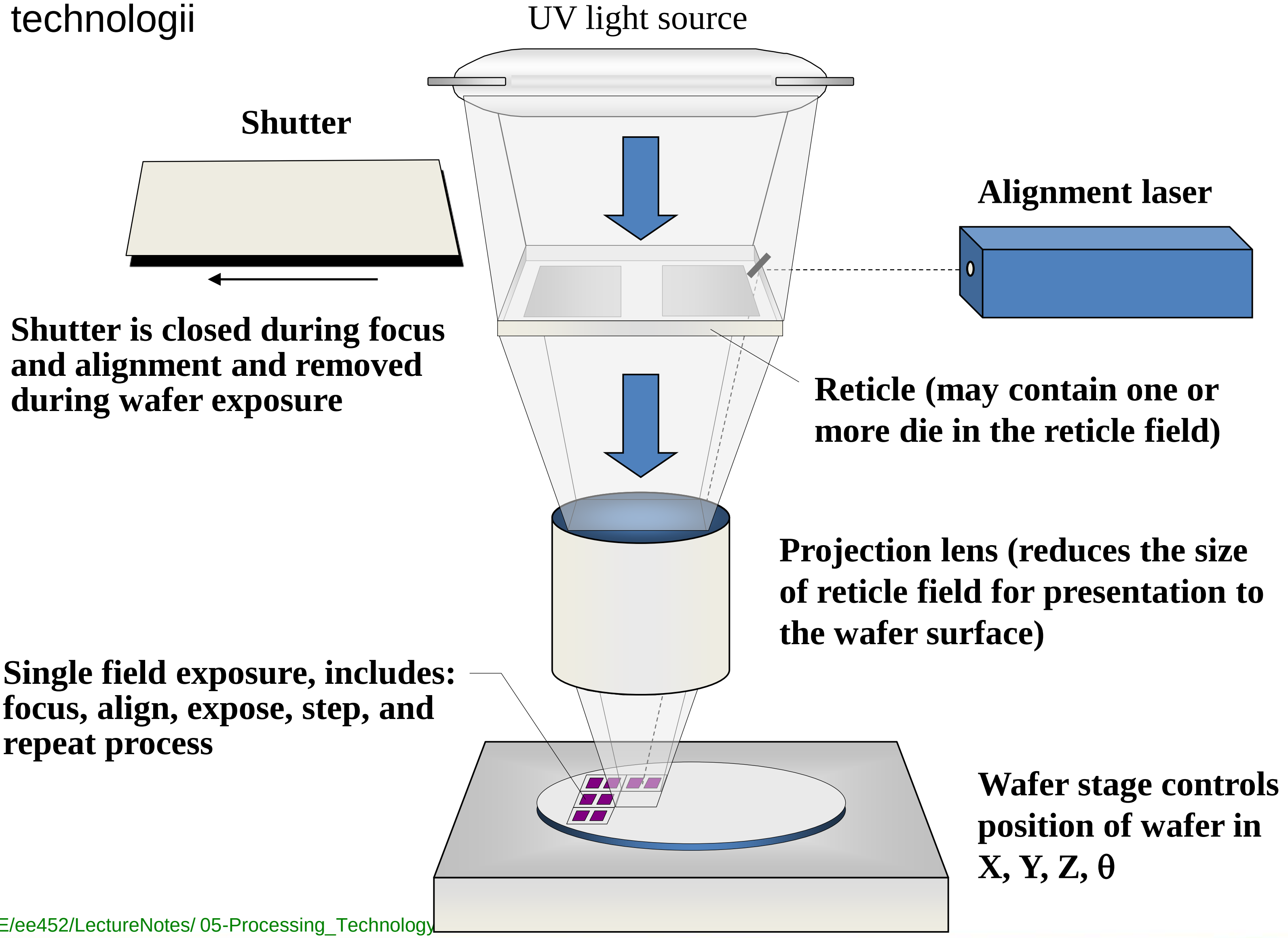
Nanotechnologia

Maszyna do technologii



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Nanotechnologia

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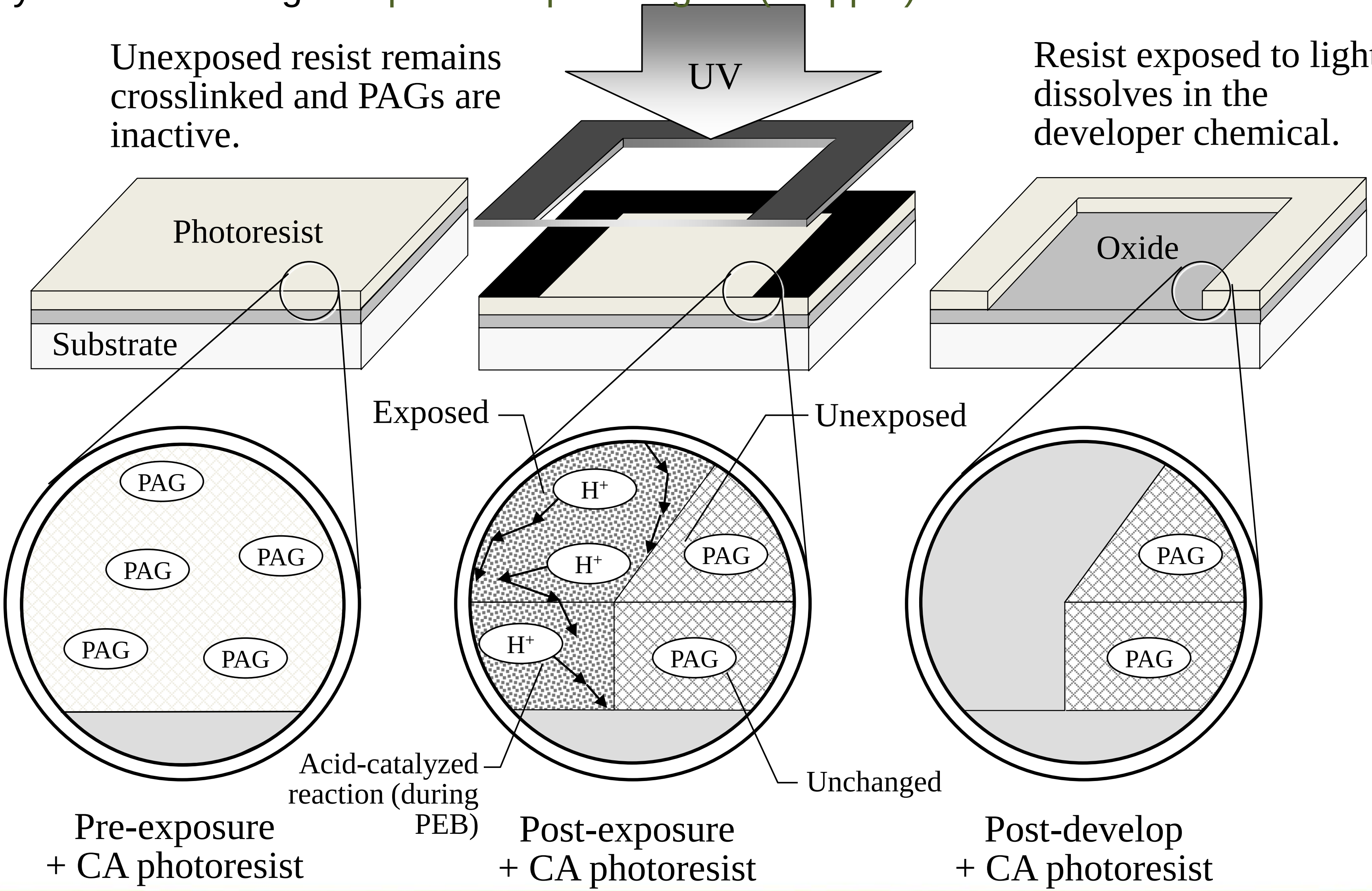
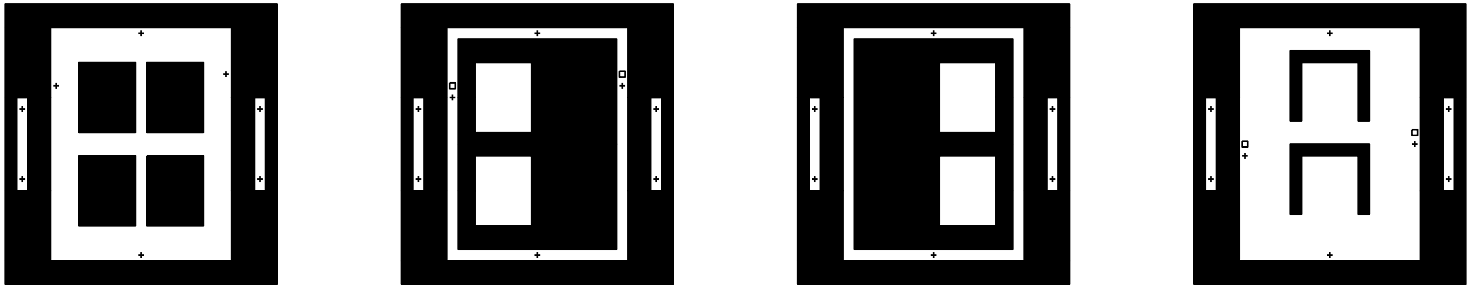
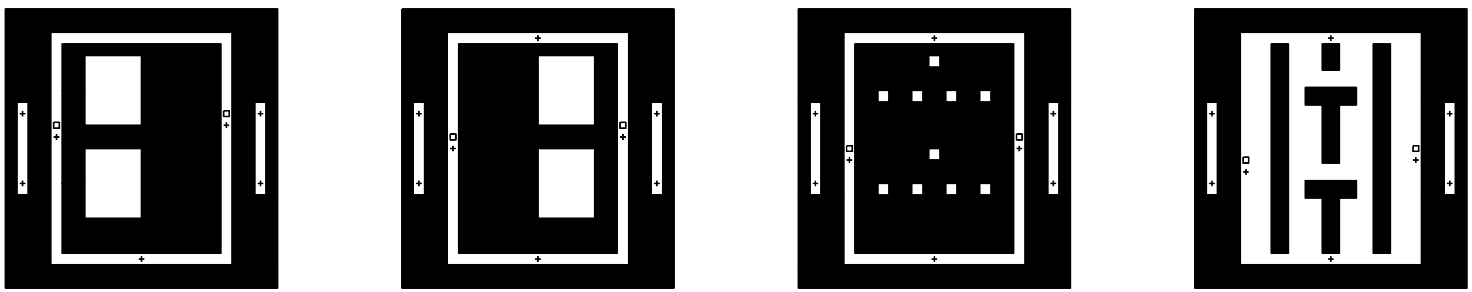


Źródło: www.usna.edu/EE/ee452/LectureNotes/05-Processing_Technology

Nanotechnologia

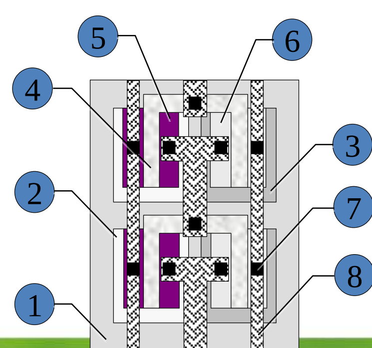


1) STI etch | 2) P-well implant | 3) N-well implant | 4) Poly gate etch

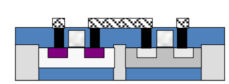


5) N$^+$ S/D implant | 6) P$^+$ S/D implant | 7) Oxide contact etch | 8) Metal etch

Resulting layers



Top view



Cross section

Źródło: www.usna.edu/EE/ee452/LectureNotes/05-Processing_Technology

Nanotechnologia

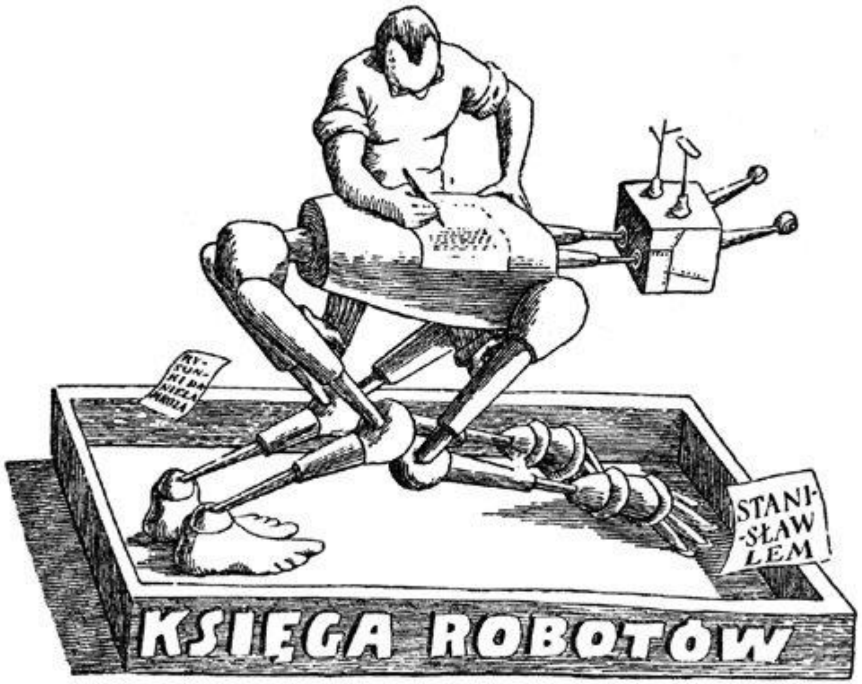
Film

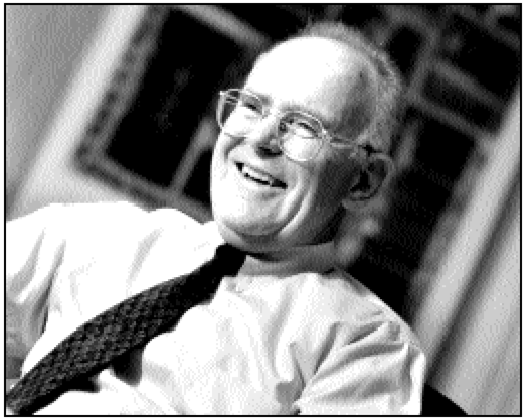
TRENDY: Prawo Moore'a

NO EXPONENTIAL IS FOREVER...

BUT WE CAN DELAY „FOREVER"

Gordon Moore, 2003



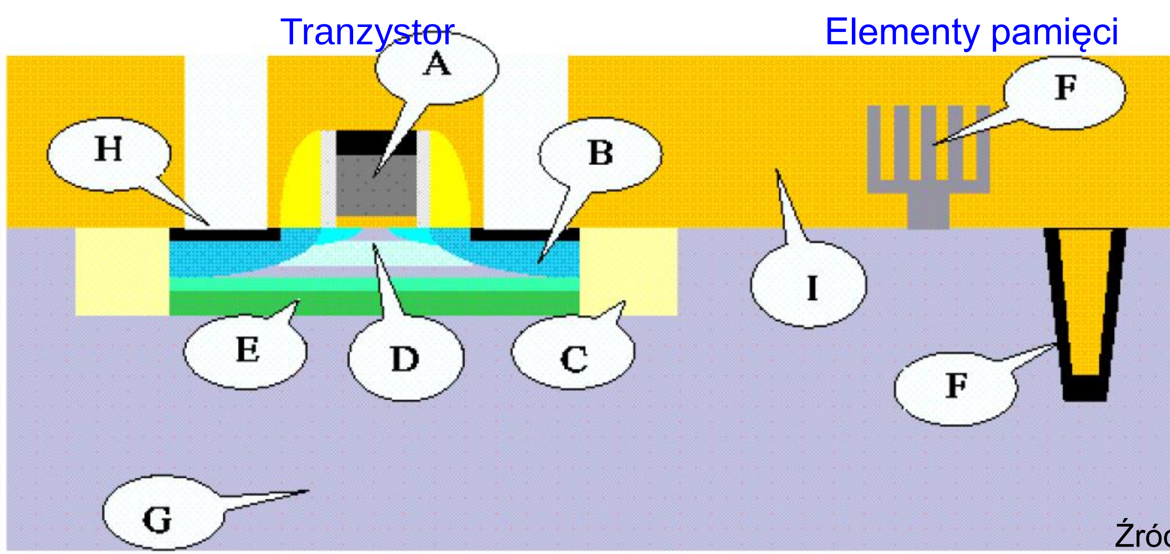


International Technology Roadmap for Semicond.

SEMATECH
Accelerating the next technology revolution.

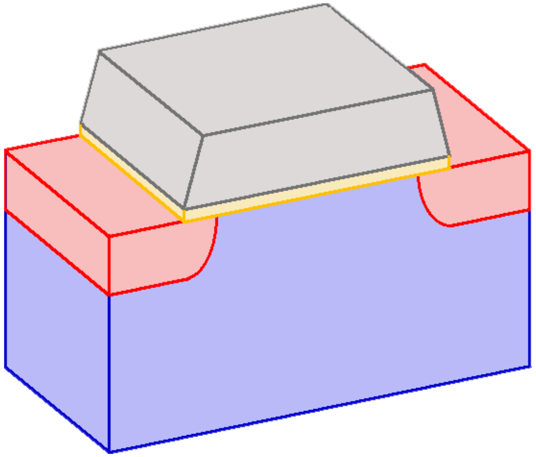
SEMATECH: międzynarodowe konsorcjum producentów półprzewodników – określa cele, opłaca badania nad rozwiązaniem problemów dotyczących „wszystkich”, w jego skład wchodzą: AMD, Agere Systems, Hewlett-Packard, Hynix, Infineon Technologies, IBM, Intel, Motorola, Philips, STMicroelectronics, Texas Instruments

Stara się zdefiniować “wyzwania technologiczne”, określić dalsze cele i przewidzieć ich specyfikację, koszt, wydajność, czas wdrożenia itp.

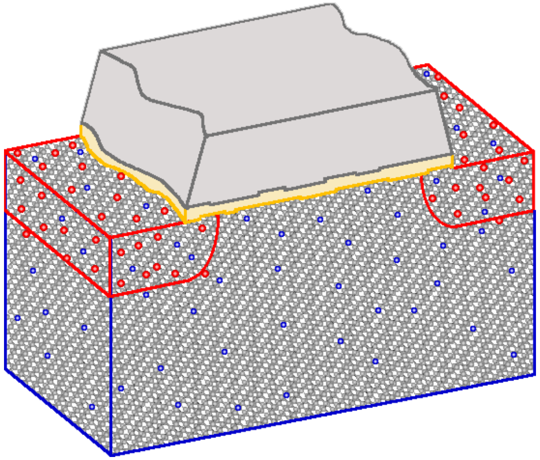


Źródło: Intel, Sematech

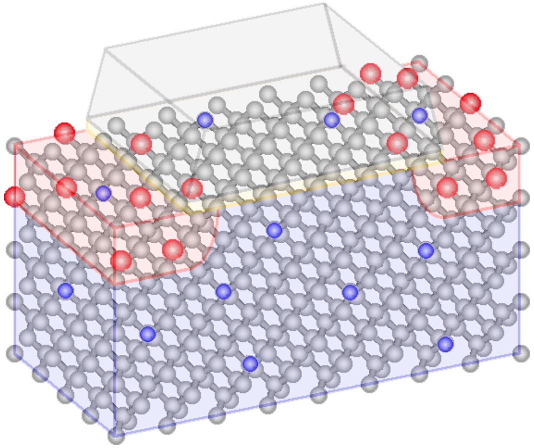
Granice miniaturyzacji



Myślimy, że tranzystor jest zbudowany tak.



25 nm MOSFET
Produkcja od 2008



4,2 nm MOSFET
Produkcja ???

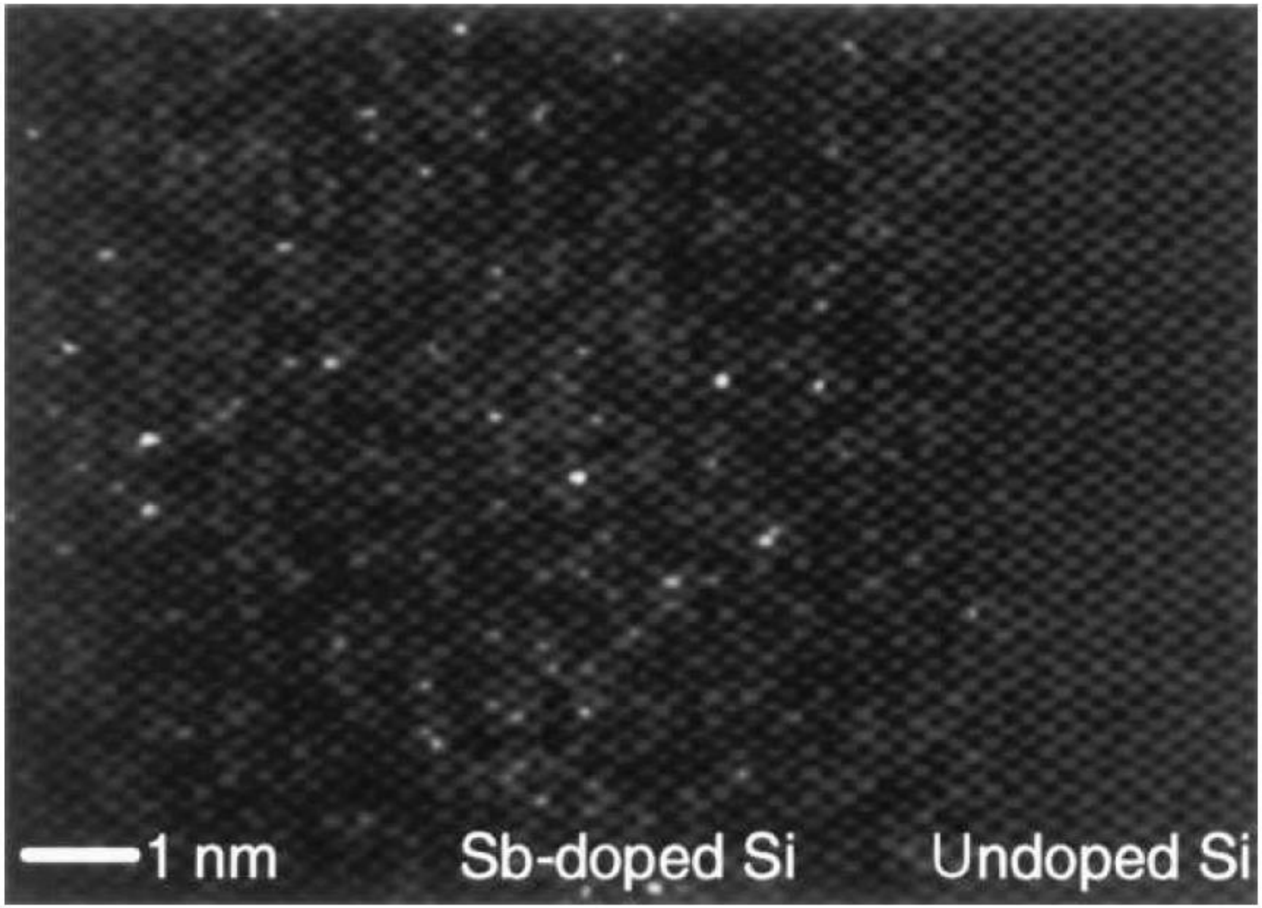
Asen Asenov, Glasgow

David Williams *Hitachi-Cambridge*

IEEE Trans Electron Dev 50(9), 1837 (2003)

PROBLEM: Statystyka domieszek

Voyles, P. M. *et al.* *Nature* **416**, 826-829 (2002)

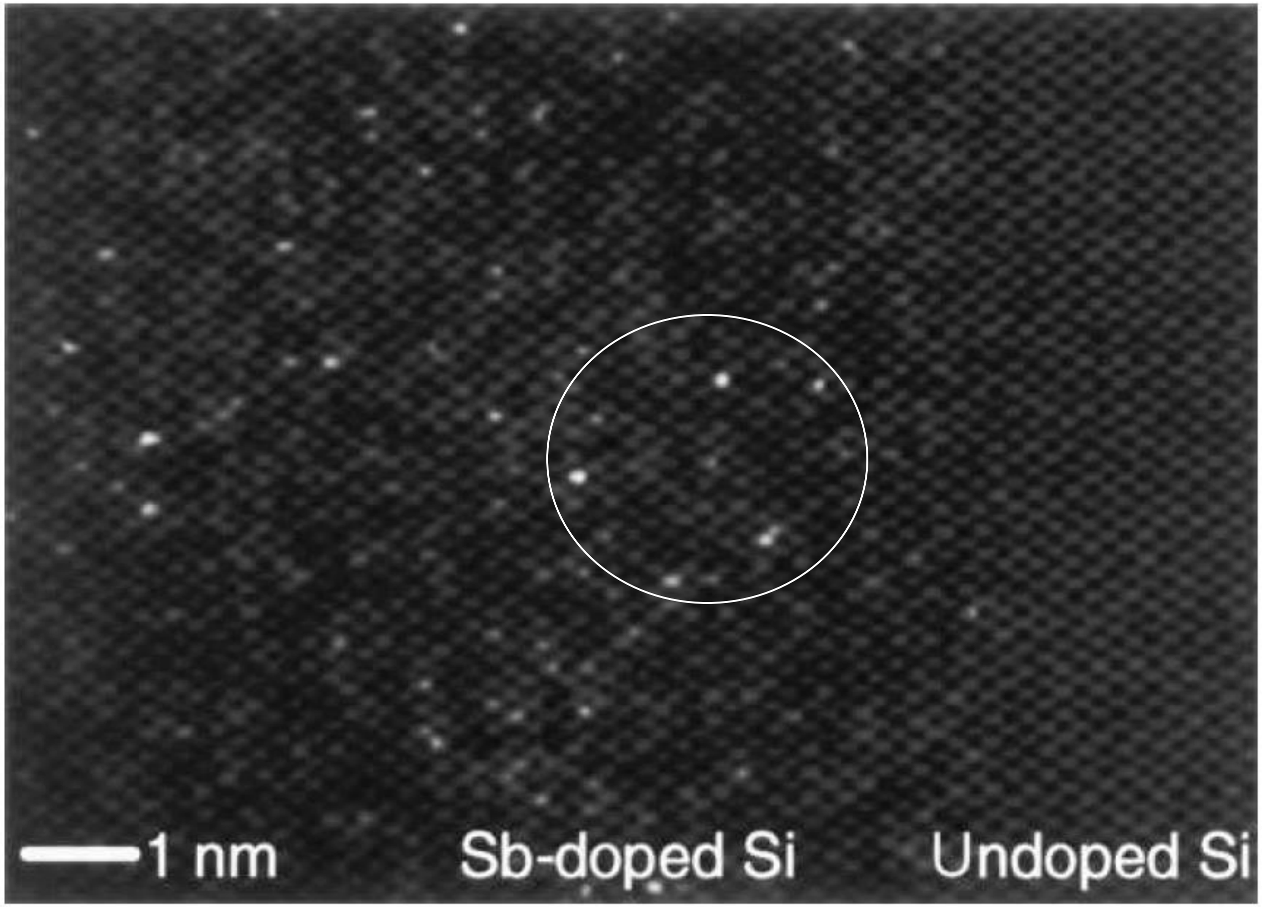


10^{22} atomów Si
10^{17} domieszek
Rozmiar tranzystora 50 nm
Średnia ilość domieszek 12.5

State-of-the-art TEM image of ultrathinned (5 nm) sample.

PROBLEM: Statystyka domieszek

Voyles, P. M. *et al.* *Nature* **416**, 826-829 (2002)

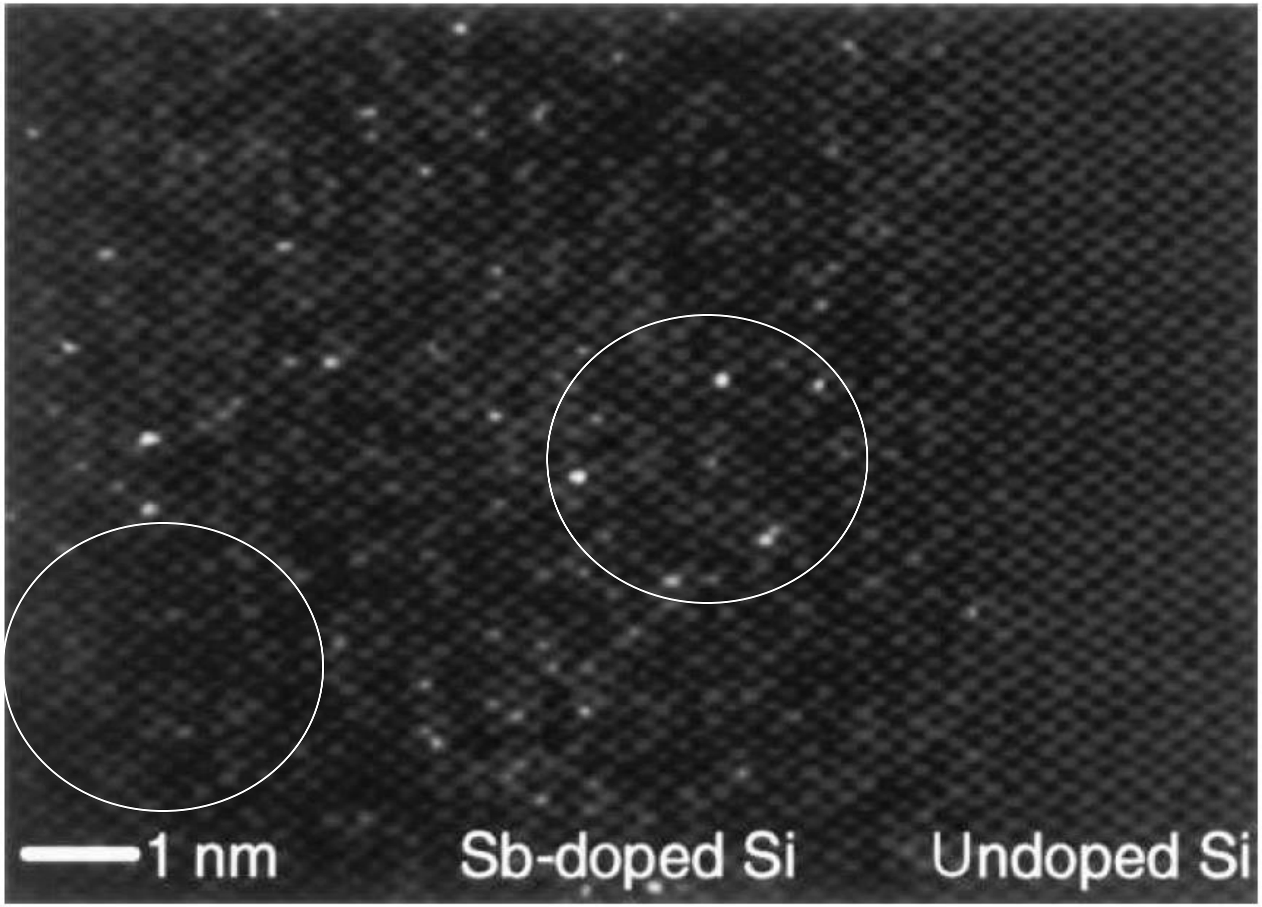


State-of-the-art TEM image of ultrathinned (5 nm) sample.

10^{22} atomów Si
10^{17} domieszek
Rozmiar tranzystora 50 nm
Średnia ilość domieszek 12.5

PROBLEM: Statystyka domieszek

Voyles, P. M. *et al.* *Nature* **416**, 826-829 (2002)



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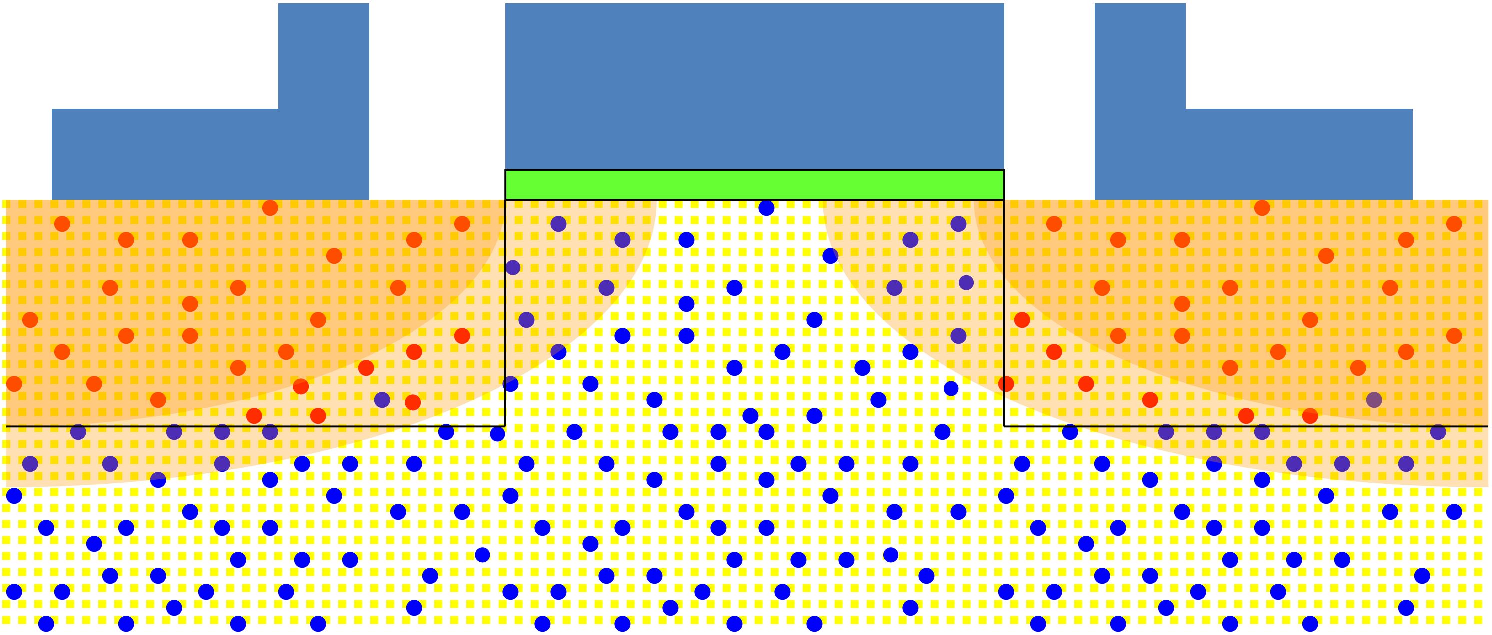
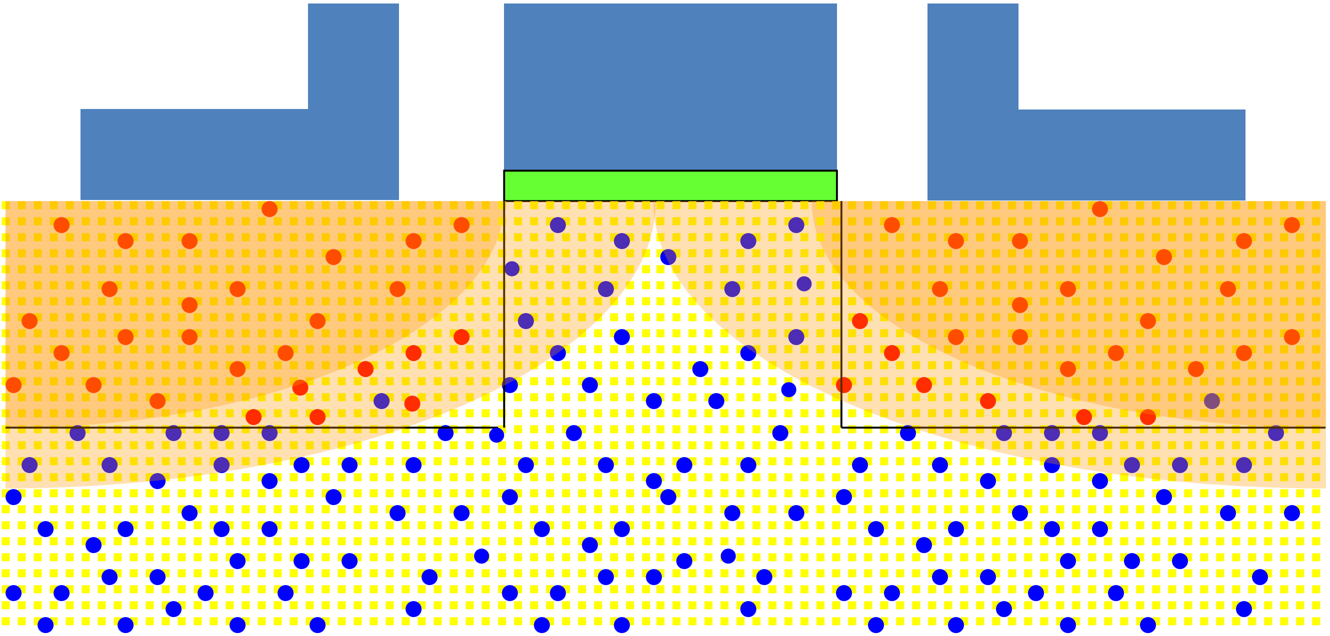
State-of-the-art TEM image of ultrathinned (5 nm) sample.

PROBLEM: Tunelowanie

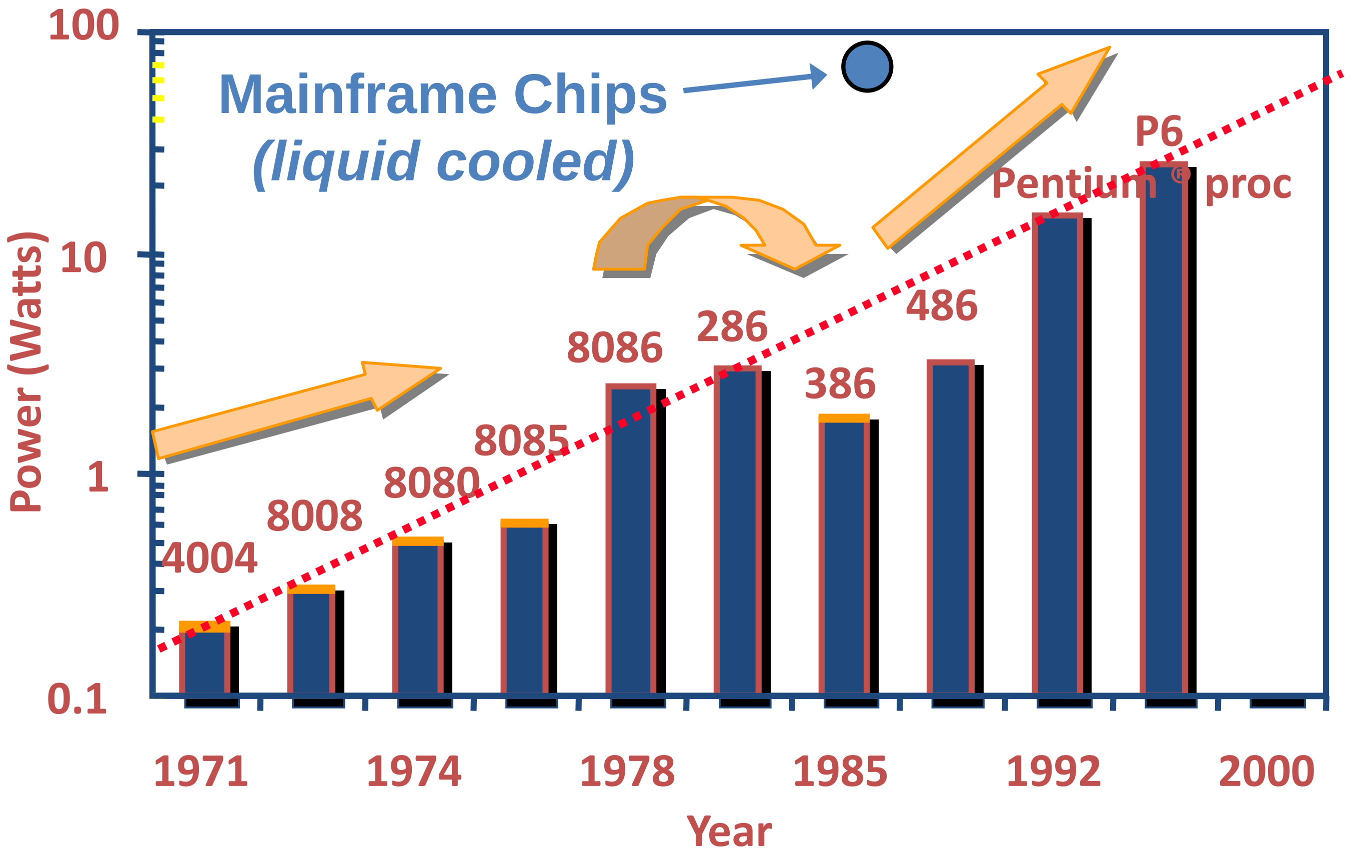


PROBLEM: Tunelowanie



PROBLEM: Chłodzenie

Z roku na rok układy wymagają większej mocy do wykonywania operacji logicznych.

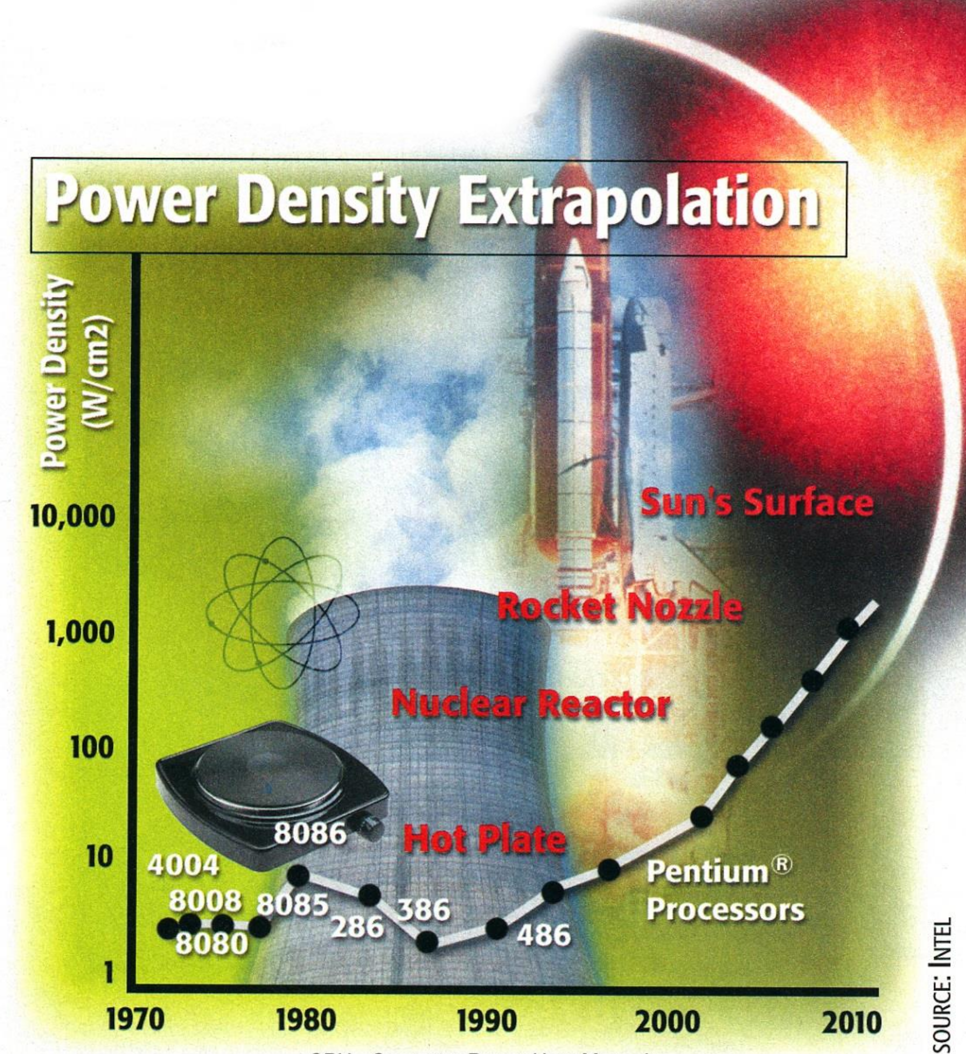


PROBLEM: Chłodzenie

Gęstość mocy rośnie dramatycznie.

10^7 tranzystorów pracujących z częstością 1.5 GHz zużywa 130 W. Zakładając, że na tej samej powierzchni za jakiś czas będzie pracować 10^8 tranzystorów z częstością 10 GHz otrzymamy gęstość mocy na poziomie 10 kW/cm^2 (porównywalną gęstość mocy ma silnik rakietowy!)

Film



CPU - Computer Power User Magazine

PROBLEM: nano-litografia

Litografia 2003,

- Długość fali światła 248 nm
- Kanał FET 90 nm:
- Wymagane jest nie więcej niż 2000/m2 <100 nm
- Fluktuacje granic rezystu 7 nm

Litografia 2007,

- Długość fali światła 193 nm (?) 153 nm (?) X-ray (?)
- Kanał FET 35 nm:
- Wymagane jest nie więcej niż 1500/m2 <100 nm
- Fluktuacje granic rezystu 3 nm

Litografia 2016,

- Długość fali światła X-ray (?)
- Kanał FET 9 nm:
- Wymagane jest nie więcej niż 500/m2 <100 nm
- Fluktuacje granic rezystu 1 nm

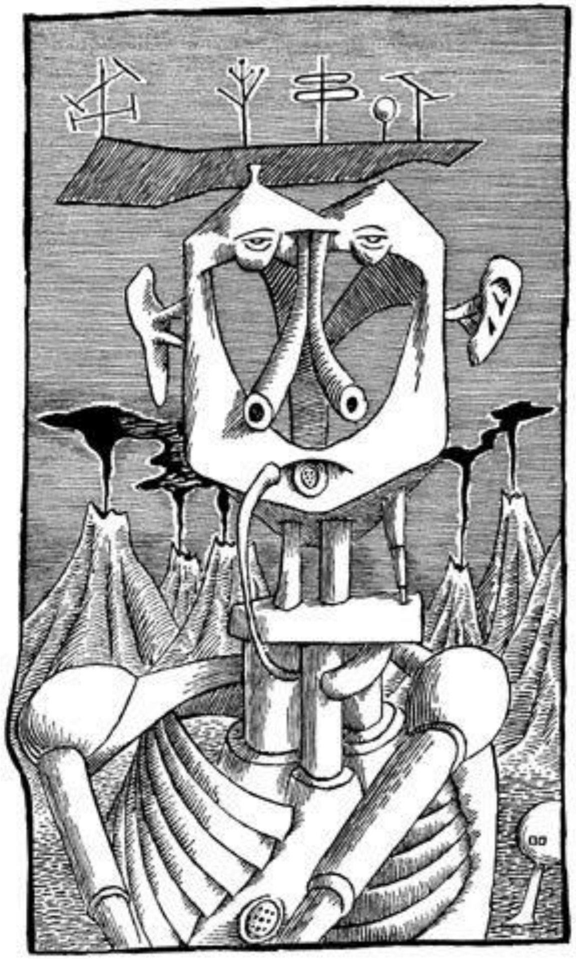
Prawdopodobnie koniec epoki polimerowych rezystów (cząstki polimerów są zbyt duże!)

PROBLEM…

itd…

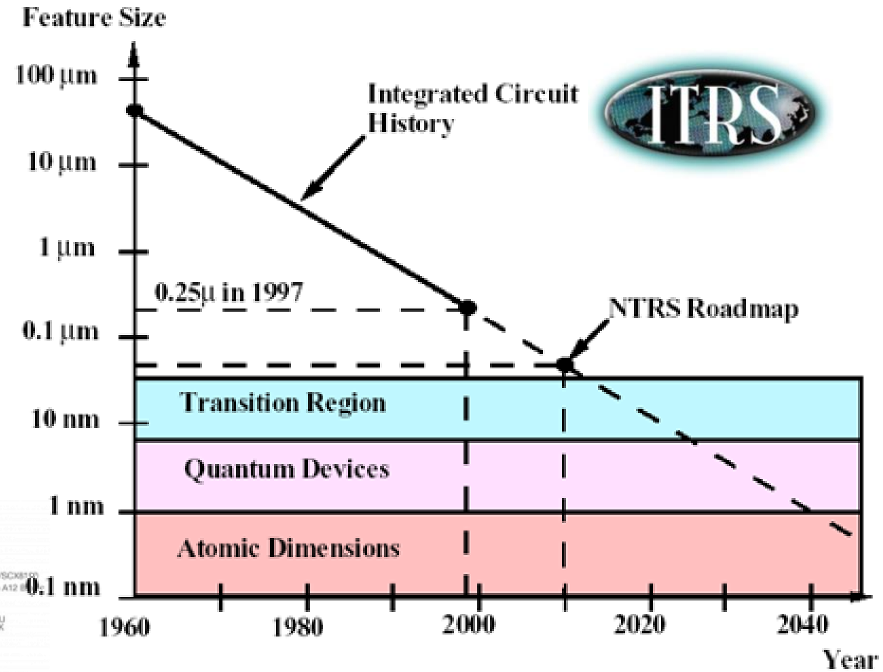
itd…

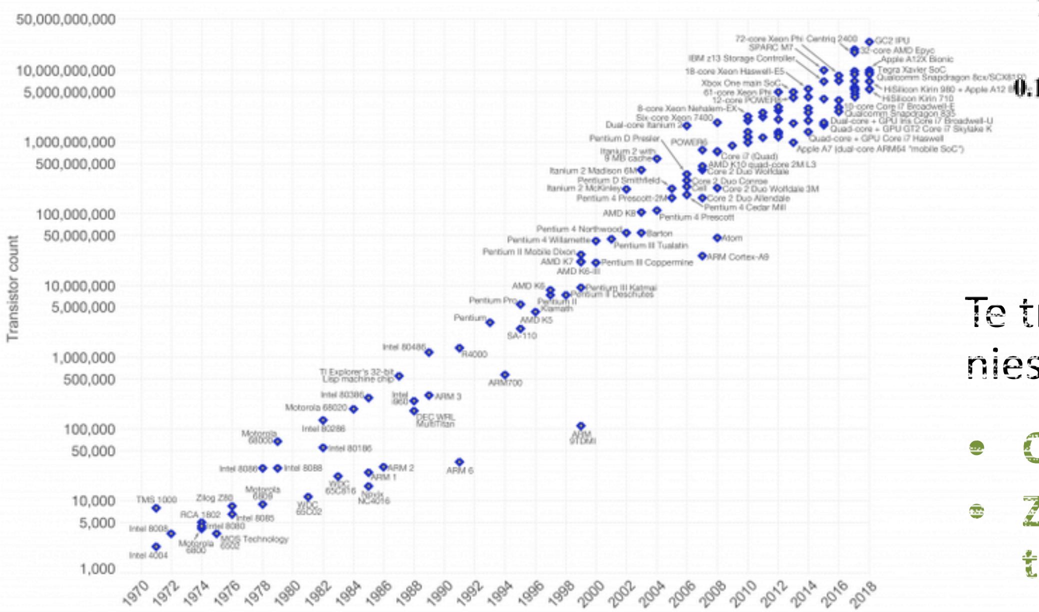
itd…



TRENDY: Prawo Moore'a

Ilość komponentów (tranzystory, połączenia, izolacje itd.) w IC podwaja się co około 18 miesięcy. Rozmiar liniowy komponentów również zmniejsza się wykładniczo w czasie.



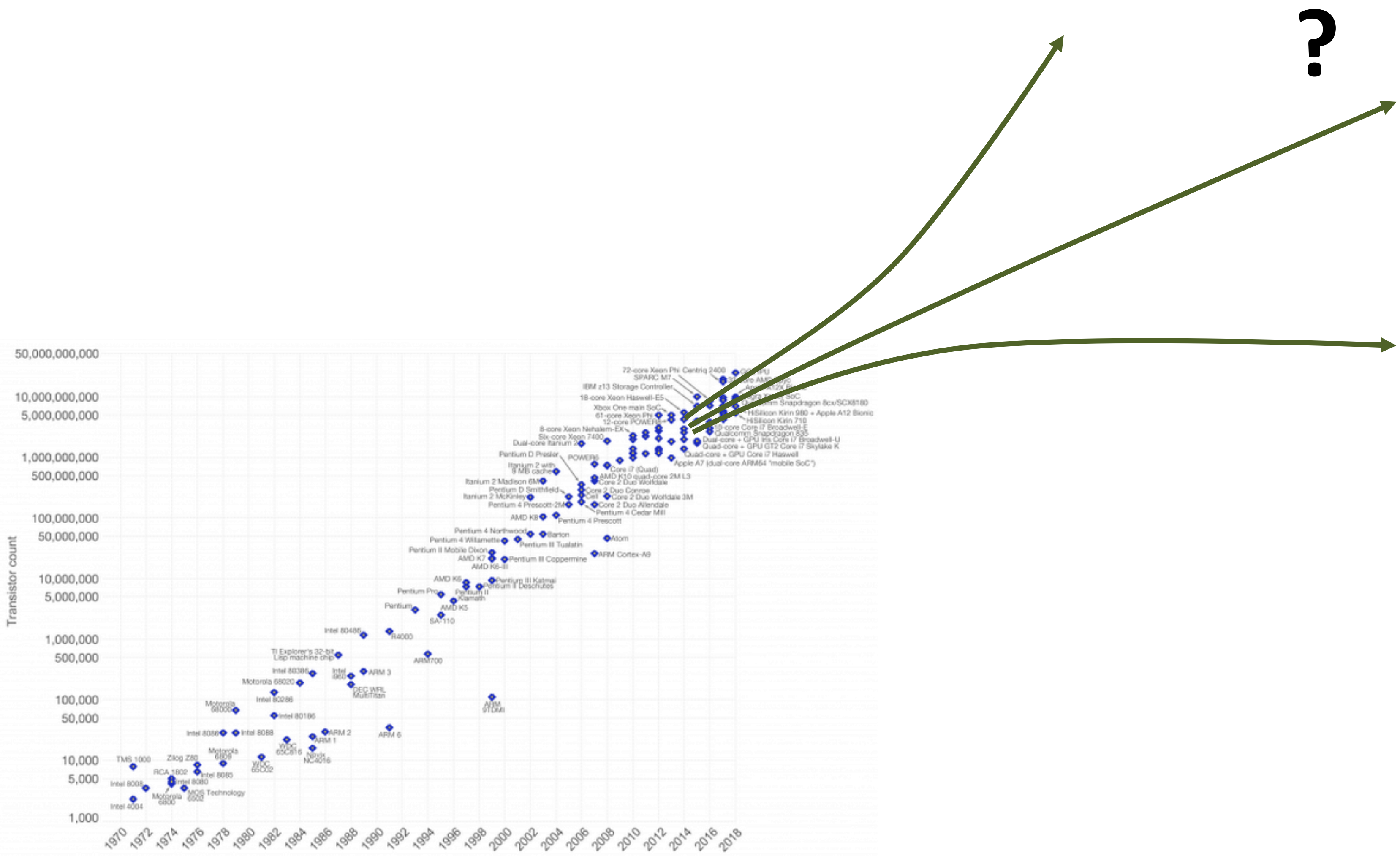


Te trendy nie mogą być kontynuowane w nieskończoność.

- **Co zastąpi technologię Si?**
- **Z czego będzie wynikała ta zmiana technologii?**

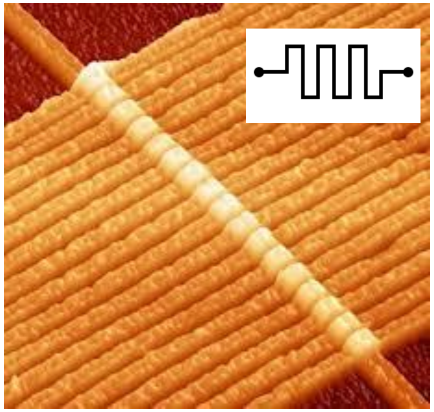
Źródło: Intel

TRENDY: Prawo Moore'a



Źródło: Intel

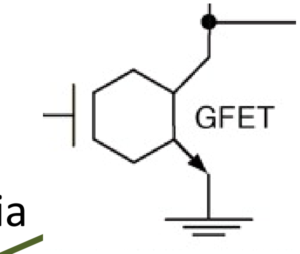
TRENDY: Prawo Moore'a



HP

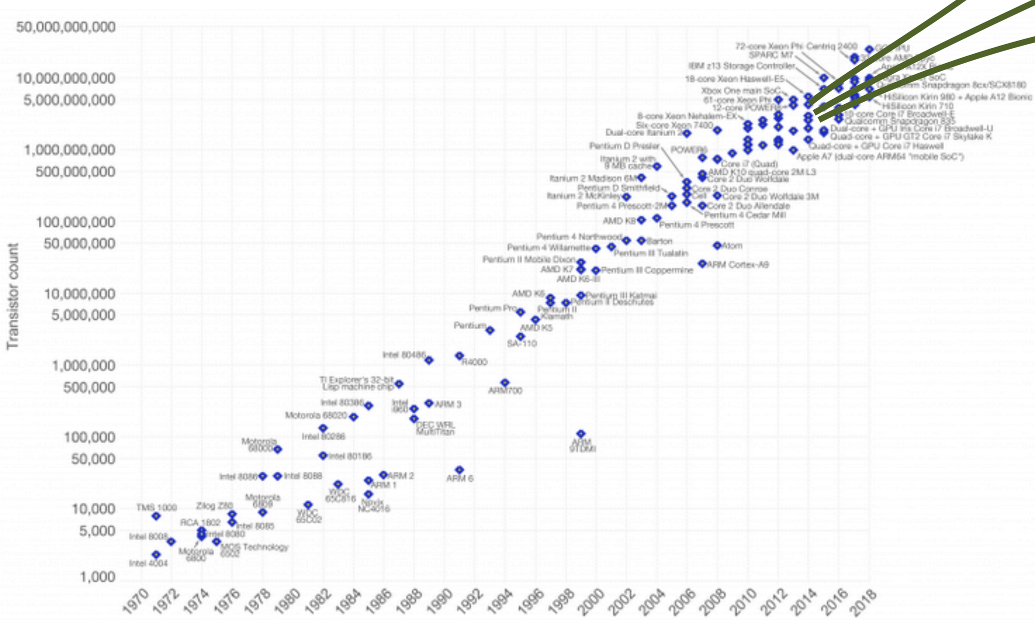
nanotechnologia,
memrystory
komputery kwantowe

nanotechnologia
grafen

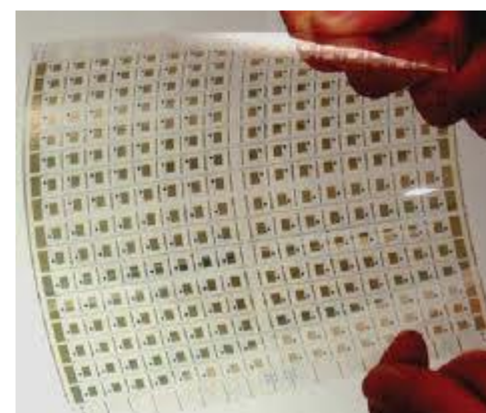


materiały organiczne

koniec prawa Moore'a



Źródło: Intel



TRENDY: Prawo Moore'a

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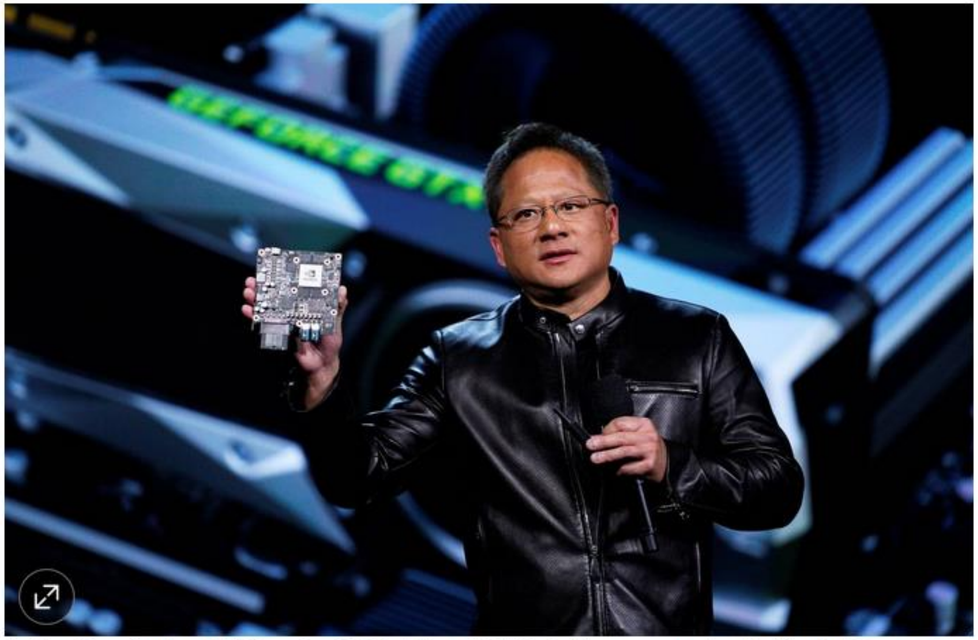
TECH | KEYWORDS

How Chip Designers Are Breaking Moore's Law

Microprocessors got smaller, faster and more power-efficient, but as they reach their physical limitations, chip architecture is driving performance gains



Jen-Hsun Huang, founder and chief executive of Nvidia, held up a Nvidia Xavier AI car supercomputer while delivering his January 4 keynote address at CES, the consumer electronics show in Las Vegas. *PHOTO: RICK WILKING/REUTERS*

By CHRISTOPHER MIMS

Updated March 19, 2017 11:54 a.m. ET

44 COMMENTS

Two of the biggest semiconductor companies made announcements last week that might

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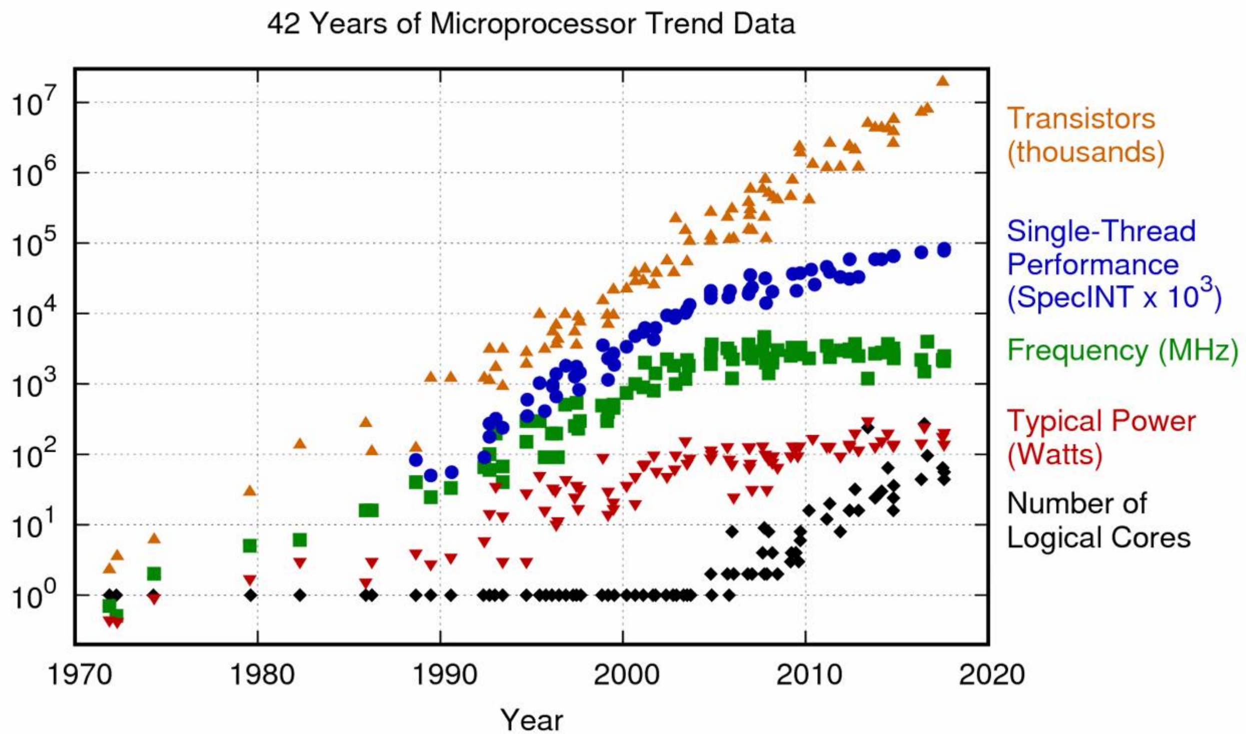
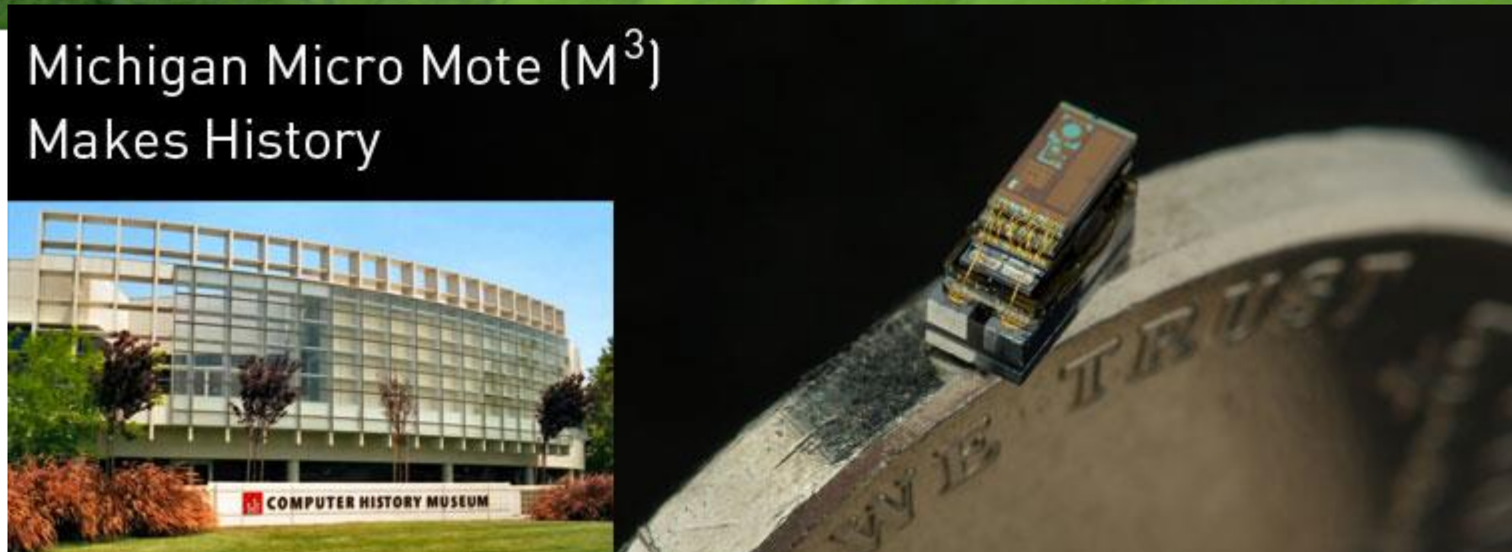
TRENDY: Prawo Moore’a

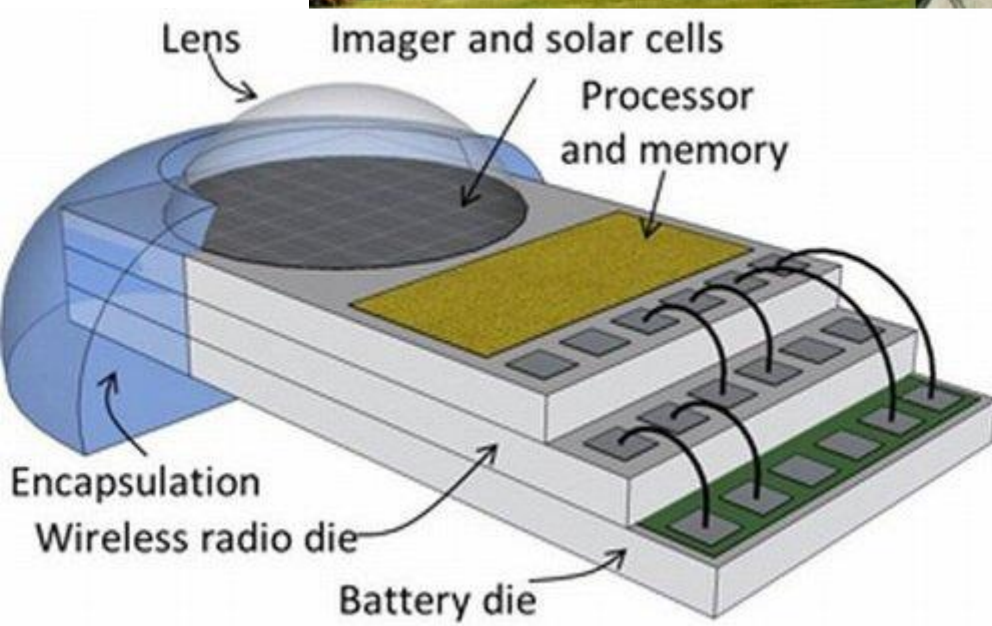
Breakdown of Dennard scaling

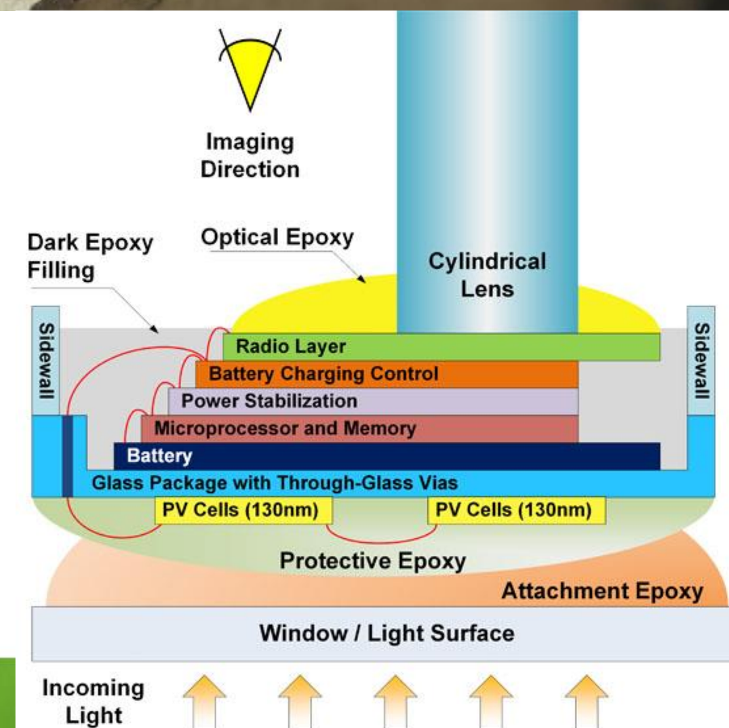


Original data up to the year 2010 collected and plotted by M. Horowitz, F. Labonte, O. Shacham, K. Olukotun, L. Hammond, and C. Batten
New plot and data collected for 2010-2017 by K. Rupp

TRENDY: Prawo Moore'a





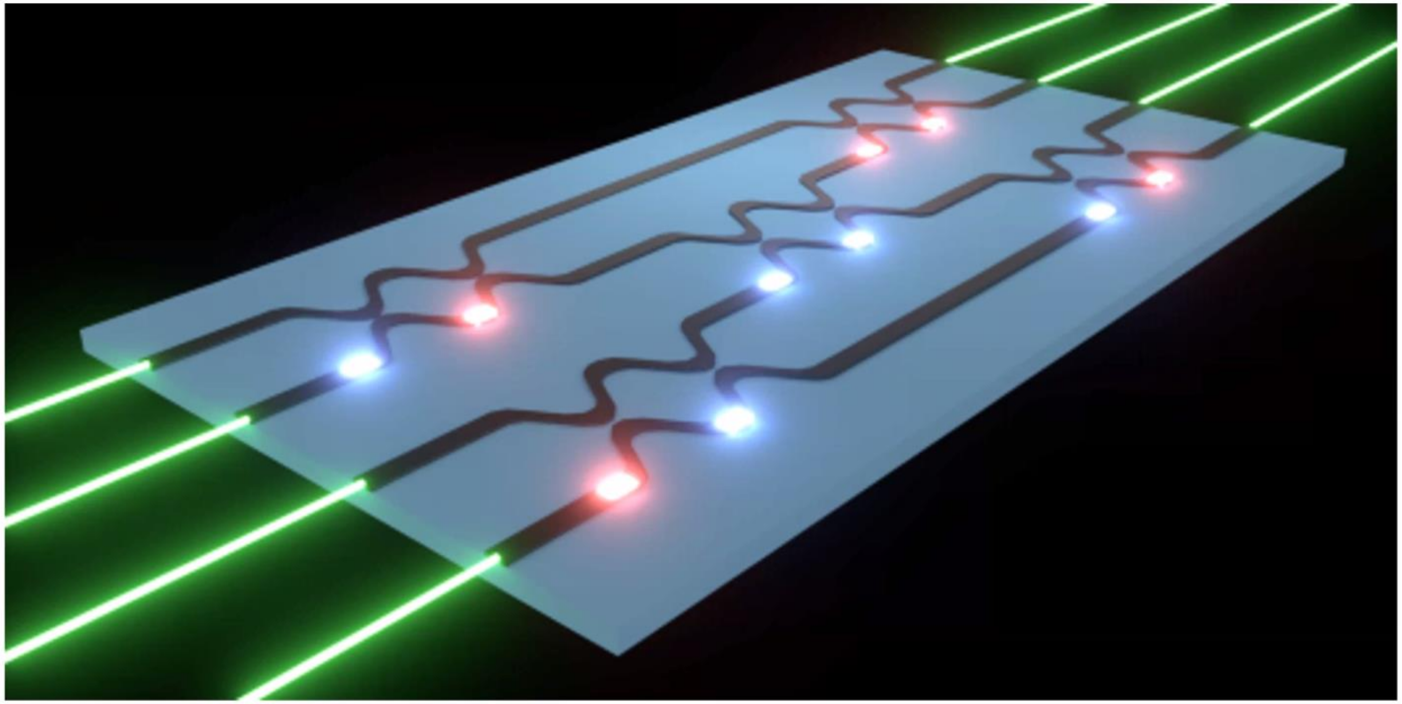


http://www.eecs.umich.edu/eecs/about/articles/2015/Worlds-Smallest-Computer-Michigan-Micro-Mote.html

TRENDY: Prawo Moore'a

IBM

Breakdown of Dennard scaling



Are optical transistors the logical next step?

David A. B. Miller NATURE PHOTONICS | VOL 4 | JANUARY 2010 |

2

Źródło: Intel

Obliczenia kwantowe

IBM Puts a Quantum Processor in the Cloud

By Rachel Courtland
Posted 4 May 2016 | 4:02 GMT

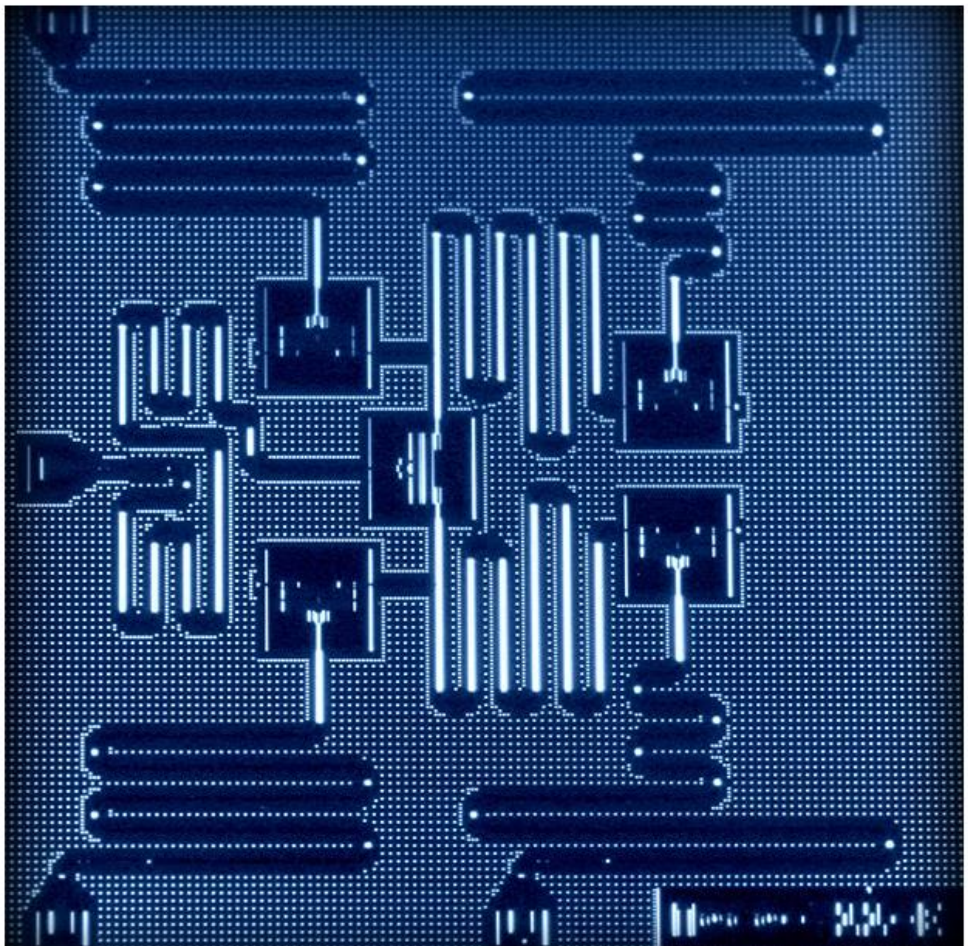


Photo: IBM Research

IBM Puts a Quantum Processor in the Cloud
By Rachel Courtland
Posted 4 May 2016 | 4:02 GMT
Photo: IBM Research

IBM announced today that it is making one of its superconducting quantum processors accessible over the Internet. Those itching to try out such hardware will be able to get hands-on experience through a new quantum computing platform—at least, the experience will be as hands-on as it can be with hardware sealed inside a remote dilution refrigerator and cooled to a fraction of a degree above absolute zero.

With just five qubits, the chip won't let you rapidly factor large numbers in order to break encryption. In fact, a classical simulation of this system takes less time to run, says Jay Gambetta, manager of the Theory of Quantum Computing and Information Group at IBM's Thomas J. Watson Research Center in Yorktown Heights, N.Y.
img
Photo: IBM Research
IBM is offering software that will let people run a five-qubit quantum processor from any computer or mobile device. Proximity to a dilution refrigerator not required.

But the goal of this tool, says Gambetta, "is to get people to start thinking quantum, to start thinking in terms of how a quantum computer works. Most people think quantum is hard or it's spooky or it's different. And yes it's different, but it's actually not hard."

http://spectrum.ieee.org/tech-talk/computing/hardware/ibm-puts-a-quantum-processor-in-the-cloud

CHIP NEWSY ARTYKUŁY TESTY RANKINGI TEMATY WIĘCEJ

CES 2018: IBM przywiózł do Las Vegas 50-kubitowy komputer kwantowy

Wintermute 10 stycznia 2018 5 komentarzy

Kwantowe maszyny przestają być tylko laboratoryjną, futurystyczną osobliwością. Najpierw Intel, a teraz IBM pokazują swoje urządzenia, oparte o tę nowoczesną i zapowiadaną od dawna technologię. Komputer skonstruowany przez IBM potrzebuje do pracy temperatury 10 milikelwinów.

Komputery kwantowe z klasycznymi komputerami łączy tylko jedno – nazwa. Pod względem konstrukcyjnym, zasady działania, architektury czy wreszcie wzornictwa to zupełnie inne urządzenia. Swój 49-kubitowy procesor kwantowy na Consumer Electronics Show pokazał już Intel – pisał o tym Jacek Tomczyk. Teraz IBM demonstruje nie tylko QPU (Quantum Processing Unit), ale cały komputer kwantowy.

CZYTAJ RÓWNIEŻ

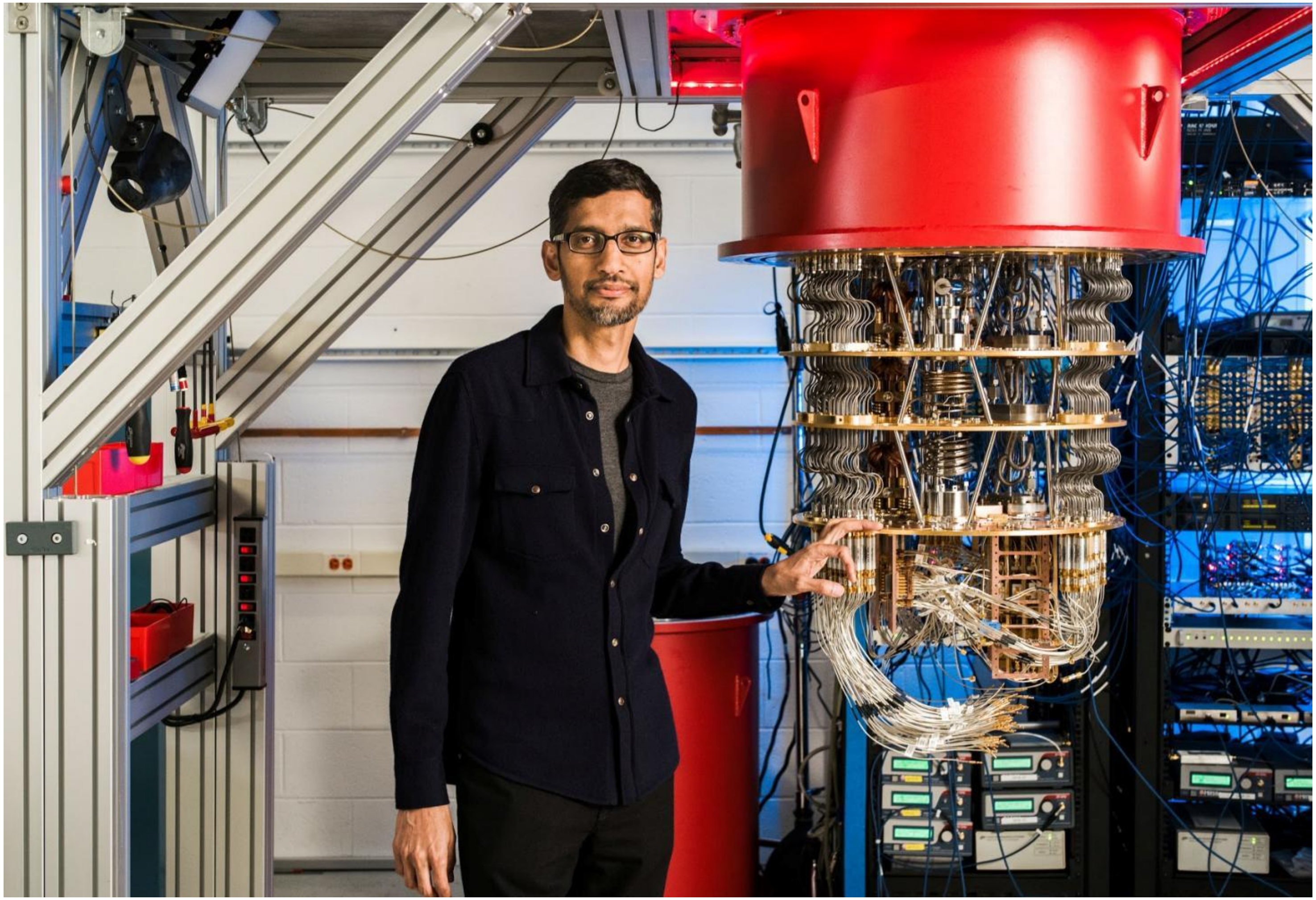
CES 2018: Razer Linda czyli smartfon, który zmienia się w laptopa

12

Ewakuacja Apple Store, straż pożarna, policja i karetki – z powodu baterii

http://www.chip.pl/2018/01/ces-2018-ibm-przywiozl-las-vegas-50-kubitowy-komputer-kwantowy/

Quantum supremacy



https://www.wired.com/story/alphabet-second-secretive-quantum-computing-team/

Quantum supremacy

Article

Quantum supremacy using a programmable superconducting processor

https://doi.org/10.1038/s41586-019-1666-5

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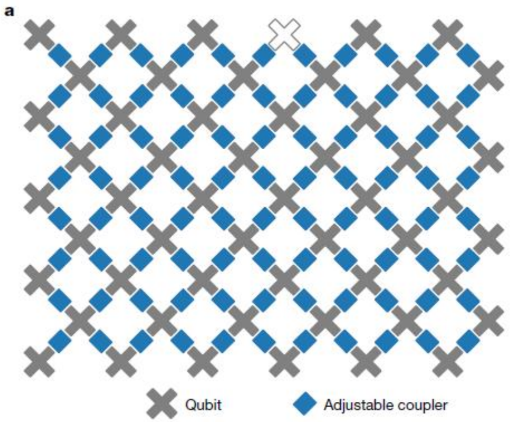
Frank Arute[1], Kunal Arya[1], Ryan Babbush[1], Dave Bacon[1], Joseph C. Bardin[1,2], Rami Barends[1], Rupak Biswas[3], Sergio Boixo[1], Fernando G. S. L. Brandao[1,4], David A. Buell[1], Brian Burkett[1], Yu Chen[1], Zijun Chen[1], Ben Chiaro[5], Roberto Collins[1], William Courtney[1], Andrew Dunsworth[1], Edward Farhi[1], Brooks Foxen[1,5], Austin Fowler[1], Craig Gidney[1], Marissa Giustina[1], Rob Graff[1], Keith Guerin[1], Steve Habegger[1], Matthew P. Harrigan[1], Michael J. Hartmann[1,6], Alan Ho[1], Markus Hoffmann[1], Trent Huang[1], Travis S. Humble[7], Sergei V. Isakov[1], Evan Jeffrey[1], Zhang Jiang[1], Dvir Kafri[1], Kostyantyn Kechedzhi[1], Julian Kelly[1], Paul V. Klimov[1], Sergey Knysh[1], Alexander Korotkov[1,8], Fedor Kostritsa[1], David Landhuis[1], Mike Lindmark[1], Erik Lucero[1], Dmitry Lyakh[9], Salvatore Mandrà[3,10], Jarrod R. McClean[1], Matthew McEwen[5], Anthony Megrant[1], Xiao Mi[1], Kristel Michielsen[11,12], Masoud Mohseni[1], Josh Mutus[1], Ofer Naaman[1], Matthew Neeley[1], Charles Neill[1], Murphy Yuezhen Niu[1], Eric Ostby[1], Andre Petukhov[1], John C. Platt[1], Chris Quintana[1], Eleanor G. Rieffel[3], Pedram Roushan[1], Nicholas C. Rubin[1], Daniel Sank[1], Kevin J. Satzinger[1], Vadim Smelyanskiy[1], Kevin J. Sung[1,13], Matthew D. Trevithick[1], Amit Vainsencher[1], Benjamin Villalonga[1,14], Theodore White[1], Z. Jamie Yao[1], Ping Yeh[1], Adam Zalcman[1], Hartmut Neven[1] & John M. Martinis[1,5]*



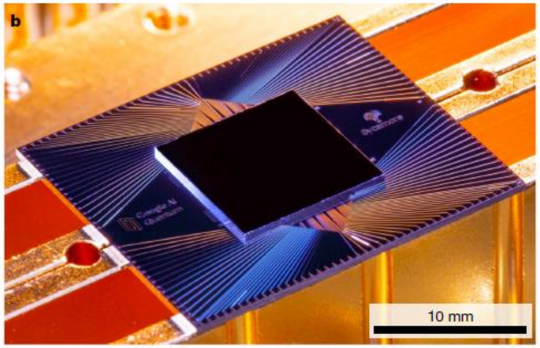


Fig. 1 | The Sycamore processor. a, Layout of processor, showing a rectangular array of 54 qubits (grey), each connected to its four nearest neighbours with couplers (blue). The inoperable qubit is outlined. **b**, Photograph of the Sycamore chip.

Nature **volume 574**, pages505–510(2019)

Jak TO działa?

- Przeprojektowanie CMOS (np. wertykalne, FIN, MOSFET z podwójną bramką)
- Urządzenia alternatywne (np. na pojedynczych elektronach)
- Urządzenia hybrydowe (np. FET z nanorurek)
- Nowe architektury (np. samonaprawiające się, defect-tolerance, automaty komórkowe)
- Zupełnie nowe architektury (np. komputery molekularne, komputery kwantowe)

Top-down ↓

Vincent Laforet/The New York Times

Galeria


Molecular Expressions: The Silicon Zoo - Mozilla Firefox
Plik Edycja Widok Przejdź Zakładki Narzędzia Pomoc
http://www.microscopy.fsu.edu/creatures/index.html
Idź
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Ever wonder what's lurking within the dark corners, nooks and crannies of your computer? Is some gremlin responsible for all those crashes---you know, the ones that happen when you are trying to save that critical document you've been working on so diligently for the past three hours? We wondered too, so we took a look to see what we could find. And guess what? When we put the computer chips under the microscope we found some very interesting creatures hiding there.
Our search has led to a new collection of photomicrographs (photographs taken through a microscope) featuring many of the interesting silicon creatures and other doodling scribbled onto integrated circuits by engineers when they were designing computer chip masks. The tiny creatures are far too small to be seen with the naked eye, so we have provided high-magnification photomicrographs to share these mysterious wonders with our visitors. Engineers designing modern computer chips have a very rich sense of humor as you will
MOLECULAR EXPRESSIONS: Exploring the World of Optics and Microscopy
Zakończono
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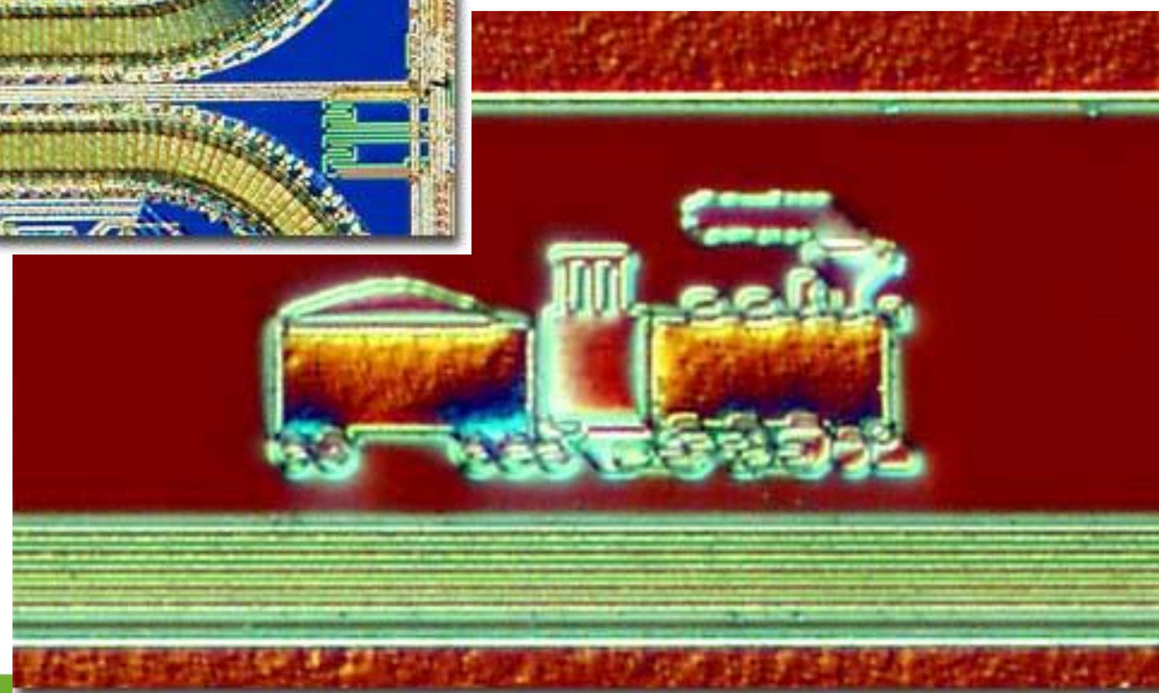
Galeria

Runaway Train

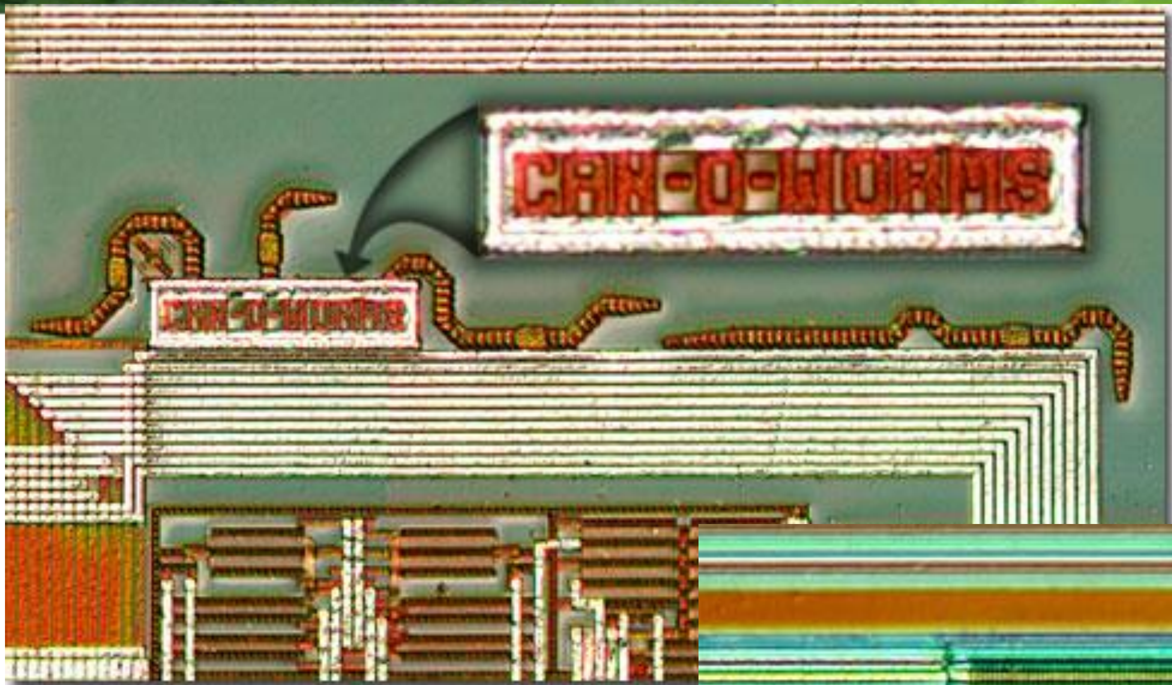
This miniature choo-choo train was discovered rolling down the tracks on a LeCroy MVV 200 analog shift register integrated circuit. The existence of the train was brought to our attention by John T. Anderson of JPS Designs located in Elburn, Illinois. The "tracks" upon which the train is apparently riding are the high speed shift register. This chip is based on Charge Coupled Device (**CCD**) technology, where analog samples of electrical charge are temporarily stored in the chevron-shaped tracks, and control signals create electrical fields that "bump" the charge along from segment to segment.

We ran into this miniature locomotive at a railroad crossing on an **Allen-Bradley/VLSI standalone ASIC** that was fabricated in 1994. Bob Weppler, designer of the train, has informed us that he placed the locomotive and coal car on the chip at the request of engineer Jerome Saint-Cyr to represent "the little engine that could". This was in reference to the fact that the chip has a small RISC core microprocessor allowing it to compete with its more advanced counterparts. Bob says that the locomotive was fabricated in two metal and one polysilicon layers during the chip's manufacturing process.

"The Little Engine That Could"



Galeria



We've Got Roaches

The term "computer bugs" arose earlier in the century when insects were discovered to be the cause of malfunctions in the relays used in very early computers. In some cases, the bugs would induce a short-circuit by getting caught in the mechanical relay contacts and would have to be removed manually. As progress would have it, we must now deal with silicon insects as evidenced by the photomicrograph of a roach that we captured scurrying across the surface of a Hewlett-Packard CPU support chip. So far, this is the only silicon bug we have found, but we're keeping our eyes peeled.
The photograph below contains a page from the 1945 logbook of the Mark I computer at Harvard University, one of the first computers ever built. Engineer Grace Murray Hopper and her associates were testing the Mark I one day when the machine suddenly stopped. Upon inspection, they found a fried moth that had become wedged into one of the relays, causing a short circuit and halting the computer. Hopper taped the bug into her logbook (illustrated below), and we have been referring to computer glitches as "bugs" ever since.

Can of worms

The can of worms illustrated in the digital image presented above is the creation of designer Greg Rohde, who placed the doodle on the Lattice Semiconductor Corporation's popular **ispPAC30** integrated circuit to symbolize the numerous problems encountered during the design. Often, these problems required one of the circuit engineers to "open up another can of worms" to solve design problems. The chip contains a total of four programmable gain instrumentation amplifiers, two multiplying digital-to-analog converters, and two configurable output amplifiers with rail-to-rail outputs. There are two additional doodles on the **ispPAC30** integrated circuit. One is a pack rat (general logo for the design team), while the other is a wolf silhouette, which is the signature of Reo Gargovich, the lead designer on this chip.

Galeria

Fine Print

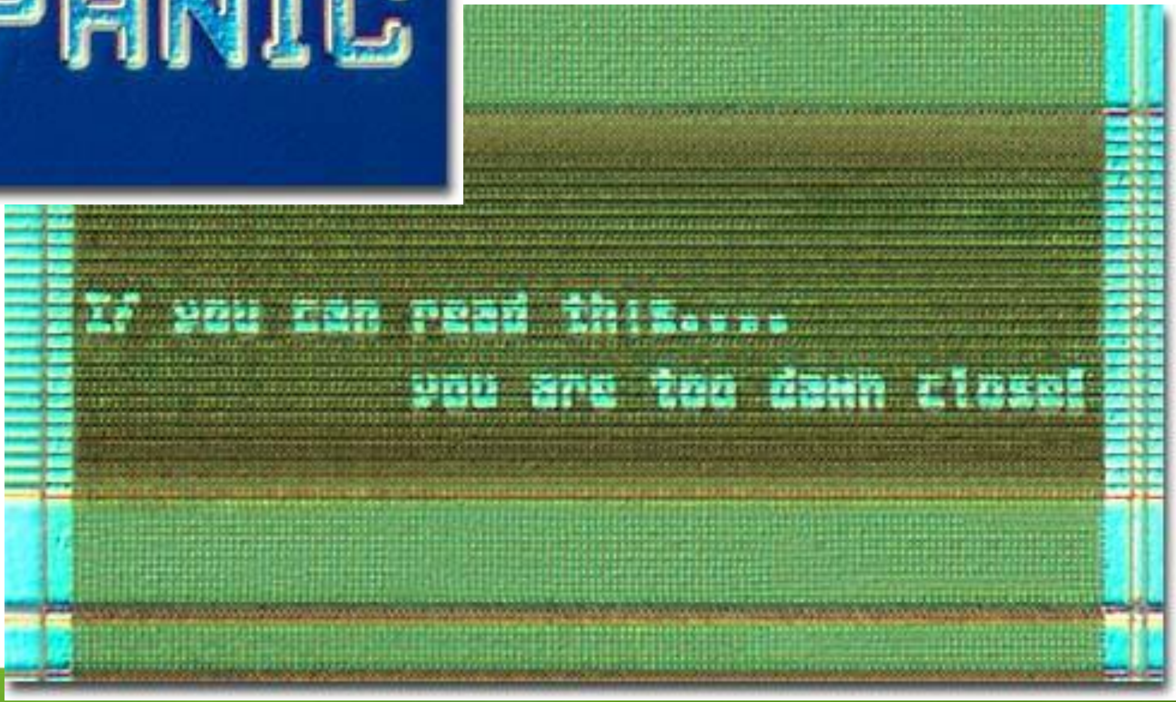
This is undoubtedly the most surprising doodle that we have ever discovered adorning the surface of an integrated circuit. Most people are used to seeing warranty disclaimers on everything from refrigerators to software, but this is the first one we have encountered on a silicon chip. Our hieroglyphics experts have not yet deciphered the entire body of text, but the phrases "No purchase necessary", "Keep away from fire", and "not for resale" are clearly visible in the magnified portion shown as an inset within the photomicrograph. The pad containing this warranty is 450 microns tall by 1850 microns wide and sports 25 lines of text, with each character being between six and eight microns high. This disclaimer--probably the smallest ever written--was found on a Hewlett-Packard "Aspen" (**A**cquisition **S**ignal **P**rocessing **EN**gine) chip used in digital oscilloscopes in the late 1980s and early 1990s.

Galeria

Don't Panic

We stumbled across this 5 micron-high phrase while examining the surface of a Hewlett-Packard **Pit Viper** memory controller chip. As the saying goes: If you can read this....you are too damn close! When we saw it, we backed off a little bit, took the photograph, then split (we don't have to be warned twice).

Too Damn Close!



Don't Panic - when uncertain about your whereabouts in the Universe or the strange customs of new aliens that might cross your path. Just consult your guidebook: "The Hitchhiker's Guide to the Galaxy", where you will find that the number 42 is the answer to the question about life and the universe. Or so says a supercomputer named "Deep Thought". We've been stuck on planet Earth these past few decades so our information about the phenomenon is incomplete.

These science fiction symbols were discovered on a node adapter chip that serves as an interface between a remote I/O link and a microprocessor-based product, developed by Allen-Bradley/Rockwell in 1988. Chip designer Bob Weppler tells us that these icons from the famous Douglas Adams sci-fi novel were included on the chip along with the **cricket wicket** and a **Sperm whale** that slammed into the planet Magrathea.

Galeria

This Bird's For You

This is a very high magnification view of what appears to be a hummingbird etched into the silicon on a Hewlett-Packard PA-RISC 7000-series microprocessor wafer. The inscription above the bird reads: "This Bird's For You", but we don't think that it is for us. We think that it is for you.

Galeria

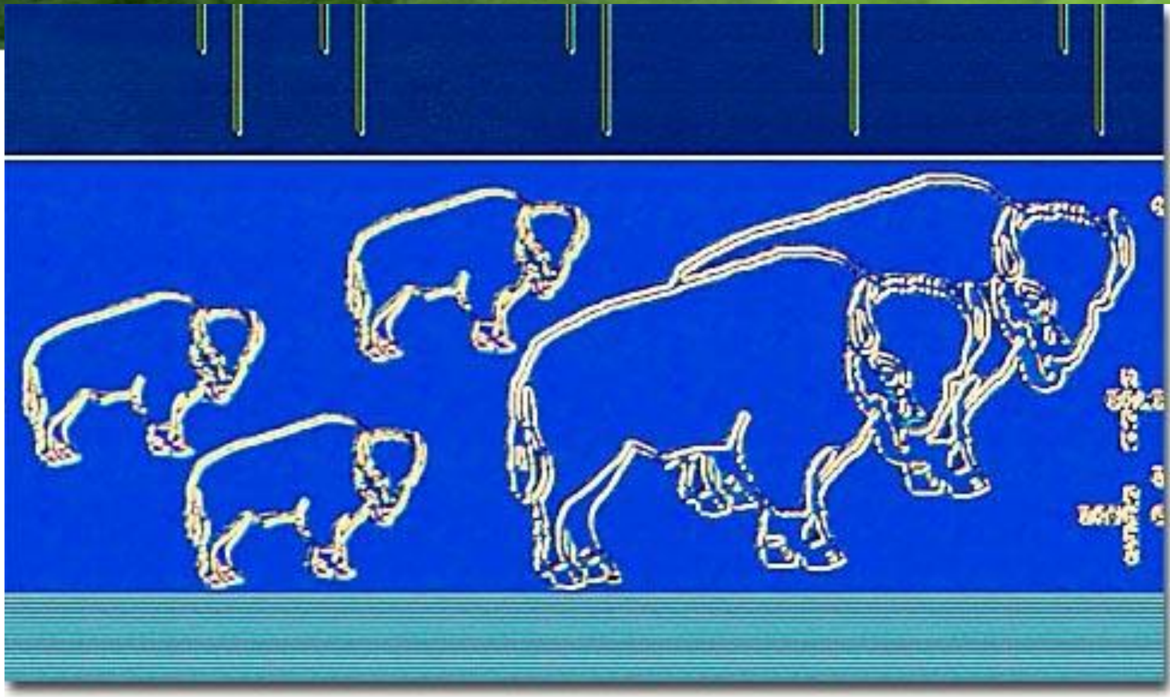
Thor: God of Thunder

This magnificent rendition of Thor, the Norse god of thunder, was discovered on a Hewlett-Packard graphics support chip. According to legend, Thor was the son of Odin and Jord and later married Sif (a fertility goddess), although he kept a mistress named Jarnsaxa (the "iron cutlass"). It was also widely believed that during a thunderstorm, Thor could be found sailing through the heavens on his goat-powered chariot, and that lightning flashed whenever he threw his hammer (named Mjollnir).

At 1.1 square millimeters in size, this silicon artwork is not only the finest we have seen to date, it is also one of the largest and required our lowest-power microscope objective (5x) to capture the entire image. Hewlett-Packard engineer Rick Butler loaned us this chip, along with the **marathon** chip that contains a tennis shoe. Rick was also instrumental in providing us with information about the "sunken via" method of creating these doodles as revealed in our interactive Java tutorial on building a silicon **Yin Yang**, and other general discussions about silicon artwork.

Hewlett-Packard chip designer Darrin Miller originally decided to incorporate the Thor rendition on this chip. He asked graphics designer April Comer to draw the Viking and she produced four ideas about how the god could appear. Darrin picked one and turned it into a contact "bitmap" for placement on the final masks, yielding the image presented above. It is somewhat ironic that both Darrin and April are graduates of the University of Florida, our in-state football rivals.

Galeria



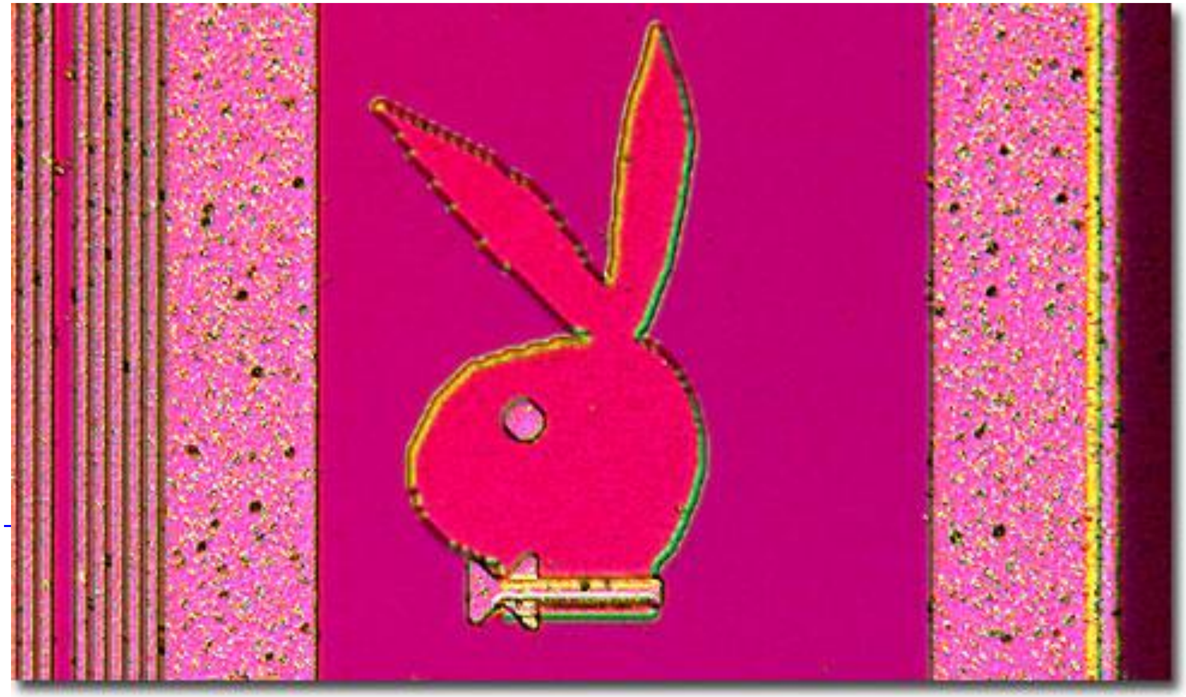
We found a herd of buffalo (well, a small herd anyway) on this Hewlett-Packard 64-bit combinatorial divider, the Focus II Math chip. We don't know the significance of these bison-like silicon creatures, but they are some of the coolest buffalo that we have seen. One suggestion about the buffalo, which we feel is worth mentioning, was brought to our attention by Travis Thomas of Austin, Texas. Travis is under the opinion that the significance of the bison is to denote "buffalo chips", of which these are certainly one form. In fact, Travis' suggestion led us to change the title of this gallery entry.
The herd of buffalo was devised and executed onto the chip by HP engineer Dick Vlach, who tells us that the buffalo are dividing and leaving chips behind. John Carlson was the chief design engineer for this chip, and Dan Zuras is responsible for the **crossword puzzle** of designers' names that appears directly to the right of the buffalo (only a small portion of the puzzle is visible in this photomicrograph). This chip was designed by the Fort Collins, Colorado HP chip design team and the buffalo are a mascot of the nearby school, the University of Colorado.

I Love Hewlett-Packard

We discovered this tiny heart on the Hewlett-Packard **buffalo chip** loaned to us by Jon Singer of the Joss Research Institute. It looks like the chip designers had a thing for Hewlett-Packard.

Galeria

Playboy Bunny



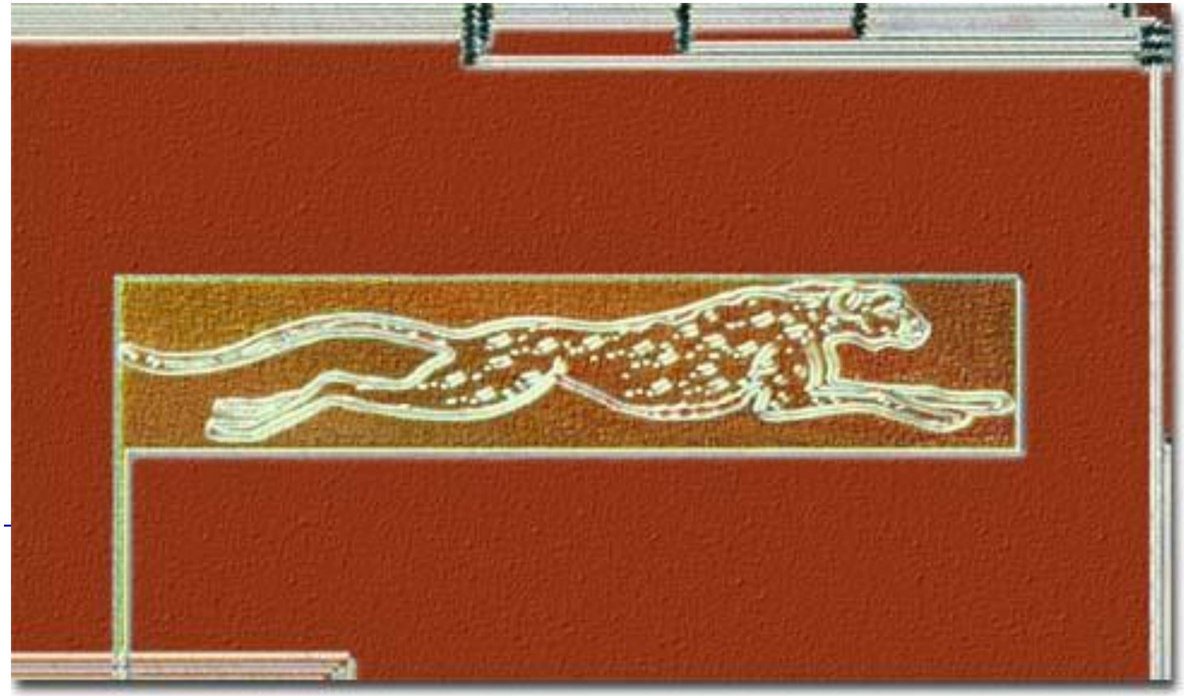
One of America's favorite icons, the Playboy bunny, was discovered on an integrated circuit made in Germany by Siemens. The bunny rabbit head logo was originally designed by Art Paul, the first art director of Playboy Magazine, and has appeared on the cover of every issue (with the exception of the very first). Hugh Hefner, creator of the concept is quoted**:**

"I selected a rabbit as the symbol for the magazine because.... he offered an image that was frisky and playful. I put him in a tuxedo to add the idea of sophistication. There was another editorial consideration, too. Since both the '*New Yorker*' and '*Esquire*' use men as their symbols, I felt the rabbit would be distinctive; and the notion of a rabbit dressed up in formal evening attire struck me as charming, amusing, and right."

The integrated circuit was donated to the Silicon Zoo by German photographer Karl E. Deckart, who is one of our featured microscopists. To view more of Karl's work, visit his **Mikro/Makro** website, which contains a sampler of his transmitted and reflected light images captured with a microscope.

Galeria

The Cheetah



We captured this beautiful cheetah racing across the surface of a Hewlett-Packard memory controller integrated circuit. The chip was designed in combination with a very early HP-PA microprocessor that was code named Cheetah and used in the HP-900/750/755 series computers. Cupertino engineer Willy McAllister originally found the image on the cover of the September 1986 IEEE Computer magazine and asked his wife, Monica (a graphics artist), to redraw the image for placement on the chip. The redrawn cheetah was digitized by Dick Vlach, one of HP's top mask designers, and incorporated into the mask--and subsequently onto silicon.

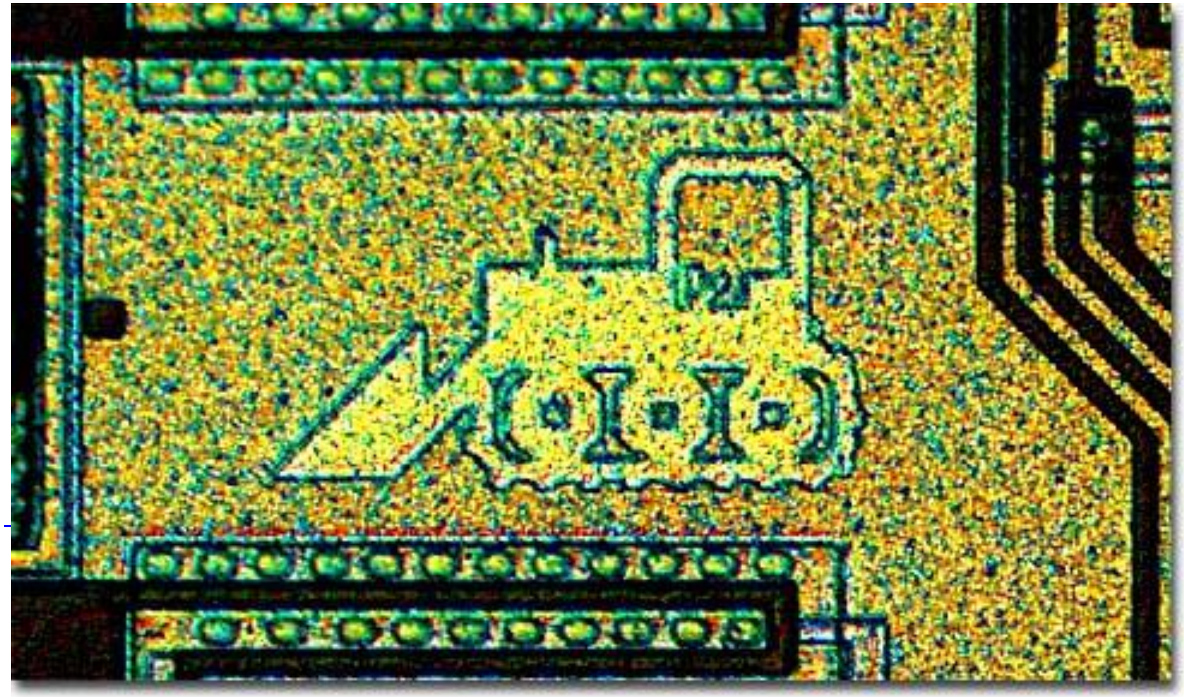
Galeria

The Chip Smurf

We caught this silicon Smurf pulling a wagon containing the copyright symbol around the pad ring on a Siemens integrated circuit of unknown function (the M879-A3). Like other Smurfs, this figurine was originally created by Belgian cartoonist Pierre Culliford (also known as Peyo), and introduced into the United States in the late 1970s. In the early 1980s, the Smurf culture exploded when the National Broadcasting Company (NBC) launched a cartoon series featuring the tiny creatures. Smurfs typically are blue, wear white hats, and stand three apples high. This guy goes against the grain with his orange skin and yellow hat. In addition, he is only about 60 micrometers high, more than 1000 times smaller than a single apple.
The photomicrograph was donated to the Silicon Zoo by German photographer Karl E. Deckart, who is one of our featured microscopists. To view more of Karl's work, visit his **Mikro/Makro** website, which contains a sampler of his transmitted and reflected light images captured with a microscope.

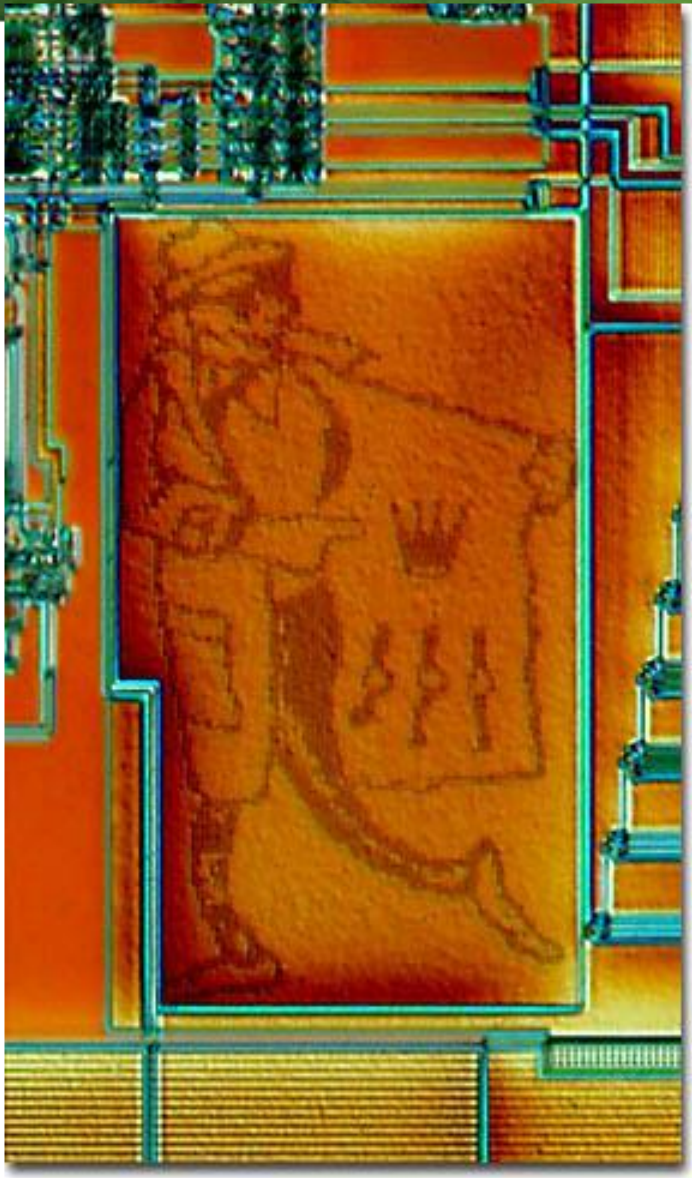
Galeria

Caterpillar Bulldozer



This miniature rendition of a bulldozer appears on a NMOS digital chip designed in 1980 for Caterpillar by Synertek for use in their heavy equipment Electronic Monitoring Systems. The integrated circuit is still used in many models of Caterpillar construction equipment, including bulldozers. We suspect that the bulldozer is busy clearing space on the chip for additional transistors. The chip was loaned to us by Chuck A. Morrill, a Semiconductor Component Engineer who conducts failure analysis testing and sourcing of chips for electronic controls at Caterpillar. Now, ain't this slick?

Galeria



The Con Artist

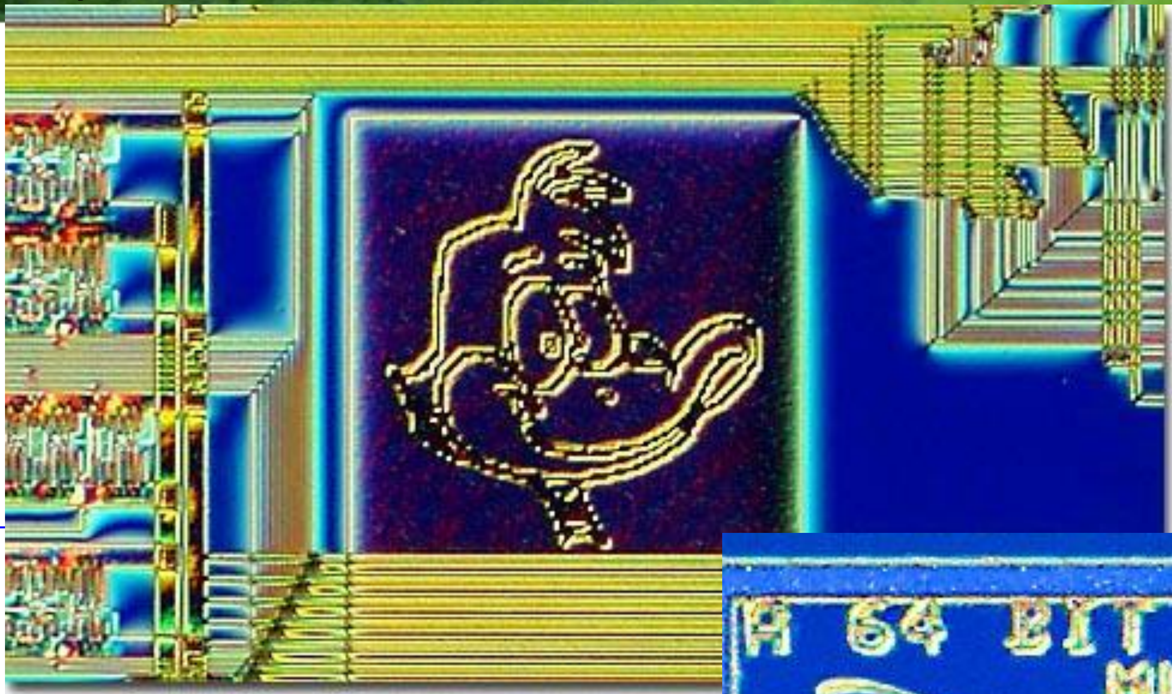
We found this interesting creature on the Hewlett-Packard superscalar PA-RISC 7100LC Hummingbird microprocessor chip not far from the hummingbird (you know---the one that is for you). The guy with the sunglasses appears to be showing a number of items, including some (probably) "hot" watches, inside his trench coat. From the crown advertisement on the inside of his coat, we think that this guy expects us to believe they are genuine Rolex watches. Although we don't understand the significance of this scam artist or whom he expects to con while lurking around on this chip, he is one of our most unusual busts to date. It's characters like this that lead us to suspect that a secret cartoon culture is being perpetuated on hidden silicon.

Several emails from HP engineers Patrick Knebel, Wayne Kever, Craig Robson, and Bob Miller have cleared up the mystery of this con artist. Early HP chipsets included a separate floating-point math coprocessor, and the HP-9000/720 workstations used a Texas Instruments chip that was termed the "Timex" coprocessor. In later microprocessors, HP integrated the floating-point unit onto the CPU die. The PA-7100 microprocessor contains the "Rolex" floating-point circuitry integrated onto the chip, and this advanced circuitry features greater performance than the Timex coprocessor. The clock circuitry was later redesigned to save space (modestly reducing double-precision performance) on the PA-7100LC (Low Cost) processor and the floating point array was then nicknamed "Lorex", a pun on the low-end Rolex. The con artist (designed by HP VLSI design engineer Bob Miller) was placed on the PA-7100LC with a modified Rolex crown that is missing a point (it only has four), to symbolize the cheap Rolex knock-offs, "Lorexes" that he is apparently trying to pawn.

Another interesting feature of the con artist is the unusual way this creature was created on the chip. The vast majority of silicon creatures are created as "wireframe" metal layers on a silicon dioxide surface. The con artist was constructed in a series of small squares, much like a bitmap image. The technique using these small squares is the safest technique that engineers have for patterning these miniature doodlings. The actual squares are really contacts (voids where a hole is produced in the dielectric medium) between two metal layers and appear as a series of slight dents in the surface of the chip. This is demonstrated with our **Yin Yang interactive Java tutorial** that illustrates how these doodles are formed on the surface of an integrated circuit.

Galeria

Daffy Duck



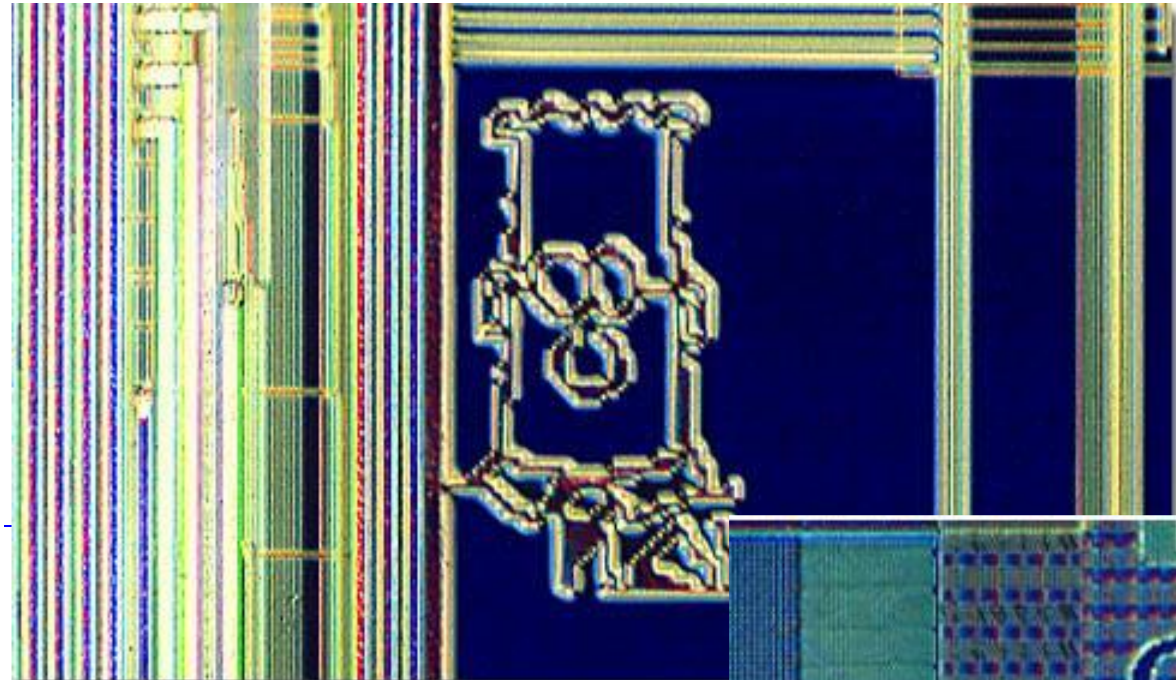
As we see it, the engineers that designed this wireframe version of Daffy Duck must have had a very interesting sense of humor. We found it deeply embedded within the circuitry of a RISC microprocessor, about 1500 microns away from a similar-style rendition of Waldo. Daffy is about 50 microns in size, making it necessary to use a high-power (40X to 60X) microscope objective to photograph the wireframe character.

The Road Runner Show, a 30-minute cartoon series, premiered on the CBS television network on September 10, 1966. The episodes featured three cartoons, one with the Road Runner and Wile E. Coyote (whom we have never found on a chip), and two with other Warner Brothers cartoon characters. The Road Runner cartoons featured humorous scenarios in which the Road Runner would out-smart the rather dumb coyote and usually cause him serious cartoon injuries. We found this version of the Road Runner on a Hewlett-Packard 64-bit combinatorial multiplier integrated circuit. The major design credit is given to Dan Zuras, whose name appears just below the Road Runner.

The Road Runner

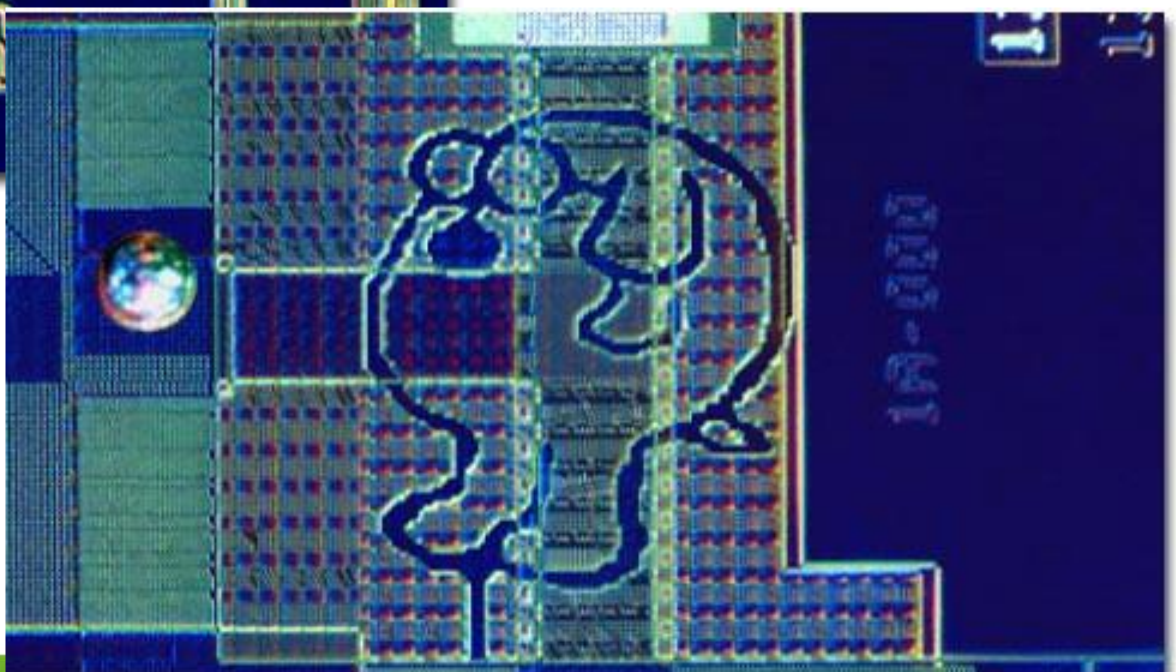
Galeria

Dilbert



From the Scott Adams cartoon strip, we present this photomicrograph of cyber-engineer Dilbert, caught hiding from his omnipresent boss within the circuitry of a computer chip. Dilbert, voted by his high school classmates as "Most likely to find a potato that resembles himself", is one of our favorite cartoon characters.

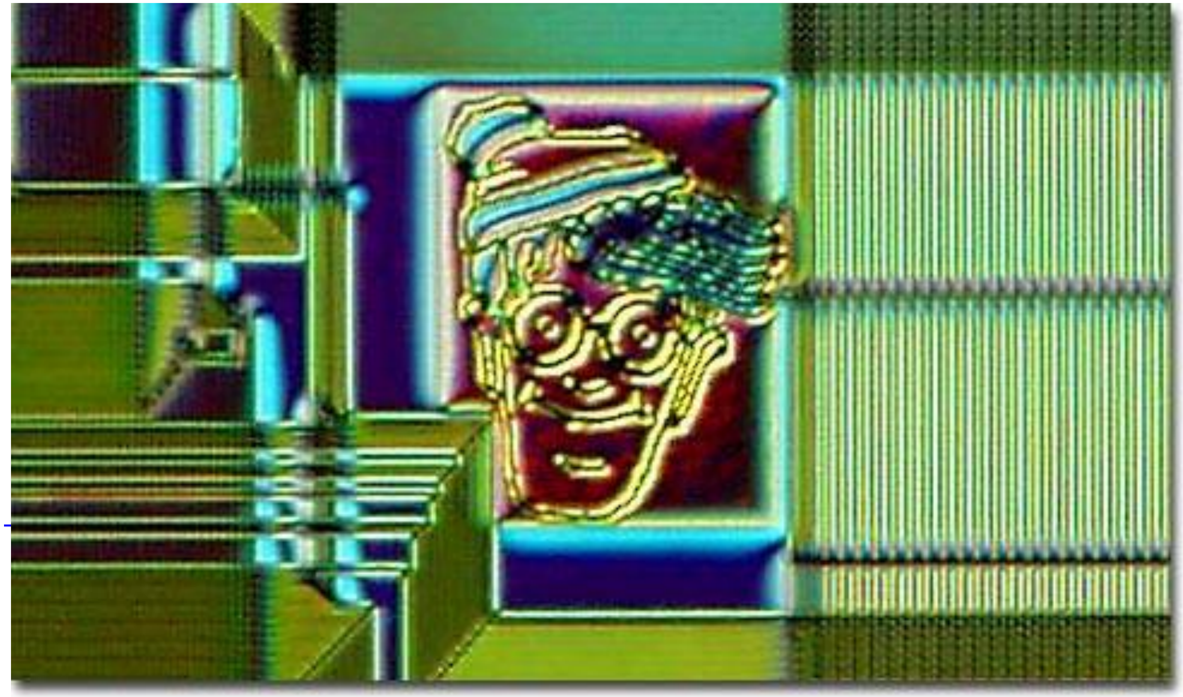
Dogbert



One of today's most popular cartoon strips is **Dilbert**, written by Scott Adams and syndicated by every major newspaper in the United States. We have found two of the main characters in this comic strip, Dilbert and Dogbert, on the two biggest and fastest microprocessors in our collection. This silicon version of the Dogbert character, as illustrated above, is about 140 microns in size.

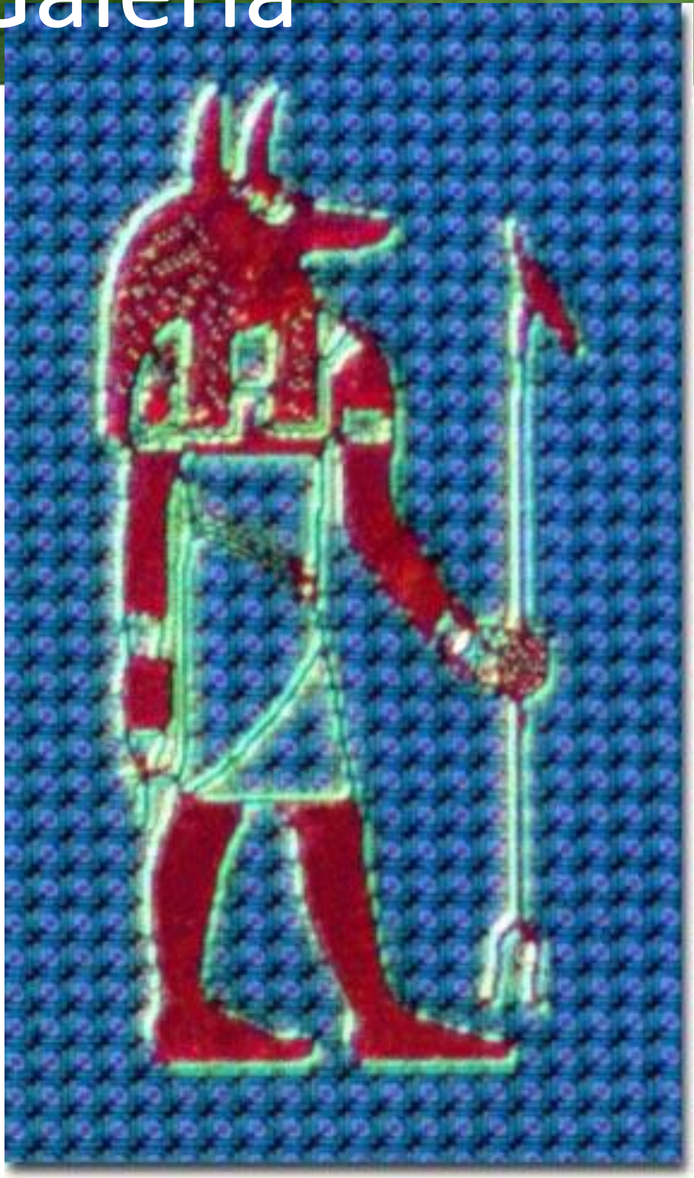
Galeria

Where's Waldo?



Just about everyone we know has spent time searching for Waldo in the comic strips (and we have too!). The photomicrograph above illustrates a wireframe rendition of Waldo that we found hiding on the surface of a microprocessor integrated circuit. Discovering this version of Waldo proved to be much more difficult than the one in the comics. When searching the Sunday comic strip, you have to screen several hundred faces to find the real Waldo hiding, usually in a crowd, behind a building or in a corner. We caught this silicon version of Waldo (that is about 30 microns in size) hiding among caches, buses, and registers while searching through many thousands of square microns of complex circuitry with a high-power optical microscope. Waldo is the first Silicon Creature that we discovered, and this led to an exhaustive search for more creatures and construction of the Silicon Zoo gallery.

Galeria



Ancient Egyptian God Anubis

While examining the Silicon Graphics MIPS R12000 microprocessor, we found a pair of Egyptian gods that appear to be guarding mask alignment targets on the chip. The photomicrograph above depicts one of the figures who we think is a representation of Anubis, a Jackal-headed Egyptian god who was in charge of embalming and mummification of the royal deceased. This creature is about 100 microns high.

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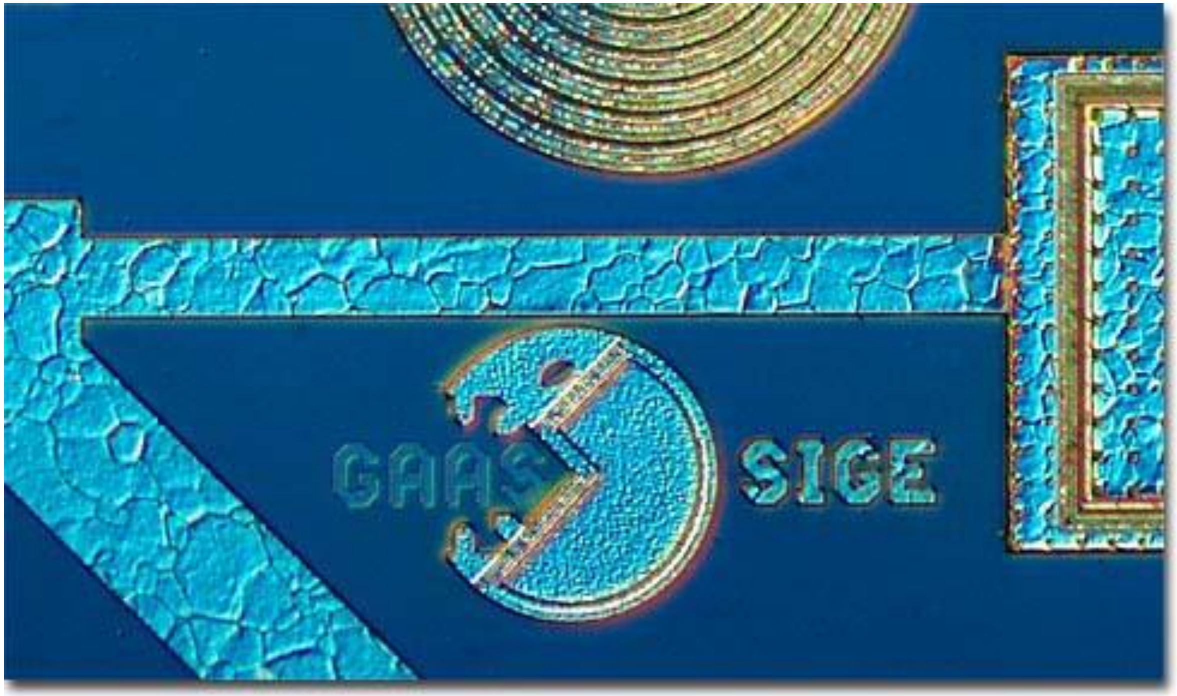
http://www.microscopy.fsu.edu/creatures/index.html

Galeria

Pac-Man



We spotted this silicon Pac-Man gobbling the initials GAAS (gallium arsenide) on a TEMIC Semiconductors silicon-germanium radio frequency integrated circuit. This chip is the first Digital Enhanced Cordless Telecommunications (DECT) device produced with silicon-germanium technology, replacing the usual gallium arsenide power amplifier devices normally used in DECT applications. Similar devices made using gallium arsenide are expensive and normally require a negative auxiliary voltage. We assume the Pac-Man silicon icon was planted on the chip as a symbolic gesture to the fact that devices made with silicon-germanium are poised to "eat up" the gallium arsenide-based competition.

Pac-Man was originally designed by Toru Iwantani and programmed by Hideyuki Mokajima and his associates. The name Pac-Man is derived from the Japanese slang "**Paku-paku**", which means "**to eat**". Originally, the Japanese named the game "**Puckman**", but it was changed to "**Pac-Man**" upon launching in the United States. Pac-Man is the best-selling video arcade game in history, and the yellow gobbling Pac is probably the most recognized video character. The game has spawned a number of side products including cartoons, lunch boxes, board games, clothing, and numerous other products.

The chip containing this artwork was loaned to us by **Chipworks**, a company that is an international provider of reverse engineering services, analyzing the circuitry and physical composition of semiconductor chips and electronics systems for competitive study, intellectual property support, and reliability assurance.

Galeria

The Pepsi Generation

Do you remember when a bottle of Pepsi cost a nickel? We can't either, so we did a little research to find out the approximate date of what is undoubtedly the smallest advertising sign yet created (the silicon rendition featured above--about 750 microns wide). Pepsi-Cola was first introduced as a fountain drink in 1898, prior to the widespread use of bottled soft drinks. A few years later, Caleb Bradham began bottling Pepsi in a plant located in New Bern, North Carolina. After the great depression, advertising emphasis was shifted to low cost and high product value. In 1934, Pepsi-Cola became the first soft drink manufacturer to replace the popular six-ounce bottle with a 12 ounce bottle for a nickel. This was widely advertised in signage of the period, as illustrated with the authentic reproduction done in silicon above. We found this sign on a Hewlett-Packard CPU-support integrated circuit. The arrow, difficult to read at this magnification, contains the text: "Look for the Trade Mark", and the bottom of the label reads: "Healthful" (thank god the FDA wasn't around!) and "Refreshing".

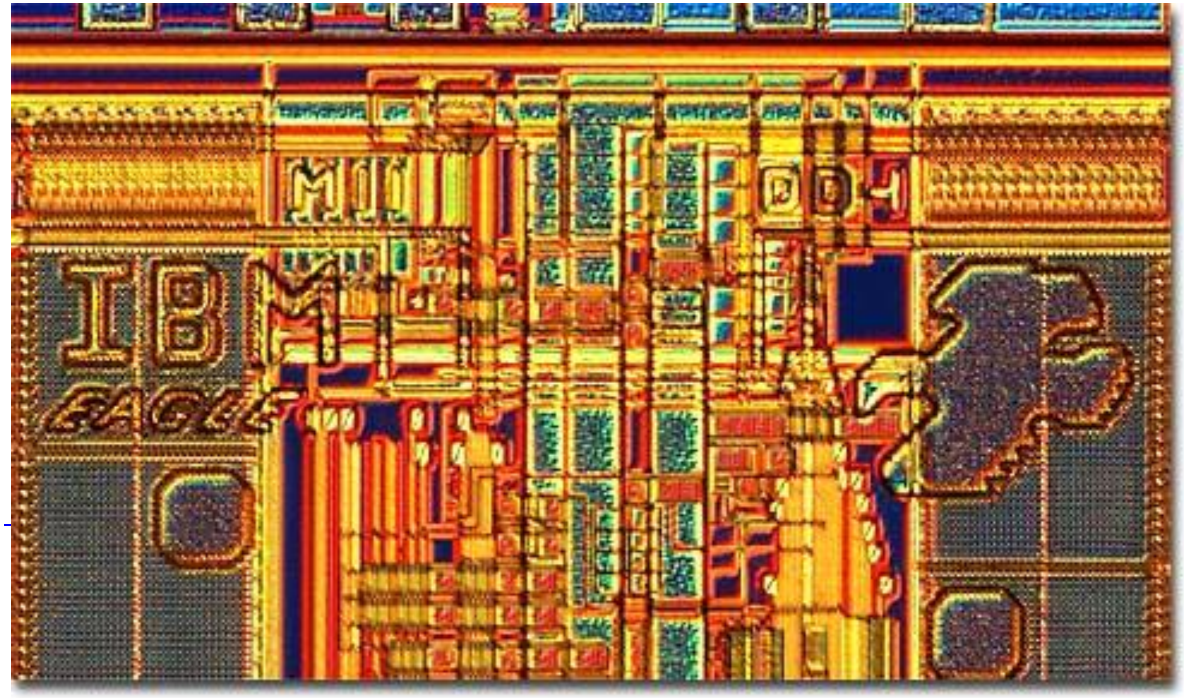
The Hewlett-Packard integrated circuit featuring this tiny silicon rendition of a Pepsi commercial was donated to us by HP chip designer Craig Robson, who designed the artwork.

This incredible rendition of a Rolex wristwatch was discovered nested within the clock circuitry of a Hewlett-Packard PA-7100 microprocessor, the chip code named ***Thunderbird*** that also contains **The Bird is the Word** entry in the Silicon Zoo. The Rolex is another example of the ingenious **Sunken Via** method of constructing doodles using a bitmap of via shafts developed by HP chip designers in Fort Collins, Colorado. This method of constructing silicon creatures is based on the formation of images through patterns (a series of tiny squares), much like bitmap images are composed of a series of pixels, where each covered via shaft represents an individual pixel. The Rolex is made with over 5000 individual via shafts. Other entries in the gallery constructed in the same manner include: **The Con Artist**, **This Bird's For You**, **The Sundial**, and **The Thunderbird**. Additional information about the evolution of silicon doodles within HP microprocessor clock circuitry can be found in text accompanying the **Con Artist** gallery entry.

The Rolex

Galeria

BM Eagle



We were notified about the existence of this eagle by John Deters, who loaned us a copy of the chip for digital imaging through the microscope. The artwork was placed on a very early version of a 1 Mb memory chip made by IBM in the mid-1980s. Because the integrated circuit used older 256 Kb technology, it was larger and slower than later 1 Mb chip designs. However, the chip was a significant cost improvement over existing 256 Kb chips of the period and enabled IBM to compete more effectively with Japanese 64 Kb chips that were selling at 1/20th the cost. Featured on the chip is the image of a bald eagle (designed by engineer Scott Lewis), which overlaps into a cache region of the chip. Also present, on the left-hand side of the image, are the letters IBM and the designation "Eagle", which is probably the code-name for this random access memory integrated circuit.

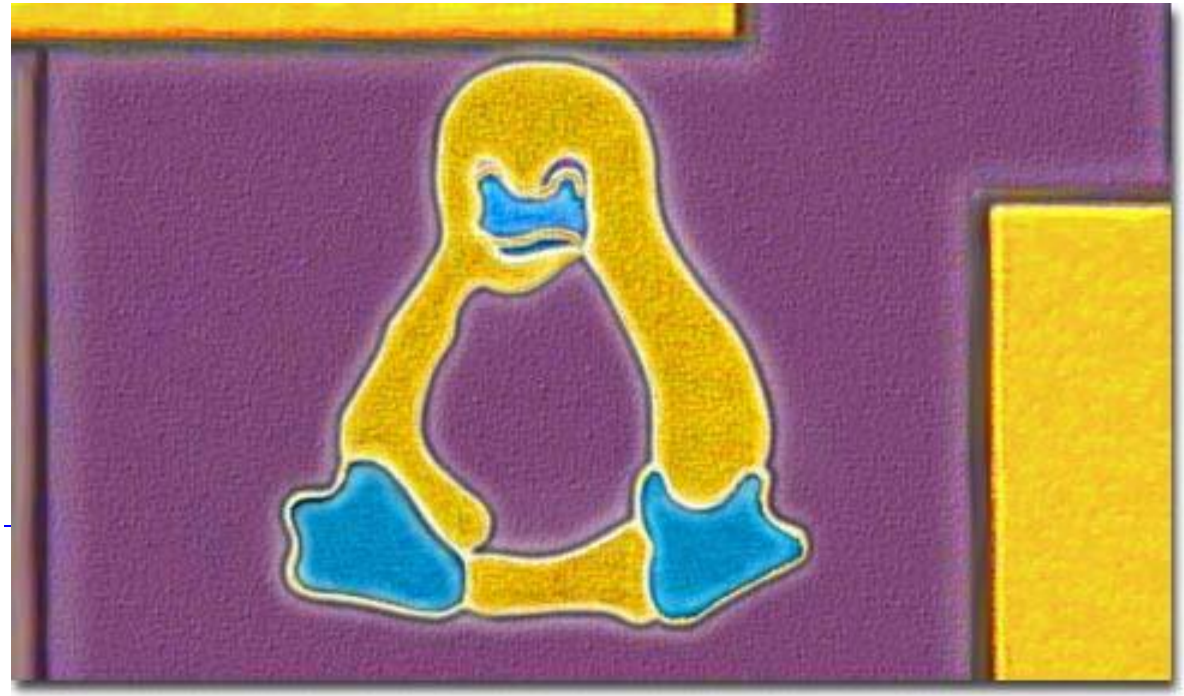
Galeria

Jumping Canine

We discovered this somersaulting canine on a Digital VAX microprocessor support chip loaned to us by designer Bob Supnik. There appears to be clumps of silicon "grass" below the dog and he seems to be having a good time (probably happy that this chip design finally made it into silicon).

Galeria

Tux, the Linux Penguin



A chip designer informed us of a miniature replica of Tux, the Linux penguin nesting in the pad ring of an integrated circuit of unknown type and function. If we obtain more information about the chip, it will be posted (maybe it's a special microprocessor that is optimized for the operating system). Linus Torvalds, creator of the Linux operating system, was the one who originally had the idea for a penguin as the Linux logo "center"piece. The cute little penguin rendition illustrated above measures about 130 microns in size.

Galeria

The Wedding Announcement

This unusual wedding announcement appears on the Silicon Graphics MIPS R10000 microprocessor. The inscription reads: Ellen & Yeuk-Hai, May 25, 1996 and we are told that the announcement is for the wedding of a MIPS design engineer who supervised the development of masks for this microprocessor. The size of the announcement is approximately 100 microns. We were given a copy of the original photograph (courtesy of Yeuk-Hai Shark Mok) from which the wedding announcement was derived, and this is displayed below for comparison purposes.

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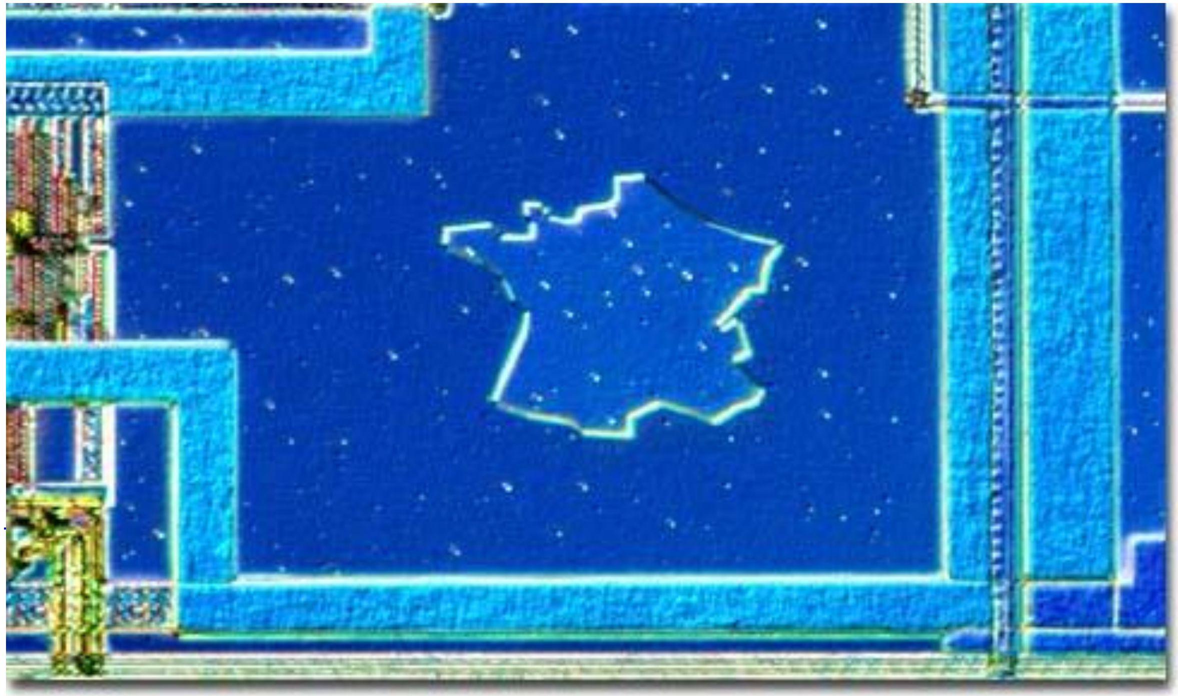
http://www.microscopy.fsu.edu/creatures/index.html

Galeria

French Silicon

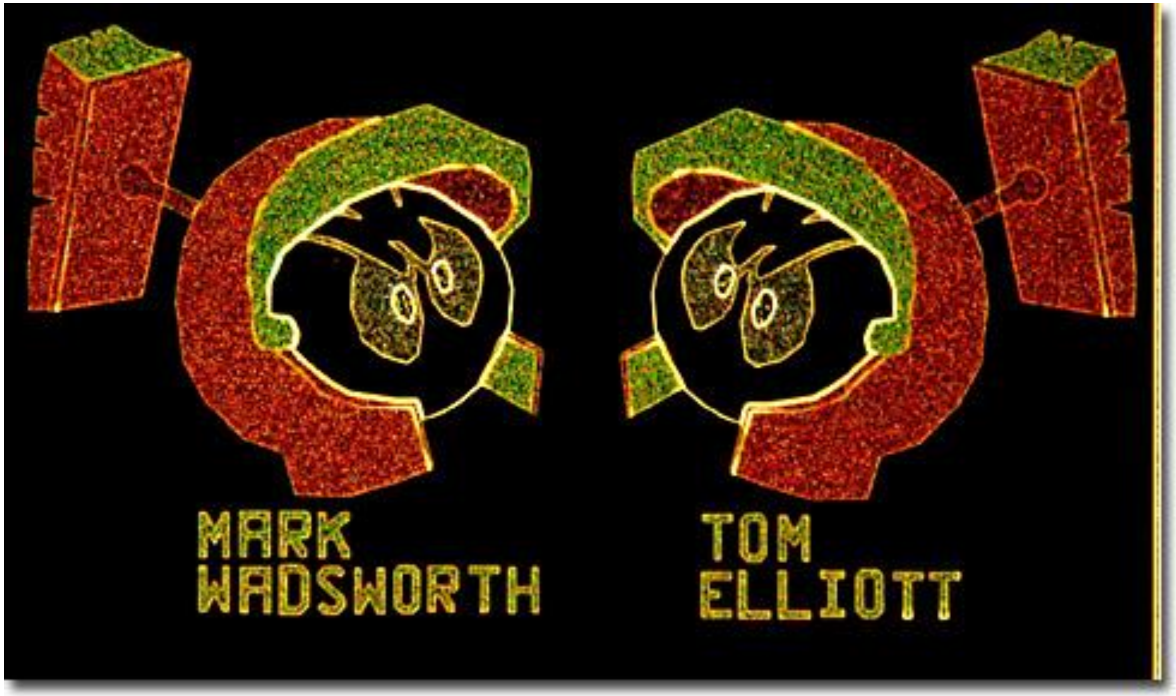


We were examining a Random Access Memory (RAM) integrated circuit manufactured by a partnership between Thomson and Mostek when we discovered maps of France and the state of Texas. The photomicrograph above depicts the map of France as seen on the chip. The tiny "bumps" on and surrounding the map do not designate cities in France---they are small particles of dirt incorporated into the circuitry during manufacture of the chip.

http://www.microscopy.fsu.edu/creatures/index.html

Galeria

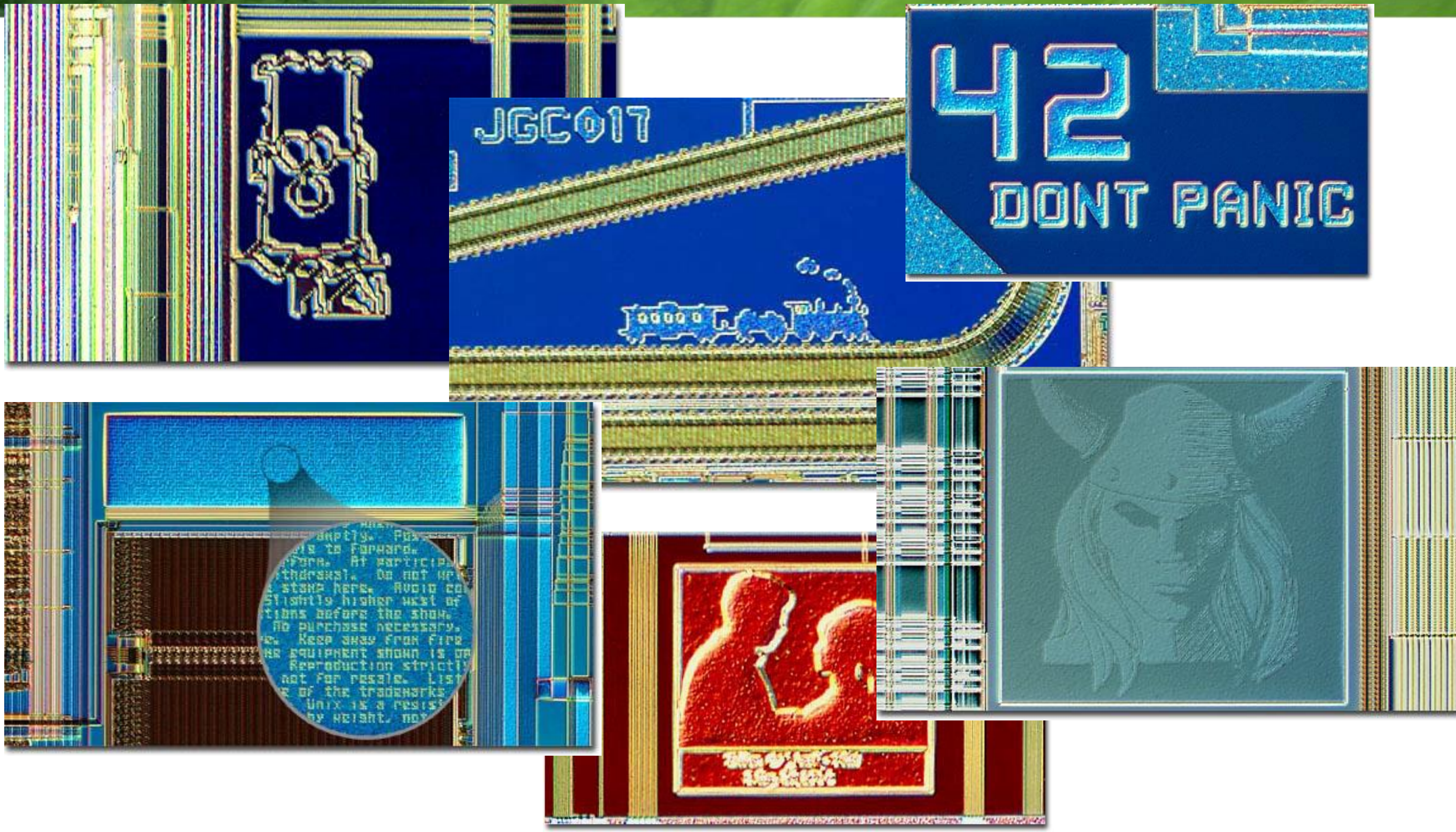
A Dog's Life (Darkfield)



We managed to capture a photograph of what are now perhaps the tiniest Martians on Mars. Appearing as an opposed duet of helmeted gladiators, these angry silicon soldiers were discovered on the surface of an image sensor used by the **Spirit** and **Opportunity** rovers sent to probe the Red planet. Maybe these are the **ONLY** Martians on Mars? Probably not. In any event, the chip was loaned to us by designer Mark Wadsworth who is a fan of the Silicon Zoo. Mark informs us that he decided to try his hand at silicon artwork after visiting the Zoo on several occasions. The title of his artwork is the "Dueling Marvin the Martians". Mark designed the image sensor for NASA's Jet Propulsion Laboratory along with Tom Elliot, who actually did the testing of the flight candidate imagers to select the 20 or so that actually made it on the two missions. Tom and Mark tended to butt heads quite a bit, which was the inspiration for the doodle.

The rover image sensors are charge-coupled devices (**CCDs**) much like those found in ordinary everyday digital cameras, but with several advanced features. In order to speed image capture, the CCD uses frame transfer technology to quickly shift the captured image behind a mask (the **shielded region** electronic shutter in the image below) after the **photodiodes** have accumulated sufficient charge (relating to the image intensity). This particular sensor contains 1024 x 1024 pixels, each of which is 12-micrometers square. The chip is a custom design that was developed to meet the rather stringent performance criteria cooked up by the mission's brainchild (Dr. S. Squyers) and his group at Cornell University.

Galeria



Hewlett-Packard, Allen-Bradley, LeCroy, Lattice Semiconductor Corporation, Siemens, Caterpillar, Silicon Graphics, TEMIC Semiconductors, IBM, Digital VAX, Thomson...

W przyszłym tygodniu ŚRODA jest we CZWARTEK!

12 listopada (też) jest środa!