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кафедра іноземних мов

АНГЛІЙСЬКА МОВА

Методичні вказівки до самостійної роботи для студентів 1-2 курсу факультету автоматики та енергетики

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Англійська мова

Методичні вказівки з дисципліни "Англійська мова професійного спрямування" для самостійної роботи студентів 1-2 курсу факультету автоматики та енергетики.

Методичні вказівки містять 8 рівнозначних за складністю текстів, завдання для перевірки загального розуміння тексту та завдання творчого характеру. Ці завдання складені для комплексної перевірки умінь і навичок студентів працювати з професійно-орієнтованою літературою. Текстові завдання підібрані таким чином, щоб виявити різнобічні знання, здобуті студентами під час вивчення своєї спеціальності, і можуть сприяти більш глибокому засвоєнню знань з фундаментальних та професійно-орієнтованих дисциплін та їх оцінюванню. Підбір текстів забезпечує достатню повторюваність термінології майбутньої спеціальності, що сприяє закріпленню знань за темою на англійській мові, а також забезпечує розвиток навичок анотування текстів за фахом.

У додатку до методичних вказівок подано тексти за фахом самостійного читання та розуміння.

Методичні вказівки розраховані як для роботи зі студентами в аудиторії, так і вдома.

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Unit One

I. Mind the pronunciation of the following words:

performance, consumption, advantage, microelectronic, function, reduction, directly, coupling, advert, array, attainable, ultimately, universally, interaction, solution, impetus, substrate, typically, technique, intellectual, reliability

II. Memorize words and word combinations:

1) reliability - надійність;
2) performance - робоча характеристика;
3) to give rise to - викликати; приводити;
4) to predict - прогнозувати
5) to shrink (shrank, shrunk) - скорочуватись, зменшуватись;
6) unaided eye - неозброєне око;
7) coupling - з’єднання;
8) attainable - досяжний;
9) manifold - в багато разів;
10) to handle - керувати; мати справу;
11) to concern - цікавити; турбувати;
12) ultimately - у кінці кінців;
13) technique - метод, технічний прийом;
14) junction - з’єднання; перехід (р-п);
15) a junction transistor - плаский транзистор, транзистор з р-п переходом;
16) gate - затвор, клапан; логічний елемент;
17) array - масив; множина;
18) mode - метод, засіб; режим; вид;
19) to respond - реагувати; n-реакція, відповідь;
20) hearing-aid - слуховий пристрій;
21) point - суть, ціль; запитання; точка; місце;
22) planar - плаский; площинний.

III. Main terms to be learnt:

1) electronic technology - технологія електронних приладів;
2) capacitor - конденсатор;
3) substrate - підкладка;
4) charge carrier - носій заряду.

ELECTRONICS AND MICROELECTRONICS

The intensive effort of electronics to increase the reliability and performance of its products while reducing their size and cost has led to the results that hardly anyone would have dared to predict.

The evolution of electronic technology is sometimes called a revolution. As a result smaller and smaller electronic components perform increasingly complex electronic functions at ever higher speeds. Then a quantitative change in technology has given rise to qualitative change in human capabilities. It all began with the development of the transistor.

The first transistors had no striking advantage in size over the smallest vacuum tubes and they were more costly. The only great advantage the transistor had over the best tubes was exceedingly low power consumption. Besides they promised greater reliability and longer life.

With the invention of the transistor all essential circuit functions could be carried out inside solid bodies.

Early transistors were actually enormous on the scale at which electronic events take place, and therefore they were very slow. They could respond at a rate of a few million times a second; this was fast enough to serve in radio and hearing- aid circuits but it was not enough for high-speed computers or for microwave communication systems.

It was in fact, the effort to reduce the size of transistors so that they could operate at higher speed that gave rise to the whole technology of microelectronics.

Microelectronic technology has shrunk transistors and other circuit elements to dimensions almost invisible to unaided eye. The point of this extraordinary miniaturization is to make circuits long - lasting, low in cost and capable of performing functions at extremely high speeds. It is known that the speed of response depends primarily on the size of transistor: the smaller the transistor, the taster it is.

The second performance benefit resulting from microelectronics stems directly from the reduction of distances between circuit components. If a circuit is to operate a few billion times a second the conductors that tie the circuits together must be measured in fractions of an inch. The microelectronic technology makes close coupling attainable.

There are four principal devices found in electronic circuits: resistors, capacitors, diodes and transistors. Each device has a particular role in controlling the flow of electrons so that the completed circuit performs some desired function.

During the past decade the performance of electronic systems increased manifold by the use of ever larger numbers of components and they continue to evolve. The overall reliability of the electronic system is universally related to the number of individual components. The more components and interactions, the less reliable the system.

The development of rockets and space vehicles provided the final impetus to study the problem. It was microelectronics development that solved the problem. The advent of microelectronic circuits has not, for the most part, changed the nature of the basic functional units: microelectronic devices are also made up of transistors, resistors, capacitors, and similar components. The major difference is that all these elements and their interconnections are now fabricated on a single substrate in a single series of operations.

The development of microelectronics depended on the invention of techniques for making the various functional units on or in a crystal of semiconductor materials. Several kinds of microelectronic transistors have been developed. It was in bipolar transistors were charge carriers of both polarities are involved. They are also known as junction transistors. The npn and pnp transistors make up the class of devices called junction transistor. The term refers to the three materials employed in its construction and is abbreviated MOSFET.

The first generation of commercially produced microelectronic devices are now referred to as small-scale integrated circuits (SSI). They included a few gates. The circuitry defining a logic array had to be provided by external conductors.

A large-scale integrated circuit (LSI) contains tens of thousands of elements, yet each element is so small that the complete circuit is typically less than a quarter of an inch on a side. Integrated circuits are evolving from large scale to very- large-scale (VLSI) and wafer-scale integration (WSI). The change in scale can be measured by counting the number of transistors that can be fitted onto a chip.

Continued evolution of microcomputer demands further increases in packing density.

The evolution of microwave integrated circuits began with the development of planar transmission lines.

Microelectronic technique continues to displace other modes. As the limit of optical resolution has been reached, new lithographic and fabrication techniques are required.

So electronics has extended man's intellectual power, microelectronics extends that power still further.

Exercises:

I. Give Ukrainian equivalents to English ones:

an increasing size, a slowly operating device, achieved results, commercially produced device, a low-powered transmitter, man-made change, semiconductor device fabrication, a much faster change, widely accepted unit.

II. Give English equivalents to Ukrainian ones:

1) збільшувати надійність електронних приладів;
2) низька витрата енергії;
3) зменшення відстані між елементами схеми;
4) характеристики електронних систем покращились в багато разів;
5) поява мікроелектронних схем:
6) мікроелектронні прилади складаються з;
7) докладати великих зусиль;
8) економічна вигода;
9) транзистор з p-n переходом;
10) масштабування;
11) реагувати на сигнал;
12) створити щільне з'єднання компонентів ланцюга.

III. Choose the key sentences from the text, write them out of the text and translate.

IV. Find the part of the text containing the information about advantages of transistors over vacuum tubes, translate this passage.

V. Look through the text containing the information about advantages of transistors over vacuum tubes, translate this passage.

VI. Answer the following questions:

1) To what did intensive development of electronics lead to?
2) What were the advantages of the first transistors over the best vacuum tubes?
3) Why is the size of transistors of prime importance?
4) What is the point of extraordinary miniaturization?
5) What is the second performance benefit resulting from microelectronics?
6) What are the principal devices of electronic circuits?
7) What does the overall reliability of electronic circuits depend upon?
8) What were the most important facts for development of microelectronics?
9) Why couldn't early transistors satisfy the needs of the growing high-speed computer industry and microwave communication system?
10) What is the major difference between electronic systems and microelectronic devices?

VII. Make a short written summary of the text.

Unit Two

I. Mind the pronunciation of the following words:

exhibit, vulnerability, suitable, available, dominant, crystalline, alternately, essentially, occur, perfection, uniformity, concentration, commercial, water vapour, durable, strategy, specification, requirement, stringent, intrinsic, refinement, inherently, gallium arsenide.

II. Memorize words and word combinations:

1) to exhibit - виявляти;
2) vulnerability - уразливість;
3) processability - можливість обробки;
4) available - доступний, придатний;
5) scaling - масштабування;
6) time delay - тимчасова затримка;
7) net - мережа; схема; ланцюг; network - схема, ланцюг; мережа;
8) to recognize the immense importance - визнати величезну важливість;
9) purity - чистота; без домішок;
10) perfection - завершеність; бездоганність;
11) intrinsic - притаманний;
    intrinsic semiconductor - власний напівпровідник;
12) extrinsic - домішковий;
13) dopant - легуючий домішок;
14) to dope - легувати;
15) doping - легування;
16) stringent - строгий, точний;
17) refinement - удосконалення, очищення;
18) net effect - чистий ефект;
19) to make a great contribution - вносити великий внесок;
20) wafer - напівпровідникова пластина, плата;
21) attributable - характерний, причетний;
22) performance of circuit - параметри схеми.

SEMICONDUCTING MATERIALS ENGINEERING PROGRESS

In microelectronics, the steady reduction of IC feature sizes, has focused the attention of technologists on newer materials which exhibit characteristics such as low contact resistance, reduced vulnerability to electromigration, and processability at low temperatures.

Over the years, the device size has been reduced tremendously, Improvements available in materials technology have allowed integration of more and more devices on the same chip, resulting in increased area. According to the theory of scaling, the smaller dimensions of a MOS transistor should enhance its speed.

However, for large circuits, the time delays associated with the interconnections can play a significant role in determining the performance of the circuit.

As the minimum feature size is made smaller, the area of cross section of the interconnection also reduces. At the same time a higher integration level allows the chip area to increase, causing the lengths of the interconnections to increase. The net effect of this "scaling of interconnections" is reflected into an appreciable RC time delay.

Thus, as the chip area is increased and other device-related dimensions are decreased the interconnection time delay becomes significant compared to the device time delay and dominates the chip performance. These are dominant factors limiting device performance.

Performance is the obvious goal of VLSI; reliability is a more subtle one. Therefore, new materials are required for VLSI interconnections.

The design of any machine or a device has always been limited by the materials available. The problem in question was that materials could be designed and tailored for any new structures.

Semiconductors are used in a wide variety of solid-state devices including transistors, integrated circuits, diodes, photodiodes and light-emitting diodes.

The intrinsic semiconductor properties of Germanium and Silicon alone have shown chemical and electrical properties suitable for electronic devices operating near room temperature.

Germanium and silicon were the first semiconductor materials in common use.

A great contribution to the study of semiconductor physics has been made by the prominent Soviet scientist A.F.Yoffe. Academician Yoffe and his coworkers started a systematic research in the field of semiconductors.

Right after World War II, physicists John Bardeen, Walter Brattain and William Shockley, and many other scientists, turned full time to semiconductor research. Research was centered on the two simplest semiconductors - germanium and silicon.

In new experiments designed to test the new theory they discovered an entirely new physical phenomenon - the transistor effect W. Shockley patented the junction transistor. Junction transistors are essentially solid-state devices having three layers of alternately negative or positive type semiconductor material.

The early history of modem semiconductor technology went back when J. Bardeen and W.H. Brattain observed transistor action through point contacts applied to poly-crystalline germanium. It was realized that transistor action occurred within the single grains of polycrystalline material.

G.K. Teal originally recognized the immense importance of single-crystal semiconductor materials. He was the first to define chemical purity, high degree of crystal perfection and uniformity of structure as well as controlled chemical composition (i.e. donor or acceptor concentration) of the single-crystal material as an essential foundation for semiconductor products.

The next decade witnessed an ingermanium and the "universal" semiconductor material, silicon. Silicon gradually gained favour over germanium as the "universal" semiconductor material.

Silicon has been the backbone of the semiconductor industry since the inception of commercial transistors and other solid-state devices.

The dominant role of silicon as a material for microelectronic circuits is attributable in large part to the properties of its oxide.

If a wafer of silicon is heated in an atmosphere of oxygen or water vapour, a film of silicon oxide forms on its surface. The film considered is hard and durable and adheres well. It makes an excellent insulator. The silicon dioxide is particularly important in the fabrication of integrated circuits because it can act as a mask for selective introduction of dopants.

However, although the silicon wafer clearly is a fundamental ingredient in the fabrication of an integrated circuit, the silicon materials specification may not be critical element in developing a successful new IC product strategy.

Large-scale integration (LSI) of devices has put great demands on electronic-grade single-crystal material The semiconductor industry now requires high purity and minimum point-defects concentration in silicon in order to improve the component yield per silicon wafer.

These requirements have become increasingly stringent as the technology changes from large-scale integration (LSI) to very large-scale integration (VLSI) and very high speed integrated circuits (VHSIC).

The yield (or circuit performance) of a device and the intrinsic and extrinsic materials properties of silicon are interdependent. The silicon wafer substrate must be practically detect-free when the active device density maybe as high as 10^5 to 10^6 per chip.

To increase further the speed of semiconductor devices requires not only refinements in present designs and fabrication techniques, but also new materials that are inherently superior to materials presently being used, like germanium and silicon. New material is gallium arsenide.

Gallium arsenide has a much higher electron mobility than germanium and silicon. But, the difficulty of producing gallium arsenide of sufficient purity has limited its application.

Yet, gallium arsenide is far from perfection. So scientists are now working at the development of better materials and devices.

Exercises:

I. Give Ukrainian equivalents to English ones:

time delay, net effect, intrinsic semiconductor, density, rectification, perfection, the silicon wafer, single crystal material, solid-state device, device-related dimension, the problem in question, material could be designed and tailored for any structures, the intrinsic semiconductor properties, requirements are stringent, inherently superior to materials being used, to determine the performance of the circuit.

II. Choose the key sentences from the text, write them out of the text and translate them.

III. Find the part of the text concerning the information about the early history of modern semiconductor technology.

IV. Answer the questions:

1) What would you say about the steady reduction of IC feature sizes?
2) What has allowed the integration of more and more devices on the same chip?
3) What does higher integration level allow?
4) What are the dominant factors limiting device performance?
5) What limits the design of any machine?

6) Who has made a great contribution to the study of semiconductor physics?
7) What would you say about polycrystalline materials?
8) What is essential foundation for semiconductor products?
9) What can you say about the application of gallium arsenide?

V. Make a short written summary of the text.

Unit Three

I. Mind the pronunciation of the following words:

insulator, process, circuit, semiconductor, tight, available, ordinary, generate, similar, requirement, vapor, conductor, technique, characterize, variety, thermal

II. Memorize words and word-combinations:

1) wafer - пластана;
2) lattice - решітка (кристалічна);
3) insulator - діелектрик;
4) expenditure of energy - витрати енергії;
5) voltage - напруга;
6) valence band - валентна зона, зв’язок;
7) conducting band - зона (смуга) провідності;
8) intrinsic semiconductor - напівпровідник з домішками;
9) pure silicon - чистий кремній;
10) to pose a problem - створювати труднощі;
11) to diffuse - розпиляти;
12) interior - внутрішній;
13) adjacent - суміжний, сусідній;
14) vacancy - пустота, вільне місце, пропуск.

PROBLEMS IN MICROELECTRONIC CIRCUIT TECHNOLOGY

The manufacture of silicon microcircuits consists of a number of carefully controlled processes, all of which have to be performed to well-defined specifications.

Processing a "wafer" of silicon, a substrate on which the microelectronic circuits are made, is not a simple technological process. In order to understand how transistors and other circuit elements can be made from silicon it is necessary to consider the physical nature of semiconductor materials.

In a conductor current is known to be carried by electrons that are free to flow through the lattice of the substance. In an insulator all the electrons are tightly bound to atoms or molecules and hence none are available to serve as a carrier of electric charge.

The situation in a semiconductor is intermediate between the two: free charge carriers are not ordinarily present, but they can be generated with a modest I expenditure of energy.

Semiconductors are similar to insulators in that they have their lower bands completely filled. The semiconductor will conduct if more than a certain voltage is applied. At voltages in excess of this critical voltage, the electrons are raised from the top of the band 1 (the valence band) to the bottom of band 2 (the conducting band). Below this critical voltage the semiconductor material acts as an insulator. Semiconductors such as that described above are called intrinsic semiconductors - they are pure materials (for example silicon or germanium). It should be noted that a crystal of pure silicon is a poor conductor of electricity. Thus, conductivity poses a problem.

Several other requirements are imposed on materials. The basic demand appears to be conductivity because it can substantially improve the resistance and delay times for VLSI.

The improvement of conductivity has been made in several ways. Most semiconductor devices are known to be made by introducing controlled numbers of impurity atoms into a crystal, the process called doping.

Two independent lines of development are considered to lead to microscopic technique that produced the present integrated circuits. One involves the semiconductor technology; the other is a film technology.

Let us consider the former one, first. To improve the semiconductor crystal the impurities known as dopants are added to the silicon to produce a special type of conductivity, characterized by either positive (p-type) charge carriers or negative (n-type) ones. The dopants are diffused into semiconductor crystals at high temperature. In the furnace the crystals are surrounded by vapour containing atoms of the desired dopant. These atoms enter the crystal by substituting for the semiconductor atoms at regular sites in the crystal lattice and move into the interior of the crystal by jumping from one site to an adjacent vacancy.

Exercises:

I. Find in the text English equivalents to the following Ukrainian words and word-combinations, and write them out:

обробка підкладки, фізична природа напівпровідників, чітко визначені параметри, кристал чистого кремнію, поганий провідник, провідність, схема, тісно пов’язаний з, вільні носії зарядів, напівпровідники з домішками, таким чином, опір, позитивно заряджені носії.

II. Choose the key-sentences from the text, write them out and translate.

III. Find the part of the text containing the information about a crystal of pure silicon.

IV. Prepare a dialogue on the text using words from it.

V. Answer the following questions:

1) What could you say about the manufacture of silicon microcircuits?
2) What is the physical nature of semiconductor materials?
3) When does the semiconductor material act as an insulator?
4) When does the semiconductor conduct?
5) What could you say about a crystal of pure silicon?
6) Why is conductivity one of the basic requirements imposed on materials?
7) Can you name one of the ways to improve conductivity?
8) What do we call impurities added to silicon?

VI. Make a short written summary of the text.

Unit Four

I. Mind the pronunciation of the following words:

dope, apply, liquid, region, area, temperature, various, precise, surface, ultraviolet, diode, sequence, beneficial, significant, property, strength, accurate, expose, procedures, organic, prevent, radiation, frequency.

II. Memorize words and word-combinations:

1) deficiency - недолік, відсутність;
2) merely - тільки;
3) pentavalent element - п’ятивалентний елемент;
4) trivalent element - трьохвалентний елемент;
5) protective layer - захисний шар;
6) to etch - травити;
7) to delineate - встановлювати розмір, контур;
8) photosensitive compound - фото чутливий матеріал;
9) to dissolve - розчиняти;
10) coated wafer - легована підкладка;
11) acid - кислота;
12) harmful - шкідливий;
13) thermal warping - термоколивання, стрибки;
14) minority carrier lifetime - час існування неосновних носіїв.

PROBLEMS IN MICROELECTRONIC CIRCUIT TECHNOLOGY
(continuation)

Silicon crystals may be doped with different elements. Suppose silicon is doped with boron. Each atom inserted in the silicon lattice creates a deficiency of one electron, a state that is called a hole. A hole also remains associated with an impurity atom under ordinary circumstances but can become mobile in response to an applied voltage. The hole is not a real particle, of course, but merely the absence of an electron at a position where one would be found in a pure lattice of silicon atoms.

Nevertheless the hole has a positive electric charge and can carry electric current The hole moves through the lattice in much the same way that the bubble moves through a liquid médium. An adjacent atom transfers an electron to the impurity atom, "filling" the hole there but creating a new one in its own cloud of electrons; the process is then repeated, so that the hole is passed along from atom to atom.

Silicon doped with phosphorus or another pentavalent element is called an n-type semiconductor. Doping with boron or another trivalent element gives rise to a p-type semiconductor. Impurities may be introduced by the diffusion process. At each diffusion step in which n-type or p-type regions are to be created in certain areas, the adjacent areas are protected by surface layer of silicon dioxide, which effectively blocks the passage of impurity atoms. This protective layer is created very simply by exposing the silicon wafer at high temperature to an oxidizing atmosphere. The silicon dioxide is then etched away in conformity with a sequence of masks that accurately delineates multiplicity of n-type and p-type regions.

To define the microscopic regions that are exposed to diffusion in various stages of the process, extremely precise photolithographic procedures have been developed. The surface of the silicon dioxide is coated with a photosensitive organic compound that polymerizes wherever it is struck by ultraviolet radiation and that can be dissolved and washed away everywhere else, By the use of a high- resolution photographic mask the desired configurations can thus be transferred to the coated wafer. In areas where the mask prevents the ultraviolet radiation from reaching the organic coating the coating is removed. An etching acid can then attack the silicon dioxide layer and leave the underlying silicon exposed to diffusion.

A transistor can be made by adding a third doped region to a diode so that, for example, a p-type region is said to be sandwiched between two n-type regions. One of the n-doped areas is called the emitter and the other, the collector; the p- region between them is the base.

The transistor described is called an n-p-n transistor. There may be p-n-p transistors. The terms are likely to denote the sequence of doped regions in the silicon.

The first transistor structures were formed by alloying or diffusion in bulk single-crystal Ge or Si, but with the development of "planar technology" in the early 1960's the possibility of forming high frequency transistors and integrated circuits using epitaxial semiconductor films was realized.

The success of silicon in microelectronics is believed to be largely attributed to excellent properties of SiO_2 interface and ease of thermal oxidation of silicon. The recent years have seen considerable interest in the subject of oxygen and its precipitates in silicon. It has now been established that their presence can have a variety of effects, harmful as well as beneficial. Oxygen concentration is known to influence many silicon wafer properties, such as wafer strength, resistance to thermal warping, minority carrier lifetime, and instability in resistivity. Oxidation is widely used to create insulating areas.

However many phenomena happen not to be understood at present. An important aspect of the oxidation process is its low cost. Several hundred wafers can be oxidized simultaneously in a single operation.

Exercises:

I. Find in the text English equivalents to the following Ukrainian words and word-combination, and write them out:

дірка, відсутність електрона, підкладка, домішки, процес дифузії, різні етапи, багато чисельність, точний, запобігати, випромінювач, колектор, нестійкість, питомий опір.

II. Choose the key-sentences from the text, write them out and translate.

III. Find the part of the text containing the information about the role of the holes in the conduction process.

IV. Prepare a dialogue on the text using words from it.

V. Answer the following questions:

1) What is a hole like?
2) Can the hole carry electric current?
3) What is called an n-type semiconductor?
4) What is called an p-type semiconductor?
5) What may be introduce by the diffusion process?
6) What is called an n-p-n transistor?
7) What is widely used to create insulating areas?
8) What could you say about oxidation?

VI. Make a short written summary of the text

Unit Five

I. Mind the pronunciation of the following words:

industry, wavelength, sputtering, cracking, anodization, oxidation,

II. Memorize words and word combinations:

1) to range - коливатися в межах;
2) deposition - осадження;
3) sputtering - розпилювання;
4) to enable - давати змогу;
5) outline - обрис, контур;
6) etching - травлення, гравірування;
7) species - різновид;
8) volatile - енергозалежний;
9) malfunction - некоректне спрацювання, аварійний режим;
10) die - кристал;
11) intricate - складний, заплутаний;
12) to stack - накопичувати;
13) mask - шаблон, маскуючий шар;
14) to pose - створювати труднощі;
15) to be due to - бути наслідком.

Problems in Microelectronic Circuit technology
(continuation)

Even before the invention of the transistor the electronic industry had studied the properties of thin film of metallic and insulating materials. Such films range in thickness from a fraction of a micron, or less than a wavelength of light, to several microns.

The techniques for the deposition of thin films are numerous and include the following methods: evaporation, sputtering, anodization, radiation, polymerization, chemical reduction, thermal reduction of oxidation and electrophoresis. The first three are the major techniques used in integrated thin film circuit construction and are also applicable to silicon integrated circuitry and device work. These methods singly or in combination enable a variety of resistive, insulating and constructive materials to be laid down onto a suitable substrate.

The two most important processes for the deposition of thin films are chemical-vapour deposition and evaporation. The film technology has proved to provide precise dimensions.

In the fabrication of a typical large-scale integrated circuit there are more thin-film steps than diffusion steps. Therefore thin-film technology is probably more critical to the overall yield and performance of the circuit than the diffusion and oxidation steps are. A thin film happens even to be employed to select the areas on a wafer that are to be oxidized.

For VLSI structures several other requirements are imposed on interconnection materials by the fabrication technology.

The deposition of layers is followed by shaping operations, such as etching, to form the required outlines. Alternatively, the film can be deposited through a mask onto the substrate to define the outlines directly. In this way many identical thin-film devices can be made on a single sheet of material, which then are cut apart to yield individual devices.

Plasma etching, which is expected to play an important role in manufacture of semiconductor and other devices requiring fine-line lithography, involves the use of a glow discharge to generate reactive species from relatively inert molecular gases. These reactive species combine chemically with certain solid materials to form volatile compounds, which are then removed by vacuum pumping system.

This plasma-etching process has been shown to have important advantages in terms of cost, cleanliness, fine-line resolution, and potential for production line automation.

Additionally, the inside of a water-fabrication must be extremely clean and orderly: a single particle happens to cause a defect that will result in the malfunction of a circuit. The larger the die, the greater the chance for a defect.

The structure of an integrated circuit is sure to be complex both in the topology of its surface and in its internal composition. Each element of such a device has intricate three-dimensional architecture that must be reproduced exactly in every circuit. The structure is made up of many layers, each of which is a detailed pattern. Some of the layers lie within the silicon wafer and others are stacked on the top. The manufacturing process consists in forming the sequence of layers precisely in accordance with the plan of the circuit designer.

Increasing interest in submicron layer now poses new problems. New developments in materials arc believed to be due to new manufacturing forms and vice versa.

Integrated circuit technology is evolving so rapid that even a period as short as six months can produce a significant change.

Exercises:

I. Find in the text English equivalents to the following Ukrainian words and word-combinations and write them out:

частка, сполука, тонка плівка, надвелика інтегральна схема, окислення, вакуумна система насосів, охайний, поверхня, шар(пласт), точно, навпаки, загальний вихід(продукції), тліючий газовий розряд, прилад, плазмове травлення.

II. Choose the key sentences from the text, write them out.

III. Find the part of the text containing the information about the techniques for the deposition of thin films.

IV. Prepare a dialogue on the text, using words from it.

V. Answer the following questions:

1) What is the range of thickness for thin films in IC?
2) What methods of thin film deposition are there?
3) Which of them can be used in silicon integrated industry?
4) What is the deposition of layers followed by?
5) How can identical thin-film devices be made?
6) A glow discharge is involved by plasma etching, isn't it?
7) What does the chance for a wafer defect depend on?
8) What can you say about the structure of an integrated circuits?
9) What are new developments in materials connected with?

VI. Make a short written summary of the text.

Unit Six

I. Mind the pronunciation of the following words:

heart, inevitably, circuit, routine, service, feasible, horizon, bipolar, versatility, technique, acquiring, temporarily, crucial, feature, architecture, capability, throughout, various, widen.

II. Memorize words and word combinations:

1) inevitably - безперечно;
2) power supply - блок живлення;
3) inferior - гірший;
4) range - діапазон;
5) feasible - жахливий;
6) security - надійність, безпека;
7) to devise - придумувати, винаходити;
8) word - слово (комп.);
9) flexibility - гнучкість;
10) no longer - більше не;
11) to acquire - одержувати, набувати;
12) temporarily - тимчасово;
13) resident - властивий;
14) to scan - сканувати;
15) intelligence - інформація;
16) troubleshooting - виявлення пошкоджень;
17) obstacle - перешкода;
18) crucial - вирішальний, критичний;
19) provision - забезпечення.

MICROPROCESSORS: A BRAIN TO THE HARDWARE

The microprocessor forms the heart of a microcomputer. By taking advantage of the knowledge and concepts gained in mainframe and minicomputer applications better and more sophisticated microprocessors are beginning to emerge.

They are now appearing in many types of equipment and their field of application will inevitably widen.

The very first microprocessors were fabricated using PMOS (p-channel metal-oxide-semiconductor structure) technology. These were, however, relatively slow devices principally because "holes” in the p-type material have a low mobility. Later, improved technology permitted microprocessors to be constructed using n-type MOS and these microprocessors are almost as fast as normal minicomputers with speeds of three or four microseconds per instruction. Some microprocessors are now made using CMOS (complementary metal-oxide- semiconductor structure).

The speed and logic density of CMOS are inferior to n-type MOS but the process does have some significant advantages. First of all, it has a low power consumption since power is only consumed when a logic element changes a state. Secondly, it can operate over a wide voltage range. As a result, electronics based on CMOS can operate successfully with "noisy" power supplies and the low consumption makes it quite feasible to use a simple battery to maintain the security of supply for several weeks.

The only cloud on the CMOS horizon comes from a new development of the normal bipolar circuit. A new semiconductor configuration called integrated injection logic (IIL) has been devised which eliminates the need for any resistors, capacitors or transistor isolation. This enables an extremely compact logic circuit to be formed, which has a low power consumption while maintaining the normal speed of transistor-transistor logic (TTL).

The key features to consider in any microprocessor are: word length: architecture: speed; programming flexibility, etc. Microprocessors are structured for fixed word length or for modular expansion by a parallel combination of building-block chips.

The versatility of the microprocessor has altered the entire architecture of modem computer systems. No longer is the processing of information carried out only in the computer's central processing unit. Today there is a trend towards distributing more processing capability throughout a computer system, with various areas.

Distributing microprocessing is a technique in which the main microprocessor of the PC directs other microprocessors throughout the PC system to perform specific functions for it and report their status.

New forms of I/O are also acquiring sophisticated capabilities with distributed microprocessing. These "intelligent" I/O modules perform some of the calculations formerly done by the main microprocessor, store information temporarily, and do other functions under the direction of the main microprocessor.

Some remote I/O modules have microprocessors resident in the modules. Remote I/O modules use the resident microprocessors to shorten the effective scan time. However, with independent intelligence in the I/O, if something happens to the PC, the I/O module might already have acted on misinformation. A trend that is beginning to emerge in microprocessor design is the incorporation of troubleshooting aids.

Provisions are being made in the architecture. Whereas early developments were concerned with implementation of simple architectures with fundamental concepts and operations, the technology has now advanced to the point where significantly more sophisticated hardware can be (and is being) implemented in current and future microprocessor generations.

The major obstacle to designing an effective distributed-processing system is the difficulty involved in writing the system's software, which must enable tie various elements of the network to operate and interact efficiently.

There is a crucial need for easy methods of documenting programs and changes made to them.

Programmability can be obtained in microprocessors on one of two levels. A very detailed level of control is provided at the micro — instruction level. These micro - instructions may be used to obtain a macro, or machine-language, instruction set, which is then used to write control programs for microprocessor. New machine- language instructions may be defined by coding new microroutines. In this way an instruction set can be tailored to an application. Control programs can also be written in microcode. This provides increased execution speed and more detailed control at the expense of more difficult programming.

Today microprocessors are designed with communications in mind, so it is possible to link these processors together in a network. It is attractive for a number of reasons.

Exercises:

I. Find in the text English equivalents to the following Ukrainian words and word-combinations and write them out:

головний комп'ютер, обладнання, перевага, споживання енергії, логічна схема, тенденція, акумулятор, розподіл, ускладнений, характерна риса, спеціально пристосований, мережа, перешкода, багатобічність, архітектура, системне програмне забезпечення.

II. Choose the key sentences from the text, write them out and translate.

III. Find the part of the text containing the information about distributing microprocessing.

IV. Prepare a dialogue on the text, using words from it.

V. Answer the following questions:

1) What is the field of applications of microprocessors?
2) What are the advantages and disadvantages of CMOS technology?
3) What can eliminate the need for any resistors, capacitors or transistor isolation?
4) What is a new trend in the architecture of modem computer systems?
5) How were I/O modules changed with distributed microprocessing?
6) What prevents to design an effective distributed-processing system?
7) What are micro-instructions used for?
8) How can control programs be written?

VI. Make a short written summary of the text.

Unit Seven

I. Mind the pronunciation of the following words:

capacity, sufficient, intermediate, digital, destination, signifying, identical, characteristics, column, accessible, assigned, circulating, previous, challenged array, succeeded, oxide, erasable, laboratories, options.

II. Memorize words and word-combinations:

1. storage - запам’ятовування, зберігання, накопичування.
2. retrieval - пошуки
3. storage device - запам’ятовуючий пристрій
4. storage capacity - ємність пам’яті
5. digital information - цифрова інформація
6. random-access memory - ЗП з довільною вибіркою
7. serial-access memory - ЗП з послідовною вибіркою
8. ferrite-core memory - пам’ять на феритових сердечниках

DEVELOPMENTS IN ELECTRONIC MEMORIES

Storage devices or memories must have capacities sufficient not only for intermediate results but also for the input and output data and the programs.

Once prepared a program can be reused any number of times, which involves remembering.

Computers can "remember" and "recall" and virtually unlimited is the capacity of computers to remember (that is to store information). Associated with the capacity of remembering is the capacity of recalling.

In the context of electronics, "memory" (or, in British usage, "store") usually refers to a device for storing digital information. Storage ("write") and retrieval ("read") operations are completely under electronic control.

The most widely used digital memories are read/write memories, the term signifying that they perform read and write operations at an identical or similar rate.

Of primary importance to characteristics for memories are storage capacity and speed of operation (defined in terms of access time). Access time is simply the time it takes to read or write at any storage location.

The demand for fast access and large capacity has grown constantly.

A prime distinction between memories is the manner in which information is stored (written) and accessed (read). Random-access memories involve column and row matrices, which allow information to be stored in any cell and accessed in approximately the same time. By contrast, "serial access" means that information is stored in column order and access time depends on the storage location selected.

Random-access memories can complete read and write operations in specified minimum period known as the cycle time, Serial-access and block-access memories have a variable and relatively large access time after which the data-transfer rate is constant. The data-transfer rate is the rate at which information is transferred to or from sequential storage positions.

The smallest block of information accessible in a memory system can be a single bit (represented by 0 or 1), a larger group of bits such as a byte or character (usually eight or nine bits), or a word (12 to 64 bits depending on the particular system).

Most memories are location-addressable, which means that a desired bit, byte or word has a specified address or physical location to which it is assigned.

Of prime interest to a reader will be the knowledge of the development of memories.

One of the first electronic memories was a circulating delay line, a signal transmission device in which the output, properly amplified and shaped, was fed back into the input. Although it was economical, it had the inherent drawback of serial access: the greater the capacity, the longer the average access time. What was really needed was selective access to any stored data in a time that was both as short as possible and independent of the data address or any previous access. This is known as random access, so named to emphasize the total freedom of accessing. The first random-access memories (RAM's) were electrostatic storage tubes.

In the early 1950's the core memory replaced these early devices, providing a solution to the need for random access that truly fired the emerging computer industry.

The core memory has become the main internal computer memory and was used universally until challenged recently by semiconductor memories. Typical arc memories with 1 million words of 30 to 60 bits each, randomly accessible in 1 microsecond, The core memory has also been extended to very large capacities, of the order of 100 million words.

In the 1950's and 1960's electronic memories were arrays of cores, or rings, of ferrite material a millimeter or less in diameter, strung by thousands on a grid of wires. Ferrite-core memories have now been largely succeeded in new designs by semiconductor memories that provide faster data access, smaller physical size and lower power consumption, and all at significantly lower cost.

Exercises:

I. Find in the text English equivalents to the following Ukrainian words and word-combinations and write them out:

проміжні результати; вимоги до швидкого доступу і великої ємності; здатність відтворювання, пов'язана зі здатністю запам'ятовувати; у цієї пам'яті є недоліки, притаманні тільки їй; пам'ять на магнітних сердечниках замінила ці ранні пристрої; це означає що потрібний біт, байт або слово має зазначену адресу; пристрій для передачі сигналу; які забезпечують більш швидку вибірку даних, менший фізичний розмір і нижчий рівень споживання енергії; чим більша ємність тим довший час вибірки.

II. Choose the key-sentences from the text, write them out and translate.

III. Find the part of the text containing the information about the types of information blocks accessible in a memory system.

IV. Prepare a dialogue on the text using words from it.

V. Answer the following questions:

1) What is a storage device?
2) What are the most important characteristics of memory?
3) What is a prime destination between memories?
4) What is the difference between random-access memory and serial-access memory?
5) What are the blocks of information accessible in a memory system called?
6) What were the first electronic memories like?
7) What were their drawbacks?
8) What was the advantage of the core memory?

Unit Eight

I. Mind the pronunciation of the following words:

purpose, integrated, installed, bubbles, tunnel, junction, versatile, further, half, binary, rectangular, simultaneous, hierarchy, conjunction, desirable solution, steadily, cryoelectronic, extremely, emergence.

II. Memorize words and word-combinations:

1) memory cells - комірки пам'яті;
2) magnetic bubble - циліндричний магнітний домен;
3) superconducting tunnel-junction devices - суперпровідні пристрої з тунельним переходом;
4) read/write memory - оперативна пам'ять з зчитуванням і записом;
5) read-only memory - постійна пам'ять;
6) binary bit - двійковий розряд;
7) binary-coded address - адреса у двійковому коді;
8) target - ціль, завдання, план;
9) option - варіант, замінник, вибір;
10) in conjunction with - разом;
11) charge-coupled device - пристрій з зарядовим зв'язком;
12) performance - робота, виконання.

DEVELOPMENTS IN ELECTRONIC MEMORIES

(continuation)

In the early 1970's semiconductor memory cells that served the same purpose as cores were developed, and integrated memory circuits began to be installed as the main computer memory.

In the 1980's new memory technologies involving magnetic bubbles, superconducting tunnel-junction devices and devices accessed by laser beams or electron beams come into play.

Semiconductor memories are extremely versatile and highly compatible with other electronic devices in both small and large systems and have much potential for further improvement in performance and cost. They are expected to dominate the electronic-memory market for at least another decade.

The most widely used form of electronic memory is the random-access read/write memory (RAM) fabricated in the form of a single large-scale- integrated memory chip capable of storing as many as 65.000 bits in an area less than half a centimeter on a side.

A number of individual circuits, each storing one binary bit, are organized in a rectangular array. Access to the location of a single bit is provided by a binary- coded address presented as an input to address decoders that select one row and one column for a read or write operation. Only the storage element at the intersection of the selected row and column is the target for the reading or writing of one bit of information. A read/write control signal determines which of the two operations is to be performed. The memory array can be designed with a single input-output line for the transfer of data or with several parallel lines for the simultaneous input or output of four, eight or more bits.

Different categories of semiconductor memories and specific data storage applications where they find primary use provide system engineers with a wide range of options. In general, metal-oxide semiconductor (MOS), erasable- programmable read only memories (EPROM's) are extensively used in micro-and minicomputer applications.

Many laboratories are looking for new options. Thus computers today use a hierarchy of large-capacity, relatively slow mechanically accessed memories in conjunction with fast electronically accessed memories of relatively small capacity. It would be highly desirable to fill the gap by some device of sufficient capacity and speed.

Candidates for gap-filling memories include metal-oxide semiconductor (MOS) random-access memories (RAM's) made by large-scale integration (LSI); magnetic bubble devices based on cylindrical domains of magnetization; electron beam-addressed memories; and optical memories based on lasers, holography, and electrooptical effects, charge-coupled devices (CCD).

Radically new technologies still at an early laboratory stage, are aimed at a more ideal solution than today's hierarchy.

One can foresee the development of cryoelectronic memories with extremely high component densities operating at speeds 10 to 100 times faster than today's fastest electronic memories.

Researchers now are looking forward to light particles — photons — which will permit the performance to be made a thousand times faster. This would mean that in the future we can expect the emergence of photon computers and that computations will be done by means of light.

Any radical improvement in memory technology will ultimately greatly affect our way of life, as previous innovations have shown.

Exercises:

I. Find in the text English equivalents to the following Ukrainian words and word-combinations, and write them out:

інтегральні запам’ятовувальні схеми, починають діяти, мають великий потенціал для подальшого вдосконалення в роботі, напівпровідникові ЗП надзвичайно різнобічні, гнучкі і дуже схожі з іншими електронними пристроями, запам’ятовувальний пристрій з відносно малою ємністю, запам’ятовуючий пристрій з довільною вибіркою на напівпровідниках структури метал-оксид, високий ступінь інтеграції, пристрої на циліндричних магнітних доменах, можна передбачити розвиток кріоелектронних запам’ятовуючих пристроїв.

II. Choose the key-sentences from the text, write them out and translate.

III. Find the part of the text containing the information about the most widely used form of electronic memory - the random-access read / write memory.

IV. Prepare a dialogue on the text using words from it.

V. Answer the following questions:

1) When were semiconductor memory cells developed?
2) When did new memory technologies come into play?
3) What can you tell about semiconductor memories?
4) In what way is access to the location of a single bit provided?
5) What options of semiconductor memories do you know?
6) What speeds do cryoelectronic memories operate at?
7) What could you tell about the emergence of photon computers?

Supplementary Texts

Who’s Liable for Insecure Networks?

It’s no news to IT administrators that security vulnerabilities expose networked computers to worms, viruses, and other dangers, but when techie jargon such as Code Red and Trojan horse make headlines, the problem is no longer relegated to the company's "computer guys". Such stories typically focus on the hackers rather than the insecure hosts that facilitated the intrusion.

Given computers' integral role in modem life, however, we can no longer tolerate negligent security. We must define standards of care and develop processes for recovering damages from those who fail to act reasonably in securing networked computers.

We face the critical task of assessing responsibilities, defining duties, and assigning liabilities in a digital environment that cultivates both traditional and neoteric relationships, conduct, and consequences.

Negligence Claims and Network Security

Negligence is primarily a civil law concept intended to address grievances between people and to encourage socially responsible behavior. Victims of cyberattacks are likely to seek compensation for losses in civil rather than criminal court because hackers can masquerade anonymously and deep pockets are plentiful. Further, unlike criminal prosecutions or breach-of-contract claims, Internet-related claims don't need to identify the miscreant or establish a prior contractual relationship under a negligence theory of liability. Finally, many hackers are juvenile offenders unlikely to be prosecuted under federal computer crime law. Specifically, negligence claims may be potent if the victim can show that the "insecure" party:

1) had a duty to use reasonable care in securing its computer systems;
2) breached that duty by failing to employ adequate security;
3) was a reasonably recognizable cause of actual damages.

Identifying situations in which an insecure network was used as a launch point to compromise data or disrupt operations is relatively easy, but there is no basis for claiming negligence unless the party that failed to secure the networked computer had a duty to do so.

Imposing a Duty to Secure Computers

Foreseeability of harm-the knowledge, real or implied, that a person's actions will result in harm to another -is a fundamental element that courts require in deciding whether a duty exists. Other instrumental factors that courts traditionally weigh include the socioeconomic impact of losses and reasonable expectations that a party in the best position to implement and maintain security will do so.

Foreseeability of Harm

Time, location, and predictable relationships limit the number of foreseeable victims in the physical world. However, everyone online is but one click away from a reasonably perceived risk—the pool of plaintiffs could thus include all users connected to a network.

For example, to say that a company hosting a Web site has a duty to protect a user from harm as a result of a computer intrusion means that the company must follow a standard of conduct to protect others on the network against foreseeable risks - namely, it must use reasonable care in adequately securing its computer systems.

The computing community knows that hackers seek unauthorized entry. Software vendors' actions in posting patches, issuing prerelease warnings, and responding to widespread security alerts show tacit knowledge that these products are routinely exploited and have sustained damage.

Internet service providers arguably possess the same awareness of intrusion methods and potential victims. Just as software vulnerabilities are a common target, so too are poorly configured networks and servers. ISPs need not be "hacker monitors," but they should have imputed knowledge of the reasonably perceived risk that an intruder will try to use their network to harm customers.

It's reasonable to expect that companies hosting Web sites should anticipate misconduct in the form of attempted intrusions. Regardless of the specific measures a company fails to take to protect its own proprietary data or information assets, its general lack of computer security can result in damage to other Internet entities. A grocery store owes a duty of care to protect its patrons. If the store owner fails to take security precautions such as mounting surveillance cameras, hiring a security guard, or installing lights in the parking lot, a customer who is injured in an attack would file a lawsuit before the swelling had begun to go down. Likewise, an Internet company that sets up a Web server without configuring for security should be held accountable for damages that its online patrons suffer, such as identity theft.

Socioeconomic Impact

The costs associated with insecure computers on the Internet weigh heavily in favor of assigning a duty to secure systems. The direct and indirect costs of distributed denial-of-service attacks and other compromises are substantial—for example, network sites can lose up to $80,000 per hour during downtime. Whereas holding vendors accountable for every bug and vulnerability is unreasonable, shifting the losses associated with negligently designed software to users is equally untenable.

Imposing a duty thus creates an economic incentive to render higher quality products. Lemon laws protect consumers from defective motor vehicles, yet no comparable regime exists for "unsafe" software products. As experts such as Bruce Schneier have pointed out, vendors have no economic incentive to use a higher degree of care in securing their products until they are held liable for negligent security- instead, they can continue focusing on speed, features, and options.

As networks evolve, the danger of false victimization claims will grow. For example, the added functionality that is at the forefront of system design comes with a vulnerability cost—the appliances and other devices being made with programmable computer chips and Internet accessibility are a case in point Until due care is properly assigned, there can be little expectation of security in the complex digital environments of the future.

Finally, assigning a duty to secure to vendors, service providers, companies with a Web presence, and users distributes the risk of loss among those who employ the technology. This policy recognizes that no single entity is responsible for the security of the entire Internet, but each should be responsible for an identifiable part.

Insofar as users are the driving force behind electronic commerce, they should be held to a reasonable standard in preventing the ill effects of their online activities where security measures are readily available and not overly burdensome. For example, those who neglect to update antivirus software should be held accountable if a hacker uses their machine to launch distributed denial of service attacks against a commercial Web site.

Reasonable expectations of security

Another factor in imposing duty is the degree of reliance an injured party places on another's actions. For example, when you make an online purchase, you expect the merchant to be aware that your credit card number is not for public distribution, that it will protect this fiduciary data, and that it has the ability to implement appropriate safeguards. The merchant may not be using reasonable care if it stores your credit card information unencrypted on its Web server and the data is subsequently stolen.

Reasonable expectations of security are created in various ways and help determine who is entitled to protection. Industry customs are one way to measure the objective reasonableness of a victim's expectations of care. Widely disseminated bulletins and company security policies and procedures represent generally agreed- upon methods to assess security and protect systems. In this way, duty may thus arise from information-security best practices that shape users' expectations.

Reasonable expectations of security are also shaped by the discrepancy in authority between the damaged party and the allegedly "insecure" party. For example, landlords have a duty to secure common-use areas over which they have control such as stairways, elevators, and lobbies. Likewise, Internet service providers, which monitor and control network traffic, could reasonably be relied on to prevent or mitigate distributed denial of service damages by configuring their routers to block spoofed addresses because customers are incapable of implementing such protection.

Reasonable expectations of security also can arise when one party makes assurances or voluntarily assumes responsibility yet leaves another party at greater risk. For example, if tenants forego putting deadlocks on their doors because the landlord has installed an alarm system, and an intruder enters the building undetected due to the system being incorrectly installed or improperly maintained and injures a resident, the landlord would be considered derelict in his standard of care.

Likewise, a software vendor may create a false sense of security in its product by misrepresenting protections or implementing them carelessly, thereby causing a user to eschew other safeguards. The vendor has thus assumed the duty to disseminate a reasonably secure product and left the user in a more vulnerable position. Similarly, users should expect software to function adequately and not leave them worse off—for example, by exposing their entire system to intrusion.

Unless society takes steps to impose a duty on software vendors, service providers, businesses with a Web presence, and users to secure computer systems, we can expect continued responsibility shifting and detrimental socioeconomic behavior. The scope of this duty should recognize each party's varying degrees of knowledge, control, and identifiable effect in securing networked computers against injurious damages.

Physical Measurements

Physical variables associated with biomedical systems are measured by a group of sensors known as physical sensors. Although many specific physical variables can be measured in biomedical systems, these can be categorized into a simple list. Sensors for these variables, whether they are measuring biomedical systems or other systems, are essentially the same. Thus, sensors of linear displacement can frequently be used equally well for measuring the displacement of the heart muscle during the cardiac cycle or the movement of a robot arm. There is, however, one notable exception regarding the similarity of these sensors: the packaging of the sensor and attachment to the system being measured. Although physical sensors used in nonbiomedical applications need to be packaged so as to be protected from their environment, few of these sensors have to deal with the harsh environment of biologic tissue, especially with the mechanisms inherent in this tissue for trying to eliminate the sensor as a foreign body. Another notable exception to the similarity of sensors for measuring physical quantities in biologic and nonbiologic systems are the sensors used for fluidic measurements such as pressure and flow. Special needs for these measurements in biologic systems have resulted in special sensors and instrumentation systems for these measurements that can be quite different from systems for measuring pressure and flow in nonbiologic environments.

We will attempt to review various examples of sensors used for physical measurements in biologic systems. Although it would be beyond the scope of this chapter to cover all these in detail, the principal sensors applied for biologic measurements will be described. Each section will include a brief description of the principle of operation of the sensor and the underlying physical principles, examples of some of the more common forms of these sensors for application in biologic systems, methods of signal processing for these sensors where appropriate, and important considerations for when the sensor is applied.

Description of sensors

Linear and Angular Displacement Sensors

Variable Resistance Sensor.

One of the simplest sensors for measuring displacement is a variable resistor similar to the volume control on an audio electronic device. The resistance between two terminals on this device is related to the linear or angular displacement of a sliding tap along a resistance element. Precision devices are available that have a reproducible, linear relationship between resistance and displacement. These devices can be connected in circuits that measure resistance such as an ohmmeter or bridge, or they can be used as a part of a circuit that provides a voltage that is proportional to the displacement. Such circuits include the voltage divider or driving a known constant current through the resistance and measuring the resulting voltage across it. This sensor is simple and inexpensive and can be used for measuring relatively large displacements.

Strain Gauge

Another displacement sensor based on an electrical resistance change is the strain gauge. If a long narrow electrical conductor such as a piece of metal foil or a fine gauge wire is stretched within its elastic limit, it will increase in length and decrease in cross-sectional area.

Inductance Sensors

Mutual Inductance

The mutual inductance between two coils is related to many geometric factors, one of which is the separation of the coils. Thus, one can create a very simple displacement sensor by having two coils that are coaxial but with different separation. By driving one coil with an ac signal and measuring the voltage signal induced in the second coil, this voltage will be related to how far apart the coils are from one another. When the coils are close together, the mutual inductance will be high, and so a higher voltage will be induced in the second coil; when the coils are more widely separated, the mutual inductance will be lower as will the induced voltage. The relationship between voltage and separation will be determined by specific geometry of the coils and in general will not be a linear relationship with separation unless the change of displacement is relatively small. Nevertheless, this is a simple method of measuring separation that works reasonably well provided the coils remain coaxial. If there is movement of the coils transverse to their axes, it is difficult to separate transverse displacement from displacement along the axis.

Variable Reluctance

A variation on this sensor is the variable reluctance sensor wherein a single coil or two coils remain fixed on a form which allows a high reluctance slug to move into or out of the coil or coils along their axis. Since the position of this core material determines the number of flux linkages through the coil or coils, this can affect the self-inductance or mutual inductance of the coils. In the case of the mutual inductance, this can be measured using the technique described in the previous paragraph, whereas self-inductance changes can be measured using various instrumentation circuits used for measuring inductance. This method is also a simple method for measuring displacements, but the characteristics are generally nonlinear, and the sensor generally has only moderate precision.

Linear Variable Differential Transformer

By far the most frequently applied displacement transducer based upon inductance is the linear variable differential transformer. This device is essentially a three-coil variable reluctance transducer. The two secondary coils are situated symmetrically about the primary coil and connected such that the induced voltages in each secondary oppose each other. When the core is located in the center of the structure equidistant from each secondary coil, the voltage induced in each secondary will be the same. Since these voltages oppose one another, the output voltage from the device will be zero. As the core is moved closer to one or the other secondary coils, the voltages in each coil will no longer be equal, and there will be an output voltage proportional to the displacement of the core from the central, zero-voltage position. Because of the symmetry of the structure, this voltage is linearly related to the core displacement. When the core passes through the central, zero point, the phase of the output voltage from the sensor changes by 180 degrees. Thus, by measuring the phase angle as well as the voltage, one can determine the position of the core.

Capacitive Sensors

Displacement sensors can be based upon measurements of capacitance as well as inductance. The fundamental principle of operation is the capacitance of a parallel plate capacitor. By moving one of the plates with respect to the other, the capacitance will vary inversely with respect to the plate separation. This will give a hyperbolic capacitance-displacement characteristic. However, if the plate separation is maintained at a constant value and the plates are displaced laterally with respect to one another so that the area of overlap changes, this can produce a capacitance-displacement characteristic that can be linear, depending on the shape of the actual plates.

The third way that a variable capacitance transducer can measure displacement is by having a fixed parallel plate capacitor with a slab of dielectric material having a dielectric constant different from that of air that can slide between the plates. The effective dielectric constant for the capacitor will depend on how much of the slab is between the plates and how much of the region between the plates is occupied only by air. This, also, can yield a transducer with linear characteristics.

The electronic circuitry used with variable capacitance transducers is essentially the same as any other circuitry used to measure capacitance. As with the inductance transducers, this circuit can take the form of a bridge circuit or specific circuits that measure capacitive reactance.

Velocity Measurement

Velocity is the time derivative of displacement, and so all the displacement transducers mentioned above can be used to measure velocity if their signals are processed by passing them through a differentiator circuit. There are, however, two additional methods that can be applied to measure velocity directly.

Magnetic Induction

If a magnetic field that passes through a conducting coil varies with time, a voltage is induced in that coil that is proportional to the time-varying magnetic field. A simple way to apply this principle is to attach a small permanent magnet to an object whose velocity is to be determined, and attach a coil to a nearby structure that will serve as the reference against which the velocity is to be measured. A voltage will be induced in this coil whenever the structure containing the permanent magnet moves, and this voltage will be related to the velocity of that movement. The exact relationship will be determined by the field distribution for the particular magnet and the orientation of the magnet with respect.

Doppler Ultrasound

When the receiver of a signal in the form of a wave such as electromagnetic radiation or sound is moving at a nonzero velocity with respect to the emitter of that wave, the frequency of the wave perceived by the receiver will be different than the frequency of the transmitter. This frequency difference, known as the Doppler shift, is determined by the relative velocity of the receiver with respect to the emitter. This principle can be applied in biomedical applications as a Doppler velocimeter. A piezoelectric transducer can be used as the ultrasound source with a similar transducer as the receiver. When there is no relative movement between the two transducers, the frequency of the signal at the receiver will be the same as that at the emitter, but when there is relative motion, the frequency at the receiver will be shifted.

The ultrasonic velocimeter can be applied in the same way that the ultrasonic displacement sensor is used. In this case the electronic circuit produces a continuous ultrasonic wave and, instead of detecting the transit time of the signal, now detects the frequency difference between the transmitted and received signals. This frequency difference can then be converted into a signal proportional to the relative velocity between the two transducers.

Medical Electronics

I

Progress in medical electronics was evident on a variety of clinical and research fronts holding out the prospect of improved health care. One noteworthy advance was in blood gas monitoring used to assess the cardiovascular, respiratory, and metabolic performance of patients during surgery and in emergency situations. It is now possible to do such monitoring in real time with the PB3300 intra-arterial blood gas monitoring system

In the PB3300 system, special sensing fibers are part of a microprocessor-based unit. The sensor contains three small optical fibers, each about the diameter of a human hair, and a thermocouple in a biocompatible package. The entire sensor is small enough to be inserted into a radial artery through an arterial catheter less than 1 mm in diameter.

Each optical fiber has at its tip a special fluorescent dye. The dye on one fiber is sensitive to partial pressures of oxygen, to partial pressures of carbon dioxide on another, and to hydrogen ion concentration on the third. (Engineers at the National Institutes of Health developed the first probes of this type.) The high-energy photons in light sent through the fibers by the system are absorbed by the dyes. They then re-emit the light at a different wavelength and intensity. Depending on the particular dye, the intensity of the re-emitted light is changed by nearby concentrations of oxygen, carbon dioxide, or hydrogen ions. This change is converted by the instrument to readings of partial pressures of O_2, CO2, and pH.

The thermocouple measures blood temperature in the radial artery which is then displayed along with the blood gas values.

Even the mundane task of taking a patient's temperature benefits from modem technology. Introduced last year was a new tympanic or ear thermometer that measures infrared heat generated by the eardrum and surrounding tissue and displays the temperature in about 2 seconds.

Support For the Artificial Heart

In July, the Institute of Medicine, Washington, D.C., released a report, "The Artificial Heart: Prototypes, Policies, and Patients" which calls for the National Heart, Lung, and Blood Institute to continue research contracts in artificial heart technology beyond their expiration. The continuance, the report said, should be for an interim period to support work on ventricular assist devices and the total artificial heart This institute is the only U.S. government source of funds for artificial heart research.

In 1988 research contracts on the total artificial heart were suspended after the institute decided the money would be better spent for research on ventricular assist devices, which were further along in development. That decision met strong resistance from congressional leaders and other officials and was later rescinded.

The first model of the total artificial heart is not likely to be approved by the U.S. Food and Drug Administration before the year 2005. Ventricular assist devices should be available by the late 1990s. Clinical trials on a long-term, fully implantable unit are scheduled to begin this year. Units are typically implanted in the abdomen, connected to tubes through which the blood is drawn from one of the heart's ventricles, and pumped into the circulatory system.

What complicates the funding issue is the uncertainty as to whether the cost of a total artificial heart will ever fall into line with the benefit to the patient.

Viewing the Brain at Work

Last year reports on the first images of the human brain as it performs the simple task of recalling a word revealed some surprises. The images showed that the recall process was going on in unexpected parts of the brain, not just in the hippocampus.

In the experiments, 18 volunteers were seated with a positron emission tomography (PET) scanner placed around their heads. Injected into their bloodstreams was water with the oxygen molecule altered to make it a positron emitter with a half-life of 123 seconds. It provides a marker of regional cerebral blood flow.

When brain cells become active, they use more energy than usual. The energy demands are met by increased blood flow in those brain regions that are active. The increased concentrations of blood in those areas show up on the PET scan as hot spots. Volunteers were presented first with a list of about 15 words on a TV screen. After a few minutes, a list of 20 word beginnings would appear on the screen in front of them, and they were asked to complete the word beginnings by saying the first word that came to mind, or by trying to complete the word beginning with a word from the studied list.

The PET images showed that the automatic form of word completion involved activity in the visual area in the back of tie brain and that conscious recall involved activity in a spot in the frontal lobe of the brain and in the hippocampus.

II

Some strides made in biomedical engineering last year that involved both devices available for clinical applications and innovations still in the research phase have profound implications for the practice of medicine and the quality of life.

Among the many developments that occurred, here are a few that are already changing the delivery of health care or are likely to do so in the near future.

One important advance was the gathering of information about the chemical composition of blood. Such information is essential for the diagnosis of many clinical disorders. Conventional blood analyzers, which provide this information and are available in doctors' offices, clinics and hospitals, test a sample of the patient's blood.

By this means, information is obtained only at discrete and infrequent intervals. But under certain clinical circumstances, it is important to closely follow changes in blood chemistry— either at frequent intervals or continuously. During open heart surgery, for example, a device placed into the arterial and venous lines of a heart-lung machine provides readings of blood oxygen and carbon dioxide content, pH, and temperature. But no device for direct measurement in a patient's artery had been available.

Now a new system is capable of measuring these parameters continuously using an optical-fiber catheter inserted directly into an artery. The device, approved for marketing by the Food and Drug Administration, is usable over long periods of time. It could revolutionize the clinical management of certain groups of patients. Other companies are expected to develop similar devices.

The most critical element in any measurement system is the sensor. This is especially important in the measurement of properties of a biological sample since the living environment is extremely hostile to foreign materials. Researchers for years have been seeking sensors that can be stable, sensitive, highly specific, and long-lasting in the living environment. One important need is a real-time glucose sensor that can be used in a closed-loop system for automatic delivery of insulin to diabetics.

Recent advances in the application of polymer science to biosensors appear to hold great promise. For example, polymers can be used to change the way in which the sensing compound interacts with the molecule of interest, such as glucose. Tightly coupling the sensing compound to the sensor electrode increases its longevity. In addition, the properties of the polymer can be adjusted to increase the rate at which glucose molecules diffuse to the sensor, thereby increasing the sensitivity and the responsiveness of the system.

Polymers may also be designed to increase specificity. For example, they can be formed to filter out molecules above a certain size, thus making the sensor specific only to smaller molecules. While still in the research phase, these polymer materials are likely to transform the field of biosensors.

Contrast agents, which enhance X-ray images of internal body structures, have been used in the clinical setting for decades. Recently paramagnetic compounds have been used to improve magnetic resonance images and now certain agents that show potential for enhancing ultrasound images are beginning to appear on the market. The contrast agent increases reflection of the ultra-sound energy by creating an interface between the living material and another element such as air. Reflection occurs at the interface.

In practice, air bubbles, or particles containing air bubbles, are injected into the blood stream. The bubbles create multiple reflections that serve to enhance

the image. To design an effective contrast agent the air-containing particle must be compatible with blood, must be excreted in a reasonable time without harmful effects, and must remain in the system long enough to produce the enhanced ultrasound image. A contrast agent using air-filled human serum albumin particles was recently approved by the Food and Drug Administration for clinical use. While intended at first to improve images of anatomic structures in the heart, future applications of this and similar agents could be used to improve measurements of perfusion to critical organs, such as the coronary circulation.

One area of medical technology receiving a great deal of public attention in recent years is the work being done on the artificial heart and partial heat assist devices. These devices represent a prime example of incremental progress through years of research and development, and show how advanced technology from other fields can be applied to the solution of a medical problem.

A new heart assist device, now undergoing clinical testing, contains a miniature centrifugal pump incorporated into a catheter, which is inserted through an artery into the left ventricle. Driven by a small external motor connected to the pump by a mechanical Shaft, the device can assist the heart by increasing blood flow markedly and so reducing heart work requirements.

Another development with a future is the use of the body's own parts to augment the function of the failing heart muscle. Research in progress is attempting to make skeletal muscle behave like heart muscle. The skeletal muscle will contract in response to electrical stimulation and can be wrapped around the heart or fashioned into an extra chamber to be used as an additional pump.

Another important milestone in 1991 was a report by a committee of the Institute of Medicine, Washington, D.C., which convened to evaluate the artificial heart program of the National Heart, Lung, and Blood Institute, Washington, D.C. The committee reaffirmed the need to continue developing a total artificial heart, recognized the importance of both total artificial hearts and heart-assist devices in treating a large patient population, and recommended that the institute continue the funding for such efforts.

Future Microprocessors

Cost, not technology, will be the greatest barrier to future chip developments.

In 15 years, microprocessors will be racing at gigahertz speeds, cashing in millions of transistors on a chip the size of your thumbnail. On it will be a mile or so of stacked wiring laid with molecular precision.

The main challenge going forward will be to maximize the speed of the interconnect-a dilemma with which PC vendors also grapple today, since on-chip speeds are roughly five times as fast as chip-to-board speeds. Signal propagation I delays across multiple metal layers will also be highly problematic for chip designers.

In the future, more powerful chips will enable an abundance of PC - applications, limited only by our imaginations. Already, microprocessors allow such functions as handwriting recognition and language translation. Still, there are obstacles to advancing chips. If technologies aren't the barrier, then what is?

Cost Barriers

One obstacle to advancing microprocessor technology is the cost of building a semiconductor-manufacturing facility (or fab), now over $1 billion. There are about 1,000 fabs today; the hundred or so that will be built before 2012 will be even more costly. Yet such costs are nothing compared with the price of bringing chips to market: Intel's first Pentium chip, for example, cost over $5 billion to develop. Developing the chips of 2012, be they of RISC or CISC architecture, may cost something like $10 billion.

In fact, Intel's Gordon Moore has identified the expense of chip making as a limiting factor. Moore should know, since he first noted, in 1965, the strategy of scaling down transistor size to create smaller, faster, more functional chips cost- effectively (in a trend known since as Moore’s Law). Hence, faster, smaller computers come out every year.

Visionaries could argue that there is no real barrier to chip development and that if we use technology properly, it will enable much more than improved productivity. Perhaps we can push the window open further to realize any number of advances. Can tomorrow's technology be embraced to allow for greater advances in areas such as education and cultural appreciation? Stranger things have happened— even in the electronics industry.

The Silicon Architects

Trying to speed processing by minimizing signal propagation delay, designers have effectively stacked metal lines of increasing length. Whereas chips in the late eighties used only one metal layer, today's state-of-the-art chips have four or five.

Though this stack will rapidly progress to eight or more layers, eventually the metal's capacity to handle the signal will reach its limit, and new methods will be necessary. The lines will likely consist of copper instead of aluminum, because it is a better electrical conductor.

So instead of the isolating silicon-dioxide film to separate the lines, fluorinated oxides will be deposited or spun on the wafer. This magical combination of materials will reduce the wire's resistance/capacitance time constant. By minimizing the metal's resistance and lowering the isolating films of electric constant, chip will enable faster signals. Here is where the choice of technologies becomes crucial.

Key Advances in Process Technologies

In the semiconductor industry, cost concerns and technology go hand in hand There are a handful of process technologies used to make chips today; wafer-processing steps monopolize the devices’ overall cost. At the wafer level, processes currently used include lithography, ion implantation, diffusion and oxidation, deposition, etching, cleaning, planarization, and metrology.

Chip manufacturers begin the wafer process by purchasing the silicon wafers is sizes of 100,125,150, and 200 millimeters. Pizza-size wafers (300 mm, or 12 inches) are expected to enter production after 1998 Development of 400-mm (16- inch) wafers may also be under way, to a small extend.

Lithography drives this market: It is the imaging technique that precisely patters as each circuit element, and it also requires the fab's most expensive toolset. In this process, optical wafer steppers use precision optics to focus a light wavelength of 365 nanometers, (soon to be 248 and ever sally to be 193 nanometers) onto the wafer, which is coated with a light-sensitive film, photoresist. The development of shorter wavelengths is heightening demands on manufacturers of steppers, quartz, and other materials. Either etching or ion implantation comes next. Selective etching of the exposed films creates the etching that will later be filled with metal. Ion implantation, a completely different process, lets engineers precisely modify the chips electrical characteristics by accelerating charged atoms (ions) in an electrical field into the silicon surface

Diffusion and oxidation take place in 12-foot vertical tube reactors holding hundreds of wafers. Technology is demanding a shift to fast-ramp furnaces but the current method has essentially been mastered and is effective.

Deposition on films also takes place in reactors but with one wafer at a time, a difference that bows down the fab process significantly. Without our enormous advances in computer technology and software, the fab would be a logistics nightmare; ironically, it depends on the very technology it enables.

Etching reactors are also single-wafer systems, selectively removing films of aluminum, tungsten, silicon, polysilicon, silicon dioxide, and photoresist, as well as a myriad of residues.

Cleaning occurs hundreds of times per wafer; astoundingly, a typical fab uses an estimated 50 acre-feet of water daily, or an area the size of 15 football fields with a depth of 1 foot. This issue is usually a logistics challenge, and it can be an economic hardship in countries without access to cheap water. This process also uses enormous amounts of electricity.

Manufacturers can accomplish planarization (the production of flat films) using a wet chemical and a mechanical polishing tool modified from prime silicon polishers. This method is only now nearing widespread acceptance in the semiconductor industry, because of issues of film uniformity, equipment reliability, and competing technologies.

Finally, there is metrology. Simply put: If you can't measure a 0.1-micron line, you don't know whether you have a 0.1-micron line. Metrology checkpoints in the fab line go a long way toward ensuring precision. But with these tools' costs rivaling those of the wafer steppers, you might prefer a smart system to a technician peering into a fancy microscope.

Future Display Technology

Breakthroughs in plasma, CRTs, and LCDs will widen and brighten our views

From the day that the first IBM PC arrived, we have peered at our data on a vacuum-tube screen. While we readily assume that our futures will be filled with inexpensive wall-size flat displays in our offices and homes, we re still a long way from affordable access to that kind of technology.

But if the road from here to there is long, it already is defined clearly in the technologies we'll be relying on for displays in the next decade and beyond. Thanks to the success of portable computers, flat-panel display technology has advanced by leaps and bounds. Not to be left behind, the familiar vacuum-tube display is changing with the times. There are also exciting and exotic-technologies beginning to emerge from laboratories around the world. It is still hard to know which technologies will be winners in the end, but you certainly can count on the future being lighter, brighter, thinner, and more affordable.

CRT: Still a long Shelf Life

The familiar CRT, or cathode ray tube, has been around in one form or another for nearly 100 years. In a CRT, a stream of electrons is beamed from one end of a vacuum tube to the other, where a layer of chemical phosphors glows with different colors in response to the electrons. The standard desktop monitor and the home television share the same fundamental design principles, though they are implemented quite differently.

Home television designs favor image brightness and compact size, while computer screens need to be engineered for higher resolution and sharp images. It is difficult to make the image on a monitor as bright as television, because the extra power required to drive the electron beam harder causes the shadow mask—a perforated metal mask that defines the pixels we see on-screen—to heat and deform, which hurts resolution and image quality. There have been many changes in recent years that improved CRT monitor quality. New materials such as invar for shadow masks have more thermal stability to resist the effects of electron beam heat. Screen technologies such as aperture grilles, black matrix masks, and Toshiba's Microfilter increase contrast and color purity, and advances in antiglare coatings have improved image quality. NEC's new CromaClear slot mask also has made CRT images noticeably sharper and brighter.

We have not yet seen everything under the CRT sun, however. The FCC finally has approved a plan that will let implementation of HDTV proceed. This could create a convergence between the television and data monitor markets, as HDTV specifications call for resolutions of up to 1,920 by 1,080 pixels, which is more than adequate for desktop data displays. Not only does this work well with digitized video (especially DVD multimedia), computer users also may appreciate the wider workspace offered by a 16:9

ratio screen (compared with the now-standard 4:3 proportion). As a result, desktop monitors may enjoy economies of scale in the consumer television market also embraces HDTV and both types of designs can use the same tubes. Is the interim, some makers are testing the waters with wide-aspect radio displays.

LCD: The Next Desktop Standard?

LCDs have significant advantages over CRTs for the portable market. They are lightweight and thin, and their power consumption is low enough that they can be run from batteries. At they move to the desktop, however, only the thin attribute provides a compelling advantage. Notebook users will pay a premium for portability and put up with a small display, but desktop users are loath to pay more for less than they can get with a CRT.

A number of important changes have occurred in the LCD market that may after this situation. First and foremost, LCD manufacturers have found ways to increase the yields of production lines, helping o drive down display costs. According to some sources, the yield on 10.4-inch active-matrix LCD panels is still as low as 60 to 70 percent, and production improvements make it possible for yields of 80 to 85 percent to be achievable.

Another change to note is that LCD production lines have been designed to produce larger and larger sheets of glass, making it possible to make more panels at a time, or fewer larger panels. We now have seen the first 20-inch production units. There may be no limit to the size of LCDs. Sharp has demonstrated a 40-inch- diagonal active-matrix screen with a resolution of 800 by 600 pixels.

New films have been designed to concentrate the light behind an LCD and diffuse it as it leaves the display. A number of different approaches have been taken to increase viewing angles, including the use of thinner LCD layers, high-tech optical films, and horizontal switching, in which the LCD cells are arranged sideways in the panel.

The biggest problem with LCDs remains cost. An LCD for a desktop system still costs four to eight times as much as an equivalent monitor based on CRT technology. The problem gets worse as the screen size increases, because production yields drop as the size of the panel and number of pixels increase. It is possible that the prices will drop enough in the near future.

Plasma: a Personal Theater

For really large flat-panel displays, a different technology has come to the fore. Plasma panels have been around nearly as long as the PC. The earliest were monochrome, with a rusty-red color to the pixels. They were used in transportable computers and as large, high-resolution displays for engineering workstations. Only in recent years were phosphors developed for full-color displays, along with new fabrication techniques required to accommodate the red, green, and blue phosphors.

A pixel in a plasma display works much like a familiar fluorescent light: Electrically charged gas emits ultraviolet light, which then strikes and excites phosphors emitting visible light. In some designs, the phosphors are at the front surface of the cell, while others have the phosphors at the backhand the front surface is transparent.

Here again, price is a limiting factor for the near term: Pixelink's 42 -inch plasma display employs a Fujitsu panel and costs about $15,000. Over time, the phosphors degrade and the screen will lose brightness. Current panels are rated for 10,000 hours of use (or five years of 40—hour work weeks), which translates into more than $1 per hour.

There are all sorts of other technologies just reaching the market, and depending on how development progresses, any one of them could become a major factor in the next generation of desktop displays. For example, a number of companies have created micropanel displays. Instead of using glass or plastic as a substrate, these designs create a display device right on a semiconductor wafer employing more or less standard fabrication processes that currently are used for memory chips and other computer components. Many of these designs use liquid crystal technology, but some are based on more exotic approaches such as ferro-electric liquid crystals or defraction technology. Texas Instruments has also created its Digital Light Processing technology, which uses microscopic mirrors on a chip to deflect light. These micropanel designs have been used for head-mounted displays and image, projectors, and they could also be utilized as the basis for small desktop rear-projection displays to replace CRTs. At least one company-Fujitsu -has discussed plans to create such a device before the end of 1996 targeted to be about 5 inches deep and the sell for about 1.5 to 2 times the price of are equivalent-size CRT monitor.

Abbreviations

CCD	charge-coupled devices - прилад з зарядовим зв'язком
CISC	complete-instruction-set computing повний набір команд (архітектура процесора)
CMOS	complementary metal-oxide semiconductor structure комплементарний метало-оксидний напівпровідник
CRT	cathode ray tube - електронно-променева трубка
DVD	digital video disc - цифровий відео диск
EPROM	erasable-programmable read only memories - постійний запам'ятовуючий пристрій, що програмується та стирається
FCC	Federal Communication Commission Федеральна комісія зв'язку США
HDTV	High Definition Television -телебачення з високою чіткістю
IC	integrated circuit - інтегральна схема
IIL	integrated injection logic - інтегральні інжекційні логічні схеми
IT	Information Technology - інформаційні технології
LSI	large-scale integrated circuit - інтегральна схема з великою ступінню інтеграції
LCD	Liquid Crystal Display рідкокристаличний індикатор (екран)
MOS	metal-oxide semiconductor - структура метал-оксид-напівпровідник (МОН структура)
MOSFET	metal-oxide-semiconductor field-effect transistor - МОН транзистор
NEC	компанія (США), яка виробляє процесори
PC	personal computer - персональний комп'ютер
PET	positron emission tomography - позитронна емісійна томографія
PMOS	p-channel metal-oxide-semiconductor structure - p- канальний МОН - прилад
RAM	random-access memory - ЗП з довільною вибіркою
RC	remote control - дистанційне управління
ROM	read-only memory - постійна пам’ять

RISC	reduced instruction set computer тип архітектури мікропроцесора зі скороченим набором команд
SSI	small-scale integrated circuit - інтегральна схема з малою ступінню інтеграції
TTL	transistor-transistor logic - транзисторно - транзисторні логічні схеми
VLSI	veiy-large-scale integration - інтеграція надвисокого рівня
VHSIC	very high speed integrated circuits - інтегральна схема з надвисокою швидкістю дії
WSI	wafer-scale integration - інтеграція у масштабі цілої пластини.

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