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PREDICTION OF THE IMPROVEMENT CHARACTERISTIS OF NANOCIRCUITS

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Abstract—*Investigated improving the characteristics and parameters of nano devices in case of microprocessors and memory devices. Held extrapolation forecasts improve the parameters nanocircuits. Analyzed the growth of the market of flash memory.*

Index Terms—Nanodevices; microprocessor; extrapolation forecast.

I. INTRODUCTION

Arrival of era of nanotechnologies in a most degree was stimulated the high rates of development of microelectronics. Therefore most achievements in nanoscience are at first estimated for the purpose the prospects of their use in electronics, computer technique and facilities of connections. The number of elements in microprocessors and blocks of dynamic memory during almost half century is doubled every one and a half years. It is answered by the steady diminishing of functional sizes of elements, increase of fast-acting, decline of energy consumption and cost. For half century a transistor diminished in million (10^6) time on linear sizes and in a milliard (10^9) time – on mass.

II. STATEMENT OF THE PROBLEM

Using the method of extrapolation, to trace the possible development directions nanodevices for the next time decade.

III. REDUCING TECHNOLOGICAL SIZES AND INCREASING THE CLOCK FREQUENCY NANODEVICES

For the construction of afore-named prognoses above all things will appeal to the empiric supervision, to done in 1965 year in the process of preparation to appearance one of founders of corporation of Intel, by Gordon Moor. He assumed that the amount of transistors on a crystal would be doubled each 18–24 months [1].

Will notice that the law of Moor is based on an economy. For creation of new processors the needed monies are on the leadthrough of researches and organization of production. On that charges were covered a cost and began to bring in a return which financing of new developments will be from, it is needed just one and a half-two years.

As early as 2005 year one of top-managers of Intel Paolo Dzhardzhini asserted that to 2020 year the sizes of transistors will attain atomic (does the diameter of atom of silicon make ≈ 0,2 nm), whereupon the subsequent diminishing will become impossible. In same queue, Pat Gelsindzher, chairman of technological subsection Intel said in 2009 year: "There were times, when Intel and its colleagues asked yourself, whether succeeded to attain a technological process in 100 nm. We did it then, and today see clear, that to us succeeded to overcome 10 nm borders. With the law of Moor we always have calculations on 10-years-old prospect, and that we will do after a border 10 nm, so far exactly unknown".

Will remind, that in 2009 year and mister Moor acknowledged, that his law stopped to operate already through atomic limitations and influence of velocity of light, and passing to more thin norms of technical process is given computer industry all with the greater expenses of forces and time. Will conduct prognoses on the basis of information about development of microprocessors of firm Intel, as they present approximately 80 % world market of microprocessors. To the table the known microprocessors of this firm are erected.

Will build the curve of diminishing of size of technological process – from first a processor, realized in 1971 year in one microcircuit – Intel 4004, to the newest, on presented January, 2014 to the processor of Intel Core i7-4960X (Fig. 1).

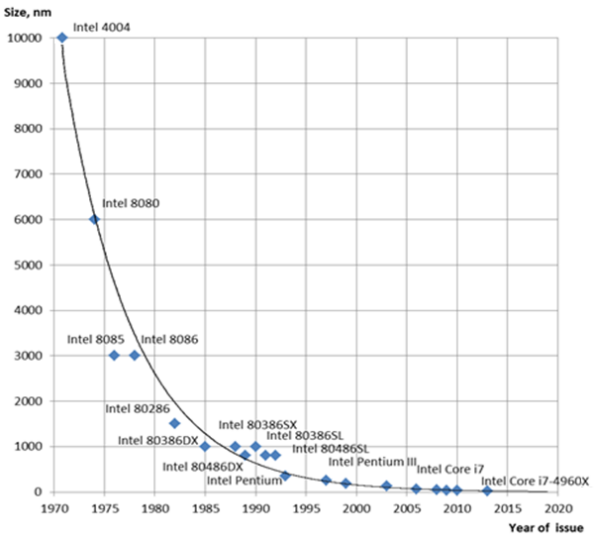

Fig. 1. Diminishing of sizes of elements of microprocessors in course of time

Development of microprocessor Intel

Processor	Year of issue	Size of elements, nm	Frequency, MHz
Intel 4004	1971	10000	0,74
Intel 8080	1974	6000	0,8
Intel 8085	1976	3000	5
Intel 8086	1978	3000	10
Intel 80286	1982	1500	12,5
Intel 80386DX	1985	1000	16
Intel 80386SX	1988	1000	20
Intel 80486DX	1989	800	25
Intel 80386SL	1990	1000	20
Intel 80486SX	1991	800	16
Intel 80486SL	1992	800	33
Intel Pentium	1993	350	60
Intel Pentium II	1997	250	300
Intel Pentium III	1999	180	600
Intel Celeron M	2003	130	1400
Intel Core	2006	65	2000
Intel Core 2 Duo	2008	45	3000
Intel Core i3	2009	32	3100
Intel Core i7	2010	30	3300
Intel Core i7-4960X	2014	22	3600

See that dependence is carried by exponences character. For the construction of adequate extrapolation got a chart will apply the logarithmic scale of axis of absis and, considering that the law of Moor will work yet decade, will build the prognosis of diminishing of sizes of nanodevices on the base of microprocessors of Intel to 2020 year (Fig. 2).

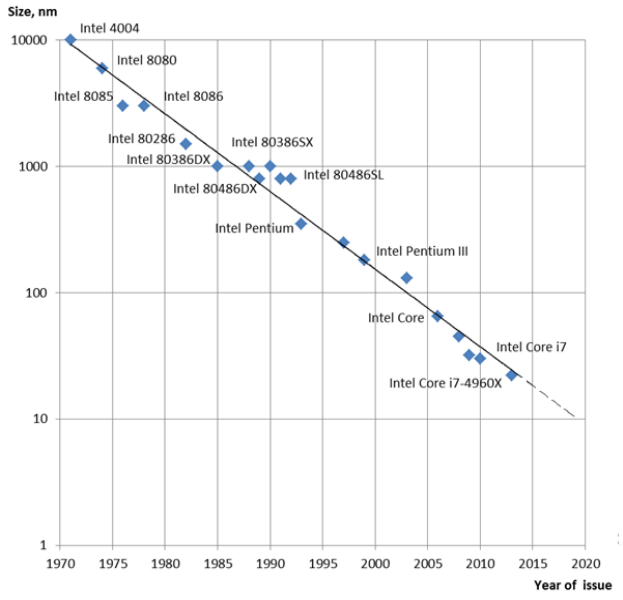

Fig. 2. Diminishing of sizes of elements of microprocessors is in course of time in a logarithmic scale

Prognoses in relation to diminishing of scales of elements of microprocessors are rotined the dotted line.

Consequently, coming from given to the chart, microprocessors will develop the same rates, as well as today, to 2020 year, while developers will not attain a limit in 10 nm, after which it is possible to foresee 2 the most important ways of development:

– subsequent development is exceptionally due to the increase of amount of kernels in a processor;

– subsequent development due to a transition from silicon on materials with the less sizes of atoms.

On the basis of information of table 1 build the curve of increase of clock rate of those processors of Intel for the last 40 years (Fig. 3).

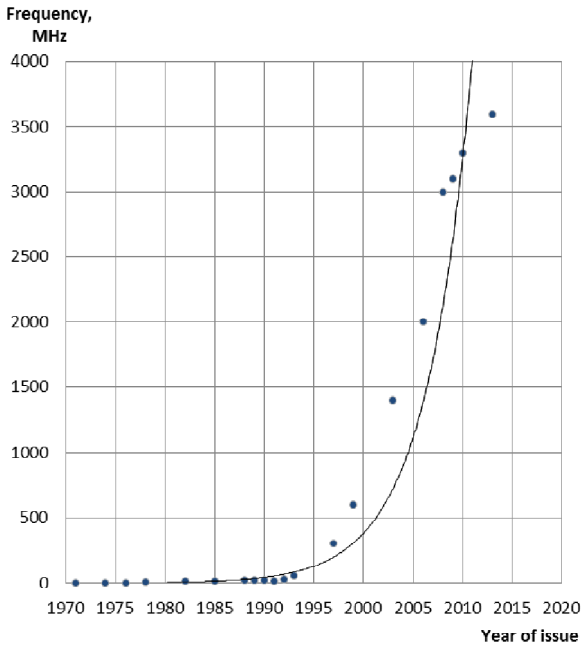

Fig. 3. Growth of clock rate for the last 40 years (it is approximated exponent)

Applying growth of clock rate logarithmic scale and continuing the got approximated line to the 2020 year, will get the reference value of clock rate (Fig. 4).

Consequently, if growth of clock rate of processors in future remained exponential, to 2020 year we must were get a processor with an almost fantastic clock rate – 35 GHz. But in actual fact the rates of increase of clock rate were substantially slowed for the last 10 years. It is evidently visible on the chart of lines 3: between 1990 and look after the sharp refraction of curve 1999 up, but on an interval between 2000 and a 2010 growth goes almost after a linear law. Building a chart for the last 10 years and continuing it yet on a decade, will get more real prognosis – not on much greater than 6 GHz (Fig. 5).

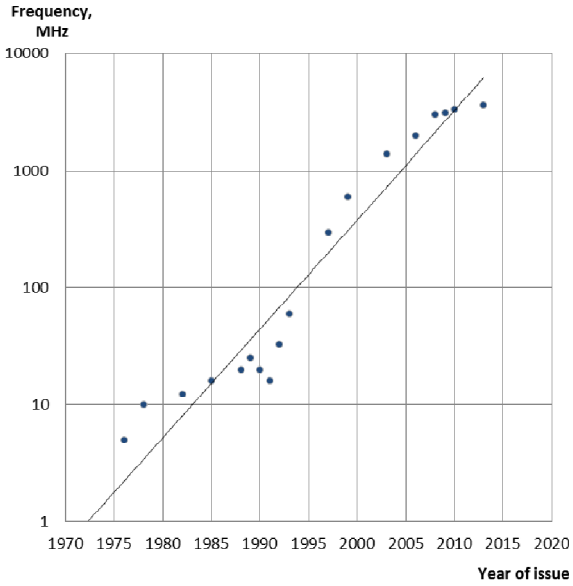

Fig. 4. Growth of clock rate for the last 40 years in a logarithmic scale

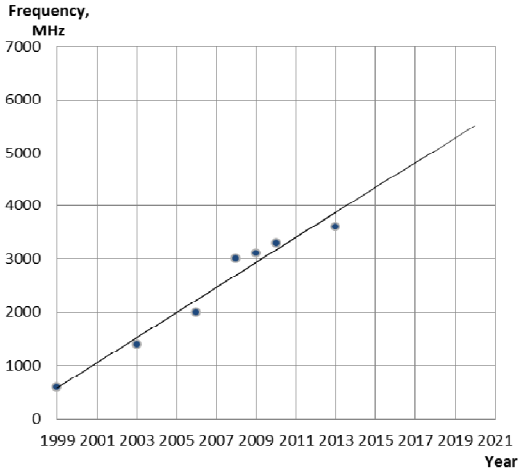

Fig. 5. Growth of clock rate, approximated a line

Consequently, if speed of increase of clock rate will remain unchanging yet 10 years, microprocessors will have a clock rate, not greater than 6 GHz next decade. More reliable in all that the process of growth of clock rate will be slowed with every year, and development of computer technique will take place due to creation of processors with the greater amount of kernels.

IV. Growth of production of transistors

Exponential growth numbers of transistors, which a microcircuit consists of, during a few ten of years resulted in a volume, that totally in 2010 it was mine-out ~ 10^{19} transistors (approximately for a 1 milliard of sht. on every tellurian), that on three orders exceeds the number of grains of wheat, which are produced in the world annually. Thus for each of these grains it is presently possible to purchase 1000 transistors. Power, dispersed on transistors for one switching, diminished for the last 40 years more than in 10^5 times.

For today on a planet for a year about 10^{21} things of transistors are created. Will rotin it on a chart (Fig. 6).

Consequently, for the maintainance of rates of development of production of transistor elements in the world, in a 2020 year for a year will be produced approximately 10^{24} things of transistors.

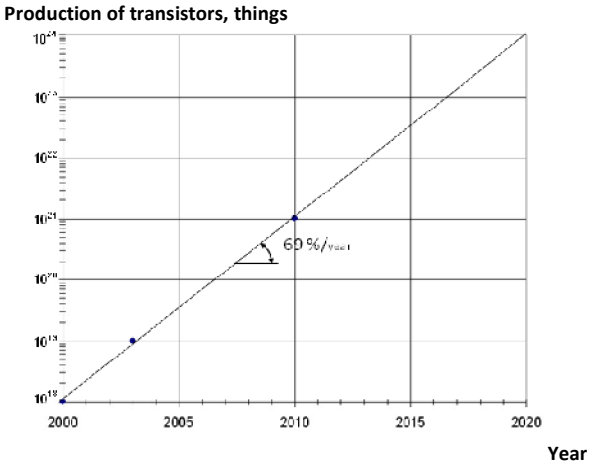

Fig. 6. Growth of production of transistor elements on a planet

V. Increasing the capacitance of operative storage devices and reduce the cost of memory cells

Will consider that the rates of development of operative memory devices (OMD) the nearest 10 years not too strongly will differ from those which dominate in this industry the last decade. At the beginning 2000 most widespread were the modules by volume of 128 MB, for a few years – 256 MB, to 2005 year actively the modules began to be used by volume of 512 MB, and afterwards – 1024 MB. For today the modules are actively used by a capacity 100 GB. Will represent it on a chart in a logarithmic scale (round markers and stroke line are on Fig. 7).

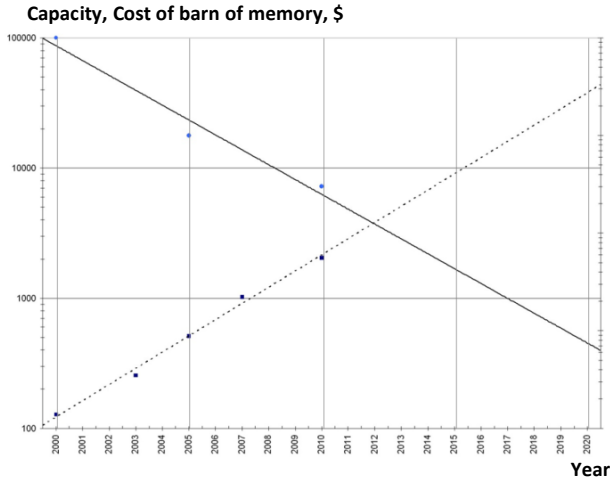

Fig. 7. An increase of capacity of OMD and diminishing of prices is on the barns of memory

Is it known that in a 2000 year the cost of one barn of memory averaged ~ $\$10^{-7}$. For today this index went down to the order $\$10^{-9}$. Possibly, that the cost of OMD will diminish the same rates and will build the chart of extrapolation prognoses (square markers and continuous line are on Fig. 7).

Consequently, is it possible to expect that the volume of OMD to the end of next decade will grow to the order 30 – 40 GB, and the cost of one barn of memory will make ~ $\$10^{-10}$[2], [3].

It is known that from 2000 to 2010 there was growth from 10,5 to 25,2 milliards of dollars of the USA (Fig. 8).

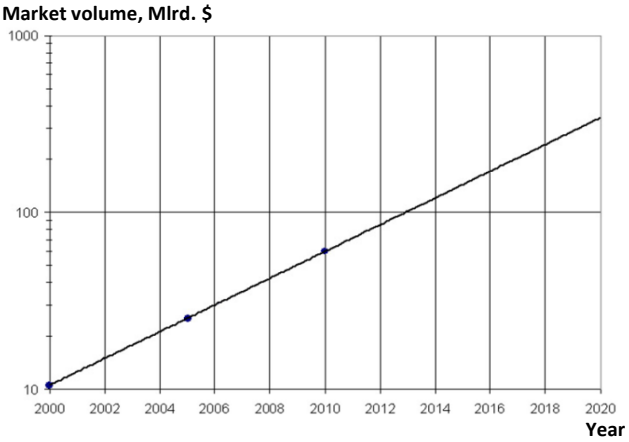

Fig. 8. Growth of market of flesh memory

Consequently, for the maintainance of rates of market of memory of flesh development, his volume on 2020 will make 250–300 milliards of dollars of the USA.

VI. Conclusions

The researches revealed this:

– empirical Moore's law, according to which the clock speed increases exponentially in the last time ceases to act through atomic restrictions and the impact of the speed of light;

– in order to support high growth rates of key parameters of the products that are produced in the future, it is necessary to 2015–2020 to reduce technological step nanoelectronic circuits up to 10 nm.

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О. С. Мельник, Н. В. Бурцева. Прогнозування поліпшення параметрів наноприладів

Досліджено вдосконалення характеристик і параметрів наноприладів на прикладі мікропроцесорів та пристроїв оперативної пам'яті. Проведено екстраполяційні прогнози щодо поліпшення параметрів наноприладів. Проаналізовано зростання ринку флеш-пам'яті.

Ключові слова: наноприлади; мікропроцесор; екстраполяційний прогноз.

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А. С. Мельник, Н. В. Бурцева. Прогнозирование улучшения параметров наноустройств

Исследовано усовершенствование характеристик параметров наноустройств на примере микропроцессоров и устройств оперативной памяти. Проведены екстраполяционные прогнозы по улучшению параметров наноустройств. Проанализирован рост рынка флеш-памяти.

Ключевые слова: наноустройства; микропроцессор; экстраполяционный прогноз.

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