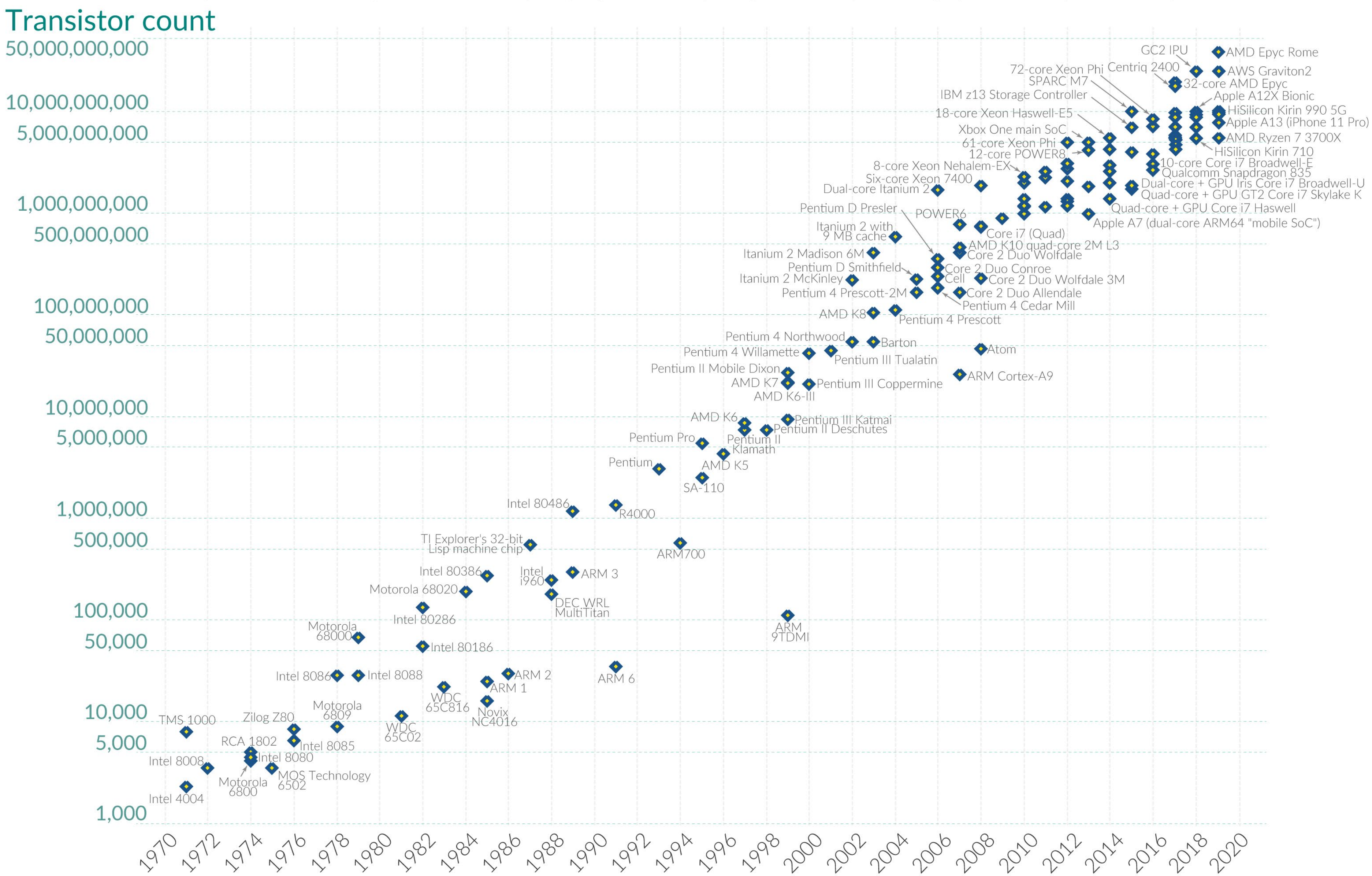
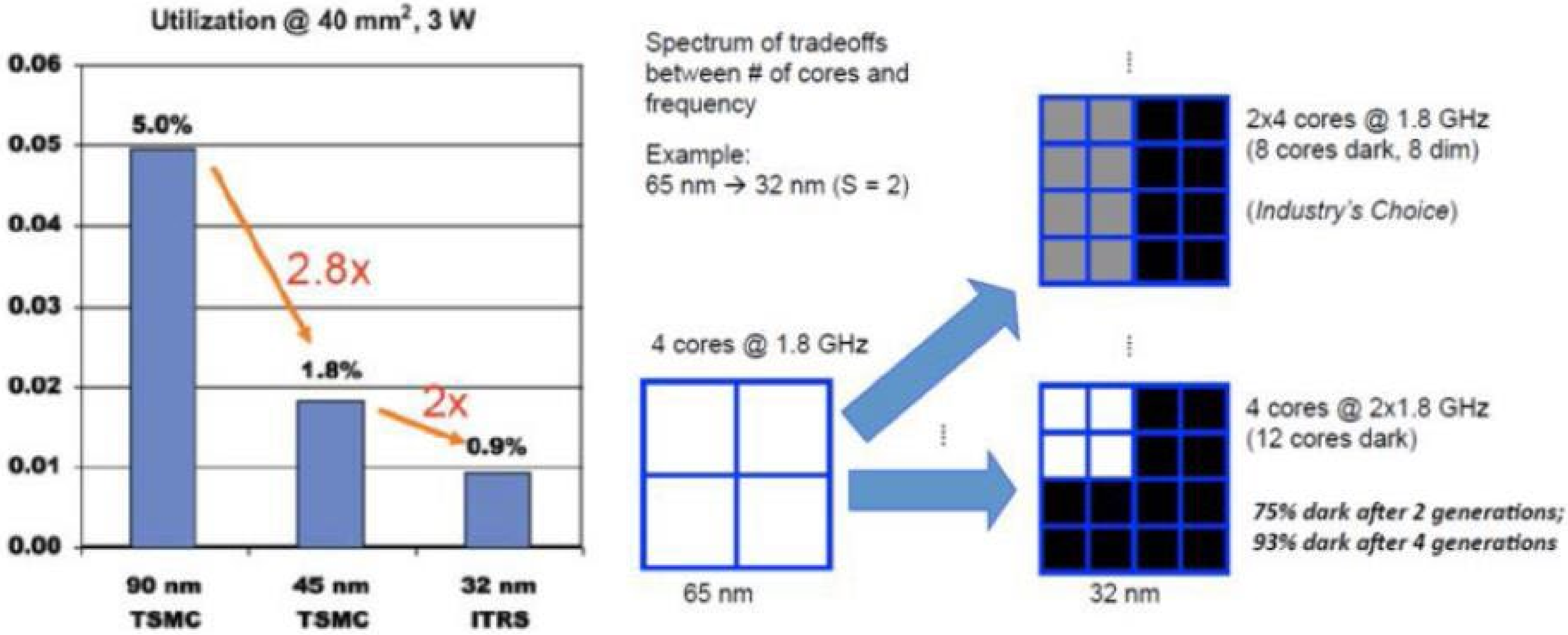
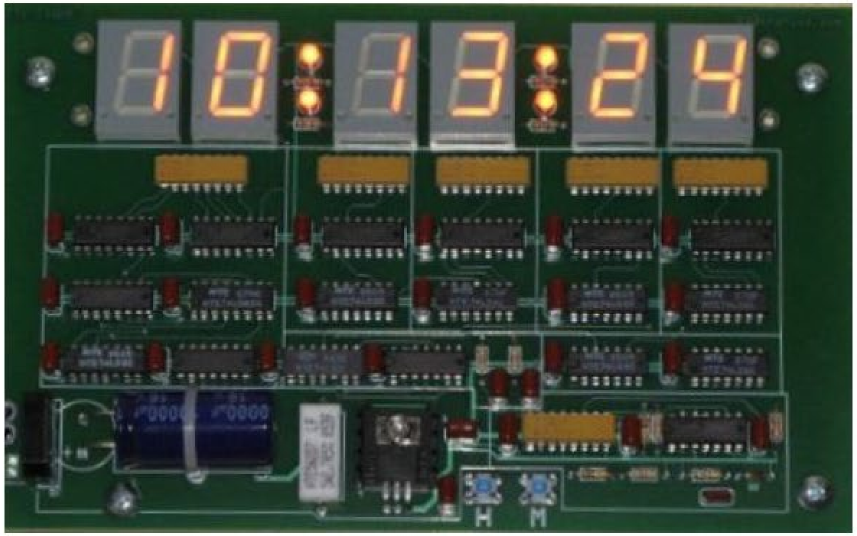
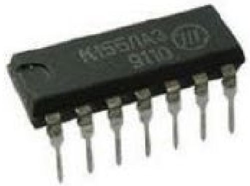


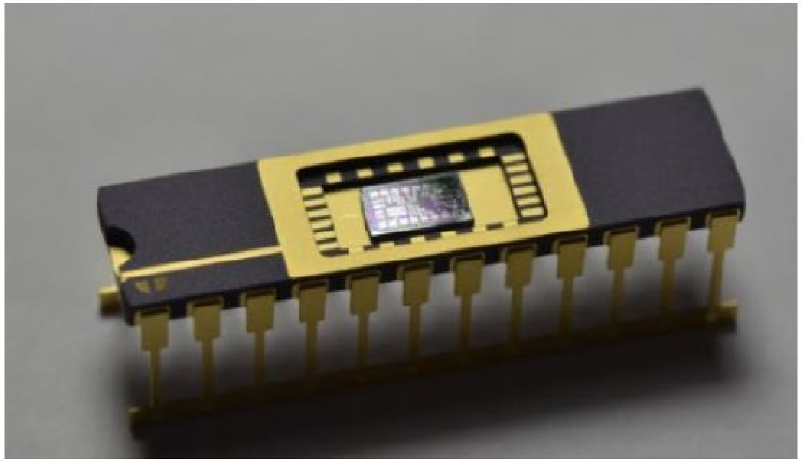
Plot of transistor counts for microprocessors against dates of introduction.

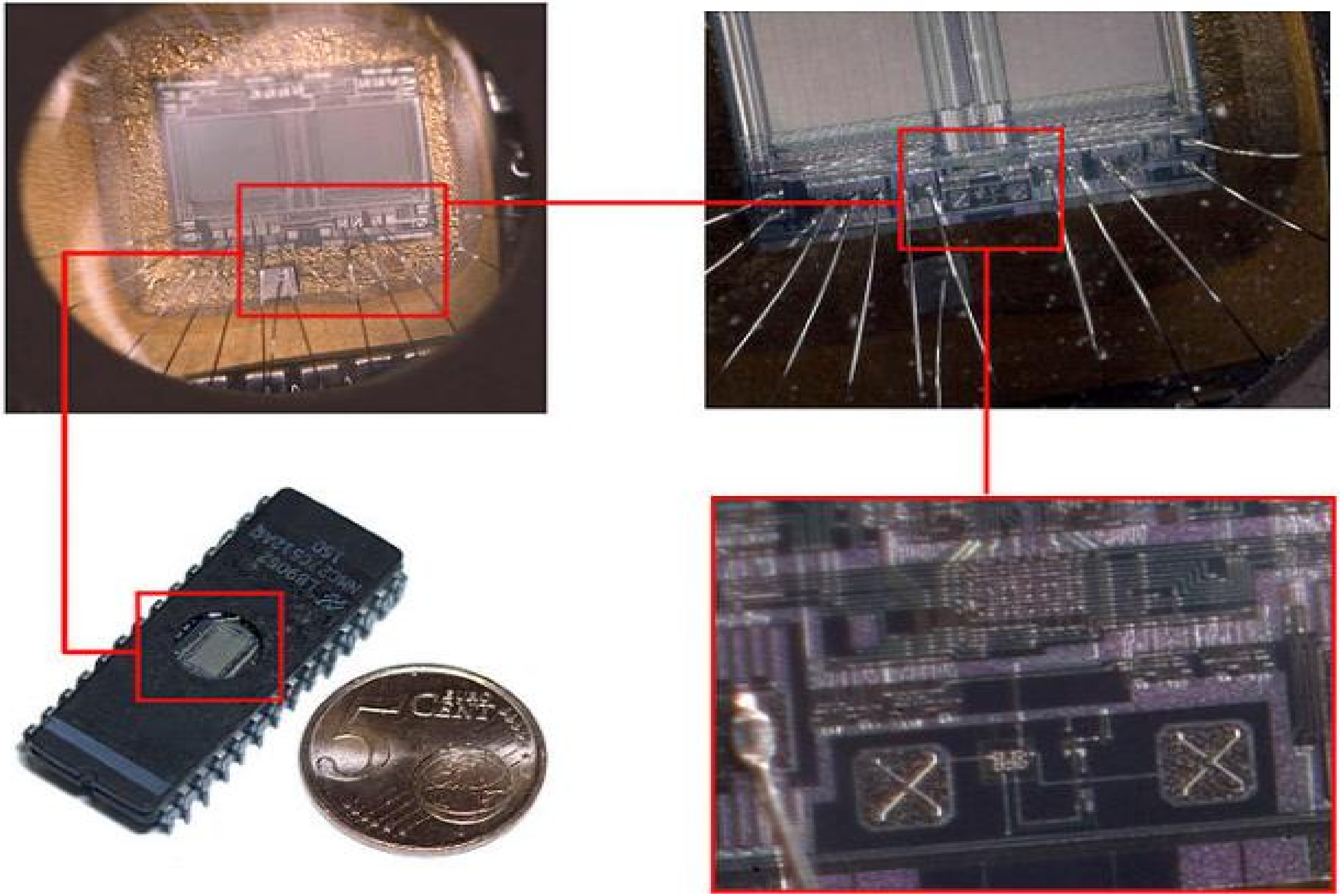


Crystal area limitation.


H
M





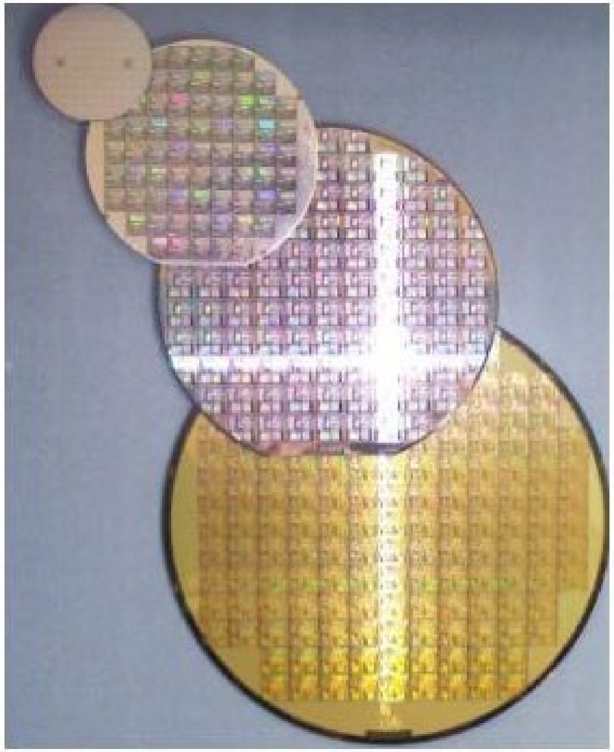


The main element of analog microcircuits is a transistor (bipolar or field-effect). The difference in the manufacturing technology of transistors significantly affects the characteristics of microcircuits. Therefore, the manufacturing technology is often indicated in the description of the microcircuit in order to thereby emphasize the general characteristics of the properties and capabilities of the microcircuit.

Microcircuits on unipolar (field) transistors are the most economical (in terms of current consumption):

- MOS-logic (metal-oxide-semiconductor) - microcircuits are formed from n-MOS or p-MOS type field-effect transistors;

- CMOS chip (complementary MOS logic) - each logic element of the chip consists of a pair of complementary field-effect transistors (p-MOS and p-MOS).

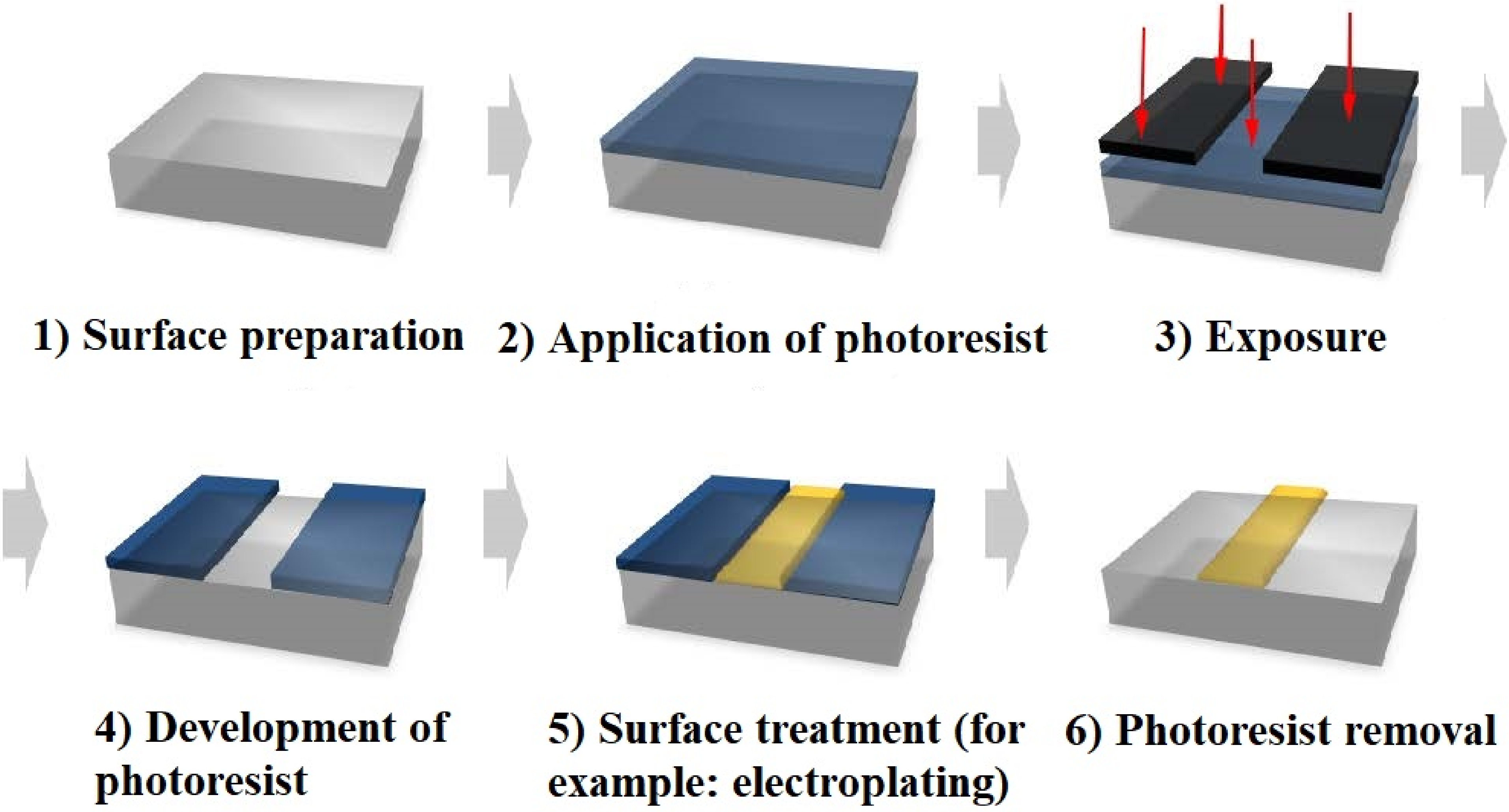


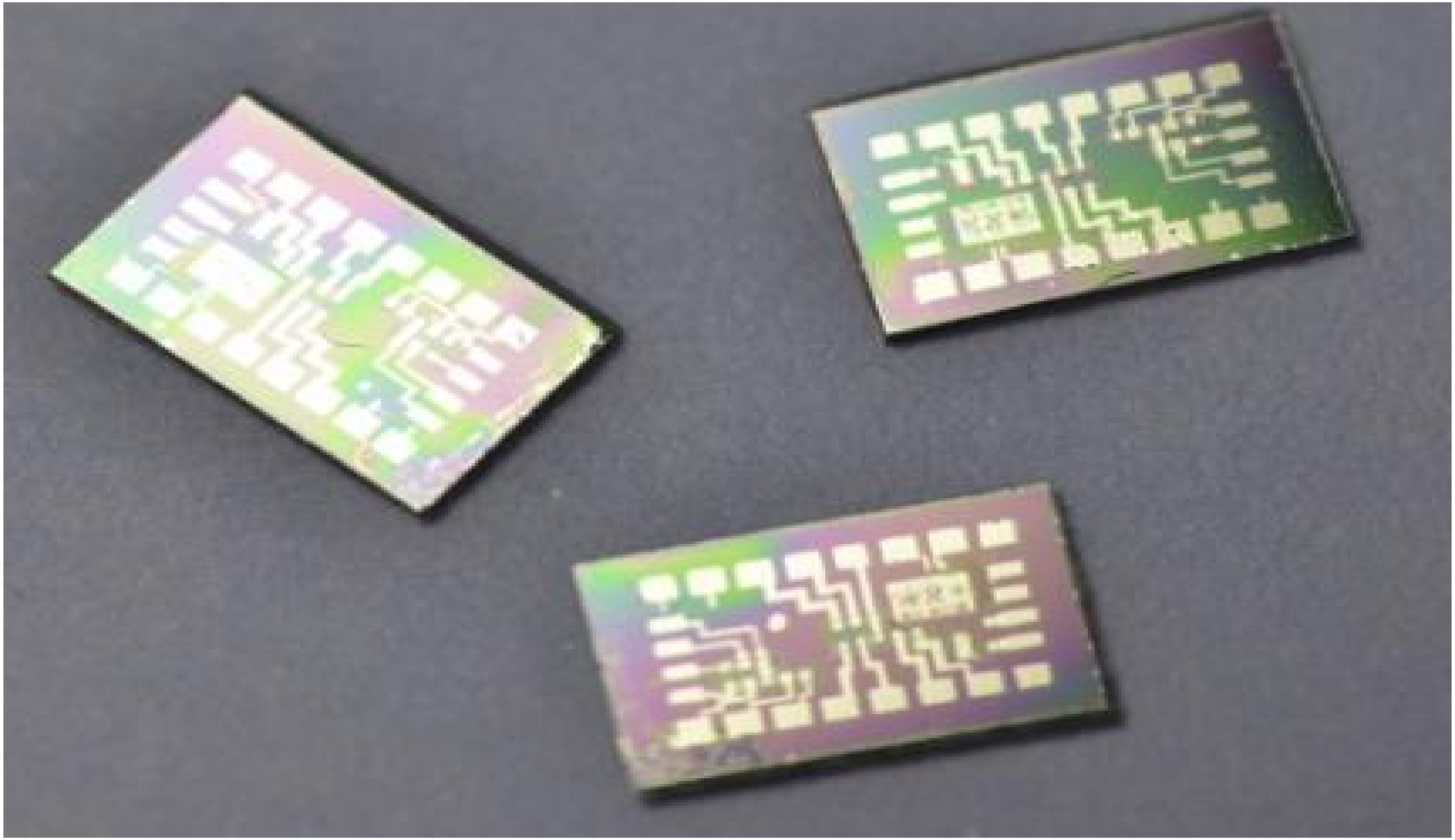
Silicon plates with ready-made microcircuits before cutting into individual crystals.

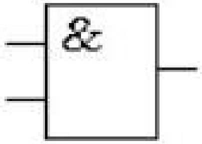
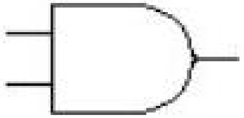
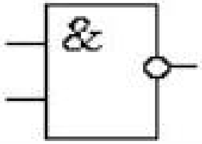
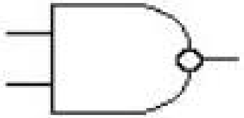
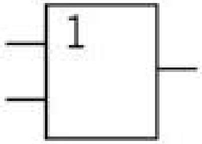
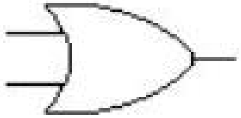
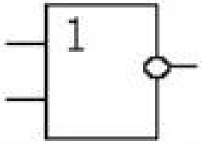
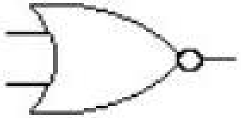
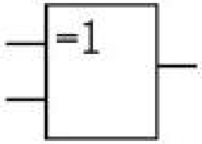
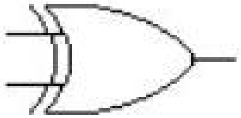
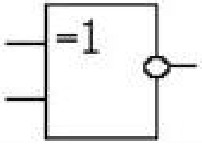
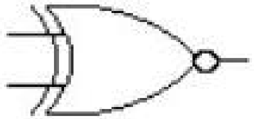
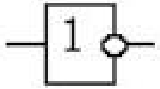
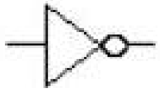
A semiconductor plate is a semi-finished product in the technological process of manufacturing semiconductor devices, microcircuits and photovoltaic elements. It is made from single crystals of germanium, silicon, arsenide and other semiconductor materials.

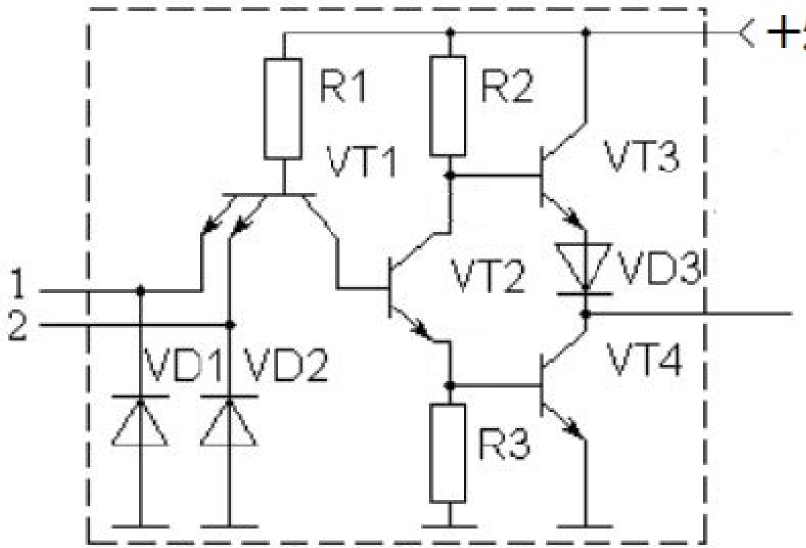
Microcircuits of the CMOS type (CMOS - complementary MOS). that are used in logic elements were created in the 60s of the XX century. Frank Wanlass from the Fairchild Semiconductor company as energy-saving.

Compared to non-complementary schemes, such a valve takes up more space and has a lower cut-off frequency, but consumes significantly less energy. Then, in connection with the increase in the degree of integration of microcircuits (during the development of large integrated circuits), the problem of energy dissipation on the elements arose. As a result, CMOS technology turned out to be in a winning position.

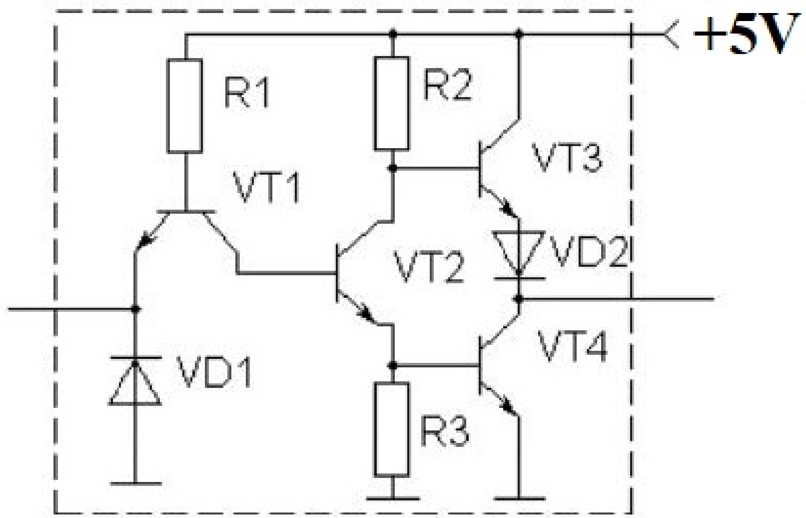

1) Surface preparation
2) Application of photoresist
3) Exposure
4) Development of photoresist
5) Surface treatment (for example: electroplating)
6) Photoresist removal



	and	
	nand	
	or	
	nor	
	xor	
	xnor	
	not	

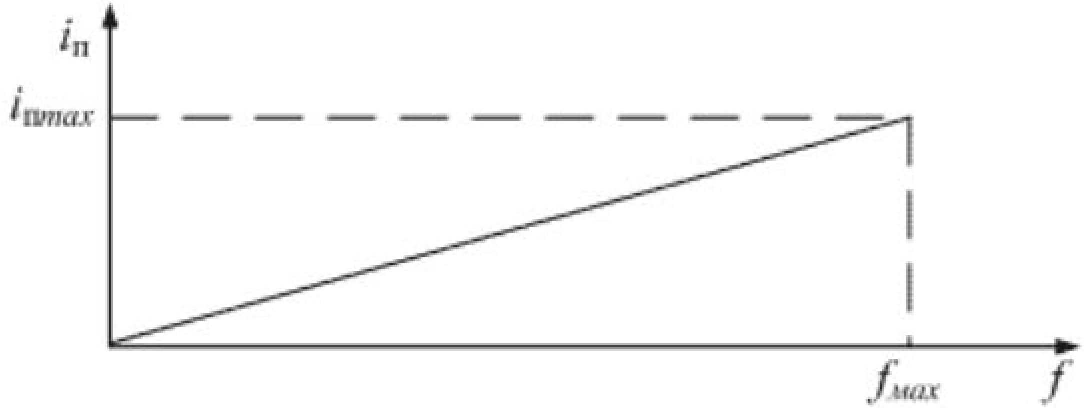


Scheme of the basic logic element TTL (transistor-transistor logic) of the microcircuit.



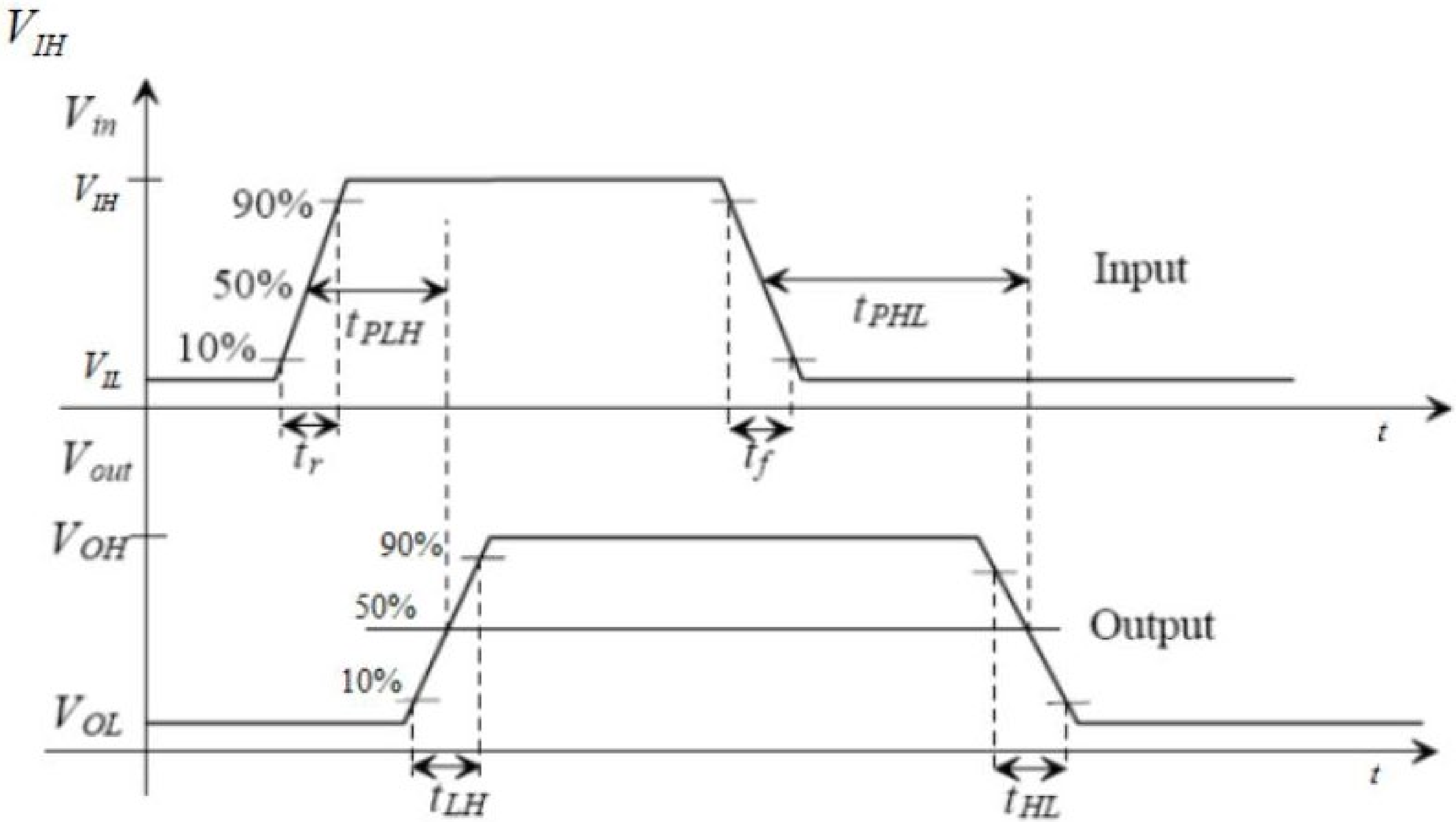
Schematic diagram of the TTL inverter microcircuit.

A feature of microcircuits on complementary MOS transistors (CMOS-microcircuits) is that the current in these microcircuits is practically not consumed in static mode. Current consumption occurs only at the moment of its switching from a single state to a zero state and vice versa.
As a result of this feature of CMOS microcircuits, they have an advantage over other types of microcircuits - they consume current depending on the input clock frequency.

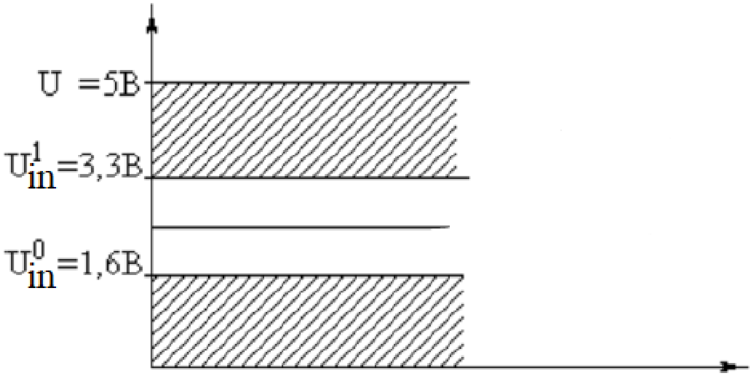


Dependence of the current consumption of the CMOS microcircuit on the frequency.

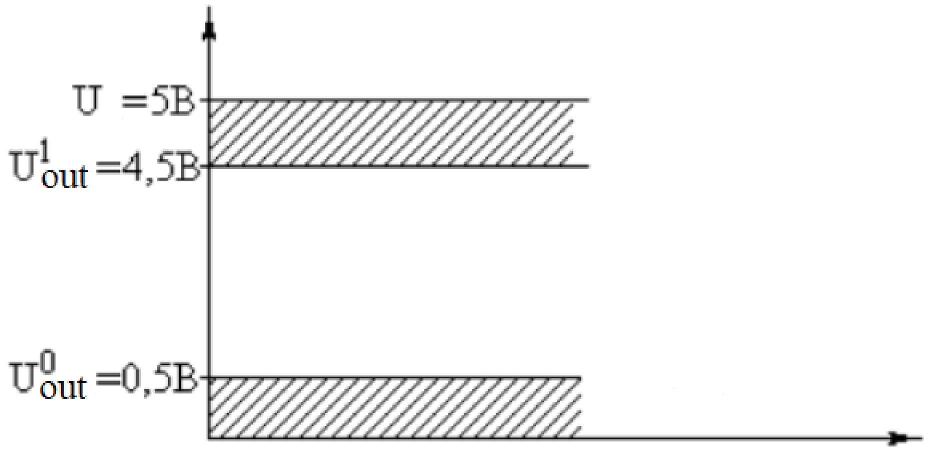
Delays in the passage of signals for the RC-circuit. $t_{PLH}=t_{PHL}=0.7RC$



Logical levels of CMOS microcircuits.



Levels of logic signals at the inputs of digital CMOS microcircuits.



Levels of logic signals at the outputs of digital CMOS microcircuits.

Advantages of CMOS logic

The practical absence of power consumption in a static state is far from the only positive property of CMOS logic. Other valuable qualities are:

- **the ability to work in a wide range of supply voltage values (this, in particular, allows you to reduce energy consumption by lowering the supply voltage, as well as to function reliably even in the case of an unstable supply voltage;**

• the maximum potential difference during the transition from logical "0" to logical "1" (practically from the "ground" potential to the supply voltage), which ensures high resistance to electromagnetic interference;

• high input resistance regardless of the state of the transistors (1O10 -1014 Om), and, therefore, the possibility of connecting a significant number of the following logic elements to the output (significant load capacity);

• the ability to function in a wide range of ambient temperatures;

• high speed;

• low power consumption at not very high switching frequencies.

The main disadvantage of CMOS logic is the danger of breakdown by static electric charges. Therefore, enhanced safety measures against static electric charges are used during transportation, storage, and installation of CMOS microcircuits. Protective diode-resistive links are additionally installed at the inputs and outputs of CMOS integrated circuits, which create conditions for the safe "drain" of accumulated static electric charges.