



Chapter 1

Basic computer knowledge and computer evolution

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Objectives

- To tell the computer development from mechanical calculator to the computer system.
- to tell difference between microprocess and microcontroller.
- To express electronic devices and electronic measurement tools
- Be able to describe the concept of data transferring and detection errors in the computer system.
- Be able to tell mechanical protection and safety in the computer system and IoT

Topic

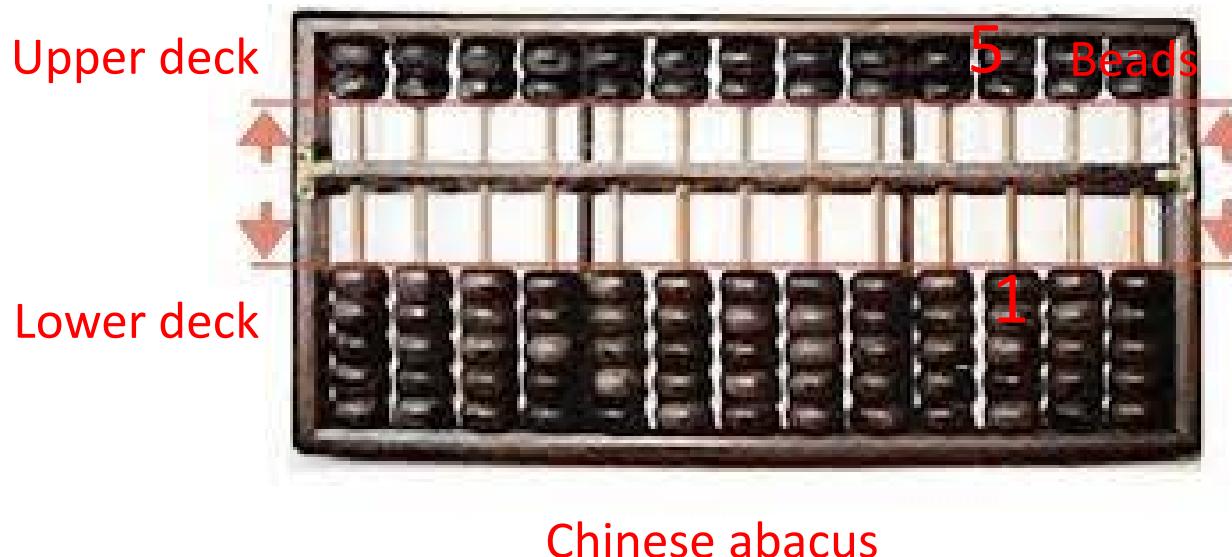
- From Mechanical machine to Computer
 - Mechanical
 - Vacuum tube
 - Silicon Transistor
- Microprocessor, microcontroller, DSP, GPU
- Quiz (5 points)

MECHANICAL COMPUTER

1st Era ~5~

1.1.1 Mechanical computer

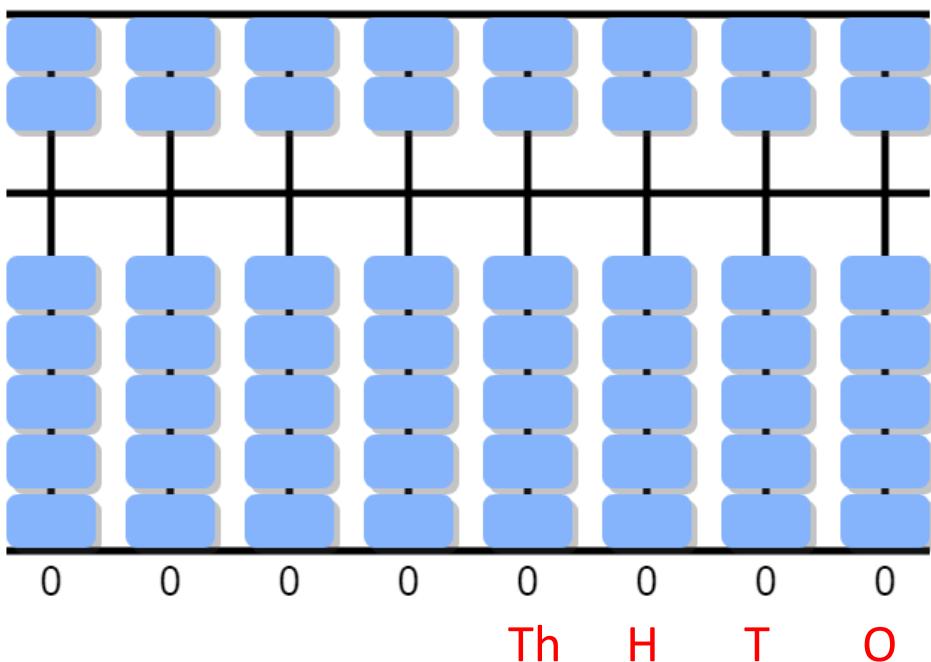
- Abacus
 - Used in China, Europa and Russia



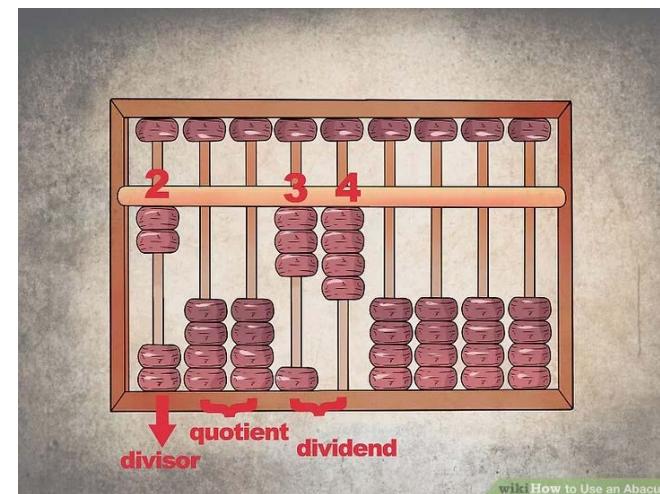
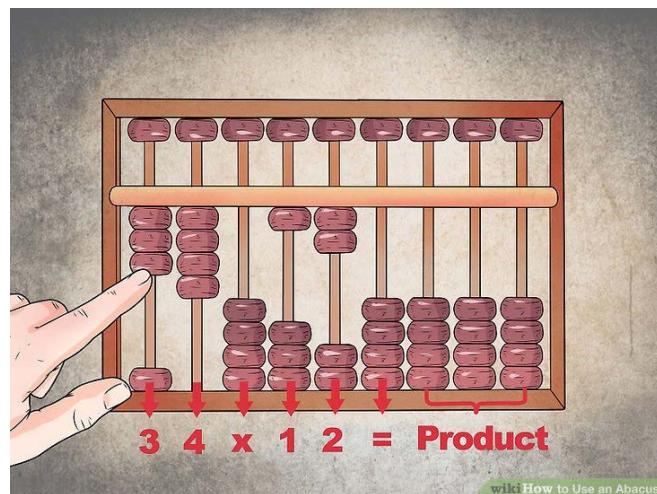
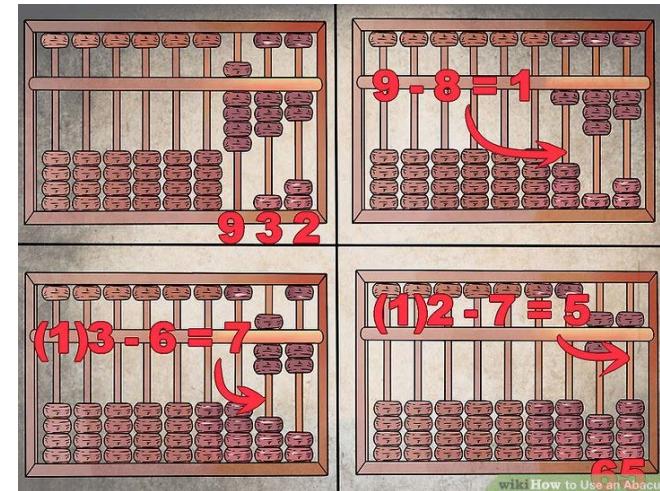
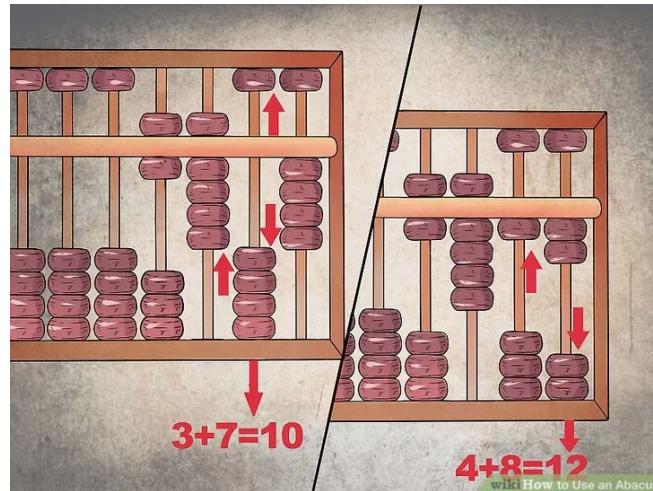
Activity 1.1 Play abacus

- Click on <https://www.mathematik.uni-marburg.de/~thormae/lectures/ti1/code/abacus/sanpan.html>

- Calculate
 - $83 + 12 = ?$
 - $112 + 12 = ?$



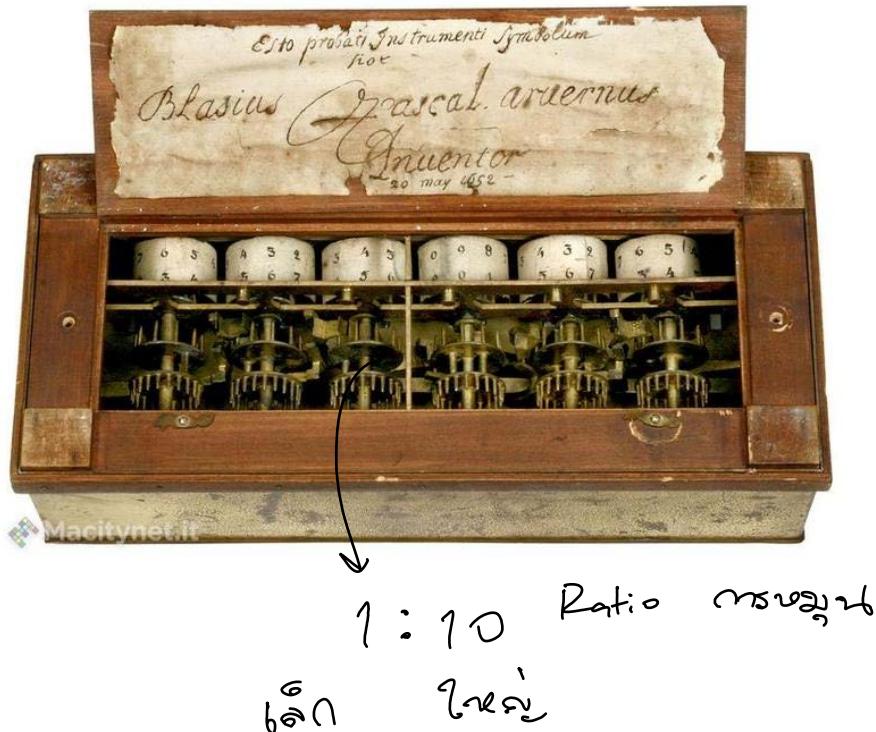
More functions in Abacus



<https://www.wikihow.com/Use-an-Abacus>

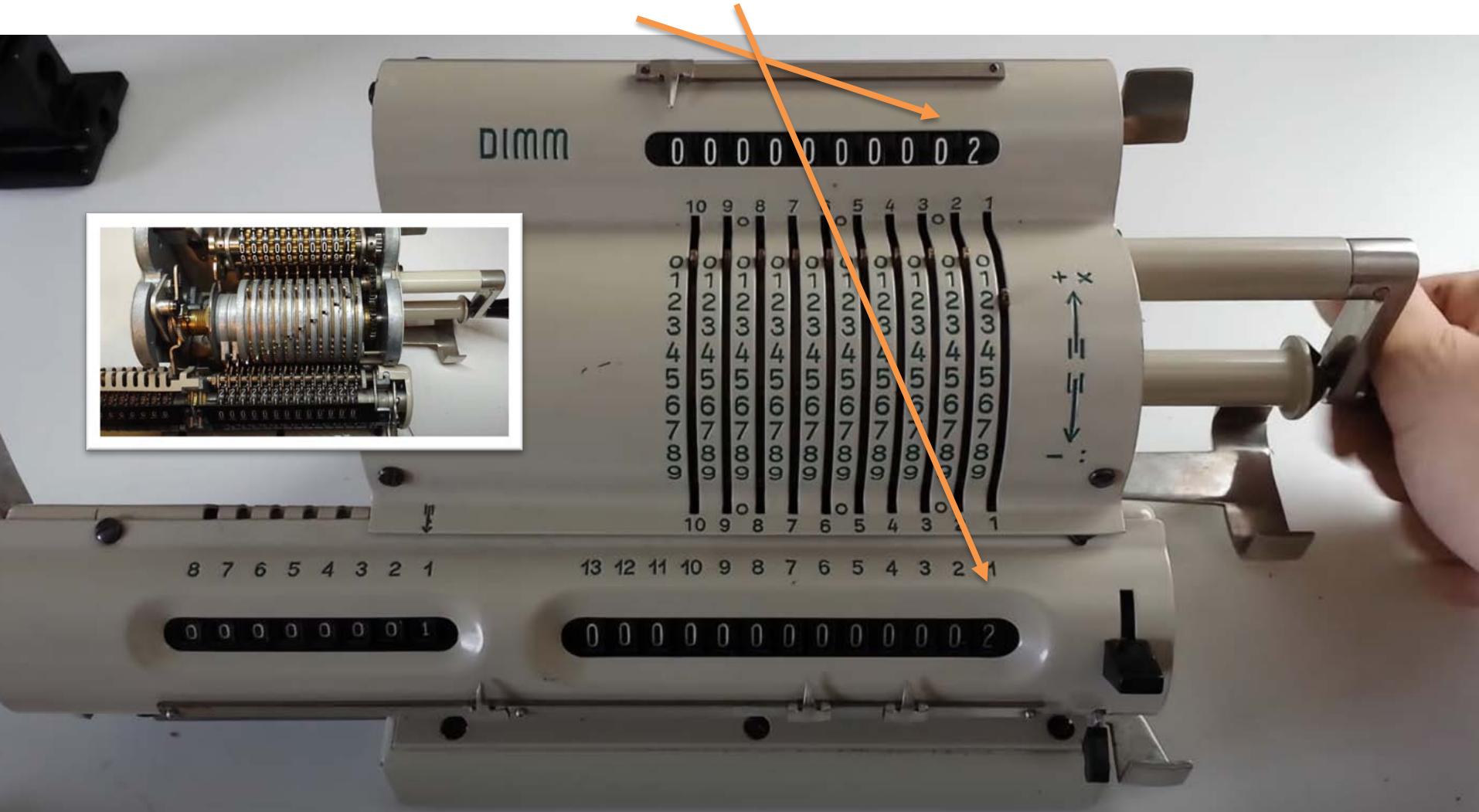
1.1.1 Mechanical computer

- Mechanical calculator
 - Blaise Pascal (1642) developed a machine to help his father working in the shop.
 - Working only function of the addition and subtraction.



2nd Era - බුද්ධ

$$2+2 = 4$$

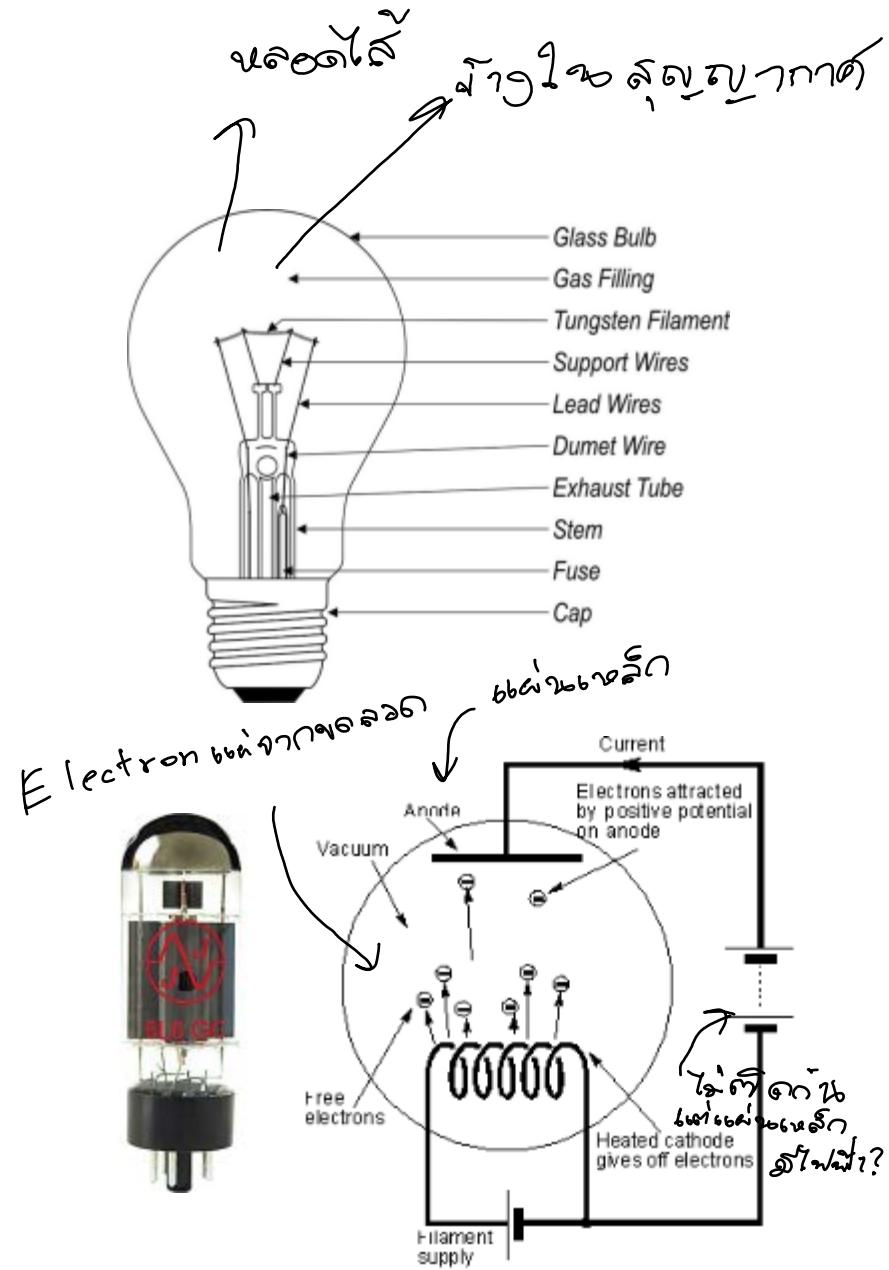


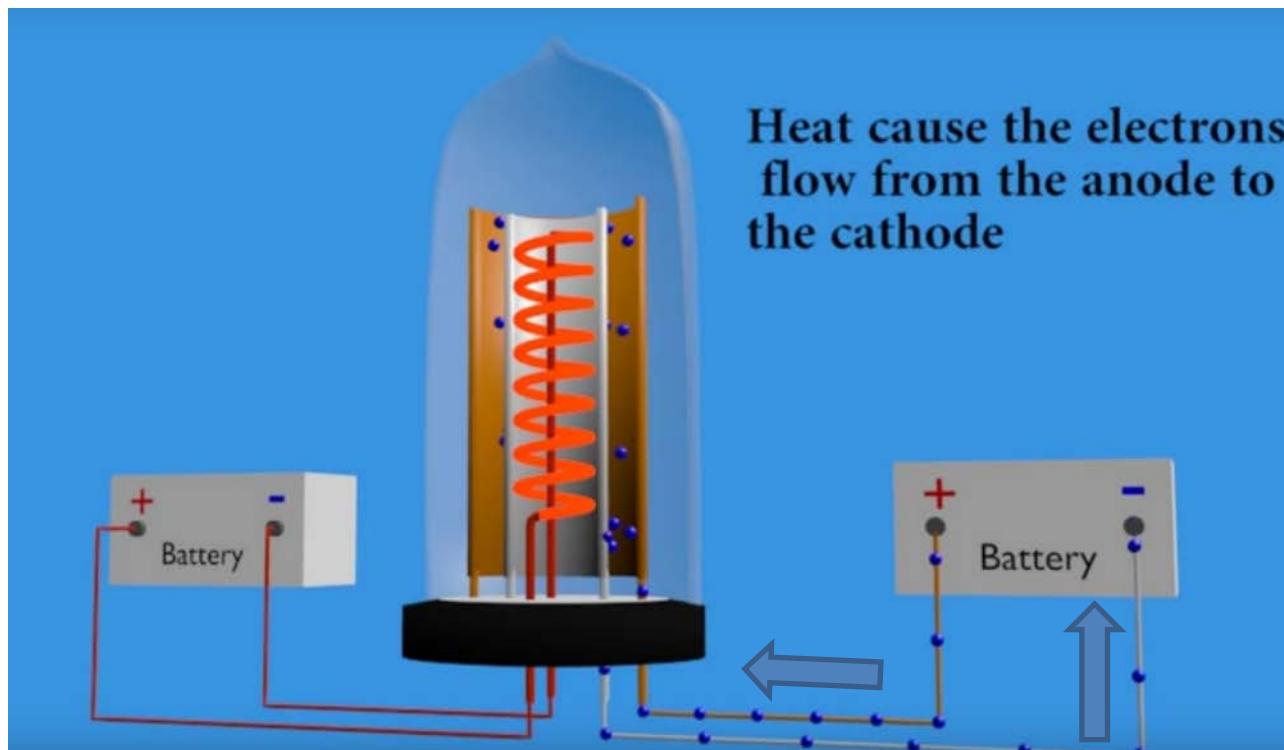
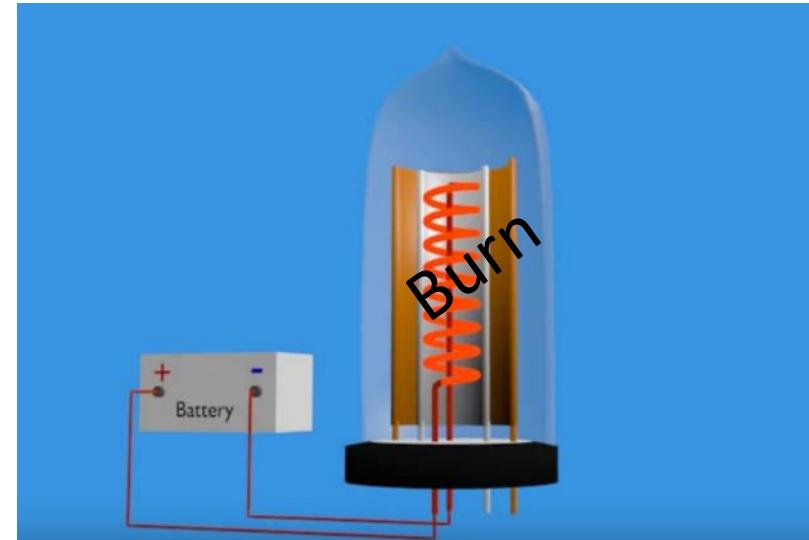
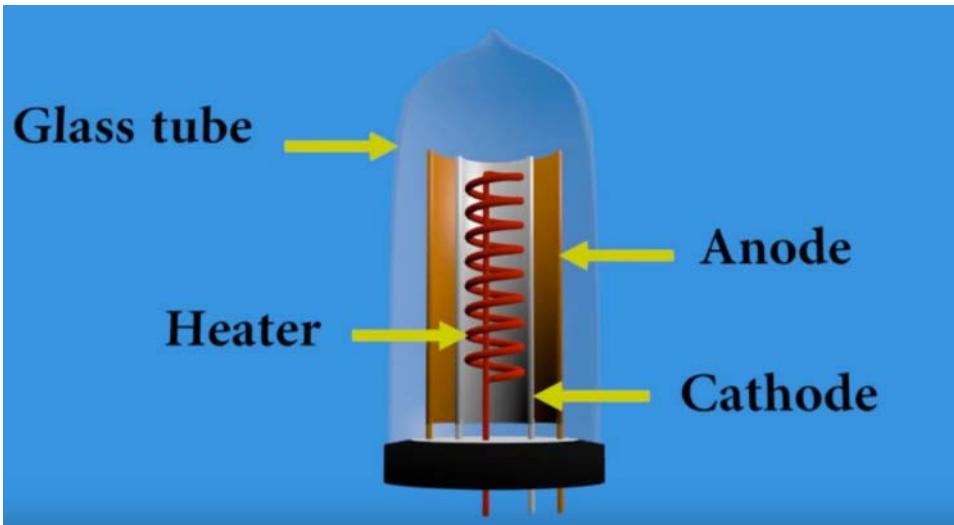
3rd Era Yawat

ELECTRICITY VACUUM TUBE

1.1.2 Vacuum Tube

- Vacuum Tube was developed from *Incandescent lamp*.
 - When a *tungsten⁷⁴* lead gets heat, it spreads electron by moving to an anode plate.
 - A grid plate uses controls number of electron moving from the tungsten lead to an anode plate.

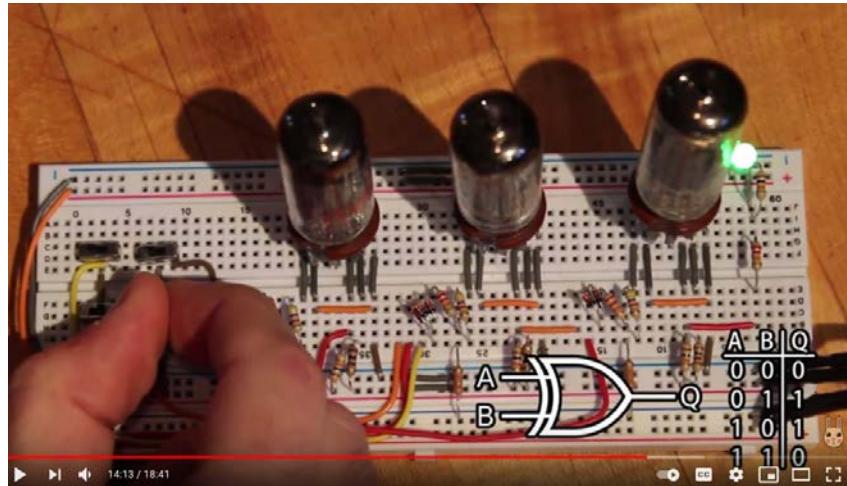




Heat cause the electrons flow from the anode to the cathode

XOR

Vacuum tube and future



<https://youtu.be/N-Sc6krlTM?t=853>

3 vacuum tubes 3 ស៊ា
ស្ថិតិយវ នឹង XOR Gate 1 ស៊ា

4.) Future: The Nano Vacuum Tube

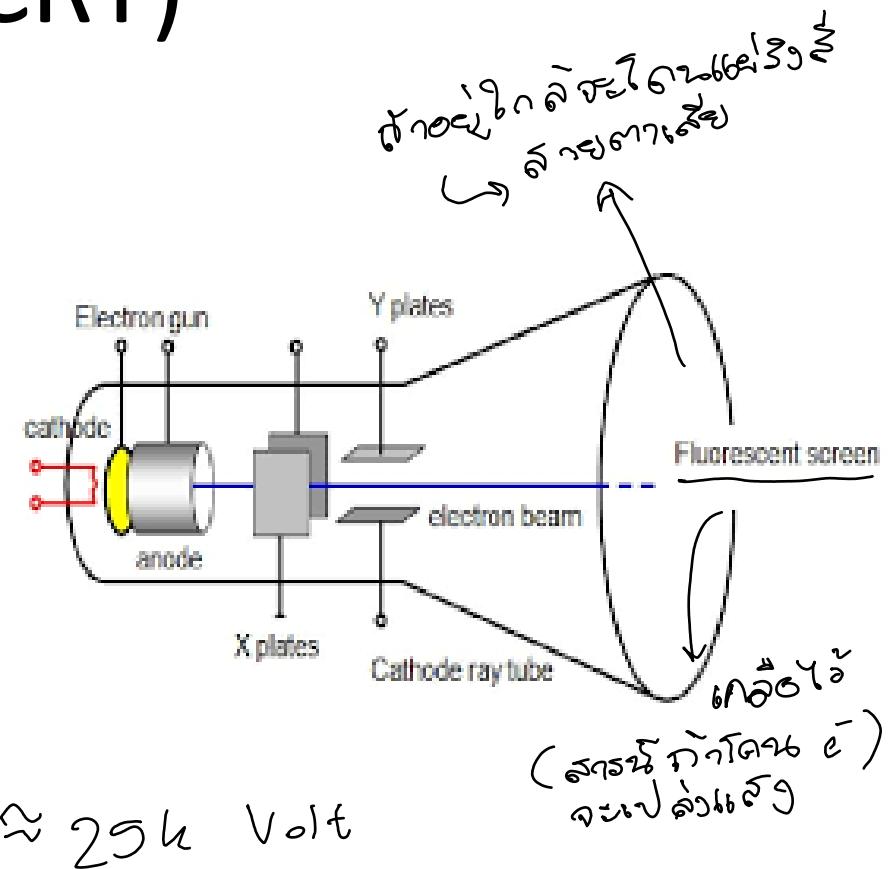
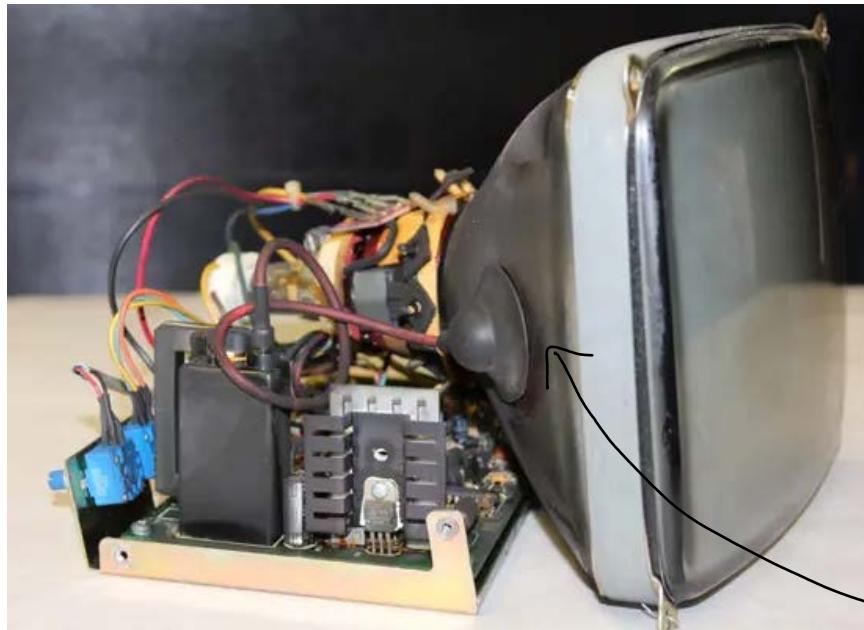
Vacuum tubes may make a comeback and replace standard microchips. Engineers have been able to build a structure in phosphorus doped silicon and use nanotubes to build a switch. These devices can operate 10 times faster than silicon transistors.



Vacuum tube ຖະຫຼາດຄວາມເກີຍ

Cathod Ray Tube (CRT)

ຂາດຄາວເງື່ນ TV

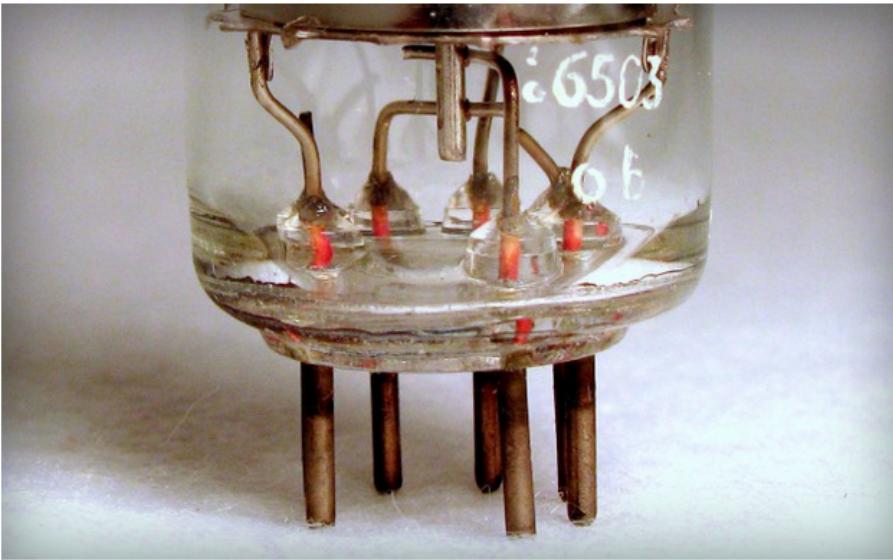




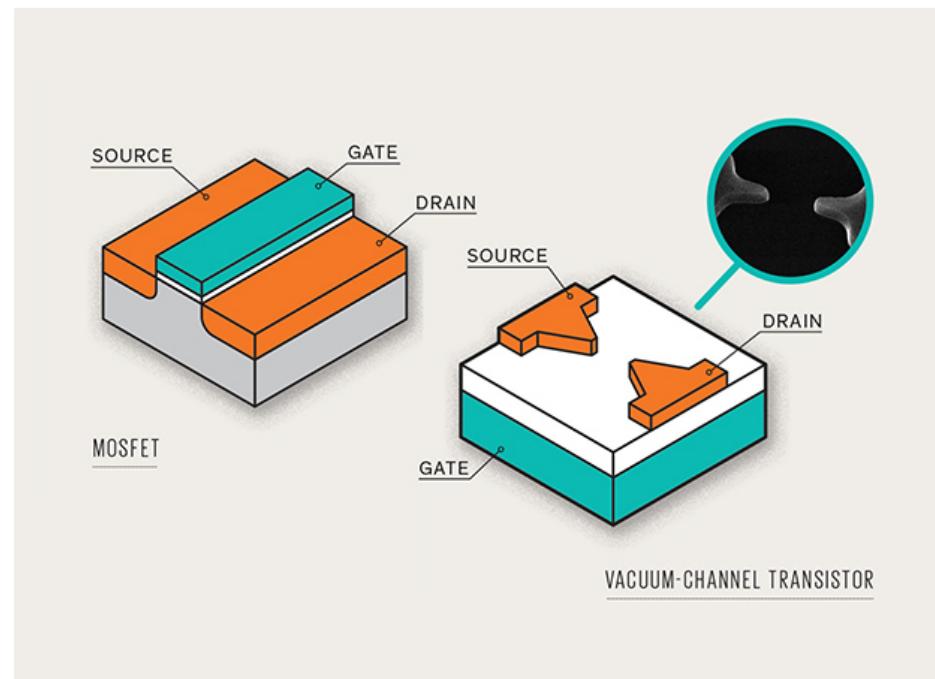
The vacuum tube strikes back: NASA's tiny 460GHz vacuum transistor that could one day replace silicon FETs

By Sebastian Anthony on June 24, 2014 at 8:12 am | [Comments](#)

92 SHARES



Way back in the salad days of digital computing (the 1940s and '50s), computers were made of vacuum tubes — big, hot, clunky devices that, when you got right down to it, were essentially glorified light bulbs. This is why early computers like the ENIAC weighed more than 27 tons and consumed more power than a small town. Later, obviously, vacuum tubes would be replaced by probably the greatest invention of all time — the solid-state transistor — which would allow for the creation of smaller, faster, cheaper, and more reliable computers. Fast forward to 2014, though, and the humble CMOS field-effect transistor (FET) is starting to show its age. We've pretty much hit the limit on shrinking silicon transistors any further, and they can't operate at speeds much faster than a few gigahertz. Which is why NASA's Ames Research Center is going back to the future with its new *vacuum transistor* — a nanometer-scale vacuum tube that, in early testing, has reached speeds of up to **460GHz**.

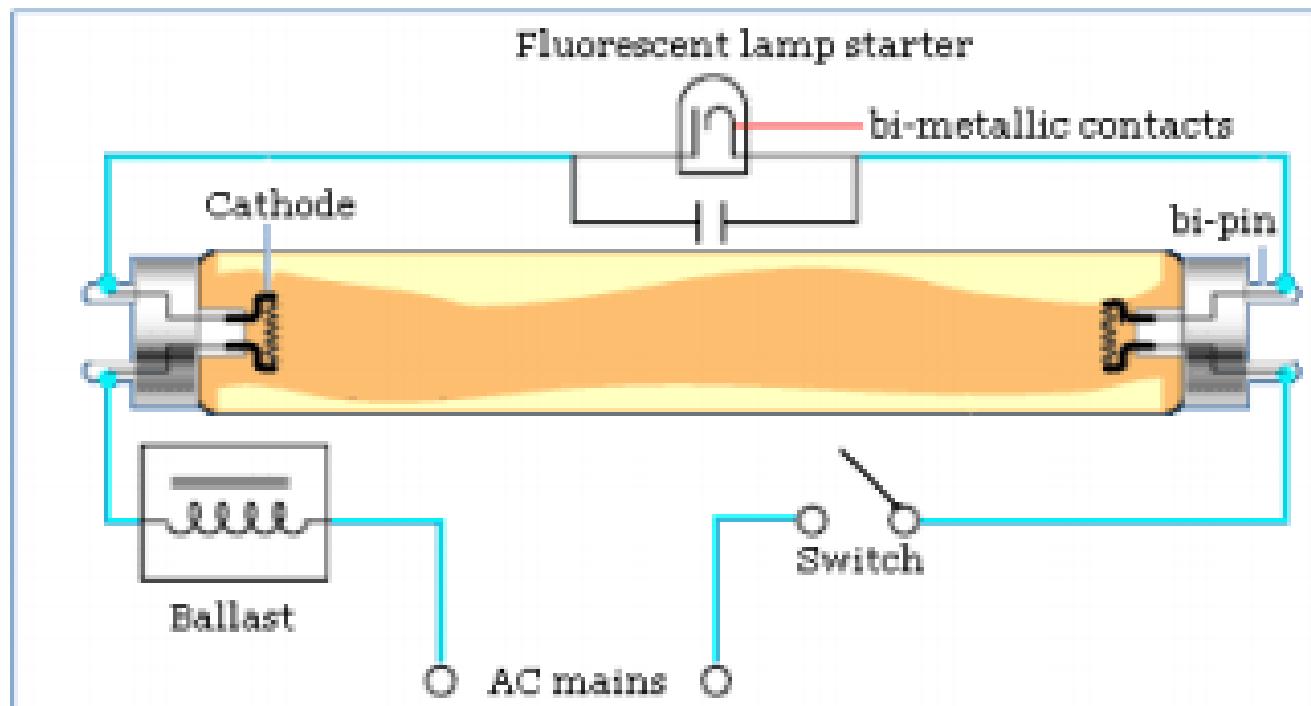


Standard MOSFET vs. vacuum-channel transistor [Image credit: IEEE Spectrum]

NASA's Ames Research Center has been working on-and-off for many years on the *vacuum-channel transistor*, which is essentially a vacuum tube that can be fabricated using conventional CMOS techniques. Instead of a gate sitting between the source and drain, there is... nothing. A vacuum. By a method known as *field emission*, electrons are drawn across the vacuum from the source to the drain when a current is applied to the gate (see diagram). By using field emission rather than the thermionic (hot) electron emission, these vacuum-channel transistors don't require a heat source. Importantly, they also don't require a vacuum — instead they use helium (it's sparse enough that the electrons have almost no chance of bumping into helium atoms while they traverse the few-nanometer gap between source and drain). The electrons also traverse the air gap a lot faster than if they had to pass through the gate electrode.

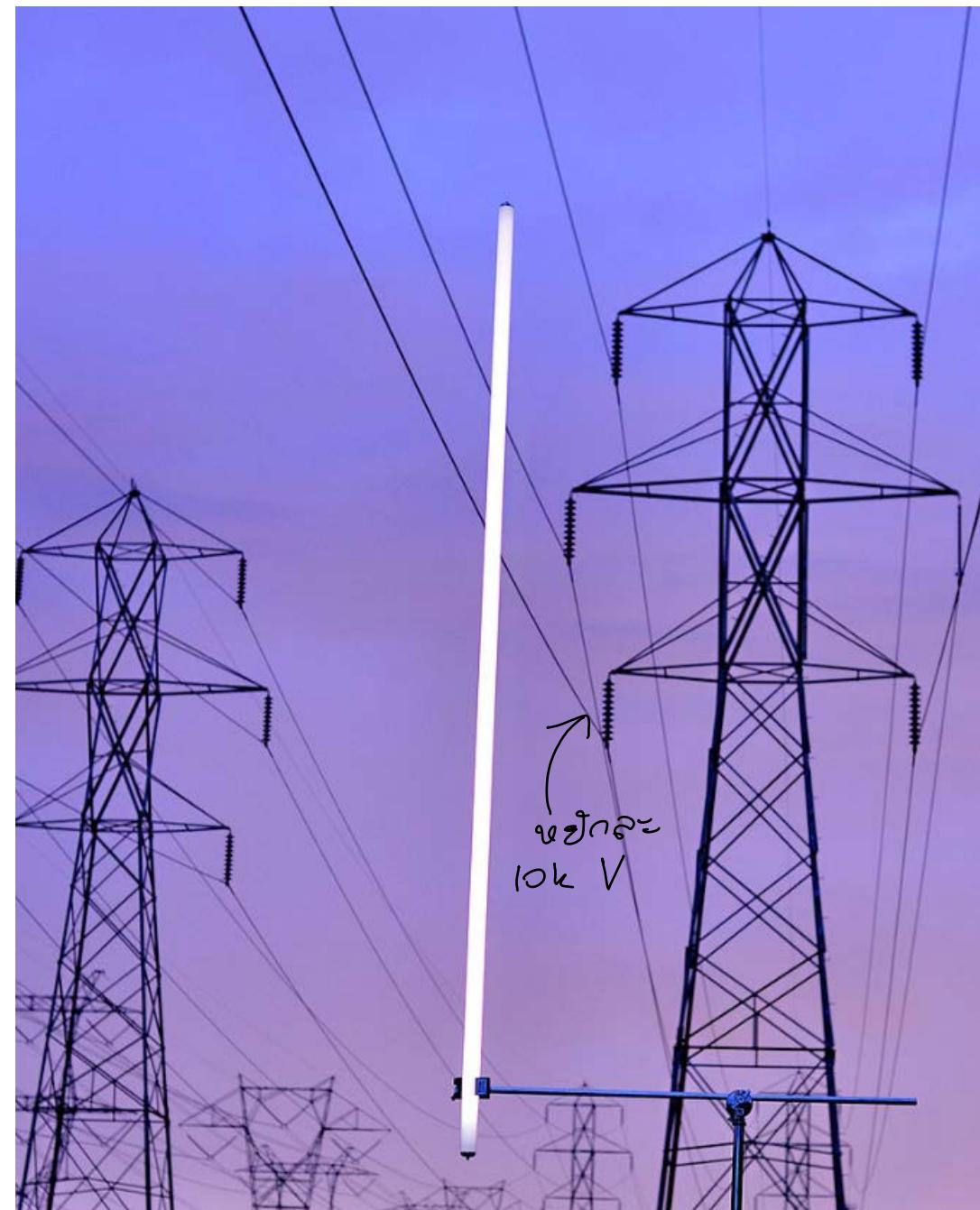
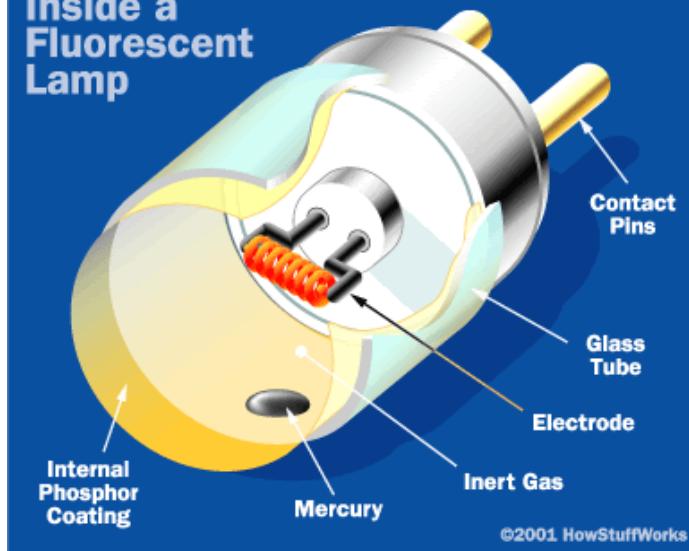
Activity 1.2

- The fluorescence lamp has two small tungsten coils. Do you know why does the fluorescence lamp generates light? (Discussion)





Inside a Fluorescent Lamp



e) A Silicon Chip

ELECTRON AND SILICON

1.1.3 Silicon Transistor

- Where are Silicon, Germanium, Boron, and Antimony on the periodic table?

ສາງກົງຕັດໄຟ (ສີເບລົ່ມ)

1 IA	H Hydrogen Atomic number 1 Symbol H Name Hydrogen Atomic weight 1.008 Electrons per shell 1	2 IIA	Be Beryllium Atomic number 4 Symbol Be Name Beryllium Atomic weight 9.012 Electrons per shell 2													18 VIIIA			
Li Lithium Atomic number 3 Symbol Li Name Lithium Atomic weight 6.94 Electrons per shell 2,1	Mg Magnesium Atomic number 12 Symbol Mg Name Magnesium Atomic weight 24.31 Electrons per shell 2,8,2	Na Sodium Atomic number 11 Symbol Na Name Sodium Atomic weight 22.990 Electrons per shell 2,8,1	Sc Scandium Atomic number 21 Symbol Sc Name Scandium Atomic weight 44.955708 Electrons per shell 2,8,7	Ti Titanium Atomic number 22 Symbol Ti Name Titanium Atomic weight 47.907 Electrons per shell 2,8,2	V Vanadium Atomic number 23 Symbol V Name Vanadium Atomic weight 50.942 Electrons per shell 2,8,3	Cr Chromium Atomic number 24 Symbol Cr Name Chromium Atomic weight 51.996 Electrons per shell 2,8,6	Mn Manganese Atomic number 25 Symbol Mn Name Manganese Atomic weight 54.938 Electrons per shell 2,8,6,2	Fe Iron Atomic number 26 Symbol Fe Name Iron Atomic weight 55.845 Electrons per shell 2,8,6,2	Co Cobalt Atomic number 27 Symbol Co Name Cobalt Atomic weight 58.932 Electrons per shell 2,8,7	Ni Nickel Atomic number 28 Symbol Ni Name Nickel Atomic weight 58.693 Electrons per shell 2,8,7	Cu Copper Atomic number 29 Symbol Cu Name Copper Atomic weight 63.546 Electrons per shell 2,8,8,1	Zn Zinc Atomic number 30 Symbol Zn Name Zinc Atomic weight 65.402 Electrons per shell 2,8,8,2	Al Aluminum Atomic number 13 Symbol Al Name Aluminum Atomic weight 26.982 Electrons per shell 2,8,3	Si Silicon Atomic number 14 Symbol Si Name Silicon Atomic weight 28.085 Electrons per shell 2,8,4	P Phosphorus Atomic number 15 Symbol P Name Phosphorus Atomic weight 30.973 Electrons per shell 2,8,5	S Sulfur Atomic number 16 Symbol S Name Sulfur Atomic weight 32.064 Electrons per shell 2,8,6	Cl Chlorine Atomic number 17 Symbol Cl Name Chlorine Atomic weight 35.45 Electrons per shell 2,8,7	Ar Argon Atomic number 18 Symbol Ar Name Argon Atomic weight 39.902 Electrons per shell 2,8,8	
K Potassium Atomic number 19 Symbol K Name Potassium Atomic weight 39.092 Electrons per shell 2,8,8,1	Ca Calcium Atomic number 20 Symbol Ca Name Calcium Atomic weight 40.08 Electrons per shell 2,8,8,2	Rb Rubidium Atomic number 37 Symbol Rb Name Rubidium Atomic weight 85.467 Electrons per shell 2,8,8,5	Sr Strontium Atomic number 38 Symbol Sr Name Strontium Atomic weight 87.62 Electrons per shell 2,8,8,2	Y Yttrium Atomic number 39 Symbol Y Name Yttrium Atomic weight 88.904 Electrons per shell 2,8,9,2	Zr Zirconium Atomic number 40 Symbol Zr Name Zirconium Atomic weight 91.223 Electrons per shell 2,8,9,2	Nb Niobium Atomic number 41 Symbol Nb Name Niobium Atomic weight 92.907 Electrons per shell 2,8,9,2	Mo Molybdenum Atomic number 42 Symbol Mo Name Molybdenum Atomic weight 95.94 Electrons per shell 2,8,9,5	Tc Technetium Atomic number 43 Symbol Tc Name Technetium Atomic weight 98.907 Electrons per shell 2,8,9,5	Ru Ruthenium Atomic number 44 Symbol Ru Name Ruthenium Atomic weight 101.907 Electrons per shell 2,8,9,5	Rh Rhodium Atomic number 45 Symbol Rh Name Rhodium Atomic weight 102.907 Electrons per shell 2,8,9,6	Pd Palladium Atomic number 46 Symbol Pd Name Palladium Atomic weight 106.42 Electrons per shell 2,8,9,6	Ag Silver Atomic number 47 Symbol Ag Name Silver Atomic weight 107.87 Electrons per shell 2,8,9,6	Cd Cadmium Atomic number 48 Symbol Cd Name Cadmium Atomic weight 112.41 Electrons per shell 2,8,9,6	In Indium Atomic number 49 Symbol In Name Indium Atomic weight 114.82 Electrons per shell 2,8,9,6	Sn Tin Atomic number 50 Symbol Sn Name Tin Atomic weight 118.71 Electrons per shell 2,8,9,6	Sb Antimony Atomic number 51 Symbol Sb Name Antimony Atomic weight 121.71 Electrons per shell 2,8,9,6	Te Tellurium Atomic number 52 Symbol Te Name Tellurium Atomic weight 127.60 Electrons per shell 2,8,9,6	I Iodine Atomic number 53 Symbol I Name Iodine Atomic weight 126.90 Electrons per shell 2,8,9,6	Xe Xenon Atomic number 54 Symbol Xe Name Xenon Atomic weight 131.39 Electrons per shell 2,8,9,8
Cs Cesium Atomic number 55 Symbol Cs Name Cesium Atomic weight 132.911 Electrons per shell 2,8,18,8,1	Ba Barium Atomic number 56 Symbol Ba Name Barium Atomic weight 137.32 Electrons per shell 2,8,18,8,2	Hf Hafnium Atomic number 72 Symbol Hf Name Hafnium Atomic weight 178.478 Electrons per shell 2,8,18,8,2	Ta Tantalum Atomic number 73 Symbol Ta Name Tantalum Atomic weight 180.478 Electrons per shell 2,8,18,8,2	W Tungsten Atomic number 74 Symbol W Name Tungsten Atomic weight 183.84 Electrons per shell 2,8,18,8,2	Re Rhenium Atomic number 75 Symbol Re Name Rhenium Atomic weight 186.21 Electrons per shell 2,8,18,8,2	Os Osmium Atomic number 76 Symbol Os Name Osmium Atomic weight 190.22 Electrons per shell 2,8,18,8,2	Ir Iridium Atomic number 77 Symbol Ir Name Iridium Atomic weight 191.22 Electrons per shell 2,8,18,8,2	Pt Platinum Atomic number 78 Symbol Pt Name Platinum Atomic weight 195.08 Electrons per shell 2,8,18,8,2	Au Gold Atomic number 79 Symbol Au Name Gold Atomic weight 196.97 Electrons per shell 2,8,18,8,1	Hg Mercury Atomic number 80 Symbol Hg Name Mercury Atomic weight 200.59 Electrons per shell 2,8,18,8,2	Tl Thallium Atomic number 81 Symbol Tl Name Thallium Atomic weight 204.20 Electrons per shell 2,8,18,8,2	Pb Lead Atomic number 82 Symbol Pb Name Lead Atomic weight 207.2 Electrons per shell 2,8,18,8,2	Bi Bismuth Atomic number 83 Symbol Bi Name Bismuth Atomic weight 208.98 Electrons per shell 2,8,18,8,2	Po Polonium Atomic number 84 Symbol Po Name Polonium Atomic weight 209.0 Electrons per shell 2,8,18,8,2	At Astatine Atomic number 85 Symbol At Name Astatine Atomic weight 210.0 Electrons per shell 2,8,18,8,2	Rn Radon Atomic number 86 Symbol Rn Name Radon Atomic weight 222.0 Electrons per shell 2,8,18,8,2			
Fr Francium Atomic number 87 Symbol Fr Name Francium Atomic weight 226.0 Electrons per shell 2,8,18,8,2	Ra Radium Atomic number 88 Symbol Ra Name Radium Atomic weight 226.0 Electrons per shell 2,8,18,8,2	89-103 Actinides	Rf Rutherfordium Atomic number 104 Symbol Rf Name Rutherfordium Atomic weight 261.0 Electrons per shell 2,8,18,8,2	Db Dubnium Atomic number 105 Symbol Db Name Dubnium Atomic weight 261.0 Electrons per shell 2,8,18,8,2	Sg Sg Atomic number 106 Symbol Sg Name Sg Atomic weight 261.0 Electrons per shell 2,8,18,8,2	Bh Bh Atomic number 107 Symbol Bh Name Bh Atomic weight 261.0 Electrons per shell 2,8,18,8,2	Hs Hassium Atomic number 108 Symbol Hs Name Hassium Atomic weight 261.0 Electrons per shell 2,8,18,8,2	Mt Meitnerium Atomic number 109 Symbol Mt Name Meitnerium Atomic weight 261.0 Electrons per shell 2,8,18,8,2	Ds Darmstadtium Atomic number 110 Symbol Ds Name Darmstadtium Atomic weight 261.0 Electrons per shell 2,8,18,8,2	Rg Rutherfordium Atomic number 111 Symbol Rg Name Rutherfordium Atomic weight 261.0 Electrons per shell 2,8,18,8,2	Cn Cn Atomic number 112 Symbol Cn Name Cn Atomic weight 261.0 Electrons per shell 2,8,18,8,2	Nh Nh Atomic number 113 Symbol Nh Name Nh Atomic weight 261.0 Electrons per shell 2,8,18,8,2	Fl Fl Atomic number 114 Symbol Fl Name Fl Atomic weight 261.0 Electrons per shell 2,8,18,8,2	Mc Mc Atomic number 115 Symbol Mc Name Mc Atomic weight 261.0 Electrons per shell 2,8,18,8,2	Lv Lv Atomic number 116 Symbol Lv Name Lv Atomic weight 261.0 Electrons per shell 2,8,18,8,2	Ts Ts Atomic number 117 Symbol Ts Name Ts Atomic weight 261.0 Electrons per shell 2,8,18,8,2	Og Oganesson Atomic number 118 Symbol Og Name Oganesson Atomic weight 261.0 Electrons per shell 2,8,18,8,2		

La Lanthanum Atomic number 57 Symbol La Name Lanthanum Atomic weight 138.91 Electrons per shell 2,8,18,8,2	Ce Cerium Atomic number 58 Symbol Ce Name Cerium Atomic weight 140.12 Electrons per shell 2,8,18,8,2	Pr Praseodymium Atomic number 59 Symbol Pr Name Praseodymium Atomic weight 141.02 Electrons per shell 2,8,18,8,2	Nd Neodymium Atomic number 60 Symbol Nd Name Neodymium Atomic weight 144.24 Electrons per shell 2,8,18,8,2	Pm Promethium Atomic number 61 Symbol Pm Name Promethium Atomic weight 147.0 Electrons per shell 2,8,18,8,2	Sm Samarium Atomic number 62 Symbol Sm Name Samarium Atomic weight 150.36 Electrons per shell 2,8,18,8,2	Eu Europium Atomic number 63 Symbol Eu Name Europium Atomic weight 151.96 Electrons per shell 2,8,18,8,2	Gd Gadolinium Atomic number 64 Symbol Gd Name Gadolinium Atomic weight 157.21 Electrons per shell 2,8,18,8,2	Tb Terbium Atomic number 65 Symbol Tb Name Terbium Atomic weight 158.93 Electrons per shell 2,8,18,8,2	Dy Dysprosium Atomic number 66 Symbol Dy Name Dysprosium Atomic weight 162.56 Electrons per shell 2,8,18,8,2	Ho Holmium Atomic number 67 Symbol Ho Name Holmium Atomic weight 164.92 Electrons per shell 2,8,18,8,2	Er Erbium Atomic number 68 Symbol Er Name Erbium Atomic weight 167.26 Electrons per shell 2,8,18,8,2	Tm Thulium Atomic number 69 Symbol Tm Name Thulium Atomic weight 169.93 Electrons per shell 2,8,18,8,2	Yb Ytterbium Atomic number 70 Symbol Yb Name Ytterbium Atomic weight 173.02 Electrons per shell 2,8,18,8,2	Lu Lutetium Atomic number 71 Symbol Lu Name Lutetium Atomic weight 174.91 Electrons per shell 2,8,18,8,2
Ac Actinium Atomic number 89 Symbol Ac Name Actinium Atomic weight 227.0 Electrons per shell 2,8,18,8,2	Th Thorium Atomic number 90 Symbol Th Name Thorium Atomic weight 232.04 Electrons per shell 2,8,18,8,2	Pa Protactinium Atomic number 91 Symbol Pa Name Protactinium Atomic weight 231.04 Electrons per shell 2,8,18,8,2	U Uranium Atomic number 92 Symbol U Name Uranium Atomic weight 238.03 Electrons per shell 2,8,18,8,2	Np Neptunium Atomic number 93 Symbol Np Name Neptunium Atomic weight 237.03 Electrons per shell 2,8,18,8,2	Pu Plutonium Atomic number 94 Symbol Pu Name Plutonium Atomic weight 244.0 Electrons per shell 2,8,18,8,2	Am Americium Atomic number 95 Symbol Am Name Americium Atomic weight 243.0 Electrons per shell 2,8,18,8,2	Cm Curium Atomic number 96 Symbol Cm Name Curium Atomic weight 247.0 Electrons per shell 2,8,18,8,2	Bk Berkelium Atomic number 97 Symbol Bk Name Berkelium Atomic weight 247.0 Electrons per shell 2,8,18,8,2	Cf Californium Atomic number 98 Symbol Cf Name Californium Atomic weight 251.0 Electrons per shell 2,8,18,8,2	Es Einsteinium Atomic number 99 Symbol Es Name Einsteinium Atomic weight 252.0 Electrons per shell 2,8,18,8,2	Fm Fermium Atomic number 100 Symbol Fm Name Fermium Atomic weight 257.0 Electrons per shell 2,8,18,8,2	Md Mendelevium Atomic number 101 Symbol Md Name Mendelevium Atomic weight 258.0 Electrons per shell 2,8,18,8,2	No Nobelium Atomic number 102 Symbol No Name Nobelium Atomic weight 259.0 Electrons per shell 2,8,18,8,2	Lr Lawrencium Atomic number 103 Symbol Lr Name Lawrencium Atomic weight 260.0 Electrons per shell 2,8,18,8,2

1.1.3 Silicon chip-making process

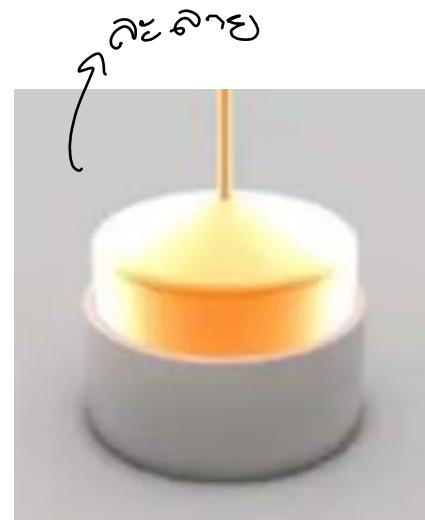
- Silicon
 - Make from the ordinary sand, quartz, rock crystal, amethyst, agate, flint, jasper, and opal.



1.1.3 Silicon chip-making process

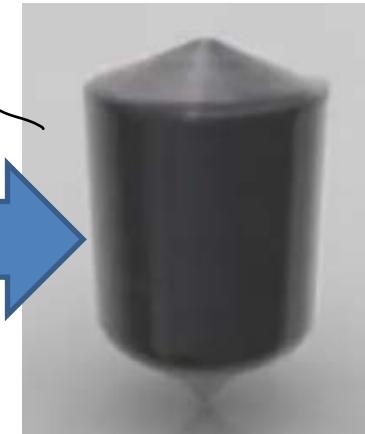


Burn



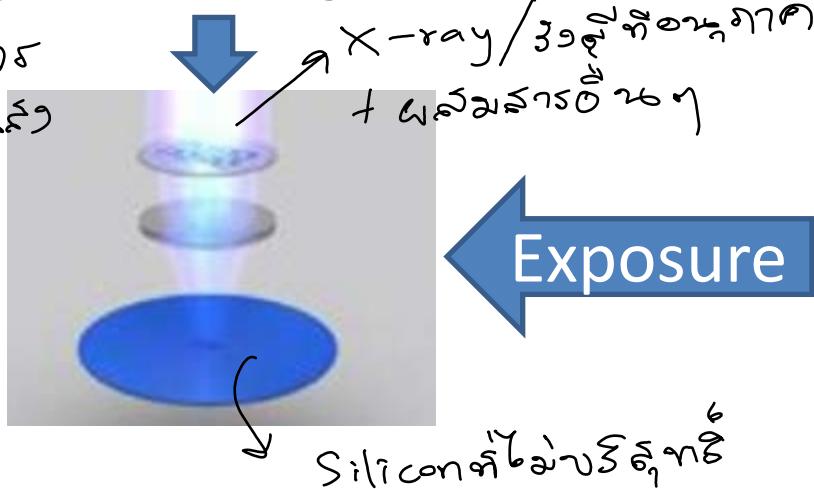
(နေရာမြတ်စွာလုပ်လာသည့်)

set



Engineer design circuit

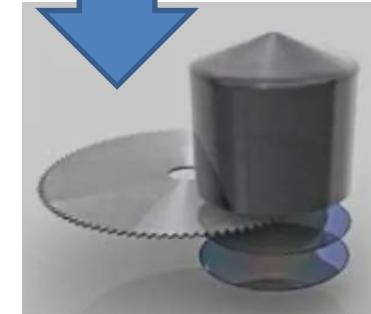
ပို့ဆောင်ရန်
+ ဓရများ



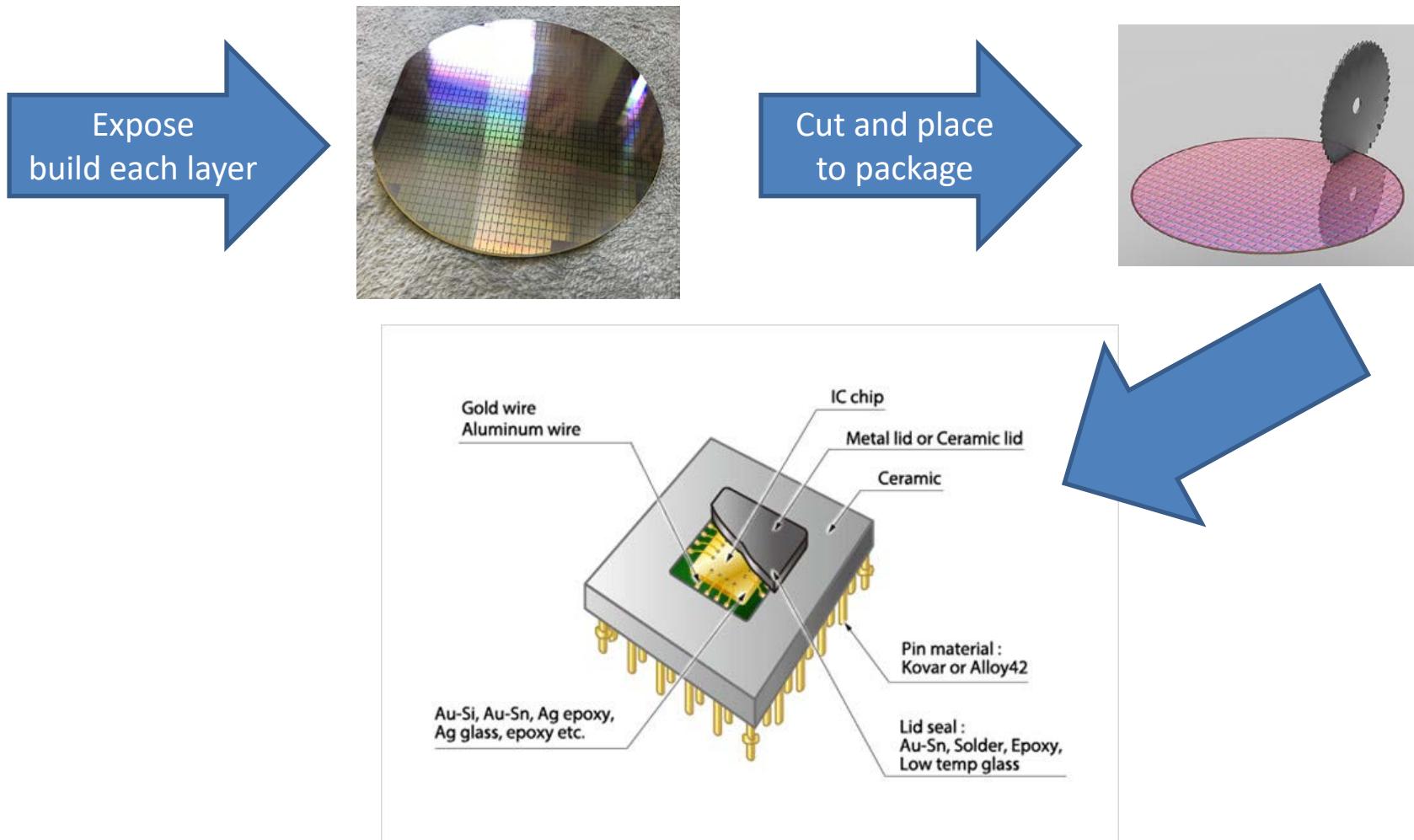
Wafer

Pure silicon
လီကျိုးလုပ်လာသည့်

Cut

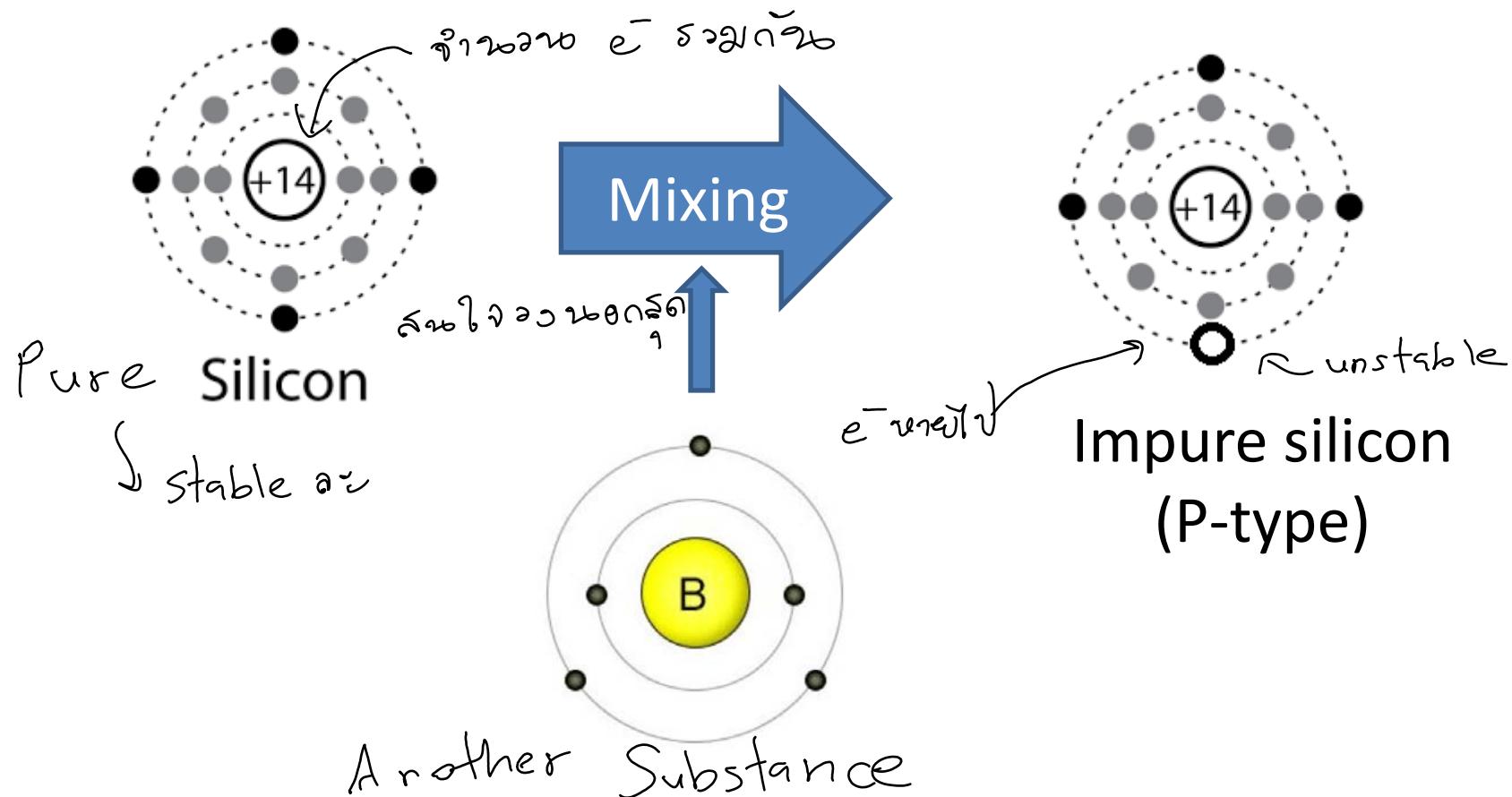


1.1.3 Silicon chip-making process



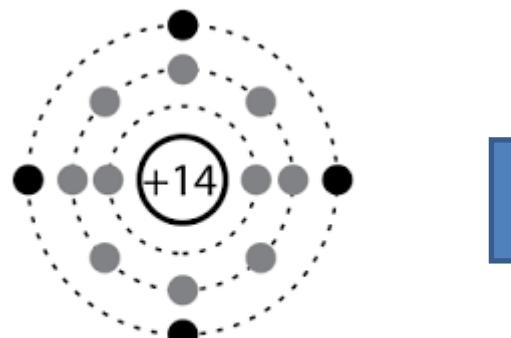
The main point of silicon chip

- Change from pure silicon to impure silicon by mixing boron to be P-type

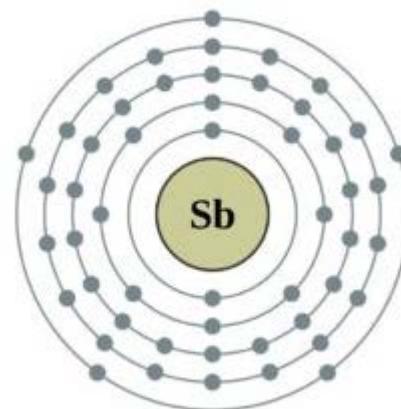


The main point of silicon chip

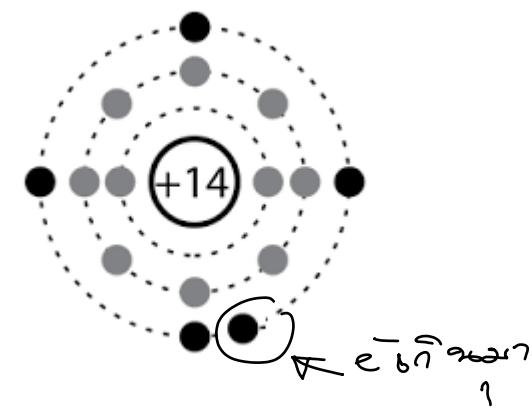
- Change from pure silicon to impure silicon by mixing antimony แอลฟ์พวง to be N-type



Silicon

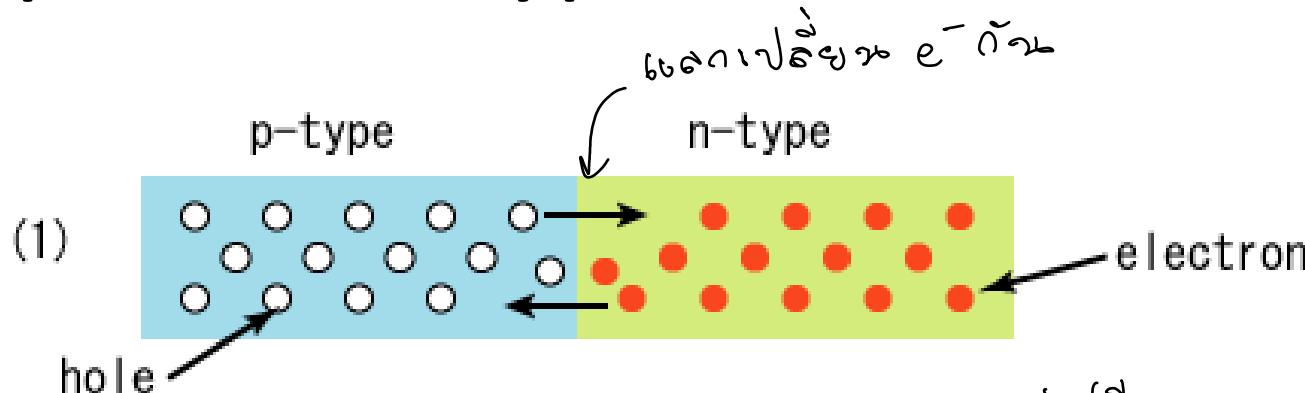


Impure silicon
(N-type)



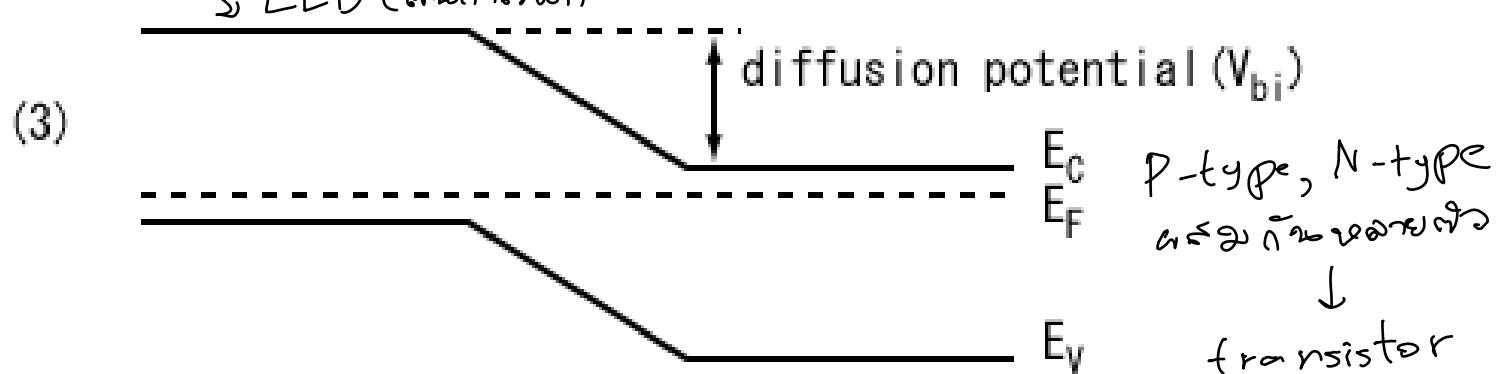
N-type and P-type

ເຕັມາຫຼັດໆ

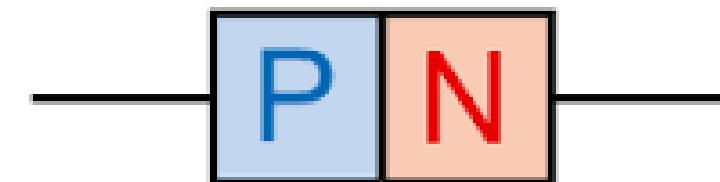


ສົດຍືນດີໃນສິນແກ້ໄຂ
electric field
↳ LED (ສະກິເນົາ)

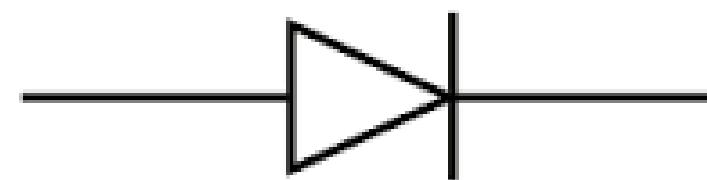
ອຸປະກອດນີ້ໃຫ້ພົກການເລີຍດາ



Diode

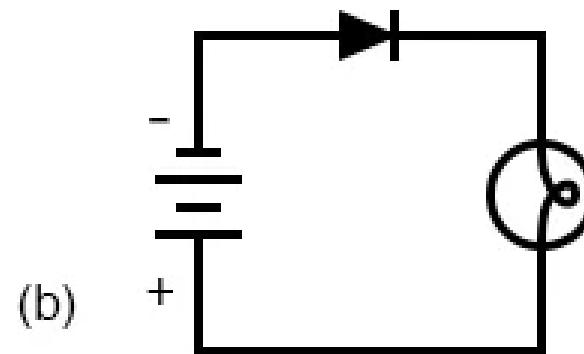
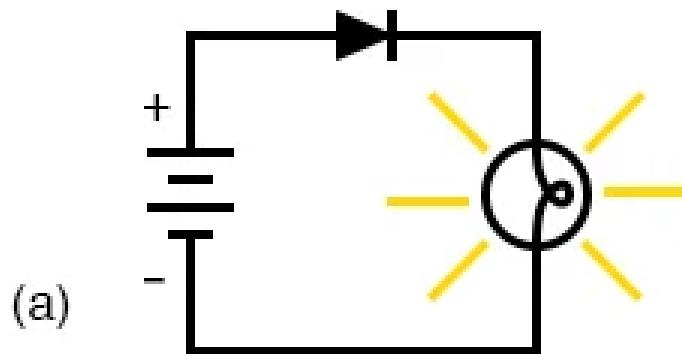


Anode Cathode

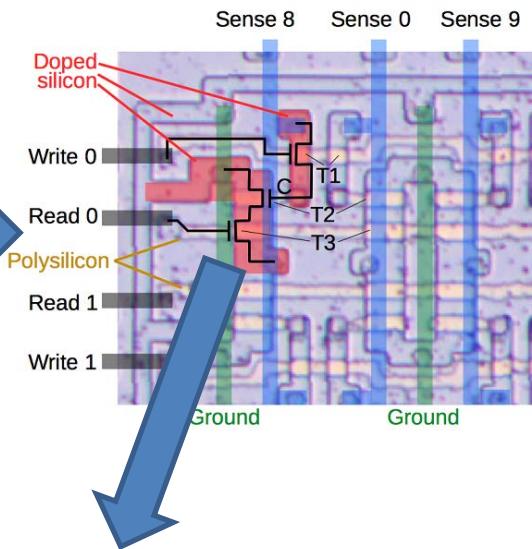
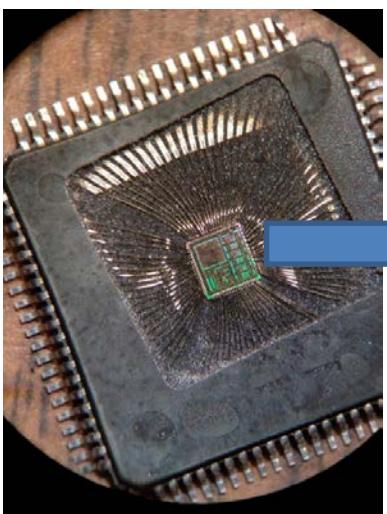


Activity 1.3

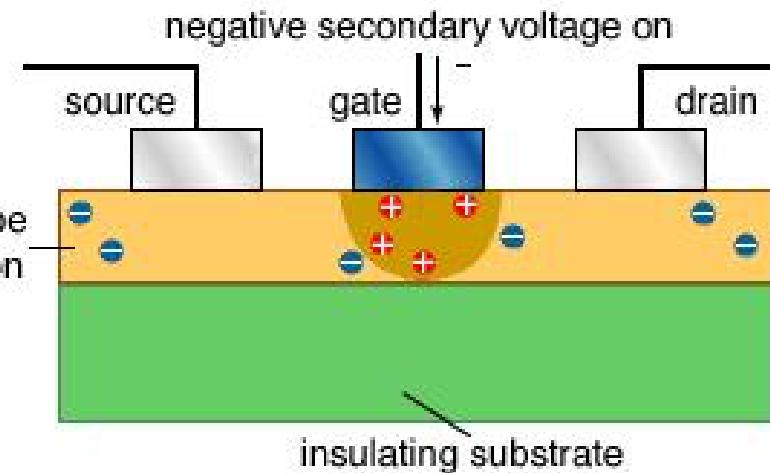
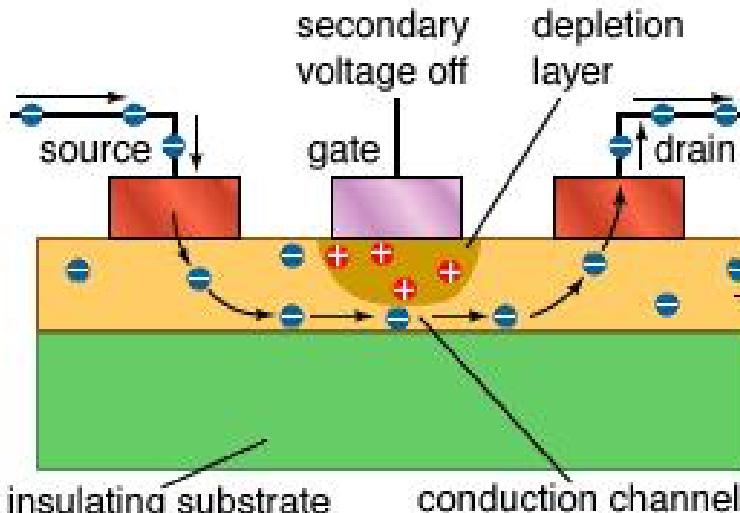
- Let's test a diode on Thinkercad.



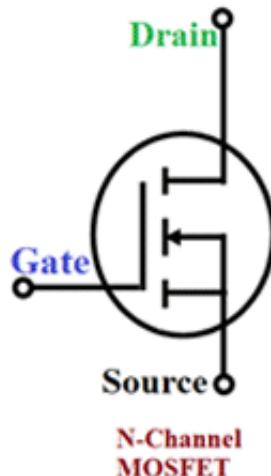
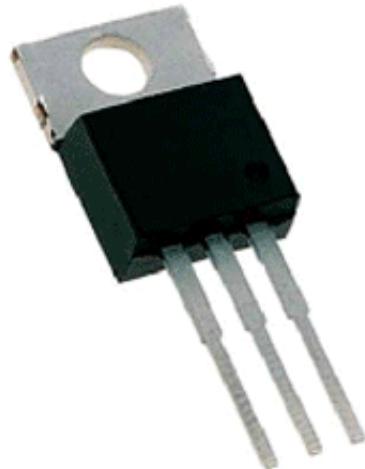
1.1.3 Silicon Transistor



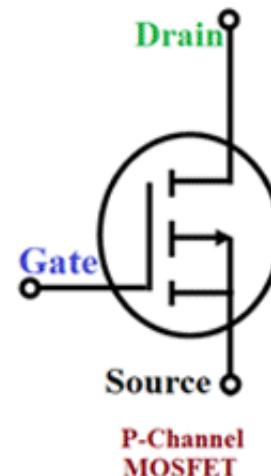
- The **gate** pin controls number of the electron move from the **source** pin to the **drain**.



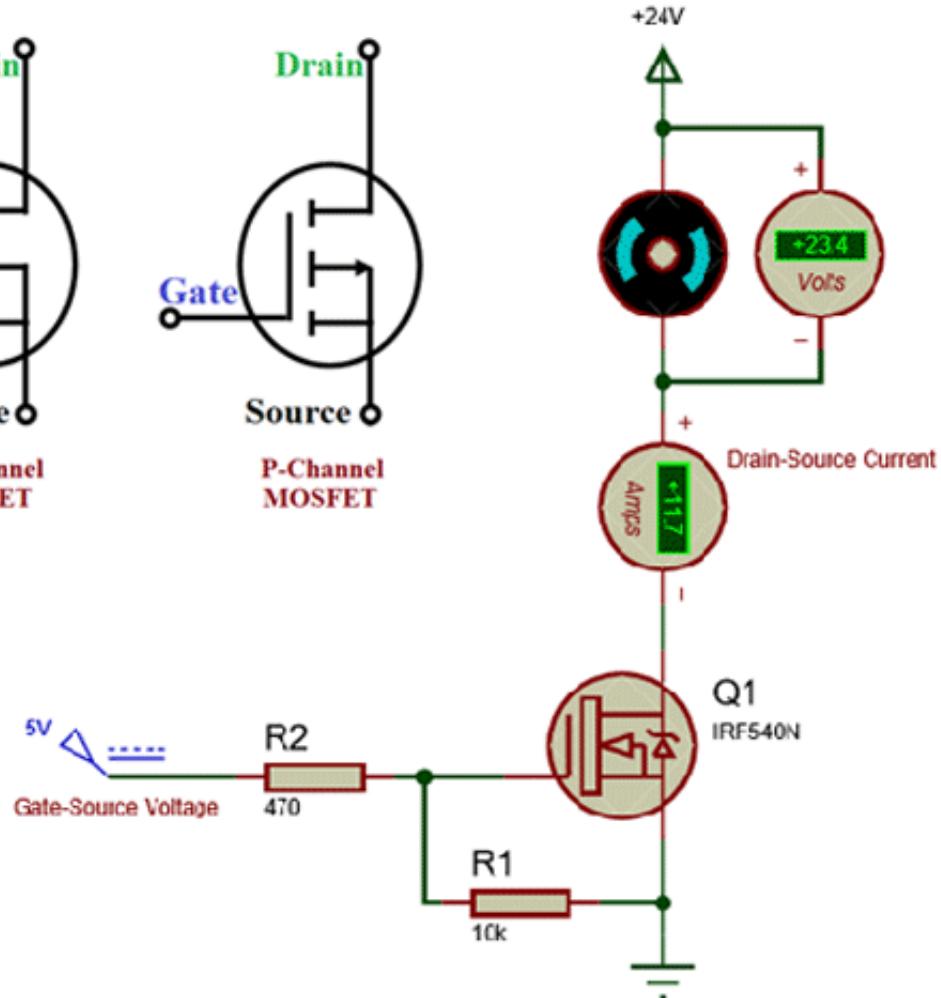
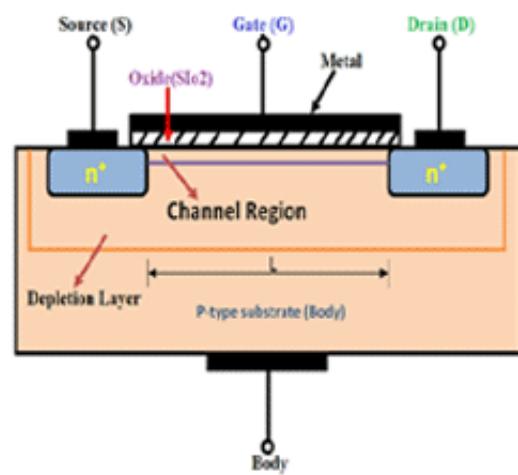
FET and Mosfet has Drain Gate Source



N-Channel
MOSFET

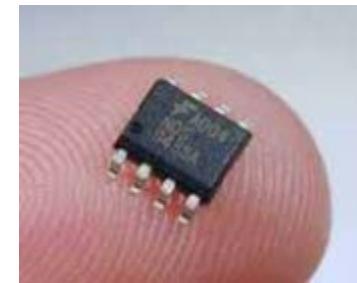
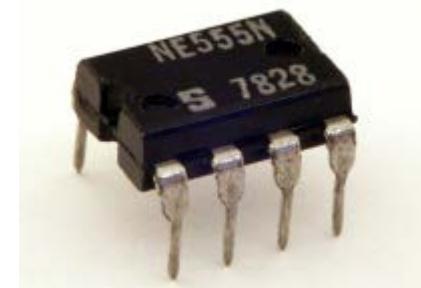
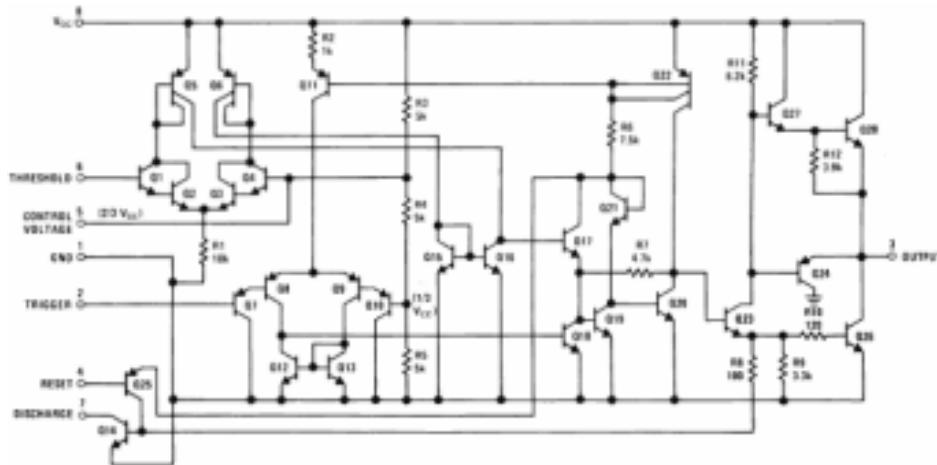


P-Channel
MOSFET



1.1.4 Integrated Circuit

- Discrete Circuit
- Integrated Circuit



1.1.4 Integrated Circuit: Chip Scale

Name	Number of Transistors	Year	Size of the transistor in chip
Small Scale IC (SSI)	10	1971 - 1985	10 µm – 1 µm
Medium SI (MSI)	10 – 1000	1989 - 1999	800nm – 180nm
Large SI (LSI)	1K – 100K	2001 - 2010	130nm – 32nm
Very LSI (VLSI)	100K – 1M	2012 - 2017	22nm – 10nm
Ultra LSI (ULS) (Nvidia GA100)	> 1M >54Bilion Transistor	2018	7nm
		2020	5nm
		Appr. 2022	3nm

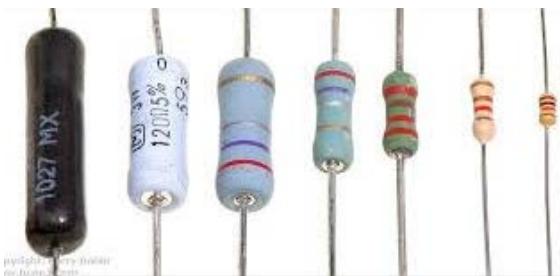
Number of transistor relate to the circuit complexity

Transistor size relate to power consumption and switching speed

OVERVIEW ELECTRONIC DEVICES

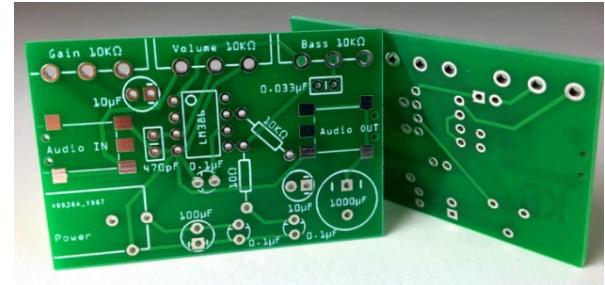
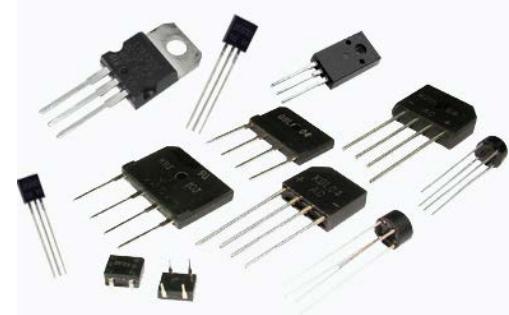
Electronic devices

- Passive device
 - Capacitor
 - Resistor
 - Inductor
 - Transformer



Electronic devices

- Active device
 - Diode
 - Transistor
 - Light Emitting Diode (LED)
 - IC, Chip
- Component
 - Print Circuit Board (PCB)



Activity 1.4

- Measure resistant and capacitance of R and C with an analog multimeter.
- Measure voltage from various battery size with an analog multimeter

PROCESSORS

1.2 The inside of Computer

- Processor
- Main memory
- System bus
- I/O Module

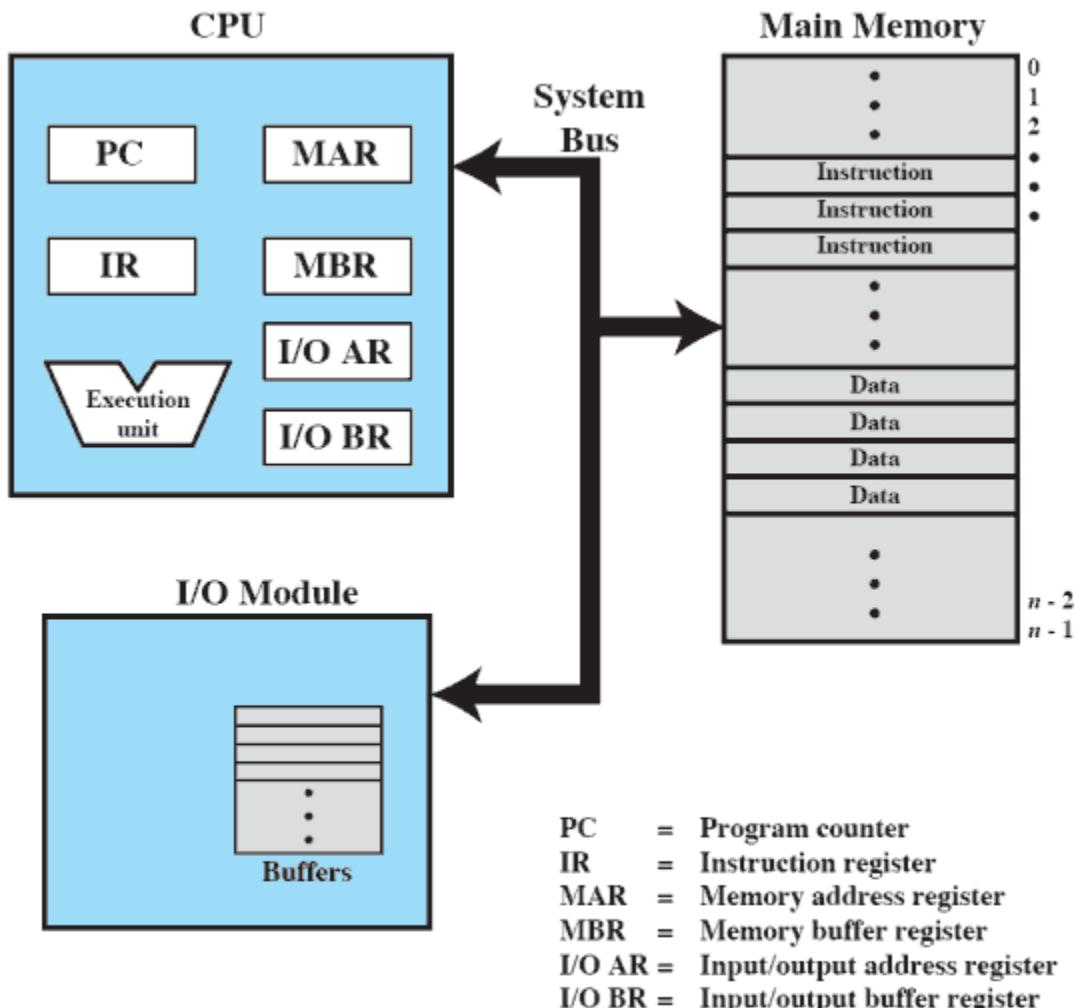


Figure 1.1 Computer Components: Top-Level View

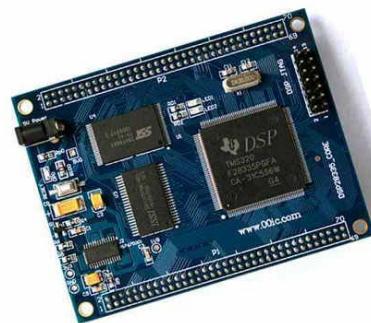
Processors

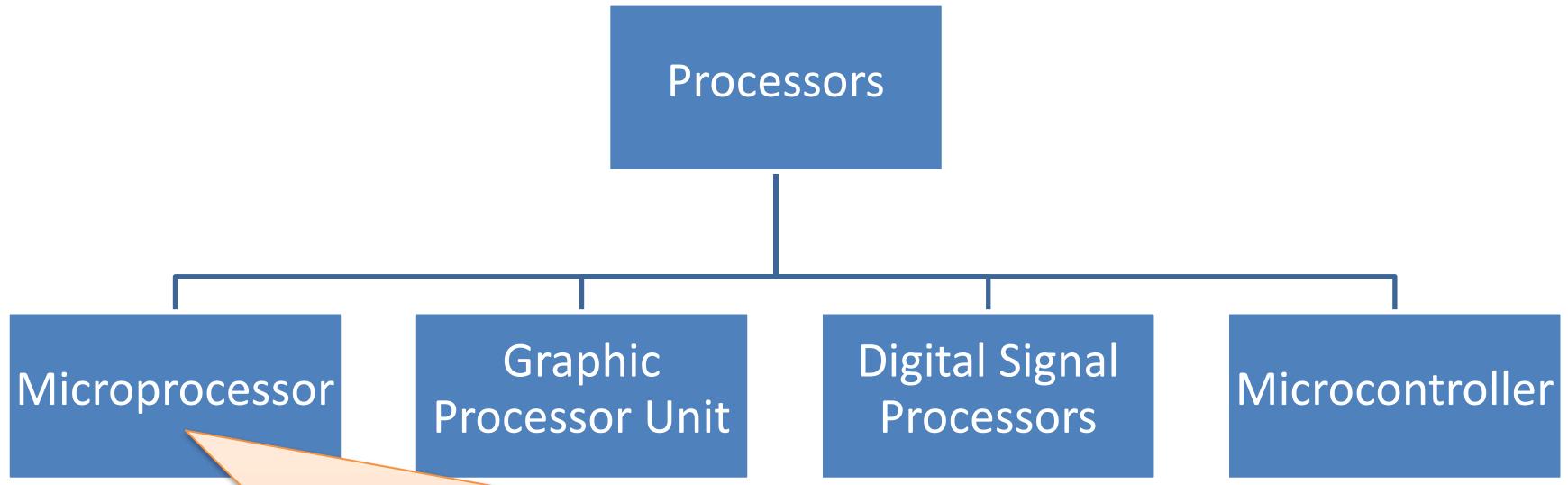
Microprocessor

Graphic
Processor Unit

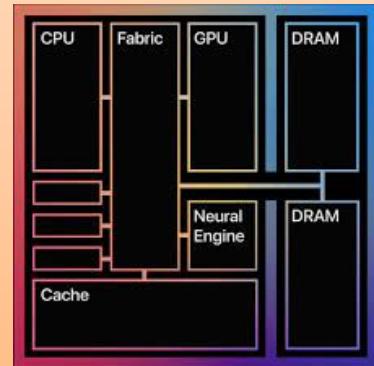
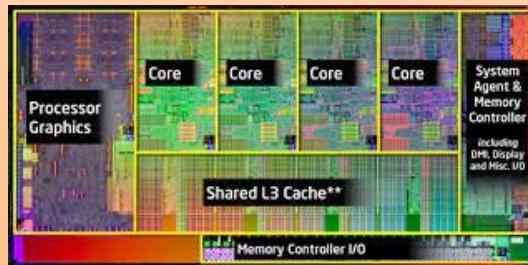
Digital Signal
Processors

Microcontroller

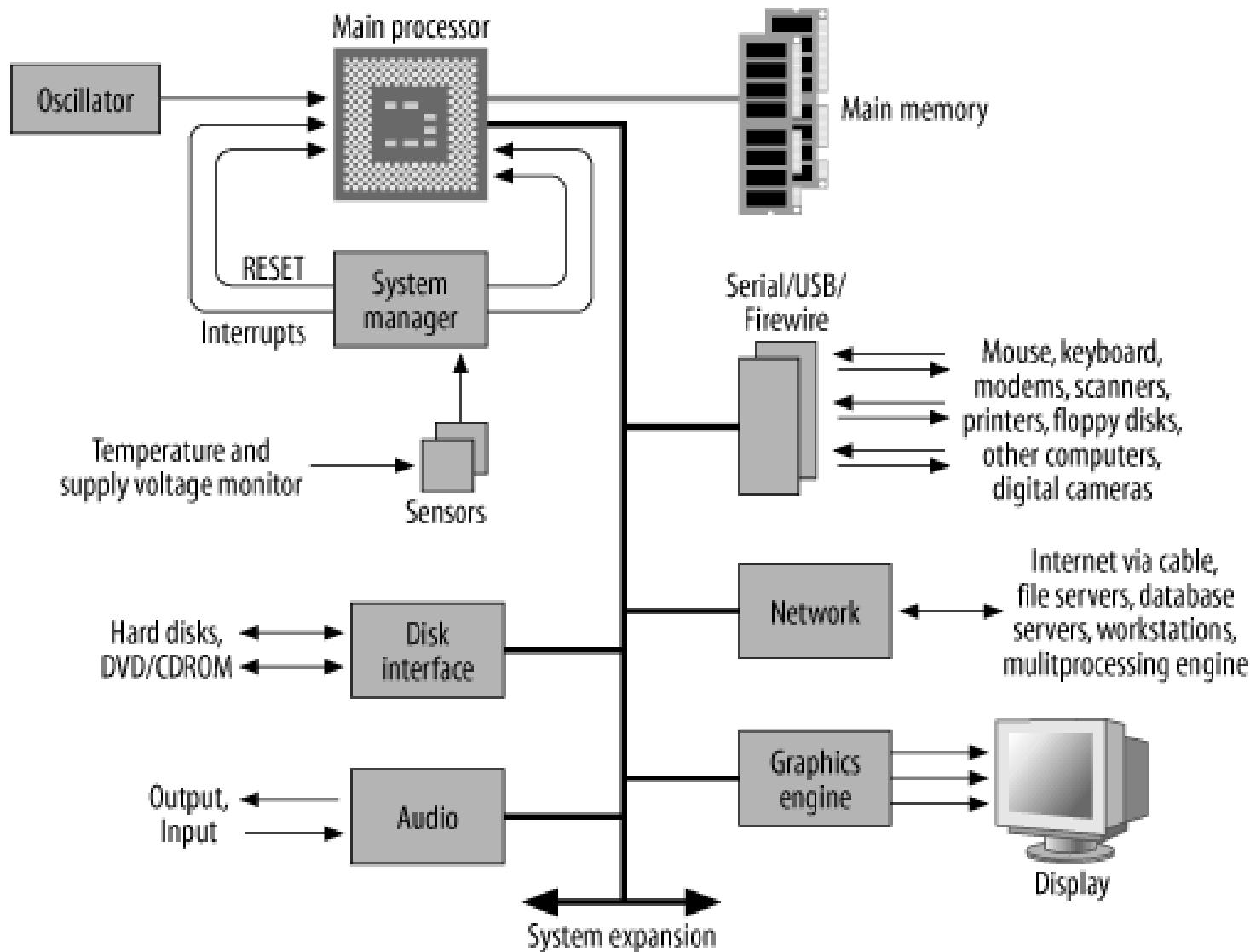


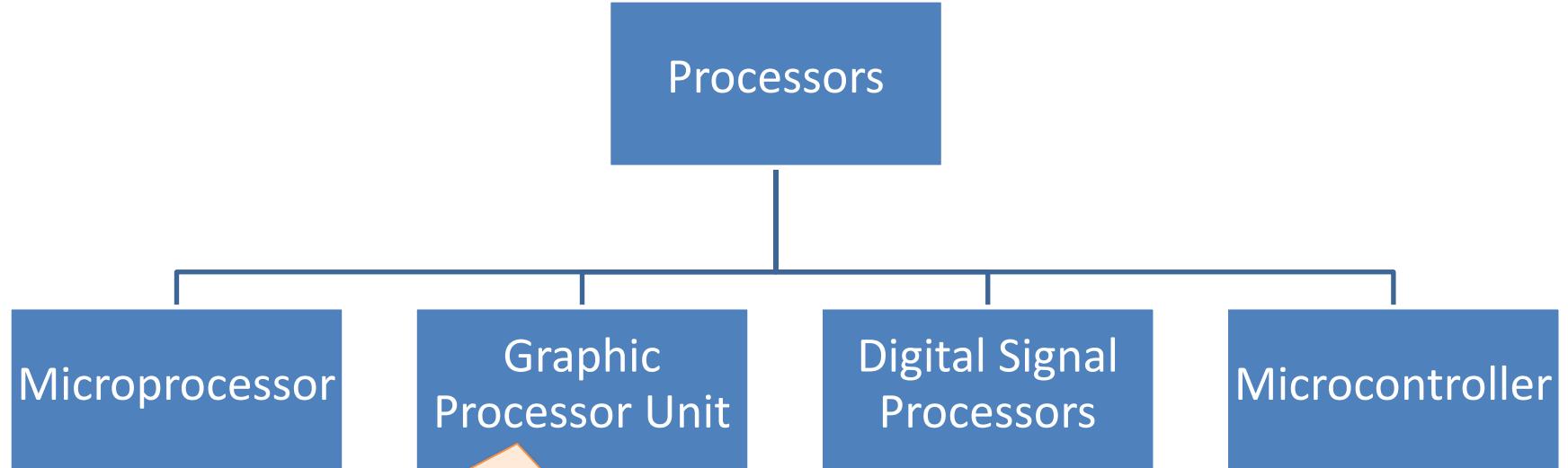


- Design instruction set for the general work
- Parallel processing
- No Input output ports (I/O)
- Some microprocessors are integrated GPU.
- Advance microprocessors are integrated GPU, I/O, and Memory by called **System-on-chip (SOC)**
- Example
 - Intel, Core-i7
 - AMD, Ryzen
 -

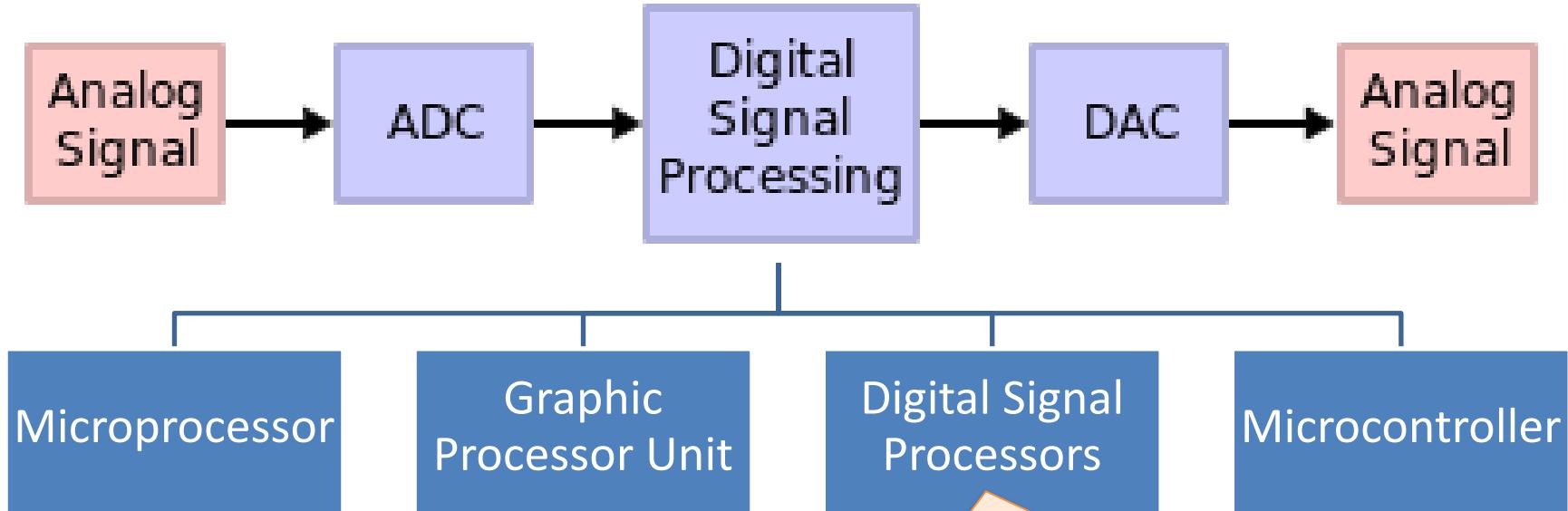


Computer systems

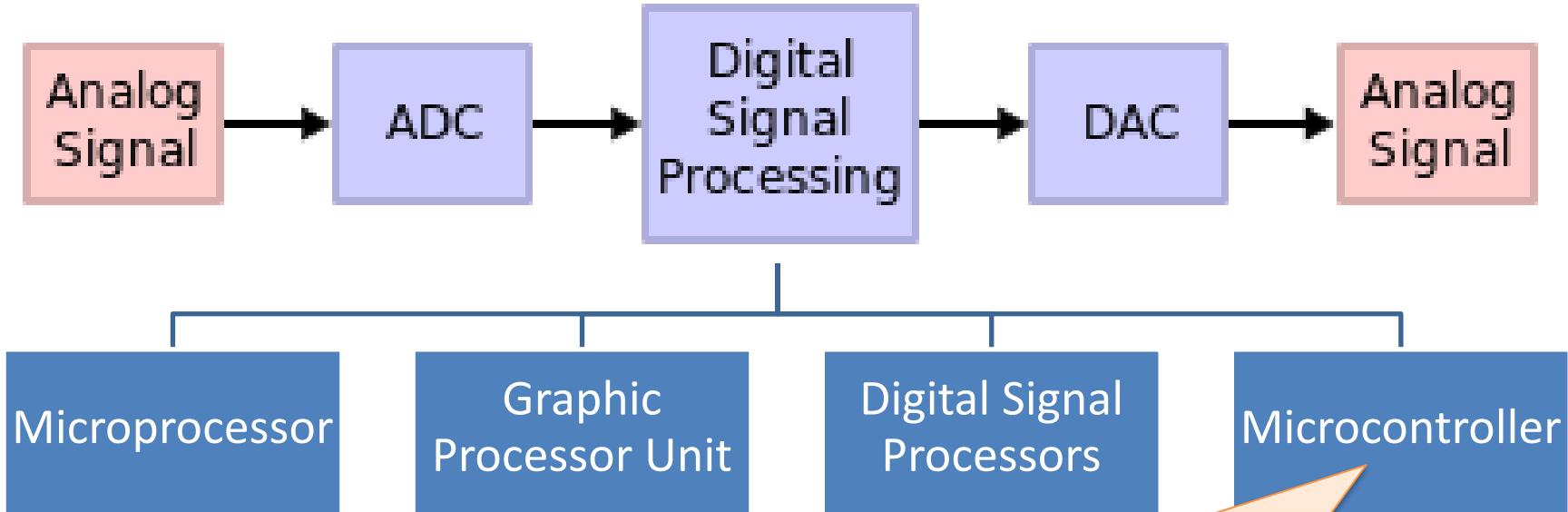




- Specific instruction set for vector and graphic computing and video rendering
- Dual ports memory interface
- Multicores
- Example family chips
 - GeForce, Radeon
 - Quadro, FirePro

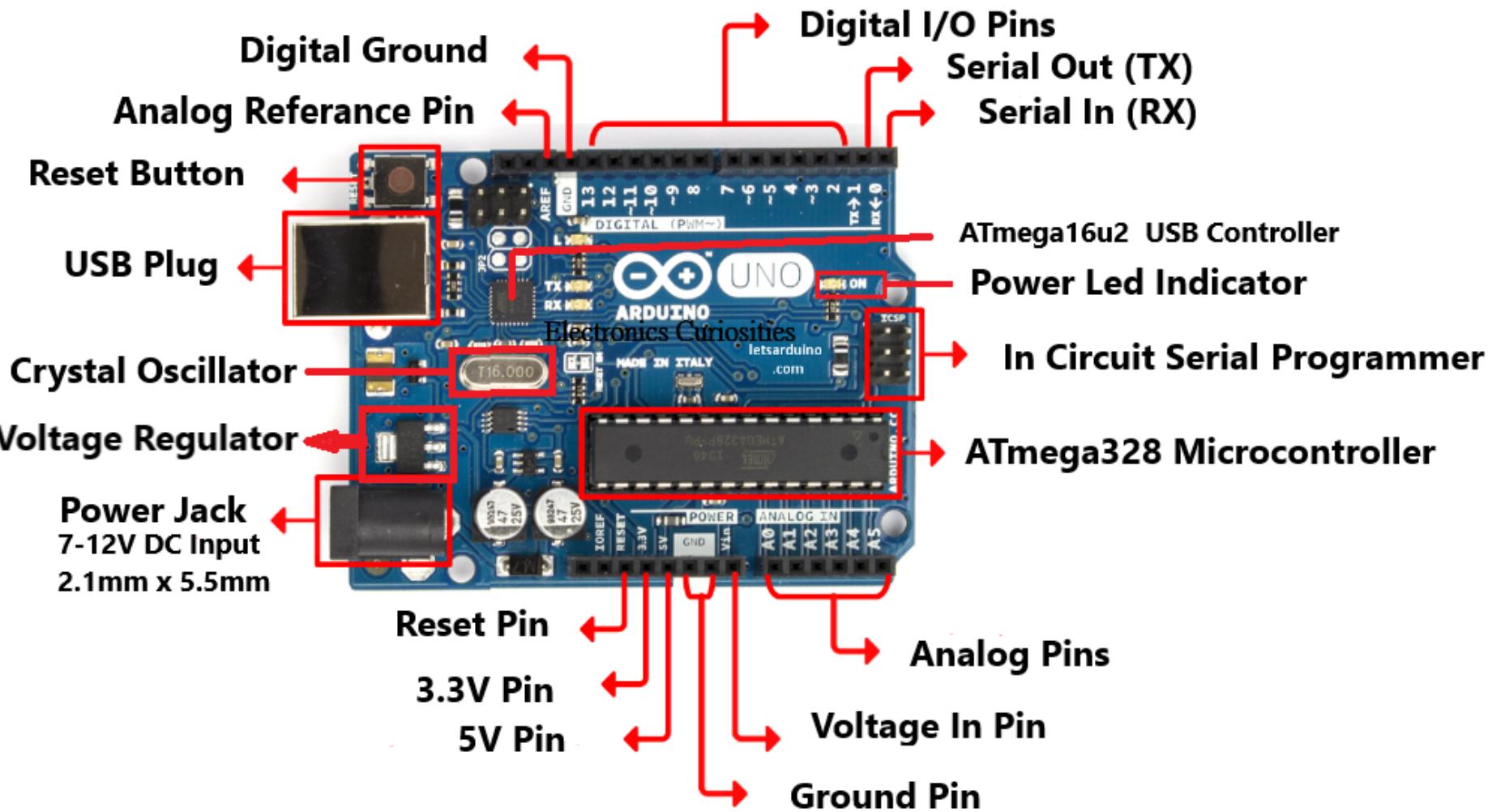


- Specific instruction set for streaming signal
 - Encoding audio/video
 - Decoding audio/video
- Example family chips
 - C6000 (Texas Instrument)
 - SHARC (Analog Devices)
 - EMU10K (Creative)



- Specific instruction set for input/output (I/O) controlling
- Design to control appliance machines such as washing machines, microwaves, toys, etc.
- Integrated I/O ports, timers, memory, Wifi, analog to digital and digital to analog.
- Example family chips
 - PIC
 - MCS-51
 - ARM

Arduino board



Activity1.5

- Identify the type of chip on the list below. You can search from Internet.
 - Z80
 - 8051
 - 68HC11
 - PIC 16Fxx
 - Atmega 328p
 - 8086
 - Geforce 1060
 - TMS32010
 - MAS3507