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DEVELOPING THE PROFESSIONAL COMPETENCE OF FUTURE ENGINEERS USING MODERN SCIENTIFIC ACHIEVEMENTS IN PHYSICS TRAINING

Erkin Khalimov
Senior Teacher of the Department of Natural and Scientific Sciences,
Chirchik Higher Tank Command Engineering Educational Institution,
Republic of Uzbekistan, Chirchik

Abstract:

The article reflects on the study of concepts and laws such as the structure, mechanical properties of nanomaterials in Physical Science in order to increase professional training in engineering specialties by linking them to science.

Keywords: Physics, nanotechnology, nanomaterials, mechanical properties, nanohard, Hall-Petch's law, Oliver and Farr's method, indenter, robustness, hardness, integration.

Introduction

FIZIKA MASHG‘ULOTLARIDA ZAMONAVIY FAN YUTUQLARIDAN FOYDALANIB BO‘LAJAK MUHANDISLARNING KASBIY KOMPETENTLIGINI RIVOJLANTIRISH

Erkin Khalimov
Senior teacher of the Department of Natural and Scientific Sciences,
Chirchik Higher Tank Command Engineering Educational Institution,
Republic of Uzbekistan, Chirchik

ANNOTATSIYA:
Maqolada muhandislik ixtisosliklarida kasbiy tayyorgarlikni oshirish maqsadida fizika fani mashg‘ulotlarida nanomateriallarning tuzilishi, mexanik xususiyatlari kabi tushuncha va qonuniyatlarni fanga bog‘lab o‘rganish borasida fikr yuritiladi.

Kalit so‘zlar: fizika, nanotexnologiya, nanomateriallar, mexanik xossalar, nanoxard, Xoll-Petch qonuni, Oliver va Farr usuli, indenter, mustahkamlik, qattiqlik, integratsiya.

АННОТАЦИЯ:
в статье рассматривается изучение таких понятий и закономерностей, как структура наноматериалов, их механические свойства, связанное с наукой на занятиях по физике с целью повышения профессиональной подготовки по инженерным специальностям.

Ключевые слова: физика, нанотехнологии, наноматериалы, механические свойства, нанохард, закон Холла-Петча, метод Оливер-Фарра, индентер, прочность, твердость, интегратsiя.

INTRODUCTION

In the current educational system, the main attention is paid to the learner in the learning process, and he acts as an object in the learning process. It is necessary for the teacher to focus on the needs of the learner, to make effective use of problematic teaching situations. Such an approach is useful in teaching modern sciences (nanophysics, nanotechnological sciences). This approach depends on the character of nanotechnologies, that is, on such peculiarities as the need for complex imaginations, the need for a lot of creative work to understand the processes. Therefore, it is necessary to control the educational context in the training so that it reaches the learner, it is interesting and understandable.

The laws of modern science are distinguished by the complexity of scientific processes, the need for deep observation and aspects of imagination. This is why the issue of humanization of the field comes first. That is, it means organizing the teaching of subjects to the extent that the educator understands and, ultimately, achieving high efficiency. To do this, it is important to state the achievements of modern sciences (elements of nanophysics, nanotechnology), comparing them with topics in another branch of physics. For example, on the topics of hardness, strength limits of substances in the mechanics section, Guk's law, Yung modules, thermodynamic properties of nanomaterials in the molecular physics section, electrostatics in the electrical section, the concept of electrical resistances, superconductivity, zone theory, properties of semiconductors, diodes and transistors, Hall effect in magnetic field concepts, etc.k. In the Department of optics, the importance should be paid to the training of interference, diffraction, light phenomena and laws, nanomaterials in connection with the electromagnetic properties of nanomaterials in the study of their optical aspects. It is becoming apparent that the development of modern sciences will be a factor that will determine the concept of human development in the near future. That is why in these areas the world community has begun to conduct serious scientific research.

LITERATURE ANALYSIS AND METHODOLOGY

The further achievements of Science and technology are important today in satisfying our daily need-our. In particular, we can include touch devices, quantum computers, telephones and other types of devices. The output of this device to a wide spectrum level of performance is inextricably linked with the development of the nanotechnology field.

New types of nanomaterials have become a major area of research in changing the mechanical, thermodynamic, electrical, magnetic and optical properties of military techniques, increasing their durability, strength, hardness and other properties.

Currently, we can confidently say that the study of nanoscale structures (nanostructures) is the most relevant issue in the direction of "nanotechnology". One of the important components of this scientific and technical direction is the development of nanostructured materials, as well as the study of the properties of nanostructures obtained under different conditions. According to the size scale, materials with grain sizes ranging from ~0.3 to ~0.04 μm are submicrochrystalline. Smaller components belong to nanomaterials.

Nanomaterials (**nanocrystalline, nanocomposite, nanophase**) are usually understood as materials whose structural elements (grains, crystallites, fibers, layers, coves) do not exceed the nanotechnological limit of 100 nm (1nm =10^{-9}m). Nanomaterials themselves are conditionally divided into nanoclasts and nanocrystals, depending on the size of the structural units and the number of atoms in them. Nanoclasts, in turn:

kichik (atomlarning soni 3-12, yuza atomlarning 100%, ichki qatlamsiz);

small (number of atoms 3-12, surface 100% of atoms, without inner layer);

large (with a number of 13-150 atoms, 92-63% of surface atoms, with 1-3 inner layers);

the bulk (with the number of atoms 151-22000, 63-15% of surface atoms, with 4-18 inner layers) is divided into nanoclusters [2-4].

A large proportion of atoms with dimensions of 3-40 nm include nanocrystals. Nanocrystalline materials come in a variety of shapes and have unique chemical, physical and mechanical properties. The choice of such a dimensional criterion is explained by the fact that the upper limit of nanostructures (the maximum size of the element) should be associated with some important characteristic parameters: the mean free path of carriers, the size of the domain, domain walls, the Frank-Read transverse diameter and length for separating fibers, de-Broyle waves, etc [5].

Nanomaterials are not a single "universal" material, it is a wide range of different materials that combine their different families with almost interesting properties. In addition, nanomaterials are very small, a misconception that "nano" particles. In fact, most nanomaterials are not individual particles, they can be complex microblocks that are nanostructured on the surface or in bulk. Such nanostructures can be considered a special case of matter, since the properties of the material formed by the nanoscale in the presence of structural elements are not similar to those of the bulk substance.

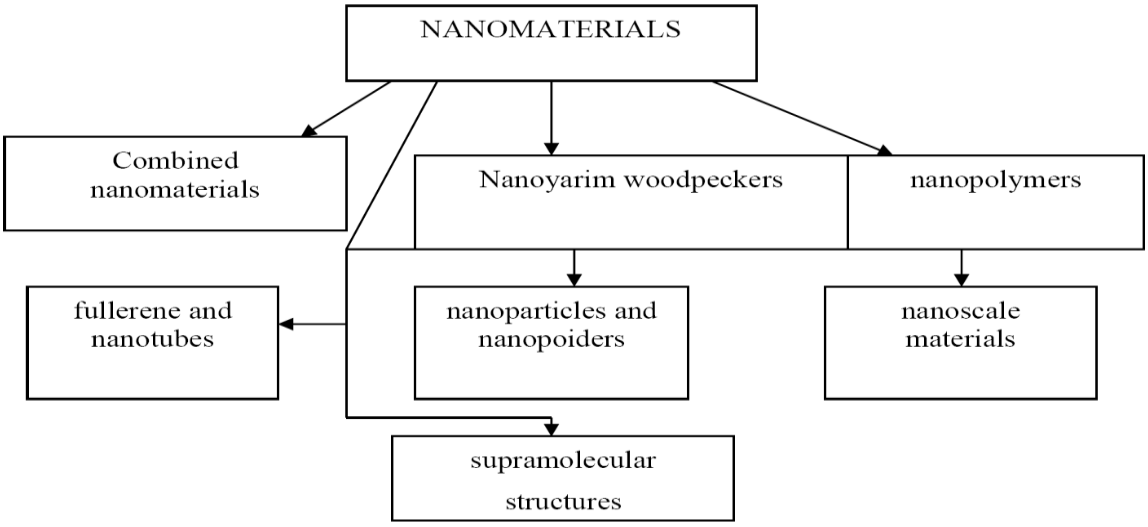

Figure 1. The main types of nanomaterials [3].

Nanomaterials are characterized by several basic properties that make them out of competition compared to other substances that have practical applications in human activities. In particular, if we get acquainted with the mechanical properties of nanomaterials on the basis of integration into physical science training.

RESULTS

Studying the physical and technical foundations of any technique in physics and the elements of nanophysics, nanochemistry, nanotechnologies and similar modern sciences requires the learner to search for creative solutions to problems. At the same time, the business qualities of a person are cultivated: practicality, discipline, frugality, strong-willed qualities, purposefulness, demandingness, concentration [6]. Also, as a result of it, a critical attitude is formed[7].

Determining the system of professional and vital (daily) tasks allows to develop a system of typical skills, and the analysis of the content of these skills allows to determine the knowledge program in which professional skills are formed. Thus, the clarity of goals means the validity and content of education.

At the present stage, the content of the principle of practical and professional direction of training can be formulated as follows: in the process of studying any topic, Future Engineers must master generalized methods of solving typical problems that ensure the implementation of specific tasks performed by a person many times in life and in the process of their professional activity. If the learner, on the example of several specific phenomena, Masters the basic invariable knowledge in the application of modern knowledge, he will be able to himself understand, analyze and acquire skills in the use of modern new generation techniques, devices without additional special training in the future.

General Education Sciences are of great importance for the formation of a future specialist, since they provide a theoretical basis for military-technical-professional training. The General Technical Sciences reveal for the learner the general laws and operational characteristics of technical objects and devices, the basic principles of the operation of multi-purpose chain and wheeled machines, various mechanisms, devices and instruments. Specialty disciplines provide a theoretical basis for the operational characteristics of technical objects in various conditions, reveal the principles and structure of operation of modern equipment, and also form relevant professional practical skills and qualifications.

O‘rganilayotgan Promotes the scientific formation of interdisciplinary tasks on the content and mental nature of the material under study, fostering cognitive activity, constant personal interest. Professionally oriented interdisciplinary tasks activate cognitive interest.

The task of the professional information function is ensured by the availability of new information, the concretization of knowledge, as well as the identification of quantities of professional importance. The development function of the problem-solving method requires the creation of conditions and conditions for the development of the personality of the educator, arming them with problem-solving methods that stimulate mental activity, ensure the interaction of abstract and concrete thinking.

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DISCUSSION

Mechanical properties of nanomaterials

The formation of nanocrystalline structures leads to a change in properties compared to mass analogs. In particular, there is a significant increase in the mechanical properties of nanocrystalline materials. Among them, first of all, it is worth noting an unusually high hardness. Since hardness characterizes the resistance of a material to plastic deformation, a solid body (such as a diamond) is processed from it. There is a proportional relationship between hardness and the degree of profitability of the material (σ_y).

Historically, the yield strength of this material was first analyzed in detail to depend on its magnitude, resulting in the so-called Hall-Petch law relationship.

$$\sigma_y=\sigma_0+k_yD^{-n}$$

here: σ_0 - internal stress that prevents space from moving, k_yD^{-n} - is the coefficient associated with the permeability of the grain boundary to the motion of the dislocation, and the value of n is ¼ of ½ (the classical Hall-Petch law). Varies up to the values located in the range 1. Each value of the n - exponent corresponds to the characteristic mechanism of the interaction of dislocation with grain boundaries. At the same time, for grain sizes greater than 10^{-6}m, a very well-executed classical law has an index of n=1/2 for metals and alloys [5,8].

Tables 1 show the results of changes in the mechanical properties of metals depending on the amount of grains [5].

Table 1. Mechanical properties of ordinary and nanocrystalline nickel

Features	Simple 10 μm	Nano - Ni	
		100 nm	10 nm
Power , MPA (25 ºC)	103	690	>900
Extreme tensile strength , MPA (25 ºC)	403	1100	>2000
Vickers hardness , kg / mm^2	140	300	650

The tensile strength of nanocrystalline materials is 1.5-2 times higher than that of coarse analogs. At the same time, a decrease in the degree of hardness was noted by the fact that the grain size falls below a certain critical volume, which is due to an increase in the share of the joint ends of the grain boundaries of the highest level. For large grains, they are characterized by an increase in consistency and hardness with a decrease in size, the appearance of additional settlement boundaries. This condition prevents the grain environment from sliding. The increase in strength with small nanoparticle grains occurs due to the low density of existing dislocations and the difficulty of forming new ones.

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The introduction of nanotechnology in modern electronics requires the measurement of the physical, mechanical and tribological properties of materials used at the submicron and nanometer levels. In recent times, a method of constant statelessness at low loads, called nanoindentation, is being used - a method for determining mechanical properties, hardness and elastic modules of surface layers, and is called indenter loading.

Materialning qattiqligini o‘lchashning odatiy usulida bo‘lgani kabi, asosiy qiyinchilik, asosan, kam yuk ostida olingan barmoq izini o‘lchash bilan bog‘liq. Nanoindentatsiya usulida qattiqlikni barmoq izining chuqurligi bilan o‘lchashda asosiy muammo bu olingan nanoindenterlarni kiritish sxemasini qayta ishlashdir. Qiyinchilik shundan iboratki, qurilma tebranish chuqurligini o‘lchamaydi, lekin bir necha atamalarning yig‘indisi bo‘lgan h_{max}ni ajratish - kontakt chuqurligi h_c va kontakt chetidagi namuna yuzasining elastik deflyatsiyasi h_s ni o‘lchash mumkin [9].

As with the usual method of measuring the hardness of a material, the main difficulty lies mainly in measuring the fingerprint obtained under low load. The main problem when measuring hardness by the depth of the fingerprint in the nanoindentation method is processing the input circuit of the nanoindenters obtained. The difficulty is that the device does not measure the vibration depth, but the h_{max} separation, which is the sum of several terms - the contact depth h_c and the elastic deflation of the sample surface at the contact Edge can measure h_s [9].

Ichki kirish diagrammasi yordamida sinov natijalariga ko‘ra namunaning nanoxardligi va elastik modulini topish uchun maksimal yuklanishda h_c kontakt chuqurligini bilish kerak. Asosiy qiyinchilik, h_s kontakt chetida elastik sirt deflyatsiyasini topish bilan bog‘liq. Elastik egilishni o‘lchash mumkin emas, uni Oliver va Farr usullari yordamida aniqlash mumkin [10]:

Based on the results of the test using the internal input diagram, it is necessary to know the h_c contact depth at maximum load to find the nanohardity and elastic modulus of the sample. The main difficulty lies in finding elastic surface deflation at the contact edge of the h_s. Elastic bending cannot be measured, it can be determined using the Oliver and Farr methods [10]:

$$h_s = \varepsilon P_{max} / S$$

here: ε=1 coefficient for a flat stamp; ε=0,75 for paraboloid and sphere; ε=0,72 for a sharp cone.
Contact stiffness =dP/dh can be found from the internal loading curve (Figure 2.).

Oliver and Farr method for the Berkovich indenter finds h_s ε = 0.75 [11] it is possible to find the projection area of the fingerprint by knowing the binding depth:

$$A = 24{,}56\ h_s^2$$

Then we find the hardness at the depth of the maximum load from the expression:

$$H = P_{max} / A$$

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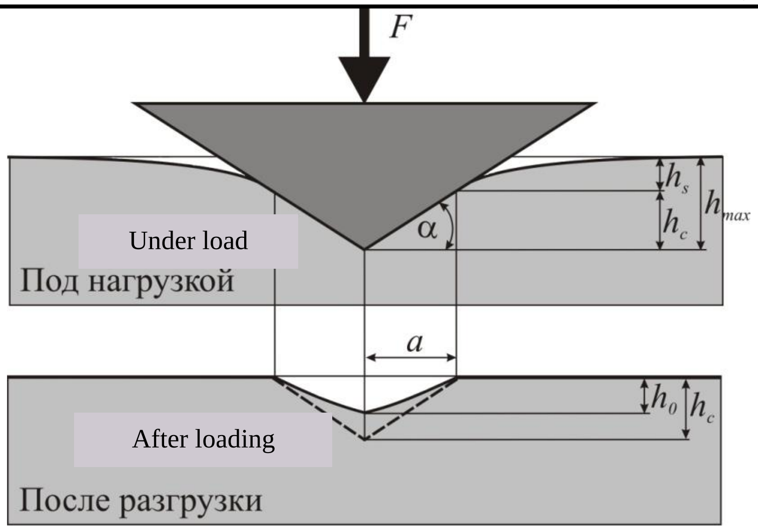

Figure 2. Schematic representation of hc contact depth visualization

Then we find the hardness at the depth of the maximum load from the expression:

$$H = P_{max} / A$$

We can also use spatial analysis and the finite element method to calculate the elastoplastic material with the full W ratio of the work spent on its elastic deformation (W_{full} - $W_{elastic}$). The ratio shown, λ, describes the elasticity of the material, which can be calculated from the curves obtained from the unloading. Such as the ratio (characteristic plasticity for separation) of the material spent on elastic and complete deformation to the Yung module (H/E*) with reduced stiffness ratio [12,13] is estimated as follows:

$$\lambda = (W_{full} - W_{elastic}) / W_{full} = 1 - 5 *$$

When processing p-h diagrams obtained by nanoindentation:

- Determination of resistance of local elastoplasty, deformation in nanocontact;
- Determination of elastoplastic hardness h=p / s (p - implementation strength, s - depth of fingerprint area, through geometry of cross-top);
- Measuring the energy absorbed by contact exposure, determining the elastoplastic properties of deformable materials (ceramic, mineral and metal glasses, carbides, nitrites, metal borides, etc.);
- Determination of the properties of isolated mobility, dislocations and their accumulation in crystalline materials;
- Determination of the coefficient of fracture toughness according to the size, the size of cracks and separation force around the print;
- Research of surface layers nanostructured areas, internal hardening and stretching processes through uniform re-installation;

- Assessment of the porosity of the material;
- Study of the structure of multistage materials;
- High pressure induced phase transition study (under the inductor);
- Elastic modulus, determination of sound speed and anisotropy, mechanical properties;
- Determination of thickness, adhesion and level of thin layers and coatings;
- The study of time-dependent material properties and speed sensitivity coefficients of mechanical properties, fingerprint after the stages of immersion and viscoelastic recovery;
- An assessment of the size and distribution of internal tailoring is carried out [14].

Due to convenience and flexibility, the nanoindentation method allows you to study the mechanical properties of solids in thin surface layers that are nearby.

Also good in the subjects is the perfect mastery of a number of physical concepts such as Tunnel effect, de Broyle wavelength, atomic perceptions, magnetic moment and spin.

CONCLUSION

In place of the conclusion, it is worth noting that the transition to nano-levels in many objects of physics, chemistry and biology leads to the emergence of qualitative changes in the physicochemical properties of individual compounds and systems obtained on their basis. Also, new materials obtained using nanotechnology are significantly superior to micrometer scale analogs in physical, mechanical, thermal and optical properties. Based on the requirements of the current period, special attention should be paid to the inclusion of information on materials and devices created on the basis of nanotechnology achievements, in particular, in the educational programs of higher education institutions, as well as issues of interdisciplinary integration in training. This is instrumental in developing the professional competency of the learner.

In this regard, we consider it necessary to supplement the topics of physical science with the achievements of modern science in accordance with professional training. Because the latest advances being discovered in science are of great importance in the creation of modern modernized techniques (military technical Corps, armor, UUA, drone, chemistry, biological weapons, etc.). In this case, the statement of the physical laws of the achievements of modern science on the topics of Physical Science in a simple, understandable language is important in the development of professional competence of future specialists in the field of engineering.

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