TE346
Engenharia Elétrica e Sociedade

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UFPR
UNIVERSIDADE FEDERAL DO PARANÁ

DELT
DEPARTAMENTO DE ENGENHARIA ELÉTRICA

Do transístor ao microprocessador
[2.ª Parte]

1

O Nascimento dos Circuitos Integrados

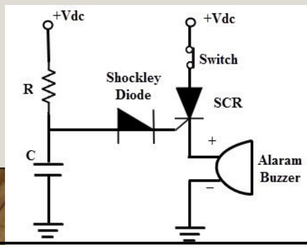
- 1947: Bardeen, Brattain & Shockley inventam o transistor no *Bell Labs*
- 1953: Shockley solicita uma licença do *Bell Labs* para atuar como professor visitante no *CalTech*
California Institute of Technology, Pasadena, CA
- 1956: Shockley sai do Bell Labs e funda a empresa *Shockley Semiconductor Laboratory* em Mountain View, CA, EUA

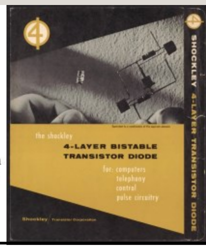
Nobel Prize Winner Shockley Hires Young Minds to Perfect His Invention

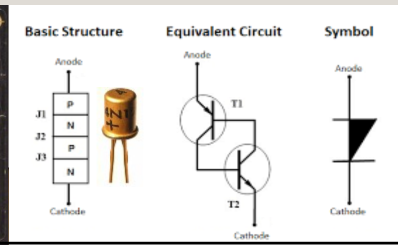
2

William Shockley (1947-1989)

- 1947: Invenção do transístor, no *Bell Labs*
- 30 de junho de 1948: *Bell Labs* anuncia publicamente a invenção do transístor
- 1951-1952: Constantes atritos de Shockley com a Diretoria do *Bell Labs*
- 1953: Shockley solicita uma licença do *Bel Labs* para assumir a função de professor visitante no *CalTec*
- 1954: Shockley pede divorcio da esposa Jean Bailey, com quem tinha se casado em 1933 (3 filhos)
- 1955: Shockley casa-se com Emmy Lanning
- 1955: Em parceria com Arnold Orville Beckman, ex-professor da *CalTech* e dono da *Beckman Instruments*, Shockley propõe fundar uma fábrica de semicondutores e sugere como local a cidade de **Palo Alto**, onde passou a infância e estava morando na ocasião. O investimento de Beckman é de 1 milhão de dólares.
- 1956: o *Shockley Semiconductor Laboratory* começa a funcionar em Montain View, CA, como uma divisão da *Beckman Instruments*, em um antigo restaurante. Os primeiros empregados foram recrutados por meio de anúncios em jornais de Nova York e palestras dadas por Shockley em universidades e na *American Physical Society*. Shokley tem grandes esperanças no sucesso do diodo de 4 camadas (PNPN), que ficou conhecido como **diodo Shokley**.







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- Logo no início das atividades do *Shockley Semiconductor Laboratory* fica evidenciada a falta de habilidade administrativa de Shockley e repetidas atitudes paranoicas (gravar todos os telefonemas, mandar espionar os funcionários, proibir conversas entre funcionário, negar-se a revelar detalhes importantes dos projetos...)
- Em novembro de 1956 o Prêmio Nobel de Física foi anunciado para Shockley, Bardeen & Brattain. Em 10 de dezembro o Prêmio Nobel é entregue em Estocolmo; logo em seguida Shockley inicia uma *turnée* de palestras e praticamente abandona a empresa
- 1957: em março, Eugene Kleiner viaja para NY, sem que Shockley saiba, em busca de investidores para uma nova empresa de semicondutores. O pai de Kleiner consegue que uma carta chegue aos investidores Arthur Rock e Alfred Coyle (*Hayden, Stone & Co.*) descrevendo a nova empresa.
- Em maio Gordon Moore conversa com Beckman sugerindo que Shockley seja afastado da direção da empresa e assuma o trabalho de professor na CalTec *full time*; Beckman não aceita a sugestão.
- Em junho Rock e Coley se reúnem em um hotel em San Francisco com Julius Blank, Victor Grinich, Jean Hoerni, Eugene Kleiner, Jay Last, Gordon Moore & Sheldon Roberts. Robert Noyce a princípio diz que não vai à reunião mas acaba comparecendo. Rock e Coley comprometem-se com o grupo a achar investidores para uma nova empresa de semicondutores e fica acertado que esta futura empresa será localizada na Califórnia.
- Em agosto Rock e Coyle tem um encontro com Sherman Fairchild (*Fairchild Camera*) onde discutem a ideia de Kleiner. Fairchild mostra-se favorável a investir US$ 1,38 milhões em uma nova empresa, já que tinha informações da perspectiva de grandes contratos militares de equipamentos eletrônicos para a fabricação de mísseis balísticos de longo alcance e de projetos para a NASA.
- Em 18 de setembro os 8 pedem demissão do *Shockley Lab*. O escritório temporário da nova empresa (ainda sem nome) passa a ser a garagem de Victor Grinick. A partir de novembro, mudam-se para um escritório alugado em Palo Alto, a 12 quadras de distância do *Shockley Lab*.
- A saída repentina de 8 importantes funcionários da *Shokley Lab* e a proximidade geográfica da nova empresa por eles fundada irrita extremamente William Shockley.

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FAIRCHILD SEMICONDUCTOR®

- Nov.1957: Fundação da divisão *Fairchild Semiconductor*, subsidiária da *Fairchild Camera Corporation*
- *Shockley*: ***The Traitorous Eight*** - Robert Noyce, Julius Blank, Victor Grinich, Jean Hoerni, Eugene Kleiner, Jay Last, Gordon Moore & Sheldon Roberts

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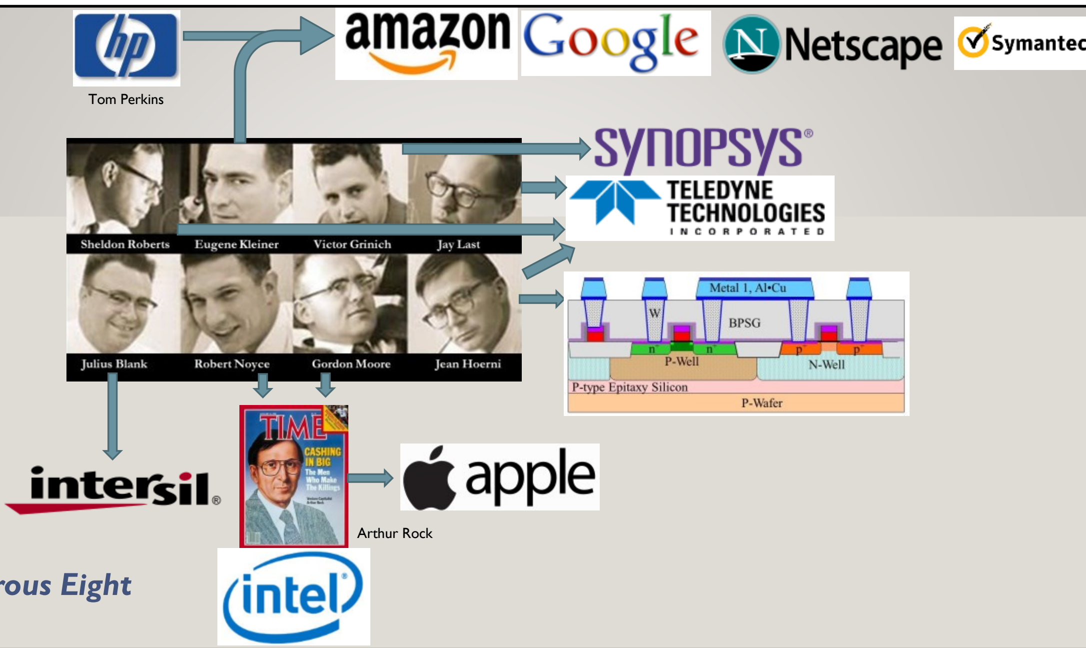

The Traitorous Eight

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O local onde funcionou originalmente a empresa *Shockley Semiconductor Laboratory* (391 San Antonio Road, Mountain View, California) é atualmente um centro comercial. Na calçada em frente ao edifício está representado um "circuito oscilador" com um "transistor" 2N696 e dois "diodos-Shockley" (diodos de 4 camadas – PNPN). Há também no local uma fonte com uma escultura metálica representado o cristal do Silício.

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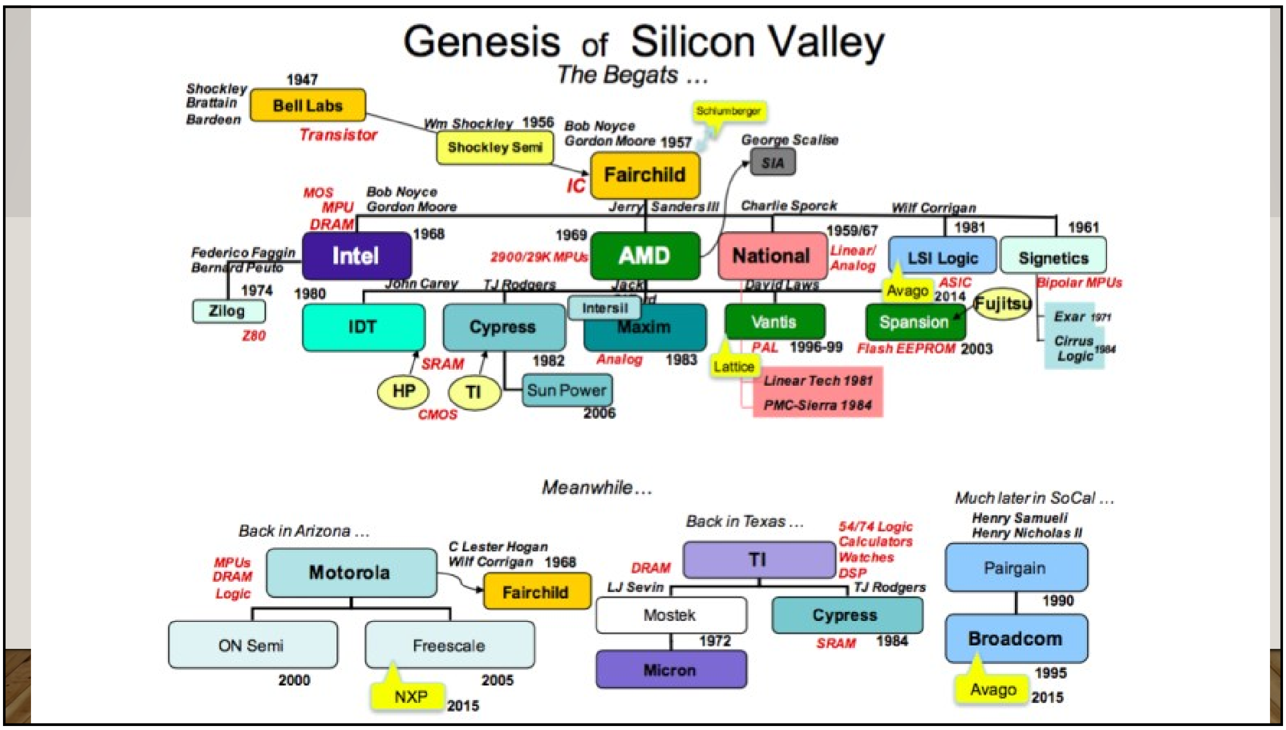

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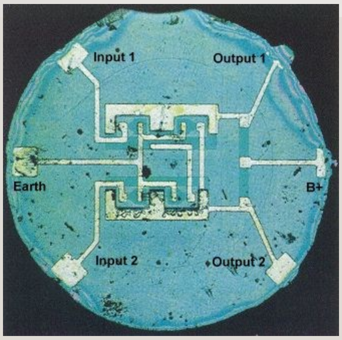
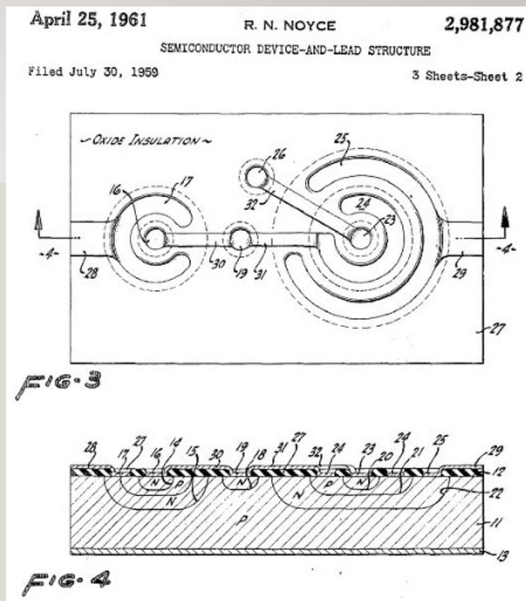
1958: Jean Hoerni: método epitaxial para fabricação de transistores

1959: Robert Noyce: circuitos integrados em Si

Robert “Bob” Noyce



1959: Primeiro CI Fairchild com 4 transistores



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• 1968: *Robert Noyce* & Gordon Moore: saem da *Fairchild* e fundam a *Intel. Andrew Grove (András Gróf)*, Diretor de Engenharia da *Fairchild*, junta-se a eles após alguns dias.

Início da *Intel*: fabricação de memórias e **design house** de circuitos integrados

• 1969: Federico Faggin na *Fairchild* desenvolve o MOSFET (transistor metal-óxido-semicondutor com terminal de gate isolado)

Faggin

• 1970: Faggin passa a trabalhar na *Intel*

• 1970: Faggin, Marcian “Ted” Hoff & Stanley Mazor: projeto de CIs para a *ETI Busicom Nippon Calculator Co.* + Masatoshi Shima, Engenheiro da Busicom que juntou-se à equipe da Intel nos EUA

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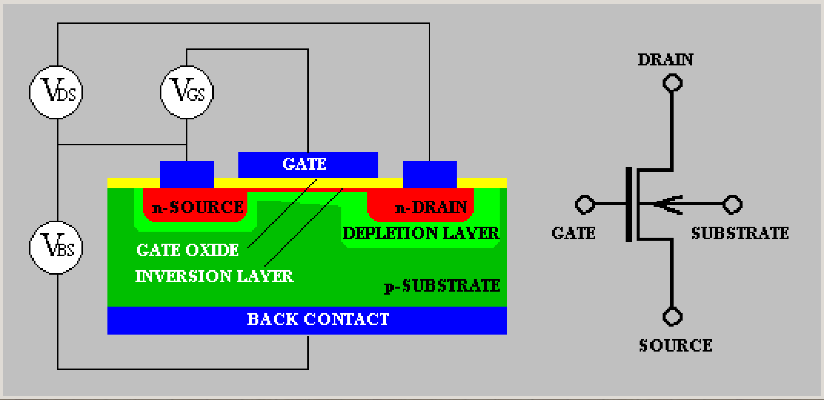
MOSFET

• Transistores Bipolares (PNP & NPN): Controle através da CORRENTE DE BASE

• MOSFET - Faggin, 1969:
Controle através da TENSÃO DE *GATE*

Pequena corrente ⟹ **Baixas perdas!**



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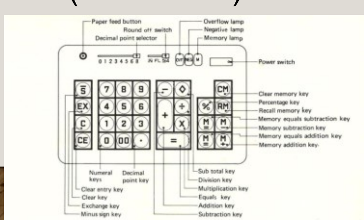
Intel: Projeto para ETI Busicom

• 1970: Projeto Original de Masatoshi Shima: 12 Circuitos Integrados

• Proposta de Faggin, Hoff e Mazor:
4 Circuitos Integrados

• 1º *chip set Intel*
4001 (2k ROM)
4002 (320-bit RAM)
4003 (10-bit I/O shift-register)
4004 (CPU 4 bits)



1971: Busicom 141PF
US$ 2 k

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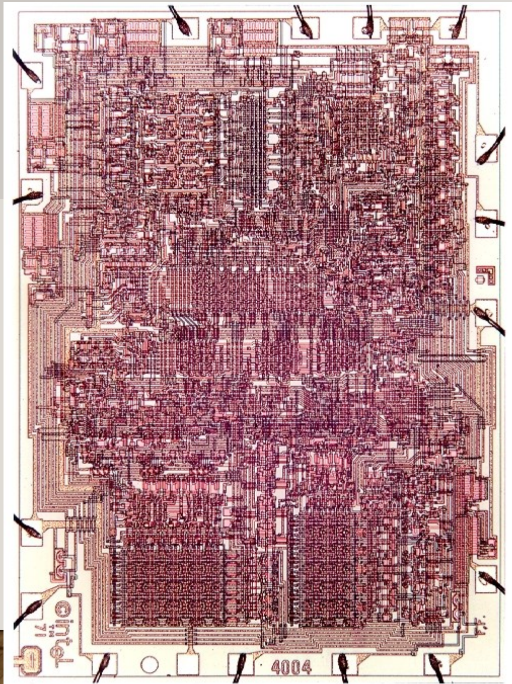
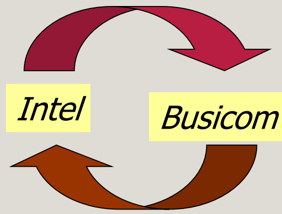


4004

2108 Transistores (Hoff)
2300 Transistores (Faggin) *gate* de 10 μm
f = 108 kHz (*)

- Projeto *Intel*: US$ 60 k



Federico Faggin com o protótipo da calculadora Busicom 141-PF. Este protótipo estava no Japão e foi presenteado a Faggin pelo Presidente da Busicom, Yoshio Kojima. Atualmente está no *Computer History Museum*, em Mountain View, EUA

(*) Versões posteriores chegaram a 740 kHz

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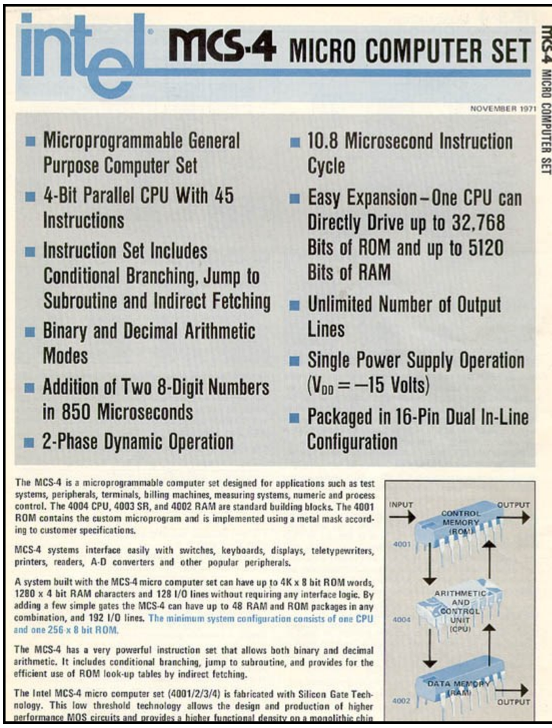


intel MCS-4 MICRO COMPUTER SET

MCS-4 MICRO COMPUTER SET

NOVEMBER 1971

- Microprogrammable General Purpose Computer Set
- 4-Bit Parallel CPU With 45 Instructions
- Instruction Set Includes Conditional Branching, Jump to Subroutine and Indirect Fetching
- Binary and Decimal Arithmetic Modes
- Addition of Two 8-Digit Numbers in 850 Microseconds
- 2-Phase Dynamic Operation
- 10.8 Microsecond Instruction Cycle
- Easy Expansion – One CPU can Directly Drive up to 32,768 Bits of ROM and up to 5120 Bits of RAM
- Unlimited Number of Output Lines
- Single Power Supply Operation (V_{DD} = –15 Volts)
- Packaged in 16-Pin Dual In-Line Configuration

The MCS-4 is a microprogrammable computer set designed for applications such as test systems, peripherals, terminals, billing machines, measuring systems, numeric and process control. The 4004 CPU, 4003 SR, and 4002 RAM are standard building blocks. The 4001 ROM contains the custom microprogram and is implemented using a metal mask according to customer specifications.

MCS-4 systems interface easily with switches, keyboards, displays, teletypewriters, printers, readers, A-D converters and other popular peripherals.

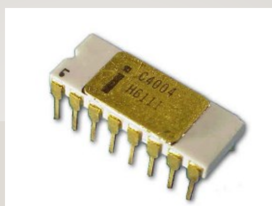
A system built with the MCS-4 micro computer set can have up to 4K x 8 bit ROM words, 1280 x 4 bit RAM characters and 128 I/O lines without requiring any interface logic. By adding a few simple gates the MCS-4 can have up to 48 RAM and ROM packages in any combination, and 192 I/O lines. The minimum system configuration consists of one CPU and one 256 x 8 bit ROM.

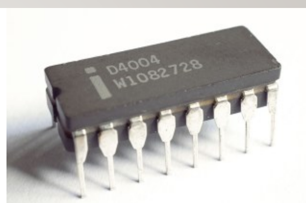
The MCS-4 has a very powerful instruction set that allows both binary and decimal arithmetic. It includes conditional branching, jump to subroutine, and provides for the efficient use of ROM look-up tables by indirect fetching.

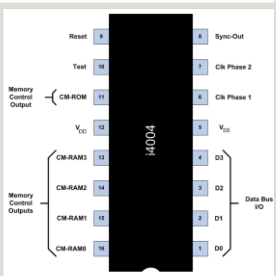
The Intel MCS-4 micro computer set (4001/2/3/4) is fabricated with Silicon Gate Technology. This low threshold technology allows the design and production of higher performance MOS circuits and provides a higher functional density on a monolithic chip

4004

- Disponível comercialmente a partir de 15-nov.1971







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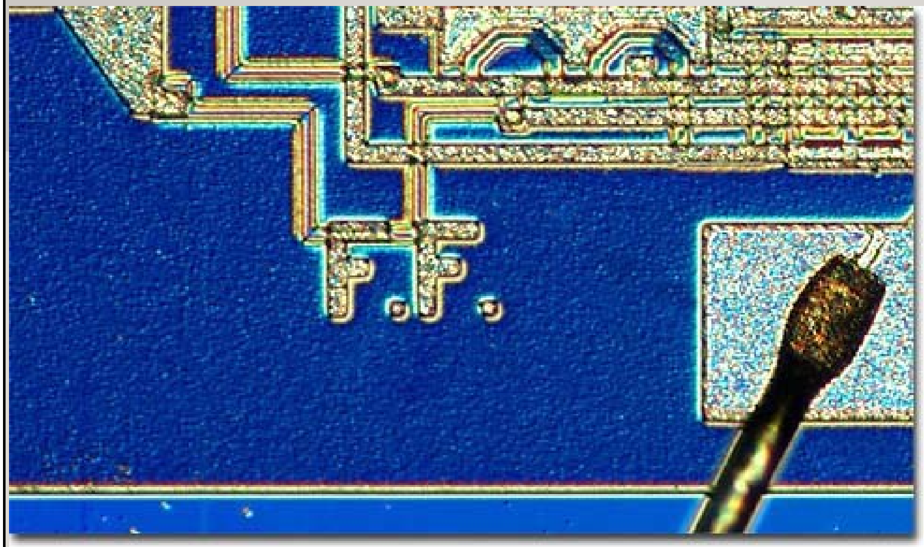
Chip Art



FF = Federico Faggin

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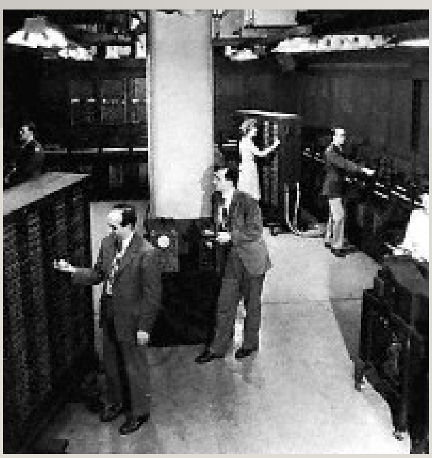
4004

Intel 4004 Microprocessor 35th Anniversary (2006)
Ted Hoff & Federico Faggin (& Masatoshi Shima)
https://youtu.be/j00AULJLCNo



1946: ENIAC

=

1971: Intel 4004

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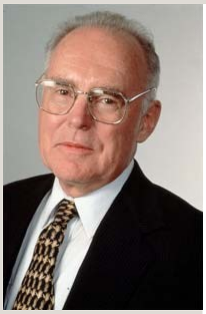
Lei de Moore

19-Maio 1965: Gordon E. Moore:

artigo na revista *Electronics* → Constatou que o número de transistores em um circuito integrado de alta complexidade vinha dobrando a cada dois anos.
Previu que este ritmo de crescimento continuaria a ser observado nos anos subsequentes (previsão CONFIRMADA!)



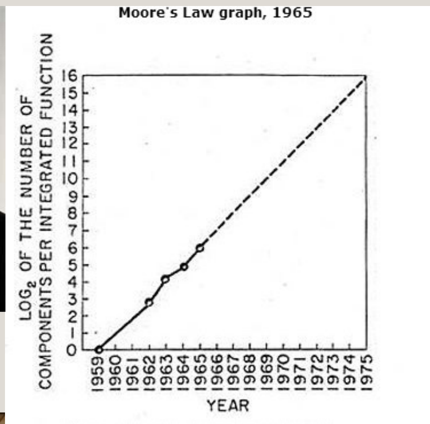
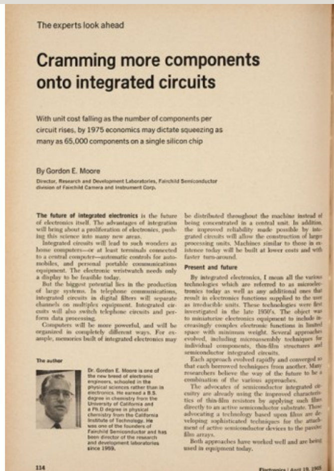


Fig. 2 Number of components per integrated function for minimum cost per component extrapolated vs time.


The experts look ahead

Cramming more components onto integrated circuits

With unit cost falling as the number of components per circuit rises, by 1975 economics may dictate squeezing as many as 65,000 components on a single silicon chip

By Gordon E. Moore

Gordon Moore
Entrevista em 2008:
https://youtu.be/gtcLzokagAw

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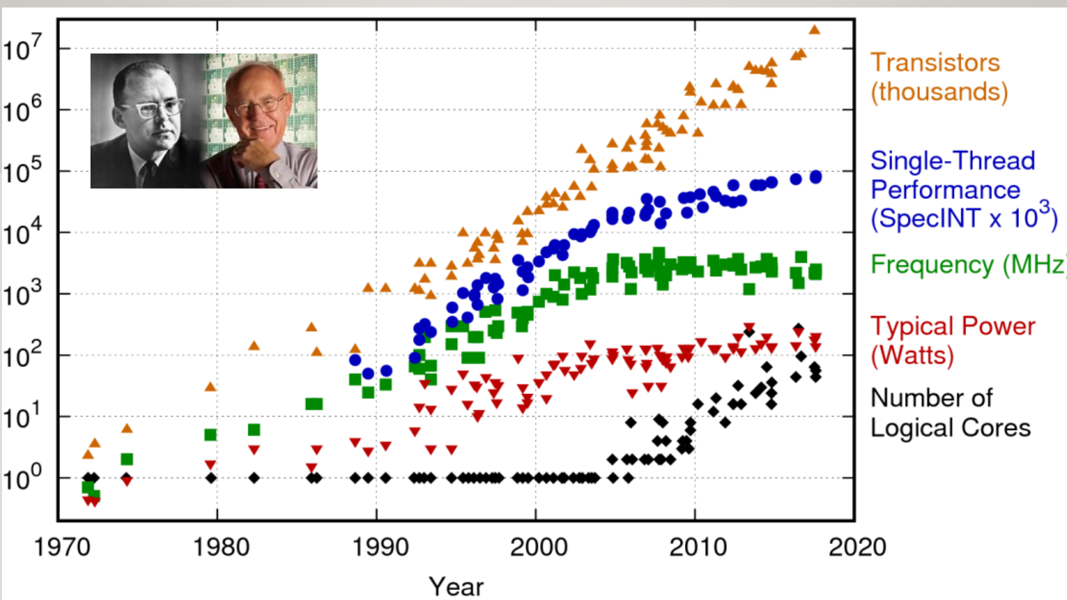
Lei de Moore



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

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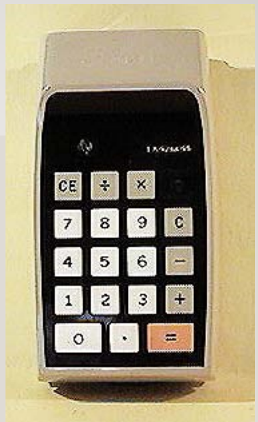
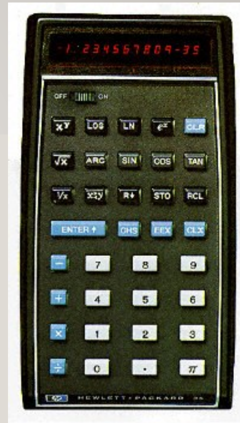
Aplicações de Microprocessadores

Calculadora eletrônica Sharp CS-10A, de 1964, ainda não possuía um microprocessador e o circuito eletrônico usava 530 transístores de germânio e 2300 diodos.
Peso: 25 kg
Preço: 535.000 ¥
(aprox. 1450 US$, na época)

A primeira calculadora eletrônica portátil, a Bowmar 901B, de 1971



A *Datamath* de 1971, a primeira calculadora eletrônica produzida pela Texas Instruments



Calculadora HP-35 de 1972, a primeira calculadora eletrônica com funções científicas

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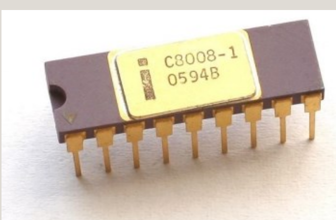
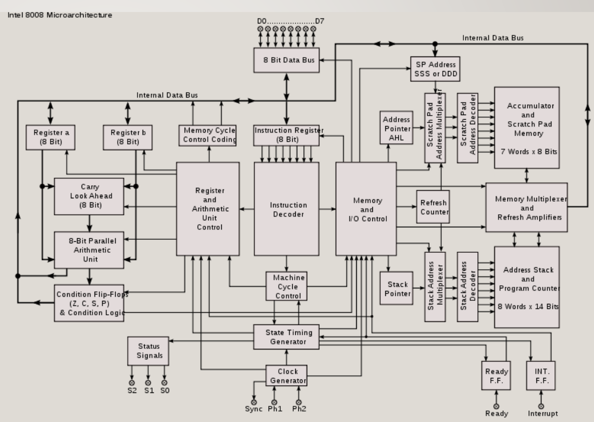
8008

1972: Frederico Faggin, Ted Hoff e Hal Feeney (INTEL)

microcontrolador de 8 bits, sucessor do 4004

Principal problema: o encapsulamento de 18 pinos tornava necessário muitos circuitos auxiliares





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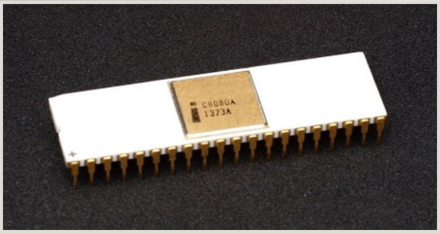
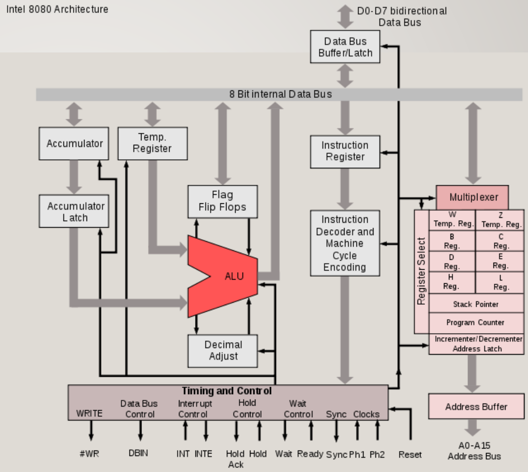
8080

1974: Frederico Faggin e Masatoshi Shima (ex-Busicom)
microcontrolador de 8 bits, versão “melhorada” do 8008





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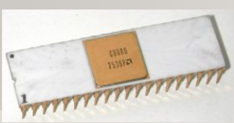
Microprocessador Intel 8080

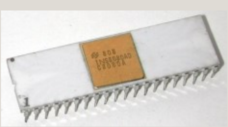


8080 AMD

8080 Mitsubishi

8080 NEC

8080 Texas Instruments



8080 National

8080 Siemens

8080 Toshiba

8080 Signetics

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Microprocessador Intel 8080

Os fundadores da INTEL, da esquerda da direita - Andy Grove, Robert Noyce e Gordon Moore, fotografados em 1978 sobre um fotolito do microprocessador 8080

Microprocessador Intel Core i9 - 12ª geração (2022)

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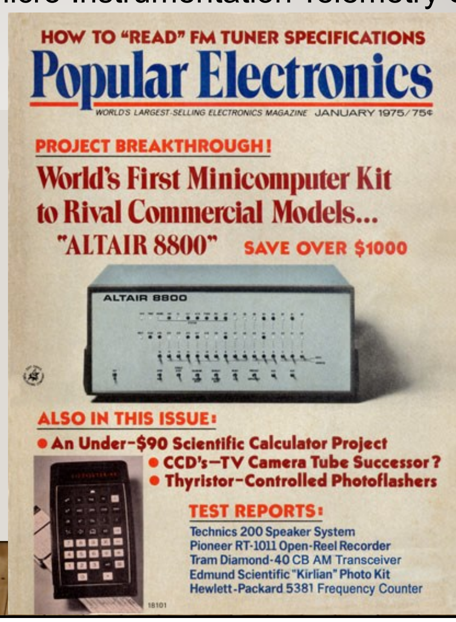
Microprocessador Intel 8080

- Henry Edward (*Ed*) Roberts: MITS (Micro Instrumentation Telemetry Systems) – fábrica de calculadoras
- Les Salomon:

Revista *Popular Electronics*



Popular Electronics
Jan, 1975
"kit" do ALTAIR 8800
Microprocessador 8080
US$ 439.00

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MITS

BUILDING YOUR OWN COMPUTER WON'T BE A PIECE OF CAKE.

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Chances are you won't be able to assemble the *Altair 8800 Computer* in an hour or two. But, that's only because the *Altair* is a real, full-blown computer. It's not a demonstration kit.

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PRICES: Altair Computer Kit with complete assembly instructions **$439.00**
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505/265-7553

MAY 1975

Altair 8800

Henry Edward (*Ed*) Roberts

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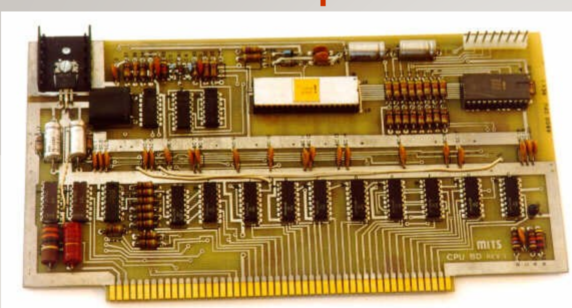
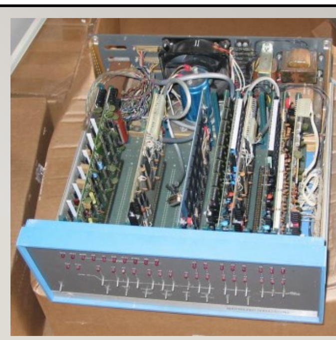
Microprocessador Intel 8080



ALTAIR 8800
Microprocessador
Intel 8080
US$ 439



- Previsão inicial: 400 / ano
- 1ª semana: 800 pedidos
- Total de ALTAIR vendidos: 50 mil em 2 anos

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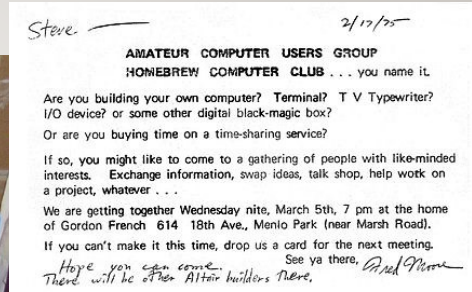
Microprocessador Intel 8080

ALTAIR 8800
Microprocessador 8080



Steve — 2/17/75

AMATEUR COMPUTER USERS GROUP
HOMEBREW COMPUTER CLUB . . . you name it.

Are you building your own computer? Terminal? T V Typewriter? I/O device? or some other digital black-magic box?

Or are you buying time on a time-sharing service?

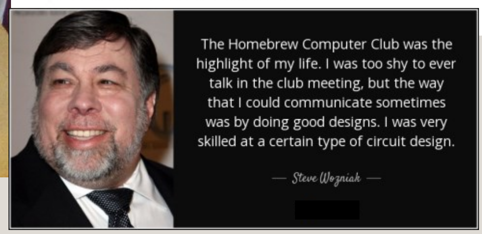
If so, you might like to come to a gathering of people with like-minded interests. Exchange information, swap ideas, talk shop, help work on a project, whatever . . .

We are getting together Wednesday nite, March 5th, 7 pm at the home of Gordon French 614 18th Ave., Menlo Park (near Marsh Road).

If you can't make it this time, drop us a card for the next meeting.

See ya there, Fred Moore

Hope you can come.
There will be other Altair builders there.



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ALTAIR 8800

Paul Allen & Bill Gates
1975

- Teclado de máquina de teletipo (TTY)
- Leitora de fita de papel
- Terminal de Vídeo:
  TV adaptado
- Interpretador BASIC:

Paul Allen & **Bill Gates** foram contratados pela MITS para desenvolverem um compilador BASIC, facilitando a programação dos ALTAIR 8800 (futura Microsoft)

- **Steve Wozniak** montou diversos Altair para colegas e projetou uma placa de circuito impresso alternativa baseada no circuito do ALTAIR 8800 (futura Apple)

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Altair 8800

Dr. Henry Edwards Roberts, the designer of the Altair 8800, died of pneumonia on April 1, 2010 at age 68, according to media reports. Roberts was the founder of Micro Instrumentation and Telemetry Systems and inventor of the Altair 8800, widely credited as the world's first personal computer. It was featured on the cover of Popular Electronics in 1975, when Paul Allen and Bill Gates contacted Roberts and offered to write software for the machine. Gates and Allen worked with MITS in Albuquerque, New Mexico, and started Microsoft.
In 1977, Roberts sold MITS and retired to Georgia where he studied medicine and became a small-town doctor.
In a joint statement, Microsoft co-founders Bill Gates and Paul G. Allen highlighted that Roberts was "truly a pioneer in the personal computer revolution and didn't always get the recognition he deserved."
They added: "Ed was willing to take a chance on us — two young guys interested in computers long before they were commonplace — and we have always been grateful to him. The day our first untested software worked on his Altair was the start of a lot of great things. We will always have many fond memories of working with Ed in Albuquerque, in the MITS office right on Route 66, where so many exciting things happened that none of us could have imagined back then."

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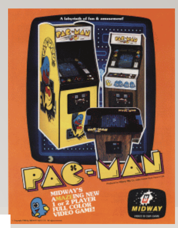
Z80 (1976)

Frederico Faggin
Masatoshi Shima

Zilog Z80



4004 → 8008 → 8080 → 8088 →

intel intel intel

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The Battle of the 80's

Think of your next microcomputer as a weapon against horrendous inefficiencies, outrageous costs and antiquated speeds. We invite you to peruse this chart.

Features:	8080A	Z80-CPU	Features:	8080A	Z80-CPU
Power Supplies	+5,−5,+12	+5	Instructions	78	158*
Clock	2Φ, +12 Volt	1Φ, 5 Volt	OP Codes	244	696
Standard Clock Speed	500 ns	400 ns	Addressing Modes	7	11
Interface	Requires 8222, 8228 & 8224	Requires no other logic and includes dynamic RAM Refresh	Working Registers	8	17
			Throughput	Up to 5 times greater than the 8080A	
Interrupt	1 mode	3 modes; up to 6X faster	Program Memory Space	Generally 50% less than the 8080A	
Non-maskable Interrupt	No	Yes	*Including all of the 8080A's instructions.		

GENTLEMEN, THE CHOICE OF WEAPONS IS YOURS.

Announcing Zilog Z-80 microcomputer products. With the next generation, the battle is joined.

The Z-80: A new generation LSI component set including CPU and I/O Controllers.
The Z-80: Full software support with emphasis on high-level languages.
The Z-80: A floppy disc-based development system with advanced real-time debug and in-circuit emulation capabilities.
The Z-80: Multiple sourcing available now.

Your ammunition: A chip off a new block.

A single chip, N-channel processor arms you with a super-set of 158 instructions that include *all* of the 8080A's 78 instructions with *total* software compatibility. The new instructions include 1, 4, 8 and 16-bit operations. And that means less programming time, less paper and less end costs.

And you'll be in command of powerful instructions: Memory-to-memory or memory-to-I/O block transfers and searches, 16-bit arithmetic, 9 types of rotates and shifts, bit manipulation and a legion of addressing modes. Along with this army you'll also get a standard instruction speed of 1.6 μs and all Z-80 circuits require only a single 5V power supply and a single phase 5V clock. And you should know that a family of Z-80 programmable circuits allow for direct interface to a wide range of both parallel and serial interface peripherals and even dynamic memories without other external logic.

With these features, the Z80-CPU generally requires approximately 50% less memory space for program storage yet provides up to 500% more throughput than the 8080A. Powerful ammunition at a surprisingly low cost and ready for immediate shipment.

Mighty weapons against an enemy entrenched: The Z-80 development system.

You'll be equipped with performance and versatility unmatched by any other microcomputer development system in the field. Thanks to a floppy disc operating system in alliance with a sophisticated Real-Time Debug Module.

The Zilog battalion includes:

- Z80-CPU Card.
- 16K Bytes of RAM Memory, expandable to 60K Bytes.
- 4K Bytes of ROM/RAM Monitor software.
- Real-Time Debug Module and In-Circuit Emulation Module.
- Dual Floppy Disc System.
- Optional I/O Ports for other High Speed Peripherals are also available.
- Complete Software Package including Z-80 Assembler, Editor, Disc Operating System, File Maintenance and Debug.

On standby: Software support.

All this is supported by a contingent of software including: resident microcomputer software, time sharing programs, libraries and high-level languages such as PL/Z.

On standby: User support.

Zilog conducts a wide range of strategic meetings and design oriented workshops to provide the know-how required to implement the Z-80 Microcomputer Product line into your design. All hardware, software and the development system are thoroughly explained with "hands-on" experience in the classroom. Your Zilog representative can provide you with further details on our user support program.

Reinforcements: A reserve of technological innovations.

The Zilog Z-80 brings to the battlefront new levels of performance and ease of programming not available in second generation systems. And while all the others busy themselves with overtaking the Z-80, we're busy on the next generation—continuing to demonstrate our pledge to stay a generation ahead.

The Z-80's troops are the specialists who were directly responsible for the development of the most successful first and second generation microprocessors. Nowhere in the field is there a corps of seasoned veterans with such a distinguished record of victory.

Signal us for help. We'll dispatch appropriate assistance.

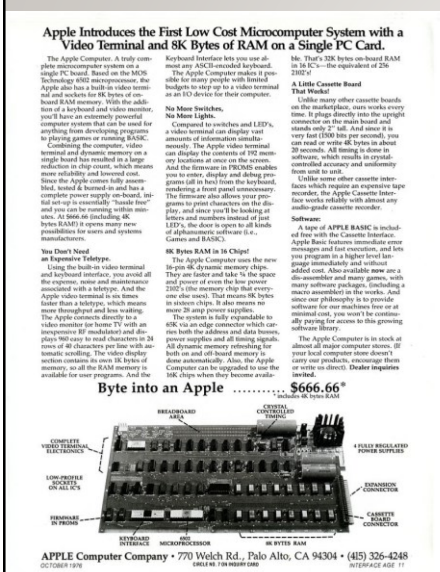
Zilog MICROCOMPUTERS
170 State Street, Los Altos, California 94022
(415) 941-5055/TWX 910-370-7955

Circle 33 on reader service card

AN AFFILIATE OF EXXON ENTERPRISES INC.

1975: MOS Technology 6502 Microprocessor

1976: Steve Jobs & Steve Wozniak: APPLE



Apple Introduces the First Low Cost Microcomputer System with a Video Terminal and 8K Bytes of RAM on a Single PC Card.

The Apple Computer. A truly complete microcomputer system on a single PC board. Based on the MOS Technology 6502 microprocessor, the Apple also has a built-in video terminal and sockets for 8K bytes of on-board RAM memory. With the addition of a keyboard and video monitor, you'll have an extremely powerful computer system that can be used for anything from developing programs to playing games or running BASIC.

Combining the computer, video terminal and dynamic memory on a single board has resulted in a large reduction in chip count, which means more reliability and lowered cost. Since the Apple comes fully assembled, tested & burned-in and has a complete power supply on-board, initial set-up is essentially "hassle free" and you can be running within minutes. At $666.66 (including 4K bytes RAM!) it opens many new possibilities for users and systems manufacturers.

You Don't Need an Expensive Teletype.

Using the built-in video terminal and keyboard interface, you avoid all the expense, noise and maintenance associated with a teletype. And the Apple video terminal is six times faster than a teletype, which means more throughput and less waiting. The Apple connects directly to a video monitor (or home TV with an inexpensive RF modulator) and displays 960 easy to read characters in 24 rows of 40 characters per line with automatic scrolling. The video display section contains its own 1K bytes of memory, so all the RAM memory is available for user programs. And the Keyboard Interface lets you use almost any ASCII-encoded keyboard.

The Apple Computer makes it possible for many people with limited budgets to step up to a video terminal as an I/O device for their computer.

No More Switches, No More Lights.

Compared to switches and LED's, a video terminal can display vast amounts of information simultaneously. The Apple video terminal can display the contents of 192 memory locations at once on the screen. And the firmware in PROMS enables you to enter, display and debug programs (all in hex) from the keyboard, rendering a front panel unnecessary. The firmware also allows your programs to print characters on the display, and since you'll be looking at letters and numbers instead of just LED's, the door is open to all kinds of alphanumeric software (i.e., Games and BASIC).

8K Bytes RAM in 16 Chips!

The Apple Computer uses the new 16-pin 4K dynamic memory chips. They are faster and take ¼ the space and power of even the low power 2102's (the memory chip that everyone else uses). That means 8K bytes in sixteen chips. It also means no more 28 amp power supplies.

The system is fully expandable to 65K via an edge connector which carries both the address and data busses, power supplies and all timing signals. All dynamic memory refreshing for both on and off-board memory is done automatically. Also, the Apple Computer can be upgraded to use the 16K chips when they become available. That's 32K bytes on-board RAM in 16 IC's—the equivalent of 256 2102's!

A Little Cassette Board That Works!

Unlike many other cassette boards on the marketplace, ours works every time. It plugs directly into the upright connector on the main board and stands only 2" tall. And since it is very fast (1500 bits per second), you can read or write 4K bytes in about 20 seconds. All timing is done in software, which results in crystal-controlled accuracy and uniformity from unit to unit.

Unlike some other cassette interfaces which require an expensive tape recorder, the Apple Cassette Interface works reliably with almost any audio-grade cassette recorder.

Software:

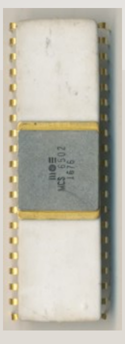
A tape of **APPLE BASIC** is included free with the Cassette Interface. Apple Basic features immediate error messages and fast execution, and lets you program in a higher level language immediately and without added cost. Also available **now** are a dis-assembler and many games, with many software packages, (including a macro assembler) in the works. And since our philosophy is to provide software for our machines free or at minimal cost, you won't be continually paying for access to this growing software library.

The Apple Computer is in stock at almost all major computer stores. (If your local computer store doesn't carry our products, encourage them or write us direct). **Dealer inquiries invited.**

Byte into an Apple $666.66*
*includes 4K bytes RAM

BREADBOARD AREA
CRYSTAL CONTROLLED TIMING
COMPLETE VIDEO TERMINAL ELECTRONICS
4 FULLY REGULATED POWER SUPPLIES
LOW-PROFILE SOCKETS ON ALL IC'S
EXPANSION CONNECTOR
FIRMWARE IN PROMS
CASSETTE BOARD CONNECTOR
KEYBOARD INTERFACE
6502 MICROPROCESSOR
8K BYTES RAM

APPLE Computer Company • 770 Welch Rd., Palo Alto, CA 94304 • (415) 326-4248
OCTOBER 1976 CIRCLE NO. 7 ON INQUIRY CARD INTERFACE AGE 11



1977: **APPLE II** US$1,298.00

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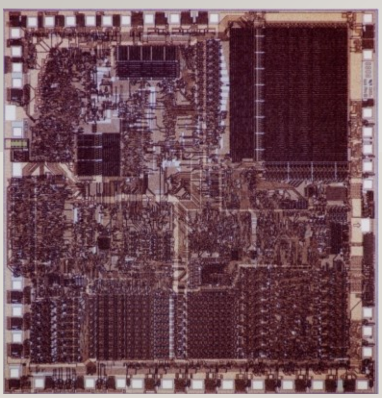
1981: IBM-PC



1981: lançamento do primeiro IBM-PC, usando processador INTEL 8088

A primeira ideia da IBM era usar o Processador 8086 da Intel. Chegou a ser cogitado também o Zilog Z80 e o Motorola 68000 e até o MOS Technology 6502 (usado pela Apple). Mas na negociação final a Intel tinha interesse em promover as vendas do recém-projetado 8088 e ofereceu o 8088 para a IBM por um preço mais baixo que o 8086.

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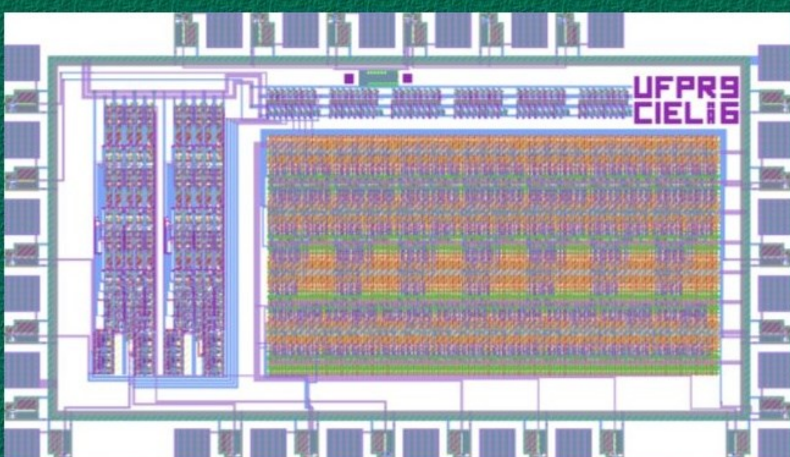
CI projetado pelo grupo de Microeletrônica do CIEL/UFPR usando a técnica de Sea-of- gates



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