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ЭЛЕКТРОНИКА И НАНОЭЛЕКТРОНИКА

Методические указания к практическим занятиям для студентов бакалавриата направления 11.03.04

ELECTRONICS AND NANOELECTRONICS

САНКТ-ПЕТЕРБУРГ
2022

УДК 621.38

ИНОСТРАННЫЙ ЯЗЫК. Английский язык. Электроника и наноэлектроника. Методические указания к практическим занятиям./ Санкт-Петербургский горный университет. Сост.: *Е.А. Варлакова, Н.В. Корниенко*. СПб, 2022. 42с.

Методические указания предназначены для студентов бакалавриата направления 11.03.04 «Электроника и наноэлектроника (Промышленная электроника)» и согласованы с программой по иностранному языку для студентов неязыковых вузов.

Предлагаемый материал направлен на совершенствование навыков чтения, понимания и перевода технических текстов, построения высказываний на основе полученной информации, а также на развитие навыков самостоятельной работы с аутентичным материалом в рамках профессиональной направленности. В методические указания включены оригинальные тексты, сопровождающиеся комплексом упражнений с целью овладения иноязычной профессиональной компетенцией.

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ПРЕДИСЛОВИЕ

Данные методические указания предназначены для проведения практических занятий по английскому языку со студентами бакалавриата направления 11.03.04 «Электроника и наноэлектроника (Промышленная электроника)». Методические указания составлены в соответствии с учебной программой по дисциплине «Иностранный язык» для формирования иноязычной профессиональной компетенции будущих специалистов.

Целью данных методических указаний является формирование у студентов-бакалавров навыков и умений, развивающих способность и готовность к речевой коммуникации в рамках письменного и устного иноязычного общения, а также получению практических навыков работы с оригинальными текстами общенаучного и специализированного характера (перевод, реферирование).

Тематика оригинальных текстов включает основные аспекты, а также наиболее употребительные термины и выражения на английском языке в области промышленной электроники, нанотехнологий и их применением.

Методические указания состоят из четырех разделов: наночастицы и наноматериалы, применение наноматериалов, риски, связанные с нанотехнологиями, профессиональные перспективы специалиста в области нанотехнологий. Каждый раздел включает в себя оригинальный текст профессиональной направленности и специально разработанные лексико-грамматические упражнения, направленные на активизацию когнитивной деятельности обучающихся, освоение нового лексико-грамматического материала, и способствуют развитию коммуникативных навыков в сфере профессионального общения на английском языке.

UNIT 1 NANOPARTICLES AND NANOMATERIALS

Text 1

Task 1. Discuss in groups Can you think of fields where size or weight of materials or products is important?

Task 2. Before reading the text can you decode the following abbreviations: MEMs, ICT, DNA, IC, FET.

Task 3. Translate the words into Russian and check their pronunciation: *density, circuit, fullerene, artificially, property, semiconductor, to manufacture, relevance, dimension.*

Task 4. Read and translate the following text.

Nanoelectronics is the field of computation and control in the nanometer scale regime (below one thousandth the diameter of a human hair) using the electronic properties of materials. Useful logical computation or storage of information may be achieved by a number of different concepts and devices. Logical circuits may be used for computation, communication, control systems, or storage of information. The major nanoelectronic devices, fabrication techniques, and architectures include silicon transistors, single electron transistors, resonant tunneling diodes, magnetic spin devices, and molecular devices.

The term 'nano' is used in science as a prefix meaning one billionth (using billion in its American sense of a one followed by nine zeros). A 'nanometer' therefore means one billionth of a meter and it is exceedingly small – about 10 atoms across. Nanotechnology refers to technologies that are working at the nanometer level and, as such, encompasses both a) techniques used to manufacture products with nano-scale characteristics and b) nanomaterials manufactured by whatever means. Both aspects have relevance in the field of modern electronics. Nanoparticles can theoretically be produced artificially from nearly any chemical. Such engineered nanomaterials are commonly defined as materials designed and produced to have structural features with at least one dimension of 100 nanometers of less. Presently, most nanoparticles that are in use have been made from transition metals, silicon, carbon

(carbon nanotubes, fullerenes) and metal oxides (zinc oxide and titanium dioxide). In some cases, engineered nanoparticles exist as nanocrystals composed of a number of compounds such as silicon and metals (as is the case for quantum dots). In electronics, the present method used in the manufacturing of electronic devices is called "top down" (i.e. manufacturing nanoscale components and materials from larger starting materials) though scientists are now also developing a new approach based on self-assembly of atoms and molecules, the so-called "bottom up" approach. Top down nanotechnology has enabled the production of progressively smaller structures to be made using lithography and related techniques for the construction of electronic components and micro-electro-mechanical systems (MEMs). Top down nanotechnology has, for example, led to the hugely successful semiconductor- and information- and communications-technology- (ICT-) industries, as well as the manufacture of tiny micromechanical machines for sensing and actuation (MEMs). Bottom-up technology is a promising alternative to top down, one which enables building of nanodevices and/or nanomachines starting from molecular building blocks instead of lithographically carving bigger pieces of matter into smaller and smaller pieces. The self-assembling properties of biological systems, such as DNA molecules, may be used to control the organisation of nanoparticles such as carbon nanotubes. This may lead to the ability to 'grow' parts of an integrated circuit, rather than relying on top down techniques.

Nanotechnology in Electronics Manufacture. Traditional electronic circuits are built by etching individual components into silicon wafers. Commercialisation of integrated circuits (IC) and the creation of the microelectronics industry began in 1965 using silicon processing technology. Over time, there has been ever-increasing progress in the technology being used and, in parallel, a progressive reduction in size of circuits. Such rapid technological progress was first predicted in 1965 by Gordon Moore in the now famous 'Moore's Law', which stated that integrated circuit density and performance would double every 18 months. This has broadly held true, the improvements being brought about by reduced transistor dimensions, increased transistor counts and increased operating frequencies. Circuits have reduced in size over the years to such an extent that current generations of chips may carry circuits only 65 nm wide and more than a million transistors on a single piece of silicon a few millimetres across. The field effect transistor (FET) was first scaled below 100 nm in the year 2000, inaugurating the era of silicon nanoelectronics. The term ‘nanoelectronics’ (circuit dimension less than 100 nm) can therefore now be used instead of ‘microelectronics’. Presently 65nm and 90nm process technology is being used to manufacture chips. For example, Intel company is now producing more than half of its mobile, desktop and server microprocessors using 65 nm process technology.

From “Nanotechnologies and nanomaterials in electrical and electronic goods”

Task 5. Answer the questions:

1. What does nanoelectronics focus on?
2. What are major nanoelectronic devices?
3. What are nanoparticles made from?
4. What is “top down” and “bottom up” nanotechnology?
5. What caused a rapid technological progress?

Text 2

Task 1. Group discussion. Can you think of other situations where scientists had to make assumptions because they couldn't see what they were studying?

Task 2. Match the words from column A to their synonyms from column B. Translate them.

A	B
strengthening	harmful
enormous	reinforcing
adverse	flammable
performance	sustainability
combustible	efficiency
steadiness	vast

Task 2. Read and translate the following text. Choose the most appropriate title to A-I paragraphs.

1) Nanoparticle-based technologies; 2) Food packaging; 3) Light control; 4) Properties of nanoparticles; 5) Batteries and supercapacitors; 6) Nanoceramics; 7) Polymers; 8) Flame retardants; 9) Nanoparticle applications in materials

A. Nanoparticles can be classified into any of various types, according to their size, shape, and material properties. Some classifications distinguish between organic and inorganic nanoparticles; the first group includes dendrimers, liposomes, and polymeric nanoparticles, while the latter includes fullerenes, quantum dots, and gold nanoparticles. Other classifications divide nanoparticles according to whether they are carbon-based, ceramic, semiconducting, or polymeric. In addition, nanoparticles can be classified as hard (e.g., titania [titanium dioxide], silica [silica dioxide] particles, and fullerenes) or as soft (e.g., liposomes, vesicles, and nanodroplets). The way in which nanoparticles <u>are classified</u> typically depends on their application, such as in diagnosis or therapy versus basic research, or may be related to the way in which they <u>were produced</u>.

There are three major physical properties of nanoparticles, and all are interrelated: (1) they are highly mobile in the free state (e.g., in the absence of some other additional influence, a 10-nm-diameter nanosphere of silica has a sedimentation rate under gravity of 0.01 mm/day in water); (2) they have enormous specific surface areas (e.g., a standard teaspoon, or about 6 ml, of 10-nm-diameter silica nanospheres has more surface area than a dozen doubles-sized tennis courts; 20 percent of all the atoms in each nanosphere <u>will be located</u> at the surface); and (3) they may exhibit what are known as quantum effects. Thus, nanoparticles have a vast range of compositions, depending on the use or the product.

B. In general, nanoparticle-based technologies centre on opportunities for improving the efficiency, sustainability, and speed of already-existing processes. That is possible because, relative to the materials used traditionally for industrial processes (e.g., industrial catalysis), nanoparticle-based technologies use less material, a large proportion of which is already in a more “reactive” state. Other opportunities for nanoparticle-based technologies include the use of nanoscale zero-valent iron (NZVI) particles as a field-deployable means of remediating organochlorine compounds, such as polychlorinated biphenyls (PCBs), in the environment. NZVI particles are able to permeate into rock layers in the ground and thus can neutralize the reactivity of organochlorines in deep aquifers. Other applications of nanoparticles are those that stem from manipulating or arranging matter at the nanoscale to provide better coatings, composites, or additives and those that exploit the particles' quantum effects (e.g., quantum dots for imaging, nanowires for molecular electronics, and technologies for spintronics and molecular magnets).

C. Many properties unique to nanoparticles are related specifically to the particles' size. It is therefore natural that efforts have been made to capture some of those properties by incorporating nanoparticles into composite materials. An example of how the unique properties of nanoparticles have been put to use in a nanocomposite material is the modern rubber tire, which typically is a composite of a rubber (an elastomer) and an inorganic filler (a reinforcing particle), such as carbon black or silica nanoparticles. For most nanocomposite materials, the process of incorporating nanoparticles is not straightforward. Nanoparticles are notoriously prone to agglomeration, resulting in the formation of large clumps that are difficult to redisperse. In addition, nanoparticles do not always retain their unique size-related properties when they are incorporated into a composite material. Despite the difficulties with manufacture, the use of nanomaterials grew markedly in the early 21st century, with especially rapid growth in the use of nanocomposites. Nanocomposites were employed in the development and design of new materials, serving, for example, as the building blocks for new dielectric (insulating) and magnetic materials. The following sections describe some of the many applications of nanoparticles and nanocomposites in materials.

D. Similar to the way in which carbon and silica nanoparticles have been used as fillers in rubber to improve the mechanical properties of tires, such particles and others, including nanoclays, have been incorporated into polymers to improve their strength and impact resistance. In the early 21st century, increasing use of non-petroleum-based polymers that were derived from natural sources drove the development of "all-natural" nanocomposite polymers. Such materials incorporate a biopolymer derived from an alginate (a carbohydrate found in the cell wall of brown algae), cellulose, or starch; the biopolymer is used in conjunction with a natural nanoclay or a filler derived from the shells of crustaceans. The materials are biodegradable and do not leave behind potentially harmful or nonnatural residues.

E. Nanoparticles have been increasingly incorporated into food packaging to control the ambient atmosphere around food, keeping it fresh and safe from microbial contamination. Such composites use nanoflakes of clays and claylike particles, which slow down the ingress of moisture and reduce gas transport across the packaging film. It is also possible to incorporate nanoparticles with apparent antimicrobial effects (e.g., nanocopper or nanosilver) into such packaging. Nanoparticles that exhibit antimicrobial activity had also been incorporated into paints and coatings, making those products particularly useful for surfaces in hospitals and other medical facilities and in areas of food preparation.

F. Nanoparticles were explored for their potential to replace additives based on flammable organic halogens and phosphorus in plastics and textiles. Studies had suggested that, in the event of a serious fire, products with nanoclays and hydroxide nanoparticles were associated with fewer emissions of harmful fumes than products containing certain other types of additives.

G. The ability to engineer nanocomposite materials to have very high internal surface areas for storing electrical charge in the form of small ions or electrons has made them especially valuable for use in batteries and supercapacitors. Indeed, nanocomposite materials have been synthesized for various applications involving electrodes. Composite materials based on carbon nanotubes and layered-type materials, such as graphene, were also researched extensively, making their first appearances in commercial devices in the early 2000s.

H. A long-term objective in materials science had been to transform ceramics that are brittle and prone to cracking into tougher, more resilient materials. By the early 21st century, researchers had achieved that goal by incorporating an effective blend of nanoparticles into ceramics materials. Other new ceramics materials that were under development included all-ceramic or polymer-ceramic blends, which combined the unique functional (e.g., electrical, magnetic, or mechanical) properties of a nanocomposite material with the properties of ceramics materials.

I. In the 1990s the development of blue light-emitting diodes (LEDs), which had the potential to produce white light at significantly reduced costs, inspired a revolution in lighting. Blue LEDs brought about a need for composite materials that could be used to coat the diodes to convert blue light into other wavelengths (such as red, yellow, or green) in order to achieve white light. One way of obtaining the desired light is by leveraging the size or quantum effect of small semiconducting particles. The application of such particles facilitated the development of nanocomposite polymers for greenhouse enclosures; the polymers optimize plant growth by effectively converting wavelengths of full-spectrum sunlight into the red and blue wavelengths used in photosynthesis. Light conversion in the above cases is achieved with submicron particles of inorganic phosphor materials incorporated into the polymer.

From https://www.britannica.com/science/nanoparticle

Task 3. Translate the following words and expressions from Russian into English: *свойства материала, фундаментальные исследования, скорость оседания, восстановление хлорорганических соединений, резиновая шина, сопротивление удару, наностекло, медицинские учреждения, выбросы, суперконденсаторы, ограждения теплицы, соединение с природной наноглиной.*

Task 4. A) Look at the underlined Passive constructions in the text and explain their grammar usage. Revise the rule.
B) Now open the brackets and put the verbs into the Passive Voice.
1. This laboratory (use) only on special occasions.
2. He (take) to the hospital today and (operate) tomorrow morning.
3. Thousands of new devices (produce) every year.
4. These nanoparticles can't (incorporate) into such coating.
5. We realized that all our copies (sell) a week before.
6. This issue (discuss) many times since our last meeting.
7. This experiment (carry out) by our best scientists.
8. More nanomaterials are going (invent) in future.

Text 3
Nanomaterials in Electronics

Task 1. Match the words and phrases with their Russian equivalents. Find them in the text below:

1. to investigate	a. потреблять
2. to possess	b. защита экрана
3. insoluble	c. свето-излучающий
4. seamlessly	d. кремниевая подложка
5. welding	e. исследовать
6. shielding	f. бесчисленный
7. silicon wafer	g. нерастворимый
8. countless	h. сварка
9. light emitting	i. обладать
10. to consume	j. бесшовно

Task 2. Skim Part 1 and answer the following questions:

1. What are the most common nanomaterials?
2. What is Nantero famous for?
3. What is commercial future of nanomaterials?

Task 3. Read and translate the text.

Part 1

Carbon Nanotubes and Fullerenes. Fullerenes are a family of substances made of carbon in the form of a hollow sphere, ellipsoid or tube. Tubular fullerenes, generally called carbon nanotubes, are considered as possibly the most famous objects in nanotechnology and possess extraordinary properties arising from their nanoscopic dimensions. They were discovered in 1991 in the insoluble material of arc-burned graphite rods. Carbon nanotubes are molecules which are composed only of carbon atoms and are markedly different from bulk graphite. They can be viewed as a graphene sheet rolled into a cylinder and seamlessly welded together. Carbon nanotubes exist in either of two forms, single-wall carbon nanotubes and multi-wall carbon nanotubes. Single-wall nanotubes consist of a single graphene layer while multi-wall nanotubes consist of multiple concentric layers. In addition to the synthetic production of carbon nanotubes for research and commercial purposes, it has recently been discovered that multi-wall carbon nanotubes can be found in particulate matter collected from propane or natural gas kitchen stoves. Multi-wall carbon nanotubes can be also found in particulate matter collected in outdoor air, with one possible source being car exhaust fumes. Carbon nanotubes can be either 'metallic' or semi-conducting depending on the actual way in which the carbon atoms are assembled in the tube. The metallic forms possess electrical conductivities 1000 times greater than copper and are now being mixed with polymers to make conducting composite materials for applications such as electromagnetic shielding in mobile phones and static electricity reduction in cars. Their use has been demonstrated in supercapacitors for energy storage, field emission devices for flat panel displays and nanometer-sized transistors.

Quantum Dots. Quantum dots are semiconductor nanocrystals (2-100 nm) which have unique optical and electrical properties. In structure, quantum dots consist of a metalloid crystalline core and a 'cap' or 'shell' that shields the core. Quantum dot cores can be formed from a variety of metal conductors such as semiconductors, noble metals and magnetic transition metals. The shells are also formed of a variety of materials. Therefore, not all quantum dots are alike and they cannot be considered to be a uniform group of substances. With regard to the cores of quantum dots, group III-V series quantum dots are composed of mixtures of compounds such as indium phosphate (InP), indium arsenate (InAs), gallium arsenate (GaAs) and gallium nitride (GaN). Group II-IV series of quantum dots are composed of mixtures of compounds such as zinc sulfide (ZnS), zinc-selenium (Zn-Se), cadmium-selenium (CdSe) and cadmium-tellurium cores (CdTe).

Use of Nanomaterials in Chips. The company Nantero Inc. announced in November 2006 that it had developed the technology to produce semiconductors using carbon nanotubes on silicon wafers and has been issued patents on the process. Nantero is developing a high density nonvolatile random access memory chip called NRAM (Nanotube-based/Non-volatile random access memory) chip. Carbon nanotubes are used as active memory elements and integrated with traditional semiconductor technology. In other words, according to the manufacturers, NRAM is a universal memory chip suitable for countless existing and new applications in the field of electronics. IBM has developed carbon nanotube transistors. They have been working towards the development of chips using nanotubes. In 2006 they announced that they had succeeded in building a complete electronic integrated circuit around a single carbon nanotube molecule. The circuit was built using standard semiconductor processes and was described as “a critical step toward the integration of the technology with existing chip-making techniques”. Intel is currently looking for the possible replacement of copper wires inside semiconductors using carbon nanotubes. The use of quantum dots in flash memory applications is also under investigation.

Use of Nanomaterials in Displays. In some cases, the use of nanomaterials for lighting technologies is being investigated. For instance, nanocrystals of cadmium selenide (CdSe) have been developed to be used in LED or OLED lighting devices. The company Norel has advertised itself as the first company to use nanostructured fullerenes in its OLED. Quantum dots have been investigated as building blocks for tuneable optical devices such as light emitting devices and lasers. Zinc oxide (ZnO) nanoparticles are under investigation for various optoelectronic devices, and galium nitride (GaN) likewise for LEDs. For example, the use of ZnO nanowires in LEDs may ultimately enable the development of large area lighting on flexible substrates. In June 2006 the successful development of the world’s first quantum dot display was announced. The display features a layer of quantum dot material sandwiched between two semiconductor regions. The display has the potential to deliver which is called a ‘super visual experience’, of an apparently higher quality than liquid crystal displays, by producing brighter, richer and more accurate colours while consuming less power. The company says that the quantum dot displays are more reliable and simple to manufacture than new display technologies based on organic light-emitting devices (OLEDs). The display industry is expected to use nanomaterials commercially in the nearest future. For example, carbon nanotubes are expected to be commercialised in the near term for backlights and field emission displays, along with polymer and transmission films that also use nanomaterials. According to the manufacturers, the technology can be used to produce large, flat panel displays with superior quality and longer lifetimes at significantly lower costs than current displays.

Task 4. Read Part 2 and insert the missing words from the box into the gaps.

Alloys	to boost	conducted	significantly	
additive	improvements	launched	anticipated	accelerated

Part 2

Use of Nanomaterials in Lasers. Research is being conducted on making laser devices from arrays of semiconductor nano-dots and nanowires. If successful, this technology is expected to bring about miniaturisation and power efficiency (1)……… compared to other laser devices. The company Fujitsu, in combination with the University of Tokyo, has developed and commercialised a quantum dot laser. The company say that quantum dot lasers are (2)………. superior to conventional semiconductor lasers and it is anticipated that they will become a core technology to realize high-performance light sources for optical telecommunication.

Use of Nanomaterials in Batteries. The properties of carbon nanotubes make them potentially useful as an anode material or as an (3)……… in lithium-ion (Li-ion) battery systems. In 2005, one article noted that the anode of Li-ion batteries is primarily made from various carbonaceous materials but that carbon nanotubes promise (4)……… this rate of growth, either by themselves or when incorporated into appropriate composite material. In 2005, Toshiba (5)……… a rechargeable Li-ion battery which used 'nano-particles', although it is not clear whether carbon nanotubes or another nano-material is used. Altair Nanotechnologies Inc. developed a nano-titanate material which it uses commercially in Li-ion batteries. Other nanomaterials under investigation for use in Li-ion batteries are nanoparticles of vanadium, manganese and cobalt compounds.

Use of Nanomaterials in Fuel Cells and Photovoltaic Cells. According to an article in Carbon Nanotubes Monthly, the use of nanotubes in fuel cells and photovoltaic cells is expected to hit the market within a decade. With regard to fuel cells, the structure of carbon nanotubes shows some promise for hydrogen storage. It is (6)……… that carbon nanotube technology will contribute to the development of fuel cells, as a catalyst support, and also as a main component of bipolar systems. Motorola is one company involved in research into fuel cells using carbon nanotubes. Sony has been developing fuel cell technology using fullerenes. Other nanomaterials under investigation for use in fuel cells are nanoparticles of platinum and platinium (7)………. Recent research on quantum dots suggested that they may also be used in fuel cells in the future. In the case of photovoltaics, there is interest from the solar cell industry in using carbon nanotubes, due to their excellent conductive properties. The licensed technology utilizes a nanoscaleengineered structure to absorb and collect solar energy. The technology, which is still in the research stage, involves design centred on a 'nanocomposite' material, which may use carbon or metal 'nanorods'.

Use of Nanomaterials in Lead-free solder. The phenomenon of melting point depression of nano-scale metal particles has been studied since the 1960s. Presently, research is being (8)……… with the application of nanotechnology to suppress lead-free solder reflow temperature. The company Motorola is leading a low temperature lead-free nano-solder initiative for the International Electronic Manufacturing Initiative (iNEMI). In another iNEMI initiative, Motorola are also looking at mechanically adhesive nano-hooks which could allow for solder-free assembly. iNEMI note that "this research project is designed to identify and demonstrate electronic assembly using only mechanical means. For example, research activity into dry adhesives has recently (9)……… with the newfound understanding of the mechanisms behind the strong adhesive force generated by the gecko.

From "Nanotechnologies and nanomaterials in electrical and electronic goods"

Task 5. Use the Internet and prepare a report why nanotechnology has the potential to cause extreme change in our society that can lead to a variety of consequences.

UNIT 2 APPLICATION OF NANOMATERIALS

Task 1. Say these words correctly. Use the proper word stress: *capabilities, oxide, consumption, developing, to generate, to manufacture, tighter, higher, to achieve, dimensions, semiconductor, to be applied, access, lattice, to occur, a lightweight, magnetoresistive, nanoemmissive.*

Text 1
Applications under Development

Task 2. Read the text and translate phrases in bold:

Nanoelectronics holds some answers for how we might increase the capabilities of electronics devices while we reduce their weight and power consumption. For example, improving display screens on electronics devices involves reducing power consumption while decreasing the weight and thickness of the screens. Nowadays, researchers are developing a type of memory chip with a projected density of one terabyte of memory per square inch or greater. Dealing with reducing the size of transistors used in integrated circuits, one researcher believes it may be possible to "put the power of all of today's present computers in the palm of your hand".

Mainly researchers are looking into the following nanoelectronics projects:

· Researchers at NIST have demonstrated an LED build with **zinc oxide nanostructures called fins** which generates much higher light output than existing designs of similar size. The researchers also found that raising the current caused the structure to generate laser light.

· Researchers at the Royal Melbourne Institute of Technology have demonstrated **atomically-thin indium-tin oxide sheets** that may make touchscreens that are cost less to manufacture and well as being flexible and consumes less power.

· Cadmium selenide nanocrystals deposited on plastic sheets have been shown to form **flexible electronic circuits**. Researchers are aiming for a combination of flexibility, a simple fabrication process and low power requirements.

· Integrating **silicon nanophotonics** components into CMOS integrated circuits. This optical technique is intended to provide higher speed data transmission between integrated circuits than is possible with electrical signals.

· Researchers at UC Berkeley have demonstrated a low power method to use **nanomagnets as switches**, like transistors, in electrical circuits. Their method might lead to electrical circuits with much lower power consumption than transistor based circuits.

· Researchers at Caltech have demonstrated a **laser that uses a nanopatterned silicon surface** that helps produce the light with much tighter frequency control than previously achieved. This may allow much higher data rates for information transmission over fiber optics.

· Building **transistors from carbon nanotubes** to enable minimum transistor dimensions of a few nanometers and developing techniques to manufacture **integrated circuits built with nanotube transistors**.

· Using electrodes made from **nanowires that would enable flat panel displays to be flexible** as well as thinner than current flat panel displays.

· Using **semiconductor nanowires** to build transistors and integrated circuits.

· Transistors built in **single atom thick graphene film** to enable very high speed transistors.

· Researchers have developed an interesting method of **forming PN junctions, a key component of transistors, in graphene**. They patterned the p and n regions in the substrate. When the graphene film was applied to the substrate electrons were either added or taken from the graphene, depending upon the doping of the substrate. The researchers believe that this method reduces the disruption of the graphene lattice that can occur with other methods.

· Using carbon nanotubes to direct electrons to illuminate pixels, resulting in a lightweight, millimeter thick **"nanoemmissive" display panel**.

· Using nanosized magnetic rings to make **Magnetoresistive Random Access Memory (MRAM)**.

· Researchers have developed lower power, higher density method using nanoscale magnets called **magnetoelectric random access memor**y (MeRAM).

· Using **self-aligning nanostructures to manufacture nanoscale integrated circuits**.

· Using nanowires to build **transistors without p-n junctions**.

· Using buckyballs to build **dense, low power memory devices**.

· Using nanowires made of an alloy of iron and nickel to create dense memory devices. By applying a current magnetized sections along the length of the wire. As the magnetized sections move along the wire, the data is read by a stationary sensor. This method is called **race track memory.**

· Using **silver nanowires embedded in a polyme**r to make conductive layers that can flex, without damaging the conductor.

· IMEC and Nantero are developing a **memory chip that uses carbon nanotubes**. This memory is labeled NRAM for Nanotube-Based Nonvolatile Random Access Memory and is intended to be used in place of high density Flash memory chips.

· Researchers at Georgia Tech, the University of Tokyo and Microsoft Research have developed a method to print prototype circuit boards using standard inkjet printers. **Silver nanoparticle ink** was used to form the conductive lines needed in circuit boards.

From https://www.understandingnano.com/nanotechnology-electronics.html

Task 3. Give more than one synonym to the following verbs: *to increase, to improve, to involve, to reduce, to develop, to project, to integrate, to research, to believe, to generate, to demonstrate, to achieve, to enable, to occur.*

Task 4. Find additional information (who/ where/ results) about other investigations: *a) silver nanowires, b) nanoglue, c) integrated circuits using carbon nanotubes, d) NOMFET (Nanoparticle Organic Memory Field-Effect Transistor), e) molecular-sized transistors, f) magnetic quantum dots*. **You can choose any example from Text 1 and give extra information.**

Text 2
Applications of Nanowires and Nanofiber

Task 1. Discuss these questions with a partner.

1. Researchers of which countries are considered to be the most progressive?
2. Which innovative applications of nanowires and nanofiber have you heard about?

Task 2. Read the text to check your answers.

The properties of nanowires have caused researchers and companies to consider using this material in several fields. Researchers at University of Massachusetts Amherst have developed **protein nanowires** that produce electric current when exposed to water vapor in air. Researchers at MIT have developed a solar cell using **graphene coated with zinc oxide nanowires**. The researchers believe that this method will allow the production of low cost flexible solar cells at high enough efficiency to be competitive. Researchers at Nagoya University are developing a **nanowire based sensor** to detect indicators of bladder and prostate cancer in urine samples. Researchers at NTU Singapore are using manganese dioxide nanowires to develop **flexible capacitors**. The idea is to have the capacitors in fabric to provide energy storage for wearable electronics.

Researchers are using a method called Aerotaxy to grow **semiconducting nanowires on gold nanoparticles**. They plan to use self assembly techniques to align the nanowires on a substrate; forming a solar cell or other electrical devices. The gold nanoparticles replace the silicon substrate on which conventional semiconductor based solar cells are built. Researchers at the Nies Bohr Institute have determined that **sunlight can be concentrated in nanowires** due to a resonance effect. This effect can result in more efficient solar cells, allowing more of the energy from the sun to be converted to electricity. Using light absorbing **nanowires** embedded in a flexible polymer film is another method being developed to produce low cost flexible solar panels. Researchers at Lawrence Berkeley have demonstrated an **inexpensive process for making solar cells**. These solar cells are composed of cadmium sulfide nanowires coated with copper sulfide.

Researchers at Stanford University have grown **silicon nanowires** on a stainless steel substrate and demonstrated that batteries using these anodes could have up to 10 times the power density of conventional lithium ion batteries. Using silicon nanowires, instead of bulk silicon fixes a problem of the silicon cracking, that has been seen on electrodes using bulk silicon. The cracking is caused because the silicon swells it absorbs lithium ions while being recharged, and contracts as the battery is discharged and the lithium ions leave the silicon. However, the researchers found that while the silicon nanowires swell as lithium ions are absorbed during discharge of the battery and contract as the lithium ions leave during recharge of the battery the nanowires do not crack, unlike anodes that used bulk silicon.

Using silver chloride nanowires as a **photocatalysis to decompose organic molecules** in polluted water. Using an electrified filter composed of silver nanowires, carbon nanotubes and cotton to **kill bacteria in water**. Using electrodes made from **nanowires that would enable flat panel displays to be flexible** as well as thinner than current flat panel displays. Using nanowires made of an alloy of iron and nickel to create dense memory devices. By applying a current magnetized sections along the length of the wire. As the magnetized sections move along the wire, the data is read by a stationary sensor. This method is called **race track memory.** Using **silver nanowires embedded in a polyme**r to make conductive layers that can flex, without damaging the conductor.

Sensors using **zinc oxide nanowire detection elements** capable of detecting a range of chemical vapors. A nanofiber is a fiber with a diameter of 100 nanometers or less. The properties of nanofibers have caused researchers and companies to consider using this material in several fields. **Nanofiber mesh containing zeolites** have been shown to absorb toxins in the bloodstream. Researchers believe this nanofiber can be used in compact and inexpensive blood purification systems as an alternative to dialysis. Researchers are using nanofibers to make **sensors that change color** as they absorb chemical vapors. They plan to use these sensors to show when the absorbing material in a gas mask becomes saturated.

Researchers are using nanofibers to **capture individual cancer cells** circulating in the blood stream. They use nanofibers coated with antibodies that bind to cancer cells, trapping the cancer cell for analysis. Nanofibers can stimulate the production of cartilage in damaged joints. Three different approaches to the use of nanofibers to stimulate cartilage are being taken by researchers at **John Hopkins University**, at **Northwestern University** and at the **University of Pennsylvania**.

Researchers at MIT have used carbon nanofibers to make lithium ion battery electrodes that show **four times the storage capacity** of current lithium ion batteries. The next step beyond lithium-ion batteries may be lithium sulfur batteries (the cathode contains the sulfur), which have the capability of storing several times the energy of lithium-ion batteries. Researchers at Stanford University are using cathodes made up of **carbon nanofibers encapsulating the sulfur**. Researchers have developed **piezoelectric nanofibers** that are flexible enough to be woven into clothing. The fibers can turn normal motion into electricity to power your cell phone and other mobile electronic devices.

From https://www.understandingnano.com/nanotech-applications.html

Task 3 Match the words in bold from the article with their meanings:

1._____. are found in all cells and essential to the diet, they are basic components of cartilage, hair, skin, etc.;

2._____. a place or part where two things or parts are connected;

3._____. a device consisting of two or more conducting plates separated from one another by a dielectric nonconductor, used for storing an electric charge;

4._____ . free from impurities or pollution;

5._____. to fill up with maximum that it can absorb;

6._____ .to break up or separate into basic components or parts;

From Webster's Dictionary

Task 4. Look at the definitions in Task 3 and try to invent your own ones to the following terms: *to encapsulate, to vapor, coating, sensor, competitive, bloodstream, to absorb, substrate.*

Text 3
Computer Memory Improvements with Nanotechnology

Task 1. Translate the following words from English into Russian: *hard drive, failure, solid state memory, tablet, flash memory, intersection, to reduce, alloy, approach, triple-decker.*

Task 2. Complete the text using the verbs in brackets in the correct form.

Hard drives used as memory in computers consume more power and have more chance of failure than solid state memory that *(not have)* any moving parts.

For that reason, solid-state computer memory *(become)* popular on smaller computers, such as tablets. This solid-state computer memory *(take up)* less space, *(use)* less battery power, and is less likely to be damaged if the device is dropped. Nanotechnology *(use)* to improve the density of solid-state computer memory.

Solid-state drives store information on a type of transistor *(call)* flash. Currently, flash memory manufacturers use nanolithography techniques to build memory chips with minimum feature sizes as small as 20 nm.

Researchers *(demonstrate)* vertical flash transistors. The idea is that by making the transistors vertically memory cells could *(stack)* on top of each other, with the potential for increasing the memory density. Researchers suggest that the memory cell density could be 8 to 16 times higher than for planar transistors.

Hewett Packard *(develop)* a memory device that uses nanowires coated with titanium dioxide. One group of these nanowires is deposited parallel to another group. When a perpendicular nanowire is laid over a group of parallel wires, at each intersection a device called a memristor is formed.

A memristor can be used as a single-component memory cell in an integrated circuit. By reducing the diameter of the nanowires, researchers believe memristor memory chips can achieve higher memory density than flash memory chips. HP *(work)* with Hynix Semiconductor to develop memory components based upon memristors, called Resistive Random Access Memory (ReRAM)

Magnetic nanowires made of an alloy of iron and nickel are being used to create dense memory devices. Researchers at IBM have developed a method to magnetize sections of these nanowires. By applying a current they can move the magnetized sections along the length of the wire. As the magnetized sections move along the wire, the data *(read)* by a stationary sensor. This method is called race track memory because the data races by the stationary sensor. The plan is to grow hundreds of millions of U-shaped race track nanowires on a silicon substrate to create low-cost, high-density, and highly reliable memory chips.

Another method of using nanowires *(investigate)* at Rice University. Researchers at Rice *(find)* that they can use silicon dioxide nanowires to create memory devices. The nanowire is sandwiched between two electrodes. By applying a voltage, you change the resistance of the nanowire at that location. Each location where the nanowire *(sit)* between two electrodes becomes a memory cell.

The key to this approach is that researchers have found that they can repeatedly change the state of each memory cell between conductive and nonconductive without *(damage)* the material's characteristics. These researchers believe that they can achieve high memory densities by using nanowires with a diameter of about 5 nm and by stacking multiple layers of arrays of these nanowires like a triple-decker club sandwich.

An alternative method being developed to increase the density of memory devices *(be)* to store information on magnetic nanoparticles. Researchers at North Carolina State University are growing arrays of magnetic nanoparticles, called nanodots, which are about 6 nm in diameter. Each dot would contain information determined by whether or not they are magnetized. Using billions of these 6-nm diameter dots in a memory device could increase memory density.

From https://www.understandingnano.com/nanotechnology-computer-memory.html

Task. 3.Do the statements correspond to the content of the text?

1. Solid state computer memory has become popular on tablets.
2. Flash memory manufacturers use nanofiber techniques to build memory chips.

3. Making transistors vertically decreases the memory density.
4. By reducing the diameter of the nanowires, researchers believe flash memory chips can achieve higher memory density than memristor memory chips.
5. By applying a current the magnetized sections can move along the length of the wire.
6. Researchers can repeatedly change the state of each memory cell between conductive and nonconductive without damaging the material's characteristics.
7. Storing information on magnetic nanoparticles can reduce the density of memory devices.

Task 4. ► You are going to watch video "Nanotechnology: research examples and how to get into the field". Look at the gapped sentences below and try to predict what words can be there. Then watch the video and fill in the gaps with the detailed information: https://www.youtube.com/watch?v=uUDWK4MGcr0. Translate the sentences into Russian.

1. Professors and a graduate student of Illinois Uni recently ……… a nanowire memory cell which will be used for ……… computers.
2. A new type of nanosensor is being worked on that has the power ……… explosives which could ……… the need for sniffer dogs.
3. Electrical engineers ……… a sensor made out of carbon nanotubes that can ……… the tread of tires in real time which can tell drivers when the rubber is going too thin.
4. NASA ……… a rocket to test the ……… of composite nanotechnology. Their computer simulation showed that carbon nanotube ……… on the spacecraft could lead to a 30% ……… in mass.
5. In terms of solar energy nanotechnology is helping to improve materials………. And reduce the cost of ……… .

Task 5. Writing. Choose one application and write a brief report.

UNIT 3 RISKS FROM NANOTECHNOLOGY

Text 1
Toxicity of nanomaterials

Task 1. In pairs, find English equivalents for the following phrases in the text above: *непосредственные и существенные риски, сыпучие свойства материала, сложные химические вещества и соединения, оценка токсичности, воздействие от деятельности, вдыхание через нос, воспалительные реакции в легких, сердечно-сосудистые эффекты, приводить к смертности, костный мозг, селезенка и лимфатические узлы, выхлопные газы автомобиля.*

Task 2. Read and translate Part 1. Use a dictionary:

Part 1

Consideration of the possible health risks of nanotechnology falls into two categories, those where the structure itself is a free particle and those where the nanostructure is an integral feature of a larger object. In consideration of health risks, the latter case would not be considered to pose immediate risks to human health or the environment from the nanotechnology itself. For instance, in electronics, the use of nanotechnology to build smaller circuits down to the nanoscale, that is, using 65nm and 90nm process technology in the manufacture chips, may not be considered in itself to present substantial risks to the environment or human health, although there may be additional concerns arising from novel processes and/or process chemicals necessary to facilitate such nanoscale constructions.

Conversely however, the manufacture, use and disposal of materials comprising or containing free or bound nanoparticles, for the production of nanomaterials such as carbon nanotubes or nano-silver, does give rise directly to human health and environmental concerns. This is because nanoscale materials typically have markedly different properties (e.g. chemical, mechanical, electrical, magnetic, biological) to the original (chemically identical) material at larger scales. These properties may in turn lead to biological activity that differs from, and cannot be predicted from, the bulk properties of the constituent chemicals and compounds.

The assessment of the toxicity of nanomaterials ('nanotoxicology') and their environmental fate remains very much in its infancy, well behind the commercial development and ongoing use of such materials in applications (including hundreds of consumer products) which ultimately result in releases of free nanoparticles to the environment. Indeed, as Braydich-Stolle et al. noted, despite the wide application of nanomaterials, there is a serious lack of information concerning their impact on human health and the environment. Deliberately manufactured nano-materials are likely to enter the environment from manufacturing effluent or from spillage during shipping or handling. Within products such as electronics, the extent to which nano-materials may leak out or be worn off over the period of use is not known as no research has been done on this subject. It is possible that nano-materials may also reach the environment when they are disposed of, during recycling, disposal in landfills or by other methods. With regard to human exposure, occupational exposure during manufacturing process may arise from particles in nanomaterials becoming airborne and then being inhaled. Research into the potential occupational health risks associated with inhaling engineered nano-structured particles is only just beginning. Inhalation may be the major route of occupational exposure but ingestion and dermal exposures during manufacture, use and disposal of engineered nanomaterials also needs to be considered.

Particular concern regarding exposure and potential health impacts of nanomaterials has arisen due to past knowledge of the hazards of exposure to nano-sized particles generated unintentionally as a component of air pollution, either in the work place or in the urban environment. Exposure to these so called 'ultrafine' particles (defined as particles <100 nm) can cause inflammatory responses in the lungs in laboratory animals and has been associated with adverse respiratory and cardiovascular effects in humans resulting in illness and mortality in susceptible sub-groups within the human population. In animals, such particles have been shown to be deposited in the lungs after inhalation and can enter the blood and lymph circulation to reach other organs of the body such as the bone marrow, spleen, lymph nodes and heart. It has been noted that, because nanoparticles can pass through biological membranes, they could affect the physiology of any cell in an animal body. Recently it was found that multi-wall carbon nanotubes were present in samples of particulate matter from outdoor air, with one possible source being vehicle exhaust fumes. Given their toxicological properties, it has been suggested that multi-wall carbon nanotubes could contribute to the adverse respiratory and cardiovascular effects of particulate air pollution, although this will require further study.

Other research that has given rise to concerns in relation to nanomaterials, specifically to fibreshaped materials such as carbon nanotubes, is the substantive body of information regarding asbestos. The concern arises from the fact that there are structural similarities between nanotubes and asbestos fibres. Both are long, durable and have potential to reside in the lungs for long periods of time. Fibre-shaped nanomaterials may represent a unique inhalation hazard and their pulmonary (lung) toxicity should therefore be evaluated as a matter of urgency. Inhalation of asbestos can lead to increased risks of both non-malignant (asbestosis) and malignant lung diseases (lung cancer and mesothelioma).

The size of a particle and its surface area are important characteristics of a material with regard to its toxic potential, and nowhere more so than at nanoscales. As the size of a particle decreases, its surface area increases in relation to its mass and this allows a greater proportion of atoms or molecules to be displayed on the surface rather than the interior of the material. The increased number of active sites at the surface gives increased potential for biological interaction and the intrinsic toxicity of the particle surface will be emphasized. Therefore, an engineered nanoparticle may have very different properties and toxicological potential than its original macro-scale counterpart, despite being chemically identical. Even two nanoparticles made of the same elements but of different sizes or chemical architecture may have drastically different properties.

From "Nanotechnologies and nanomaterials in electrical and electronic goods"

Task 3. Give the main content of each paragraph in one sentence.

Task 4. Read the text about the toxic effects of quantum dots. Pay special attention to the words in bold.

Part 2

As stressed above, quantum dots vary greatly in their chemical composition and cannot be considered to be a uniform group of substances. Each individual type of quantum dot possesses its own unique physiochemical properties which, in turn, may be expected to influence its potential toxicity. Nevertheless, a recent review of studies assessing the toxicity of quantum dots suggested, in general terms, that "they may pose risks to human health and the environment under certain conditions". Little information is available on routes of exposure to quantum dots, their stability, aerosolization, and how they partition into different environmental compartments (e.g. soil, sediment, water, air, biota). Potential routes of human exposure include inter alia indirect environmental exposure and occupational exposure via the workplace for employees such as engineers and researchers. **Workplace exposures** may occur through routes of inhalation, **dermal contact or ingestion**. As discussed above, it is already well established that human exposure to ultrafine particles can occur commonly as a result of **air contamination** and has toxicological implications. For quantum dots, inhalation exposures may pose potential risks given that quantum dots have been shown to be incorporated into a variety of cells experimentally and remain there for weeks to months.

Environmental exposures could result from, for example, **leakages and spillage** during manufacturing and transport. This is of concern primarily because many quantum dot core metals, such as cadmium, lead and selenium are known to be toxic to **vertebrates** at relatively low concentrations (parts per million). Cadmium and selenium are two of the most widely used **constituent metals** in quantum dots and these are of considerable human health and environmental concern. The toxicological properties of these metals in the form of nanoparticles may differ substantially from the bulk materials, but are clearly of concernnonetheless. Hardman reviewed studies on the toxicity of quantum dots in cell culture systems (in vitro). While some studies have shown that quantum dots were not toxic to cells, others have shown they can have toxic effects. In some cases, toxicity was attributed to oxidative and photolytic conditions which resulted in degradation of **the core-shell**

coatings of the quantum dots. In turn, this resulted in exposure of cells to potentially toxic 'capping' material or intact core metalloid complexes.

There are few in vivo studies so far available on quantum dots, but three studies have shown that the quantum dots can accumulate in a variety of organs and tissues in rodents. Overall, the studies showed that toxicity depends on many factors, including the physiochemical properties of quantum dots and environmental conditions. For instance, influencing factors included quantum dot size, electrical charge, concentration, **outer coating bioactivity and stability**.

From "Nanotechnologies and nanomaterials in electrical and electronic goods"

Task 5. Choose a different type the toxic effects *(e.g. carbon nanotubes, fullerenes, nanoparticles of silver, etc.)* **and write a brief passage.**

Text 2
What are the possible dangers of nanotechnology?

Task 1. Match the words from the text with their synonyms:

1. divided	a. surveillance
2. endurance	b. accurately
3. significant	c. discrete
4. precisely	d. to circumvent
5. to come over	e. to facilitate
6. assumption	f. considerable
7. observation	g. durability
8. to ease	h. speculation

Task 2. Fill in the gaps with words and phrases from Task 1 (right column):

Although most of the press coverage has been on the dangers of "nano-goo" such as self-replicating particles that get out of control, or "nano-robots", the real risks are much more simple, and real. The miniature size of nanomaterials and the way their surfaces are modified to increase the ease with which they can interact with biological systems -

the very characteristics that make them attractive for applications in medicine and industry - makes nanomaterials potentially damaging for humans and the environment.

Nanoparticles are likely to be dangerous for three main reasons:

1. Nanoparticles may damage the lungs. We know that "ultra fine" particles from diesel machines, power plants and incinerators can cause (**………)** damage to human lungs. This is both because of their size (as they can get deep into the lungs) and also because they carry other chemicals including metals and hydrocarbons in with them;

2. Nanoparticles can get into the body through the skin, lungs and digestive system. This may help create "free radicals" which can cause cell damage and damage to the DNA. There is also concern that once nanoparticles are in the bloodstream they will be able to cross the blood-brain barrier;

3. The human body has developed a tolerance to most naturally occurring elements and molecules that it has contact with. It has no natural immunity to new substances and is more likely to find them toxic.

The danger of contact with nanoparticles is not just **(………)**. As more research is undertaken, concerns increase. Here are some of the recent findings: a) some nanoparticles cause lung damage in rats. Several studies have shown that carbon nanotubes, which are similar in shape to asbestos fibres, cause mesothelioma in the lungs of rats; b) other nanoparticles have been shown to lead to brain damage in fish and dogs; c) a German study found clear evidence that if **(………)** nanometer diameter particles were deposited in the nasal region (in rodents in this case), they completely **(………)** the blood/brain barrier, and travelled up the olfactory nerves straight into the brain; d) inhaled carbon nanotubes can suppress the immune system by affecting the function of T cells, a type of white blood cell that organises the immune system to fight infections.

The US government safety research body has produced a guide which states nanomaterials may interact with the human body in different ways than more conventional materials, due to their extremely small size. For example, studies have established that the comparatively large surface area of inhaled nanoparticles can increase their toxicity. Such small particles can penetrate deep into the lungs and may move to other parts of the body, including the liver and brain.

The NTRC was established to coordinate and **(………)** research in nanotechnology and develop guidance on the safe handling of nanomaterials in the workplace. The report identifies 10 critical OHS areas and reports on the advancements to date. The areas include toxicity and internal dose -determined heart and lung responses to nanoparticles; risk assessment; epidemiology and **(………)**.

In June 2011 a research report "Durability of carbon nanotubes and their potential to cause inflammation" considered the **(………)** of carbon nanotubes and the tendency to cause lung inflammation if inhaled, two indicators of potential asbestos-like behaviour. Carbon nano-tubes are already being used in a number of different applications. Key findings in the report include: a) some types of carbon nanotubes can be durable, but others may also break down in simulated lung fluid; b) carbon nanotubes of certain length and aspect ratio can induce asbestos-like responses in mice, confirming previous findings. However, this response may be reduced if the nanotubes are less durable; c) tightly agglomerated particle-like bundles of carbon nanotubes did not cause an inflammatory response in mice. The report recommends classification of carbon nanotubes as hazardous for repeated or prolonged inhalation exposure and for carcinogenicity.

Further recommendations include reducing worker exposures to airborne concentrations of those materials to no more than 1 microgram per cubic meter of air as a recommended exposure limit. This is the lowest airborne concentration that can be **(………)** measured. The recommended exposure limit is intended to minimize the potential risk for adverse lung effects in workers who might be exposed at this concentration over a working lifetime.

From https://www.ohsrep.org.au/nanotechnology_-_a_new_hazard

Task 3. Write down all adjectives from the text and make up new sentences with them.

Task 4. Give a brief gist of the text.

Text 3
The importance of prevention

Task 1. Find and correct grammar mistakes. Give your explanations.

1. I visiting my new workplace tomorrow.
2. I have bought this computer 2 years ago.
3. It is more cold in Antarctica than in Russia in winter.
4. Have you ever be in the USA?
5. Tom is agree with his boss.
6. When has he called for the additional information?
7. Is your company operate in South America?

Task 2. Read the text and answer the question: which preventive actions have already been taken by different companies and the government.

At the moment no one knows for certain how dangerous different types of nanoparticles are likely to be to humans. However, it is important that we do not allow workers to be exposed to an unknown danger where effects may not be known for years, even decades.

These risks were highlighted in a report from the UK's Royal Society which said 'nanotechnology offers many potential benefits, but its development must be guided by appropriate safety assessments and regulation to minimise any possible risks to people and the environment. It also called for a tightening up of regulations.

The UK Royal Commission on Environmental Pollution released a report in November 2008: Novel Materials in the Environment: The case of nanotechnology, stating that nanomaterials are likely to kill people in the future just as asbestos did unless extensive safety checks are put in place. The team of experts assessing the likely impacts of the emerging technology expressed concerns that when nanomaterials escape into the environment they will damage people and wildlife - but that it will be years before the effects are seen. Past generations have brought into general usage materials such as asbestos, leaded petrol, CFCs and cigarettes without adequately considering the potential damage and the commission fears nanomaterials will prove similarly dangerous.

The international insurance company, Swiss Re issued warnings at least fifteen years ago that the uncertainty about the risks that nanotechnology and nano-pollution pose means that they currently will not offer insurance to the industry.

There has been very little attention paid to nanotechnology in Australia. Unions made a number of submissions to a Senate inquiry into Workplace Exposure to Toxic Dusts that raised the emerging issue of nanotechnology in Australia. The VTHC, together with the ACTU and our union affiliates is calling on government to use its existing capabilities and authorities, or develop new ones as needed, to ensure that the risks of nanomaterials are identified before they are incorporated into products for commercial production.

Employers should take a precautionary approach and ensure that workers are not exposed to nanoparticles. This is the advice given by the UK government, which adds that as the risks arising from exposure to many types of nanoparticles are not yet completely understood, control strategies should be based on a principle of reducing exposure as much as possible. For unions that means seeking to ensure that the production and use of nanoparticles is done within a contained process so that employees are not exposed to any potential unknown risk. Nanomaterials should be treated just like any other serious health risk.

On September 19, 2007, the ACTU and its affiliates signed up to the international Declaration on the Principles for the Oversight of Nanotechnologies and Nanomaterials. The declaration identifies eight fundamental principles for the effective oversight and assessment of nanotechnology, including mandatory government regulation. It can be downloaded at the top right hand side of this page.

In June of 2008, the European Trade Union Confederation (ETUC) adopted its first resolution on nanotechnology and nanomaterials: that the precautionary principle must apply. The resolution states: “nanometre forms of chemicals should not be allowed on the market unless sufficient data are supplied to show no harmful effect for human health and the environment”. It adds that risk reduction measures must be used and employers must involve workers and their representatives in the assessment and reduction of nanomaterial-related risks. Other measures called for by ETUC include training and health surveillance for workers exposed to nanomaterials, at least 15 per cent of public research budgets on nanotech to be dedicated to health and environmental aspects and for workplace health and safety to be included in all research programmes.

The Federal Government established a National Nanotechnology Strategy Taskforce under the auspices of the then Department of Industry, Tourism and Resources (DITR). The task force did work in the following areas: a) details of research and other activities - recently undertaken, current and planned; b) a critical review of substantial work done. This will include input from nanotechnology scientific expertise to ensure the scope of the review is relevant and covers current technologies; c) a synthesis of the current state of knowledge in the area relevant to OH&S, and relevant to the workplaces in Australian industries; and d) identification of key gaps in knowledge and areas where further research may be targeted.

The report recommended addressing the “greatest gaps in our current knowledge” as a matter of priority, namely: a) developing cost-effective and robust ambient air monitoring systems to provide accurate information on worker exposures; b) setting priorities to acquire the necessary information for the determination of meaningful workplace exposure standards and adequate worker protection; c) undertaking chronic exposure studies in order to generate information on the long-term health effects.

A 2007 publication from NSW WorkCover, Nanotechnology: OHS overview, summed up some of the concerns. It called for a more proactive approach to regulating public and worker safety when it comes to nanotech. The paper pointed out that the pace of the industry's development meant OHS researchers and regulators already lagged behind. There is still no specific nano regulation. Some of the points in the paper: a) existing regulations do not sufficiently cover nanotechnology; b) current OHS risk management processes do not readily apply because of the different structures and behaviours of nanoparticles; c) so, there is no guarantee that existing safe work practices will transfer to nanotech; d) there is a crucial gap because OHS regulations focus on the chemical composition rather than the size or surface area, such as is the case with nanoparticles; e) However, an effective gap analysis of how existing legislation applies to nanotech will not be possible until further knowledge of measurement procedures and exposure levels is gained.

From https://www.ohsrep.org.au/nanotechnology_-_a_new_hazard

Task 4. Which words in the text mean the same as the ones given below: *to emphasize, suitable, flora and fauna, security, associate, ability, preventative, to found, considerable, compulsory*.

Task 5. Work in two groups. One group makes a list of benefits of the nanotechnology changes and the other one lists all cases that such changes would bring more harm than good to our society.

UNIT 4 PROFESSIONAL PROSPECTS OF A "NANO" SPECIALIST

Text 1
What does a microelectronics engineer do?

Task 1. Racing in groups. During 2 minutes make a list of all job opportunities a "nano" specialist can get.

Task 2. Read and translate the text. Pay special attention to the words in italics.

The tiniest electronic components can present some of the biggest *challenges* for an engineer. Microelectronics engineers revel in those challenges. As a microelectronics engineer, you spend every day working with printed circuits, microprocessors, and other incredibly small components.

In this increasingly technological world, these things power many of the devices we use every day. Microelectronics engineers have the potential to change the world every time they come to work. There's no limit to what you can do with a career as a microelectronics engineer. Major computer companies like Intel and IBM need new microelectronics engineers to help design the next generation of microprocessors. Semiconductor research *facilities* and cell phone companies also *retain* the services of microelectronics engineers to improve and upgrade their own products. The work is *diverse* and ever changing.

Microelectronics engineers are part of a team, *troubleshooting*, testing, artificially aging components, and always looking for the next big *breakthrough*. Think about this: a college student's laptop today is more powerful than the computers that helped humans reach the moon for the first time. Who helped make that happen? Microelectronics engineers, that's who.

Microelectronics engineers work standard workweeks in offices and "clean room" laboratories, as well as manufacturing facilities. Overtime will sometimes be needed when there's an especially hard problem to solve. They will learn to use specialized testing equipment, as well as *image-intensifying* tools to handle and properly view the extremely small components they will be dealing with. Engineers need good *eyesight* and steady hands for this work.

A close *adherence* to safety, cleanliness, and other procedures will be vital, as dust, dirt, and even a little static electricity can completely destroy a *delicate* piece of circuitry. If you love the idea of holding some of the most powerful processors in the palm of your hand, then being a microelectronics engineer could be right for you.

Microelectronic engineer must know the RTL modelling (VHDL or Verilog), simulation, logical synthesis and/or timing static analysis steps and the main simulation tools, which include Cadence (PKS, NCSIM), Mentor Graphics (Modelsim) and / or Synopsys (Design Compiler / PrimeTime). It is important to appreciate working in a team, especially in an international context. Finally, they must be *rigorous*.

From https://www.elsys-design.com/en/microelectronic-engineer/

Task 3. Make your own sentences with the words in italics.

Task 4. ► You are going to watch the video "Microelectronics fabrication center". Answer the questions after watching: https://www.youtube.com/watch?v=oDC6WWj3gmk.

1. Which rooms does microelectronics fabrication center include?
2. What do microelectronics engineers offer?

Text 2
Who is a Nanoengineer?

Task 1. Correct spelling errors.

1. It may have evolved from an existing ocupation.
2. Nanoengineers should be able to create desin.
3. It's important to provide sientific guidance.
4. They should enjoy being inovative.

Task 2. Before reading can you predict the answers for the questions:

1. What should a candidate know to become a nanoengineer?
2. What are any nanoengineer's duties?

Task 3. Now read the text to check your answers and translate inserted Russian words into English.

Nanoengineers design and develop materials, devices, and systems of unique molecular, atomic, or macromolecular composition. They do this by combining principles of nanoscale physics with those of electrical, chemical, and biological engineering. This is **новый род деятельности**. It may have evolved from an existing occupation or emerged in response to **нужды потребителей** or **передовые технологии**.

Nanotechnology has **применения** across a range of industries, products, and processes. It is used in producing power, pharmaceuticals, textiles, cosmetics, foods, coatings, and automobiles. Duties **различаться** greatly from one industry to another. But in general nanoengineers should be able to: a) **проводить исследование** in fields such as nanoparticle dispersion, nanocomposites, nanofabrication, optoelectronics, and nanolithography; b) create designs or prototypes for applying nanosystems, such as microelectromechanical systems (MEMS), nanoelectromechanical systems (NEMS), and integrated biomedical diagnostic-and-delivery (lab-on-a-chip) circuits; c) design or engineer nanomaterials, nanodevices, nano-enabled products, or nanosystems using software such as 3-D computer-aided design (CAD) and quantum mechanical simulation; d) coordinate or **наблюдать** the work of suppliers or **продавцы** who design, build, or test nanosystem devices; e) design or conduct tests of new nanotechnology products, processes, or systems; f) develop processes for applications such as nanofabrication; g) **определять оборудование** needed for pilot or commercial nanoscale production; h) provide scientific or technical guidance and expertise to scientists, engineers, technologists, technicians, or others who apply chemical, physical, or biological processes to micro and nanoscale systems; i) prepare nanotechnology-related **описание сути изобретения** or **заявления на патент**; j) prepare reports, make presentations, or participate in program reviews to share engineering results and recommendations.

Nanoengineers need: a) scientific **любопытство**; b) an aptitude for physics, mathematics, chemistry, biology, or engineering; c) analytical thinking; d) communication and **принятие решений** skills; e) the ability to work **независимо** or as part of a team; f) the ability to visualize complex processes and equipment. They should enjoy being innovative and doing **точный** work.

Most emerging occupations develop from more than one occupation. People working in this occupation may come from a variety of education and training backgrounds. Before **зачисление** in an education program, prospective students should contact associations and employers in this field to investigate education options and **трудоустройство** possibilities.

From https://alis.alberta.ca/occinfo/occupations-in-alberta/occupation-profiles/nanoengineer/

Text 3
Nanotechnologist

Task 1. State to what part of speech the following words belong and translate them into Russian

Identify – identification – identified; conclusion – conclude – concluded; confidence – confident – confide; durable – duration – endure; implication – imply – implicit; resistant – resist – resistance; measure – measurement; relative – relate – relation; practice – practice – practitioner; scientific – science – scientist; interpretation – interpreter – interpret - interpretable.

Task 2. Read and translate the text.

Nanotechnologist is the professional in the field of nanotechnology who deals with the design and manufacture of extremely small electronic circuits and mechanical devices built at the molecular level of matter. Nanotechnology is being considered as that field of science and technology which will lead to the greatest technological advances of the twenty-first century. The practitioner of nanotechnology is known as a nanotechnologist. If you are a person who has the curiosity to create and scrutinize the minute objects, measuring between 1 to 100 nanometres and develop them to novel materials and devices in different fields in the nano-range then this the profession for you to adopt.

The scope and importance of a nanotechnologist are tremendous and it is one of the hottest career options available to today's engineering graduates. It is a right career for those who have a scientific bent of mind and a passion for solving mysteries of the minute molecules. Students with science and engineering background and even mathematics with a physics background can pursue nanotechnology as a career.

Nanotechnologists should have good interpretation skills, be confident in accepting challenges and an ability to understand things as they come before him. They should be able to identify measures or indicate of system performance and the action needed to improve or correct performance, relative to the goals of the system. They should be able to use logic and reasoning to identify the strengths and weaknesses of alternative solutions, conclusions or approaches to problems. They should be able to understand the implications of new information for both current and future problem-solving and decision-making.

Any candidate has to go through all the major aspects given below: a) designing of durable, resistant and cheaper materials; b) designing electronic components with special emphasis on dimension and power; c) techniques for tapping solar energy and increase its power; d) convergence of genetic medicine, nanotechnology and development of a unique drug delivery system; e) the relation between environmental science and nanotechnology. Nanotechnologist job includes dealing with the design and manufacture of extremely small electronic circuits and mechanical devices built at the molecular level of matter.

From https://targetstudy.com/professions/nanotechnologist.html

Task 3. ► You are going to watch the video "Nanotechnology Engineering 2021". Answer the questions after watching: https://www.youtube.com/watch?v=pMe9ZGIg-Jg.

1. Which career opportunities for nanotechnologists are prospective in near future?
2. Which developing countries need nanotechnologists?
3. What are average salaries for nanotechnologists in different spheres

Task 4. Make a short report about other professions that a "nano" specialist can get *(nanomaterials scientist, nanophysicist, programmer-developer, process engineer)***.**

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