ISSN 0798 1015

REVISTA ESPACIOS

HOME Revista ESPACIOS ÍNDICES A LOS AUTORES

EDUCACIÓN • EDUCAÇÃO • EDUCATION Vol. 38 (Nº 25) Year 2017. Page 7

Methodology for the study of the electron irradiation influence on mechanical characteristics of certain composites in condensed matter physics for pedagogical higher education institutions

Metodología para el estudio de la influencia de la irradiación de electrones en las características mecánicas de ciertos compuestos en la física de la materia condensada para las instituciones pedagógicas de educación superior

Maira Sametovna MOLDABEKOVA 1; Zhazira Maratovna BITIBAYEVA 2

Received: 09/03/2017 • Approved: 15/04/2017

Content

ABSTRACT:

This article discusses some aspects of the training of the future specialists in a pedagogical university. The organization of the educational process according to the credit technology contains a cycle of majors that are important for learning the ways of dealing with professional and pedagogical tasks. The formation of professional competence was demonstrated using the example of the methodology for the study of interaction between electrons and matter in condensed matter physics. The pedagogical experiment has been

RESUMEN:

Este artículo discute algunos aspectos de la formación de los futuros especialistas en una universidad pedagógica. La organización del proceso educativo de acuerdo con la tecnología crediticia contiene un ciclo de mayores que son importantes para el aprendizaje de las formas de abordar las tareas profesionales y pedagógicas. La formación de la competencia profesional se demostró utilizando el ejemplo de la metodología para el estudio de la interacción entre los electrones y la materia en la física de la materia

associated with several sequentially increasing tasks, which studied the changes in the electrical and mechanical characteristics of composite materials after irradiation with electrons with different energies. It has been demonstrated that the study of the physical mechanism of deformation and destruction of composites using visual examples of introduction of scientific research methods into educational process leads to the actual formation of professional competence, i.e. improving the quality of training in pedagogical higher education institution.
Keywords: methodology, competence, training, deformation, destruction, characteristics, composites, studying, majors, electrons, interaction

condensada. El experimento pedagógico se ha asociado con varias tareas secuencialmente crecientes, que estudiaron los cambios en las características eléctricas y mecánicas de los materiales compuestos después de la irradiación con electrones con diferentes energías. Se ha demostrado que el estudio del mecanismo físico de deformación y destrucción de compuestos utilizando ejemplos visuales de introducción de métodos de investigación científica en el proceso educativo conduce a la formación efectiva de la competencia profesional, es decir, mejorando la calidad de la formación en la institución pedagógica de educación superior.
Palabras clave: metodología, competencia, formación, deformación, destrucción, características, compuestos, estudio, mayores, electrones, interacción

1. Introduction

The higher school of the Republic of Kazakhstan has an important task of implementing the education quality and finding ways to achieve it. This task should satisfy the needs of labor market and conditions of forced industrial-innovative development leading to a significant expansion of the integration processes and interaction between education, science and innovation (State Program of Industrial-Innovative Development of the Republic of Kazakhstan for 2015-2019).

The improvement of the vocational education quality in order to supply economic sectors with competitive personnel with higher and postgraduate education implies high requirements towards the content and realization technology of educational programs and assessment of their results, namely, orientation towards competent approach and strengthening of the practical training of specialists (Moldabekova, et. al. 2015; Moldabekova, et. al. 2013). In such circumstances, the educational process in a pedagogical university can be seen as training in finding solutions to professional and pedagogical tasks. The main bachelor educational programs provide general scientific training, which can be further deepened and expanded through a wide range of magister educational programs.

The most complete formation of professional competences occurs in various organizational education forms of majors that combine scientific research with theoretical and practical training (Moldabekova, et. al. 2013). The organization of educational process according to the credit implies majors as an important part of training of a competent expert in the field of future professional activities. These disciplines address the following main issues:

- formation of professionals, including teachers, with deep professional knowledge acquired and supported through systematic and continuing education at all levels due to basic training that provides means for further self-education, capable of social mobility and adaptation to the practice;
- training of scientific and pedagogical personnel possessing in-depth scientific and pedagogical knowledge and providing high quality education due to the integration of fundamental and applied knowledge, whose creativity, versatility and research orientation meets the social needs.

2. Methods

In the process of studying the majors, in particular physics of condensed state, one forms special professional competence that reflects the specificity of the domain for the future professional-pedagogical activity.

In order to complete the set tasks, we propose to design the special educational tasks that encourage learners to not only understand the material, but also to create an explanation for certain phenomena and processes, i.e. encourage the self-facilitated academic and research activity.

The path towards the formation of the professional competence lies through the development of learning technologies of specific sections and questions of basic and primary physical

disciplines. One of such sections of solid-state physics is the study of the mechanical characteristics related to the structural characteristics. Structural heterogeneity, which is expressed through areas with different degree of order and defects, determines unequal stress distribution, occurrence of overstresses in some areas and the emergence of cracks. Their diagnosis using electron microscopy is used for adequate interpretation of experimental data in order to predict the result of the technological impact of electron beams on the matter. These circumstances urgently require familiarization of trainees with some issues of electron passing through the matter (Tamuzh, et. al. 2016; Kozhamkulov, et.al. 2004). We explained the physical essence of the phenomena avoiding complex mathematical equations and some details relevant to a more in-depth study of the subject to the future teachers.

Our long-term teaching experience shows that certain issues of interactions between electrons and atoms/molecules are difficult to understand. As a result, the trainees cannot explain and generalize the calculated and experimental data in the field of electron-nuclear confrontations. Therefore, one should at least briefly explain the structure of matter, which is associated with the study of motion, i.e. the dynamics and interaction of its structural units. Finally, one should draw the trainees' attention to our knowledge about atoms and molecules as the structures with certain chemical properties that are not the ultimate building blocks of the universe: there are more fundamental constituents – the atomic nuclei, nucleons and, eventually, quarks, leptons and interaction mediators. This information is obtained through the analysis of the experimental results on interaction between particles and matter. The registration of particles also occurs because of their interaction with detector matter. The interaction of particles with matter depends on their type, charge, mass, energy, and other characteristics of the matter, such as its density, atomic number and average ionization potential.

The outlined difficulties indicate that the trainees have not formed appropriate prior domain expertise. The ability of trainees to integrate knowledge, hold discussions on the basis of limited or incomplete information taking into account previous education results both at the level of the whole program and at the level of a discipline is the basis of the overall professional competence. The formation of professional competences is a complex multi-level dynamic process occurring in stages. Professional competence is an integral characteristic of personally and professionally significant qualities of a specialist with knowledge and skills ensuring his or her readiness to the effective relevant activities, as well as the capacity for professional self-development and the future professional activities under new modern conditions (Moldabekova, et. al. 2015; Moldabekova, et. al. 2013).

It should be emphasized that an analysis of some complex issues of the studied theme is meant for individual work under the guidance of a teacher. This is one form of the training according to the credit technology of education.

---

3. Results

In order to clearly explain the properties of substances under electron irradiation, we have used the research examples of some polymers like polyethylene terephthalate (PETP) film with the thickness of 50 microns, polyimide (PI), polytetrafluoroethilene (PTFE) and poly-m-phenyleneisophthalamide (PP) films with the thickness of 40 microns. During our pedagogical experiment, each trainee was asked to analyze a series of tasks with consistently increasing complexity. First, it was necessary to formulate the task (problem), which is very important for finding the true causes of difficulties in the studying process that would lead to an effective solution. Then to define:

- What are the issues and challenges need to be addressed;
- Where these issues and challenges arise or occur;
- What aspects are important.

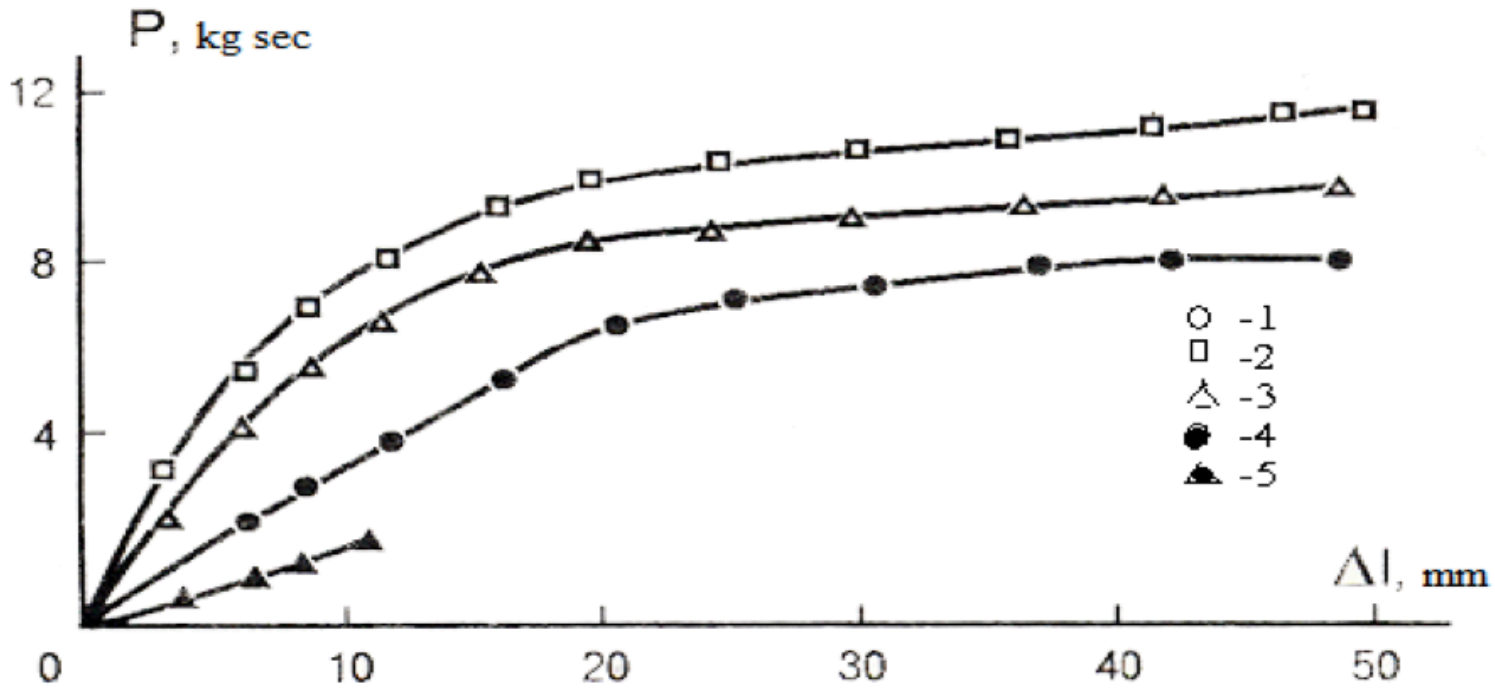
As our research shows, the processes of the interaction of electrons with different energies with substances, the transfer equations describing the scattering of electrons in medium and figuring

out radiation-chemical transformations and their impact on the electrical and mechanical characteristics are interesting, but sometimes confusing for the trainees (Tamuzh, et. al. 2016; Kozhamkulov, et.al. 2004). Therefore, each trainee should pay attention to the characteristic feature of composite materials, which is due to the high molecular weight of the initial substance. Since every interaction results in particle energy loss and changing of its motion trajectory, it is necessary to discuss the interaction between electrons and substances again. In case of a charged particle beam with kinetic energy E, passing through substance layer, the energy of the particles decreases as they progress through the substance, and the variation of particle beam energies increases. The beam is extending due to multiple scattering. Different reactions can occur between particles passing through the medium and particles of the substance (electrons, atomic nuclei). The passage of electrons through the substance is different from passing of heavy charged particles. The main reason is the low mass of the electron. This leads to a relatively large change in electron pulse whenever it collides with particles of the medium, which causes a noticeable change in the direction of electron motion and, as a result, the electromagnetic radiation (Tamuzh, et. al. 2015; Tamužs 2013).

Sample materials intended for mechanical tests were shaped as bars with the dimensions of 10 × 200 mm2, and for electrical studies – as squares 100 × 100 mm2. The irradiation with electrons was conducted up to absorption of doses 106, 3.106, 107, 3.107, 108 Gy. The temperature for each sample type was determined by the appropriate beam current under cooling and did not exceed 50 °C. The irradiation conditions were as follows: beam current 20 μA, irradiation area 6 cm2, i.e. current density 3.3 μA/cm2 (Tamužs, 2014; Klein, et. al. 1987).

Electrical and mechanical characteristics were determined after a set of predefined absorbed doses according to standard methodologies using devices in accordance with the standard requirements. Non-irradiated and irradiated polymer films were tested on stretching. Figure 1 represents the dependency “load P – deformation Δl” for PETP under different irradiation doses.

Figure 1: The curves “load-deformation” for PETP under different irradiation doses.
1. D = 0; 2. D = 1 MGy; 3. D = 10 MGy; 4. D = 100 MGy. The calculated curves are plotted in dotted lines.



Mechanical tests were performed with automatic record of “load-deformation”. The experimental results revealed that the most solid non-irradiated polymer film is PETP. One can see on Fig.1 that the shape of dependency “load-deformation” for the PETP film varies significantly with increasing radiation dose. The dose of 1 MGy causes the film to become brittle, the dose of 30 MGy decreases its strength 8 times, and the dose of 100 MGy causes the destruction of this film under the beam. Further irradiation affects the relative deformation at break er, where changes reach two orders of magnitude at the dose of 30 MGy. The phenylone

film behaves in a peculiar manner: there is some increase in strength reduction of deformation at the dose of 5 MGy. It is probably because the rate of cross-linking of broken polymer chains prevails over the rate of destruction. The destruction rate is apparently higher at the increased dose of 50 MGy, which leads to a reduction of the polymer strength. Indeed, when small doses of radiation are absorbed, the extremum of strength is associated with a relative increase in the number of passing molecules and the extremum of elongation – with more complete unfolding of the folded molecules from several cross-linked ones. More absorbed doses lead to the increase in relative contribution of intermolecular cross-linking, which prevents an increase in strength and leads to a decrease in the relative deformation. The fluoroplastic film possesses the lowest radiation resistance. It is easily destroyed at a dose of 10 MGy. The polyimide film is the most radiation-resistant. Irradiation of up to 100 MGy does not affect its mechanical characteristics.

Thus, actual examples can clearly show changes in the electrical and mechanical characteristics of composite materials after irradiation with electrons. The study of the effect of simultaneous mechanical stress and irradiation on the polymeric films was conducted under load of 40, 50, 60, 70, 80% from P0 (P0 is the initial value of destructive load). The irradiation conditions remained the same as in the experiment with free states.

The polyimide film under the load P50%= 4 kg was irradiated up to D = 3 MGy, the sample was not destructed. The PETP film was irradiated under the load P50% = 4.3 kg. The film was destructed at D = 3 MGy. The fluoroplastic film is destructed under the load P50%= 1.3 kg at 3×103 Gy. It is destructed under the load P25% = 0.65 kg at D = 8.8×105 Gy. The strength of samples irradiated under load is much lesser then the corresponding value without load. Attention of trainees is drawn to the differences in radiation resistance. It is expected that it could be connected with the peculiarities of formation and modification of defects in irradiated materials, as well as with different mechanism of destruction. The strength of unloaded, i.e., undirected polymers is mainly determined by the magnitude of the van der Waals forces. Intermolecular interaction is increasing along with orientation degree as a result of straightening of the molecular chains, which in turn leads to the higher polymer strength due to the significant influence of the basic valence forces. This leads to the fact that starting from a certain molecular weight (after irradiation), intermolecular forces become weaker than basic valence forces and the polymers break at the intermolecular bonds.

Thus, the radiation resistance of polymers is reflected in the following row

The change of the mechanical properties of the studied polymers caused by electron irradiation effects is related to the amount of benzene rings and other cyclic groups in these structures. The protective effect against radiation exists due to the fact that benzene core excited to the singlet state dissipates this absorbed energy in the form of fluorescence in the visible and ultraviolet spectrum (Kozhamkulov 1997).

It should be noted that although experimentally-determined parameters are known for more than a decade, the quantitative correlation between radiation and chemical properties of polymers and these parameters has not been determined so far. Thus, the trainees realize that this important scientific and technical area requires a detailed clarification of the physical mechanism of deformation and destruction in order to create theories and predict the functionality of composite materials.

---

4. Discussion

One can see that while solving these tasks, a trainee obtains characteristic ways of cognitive activities that contribute to the formation of professional competence. He or she acquires practical skills in observing composite strength tests. Trainees also learn mathematical methods of experimental data processing and their comparison with tabular data and data from other authors.

Therefore, the integration of scientific research and education will overcome known

unilateralism in the training of future teachers of physics under conditions of modern university education. In this regard, it may be noted that the integration of fundamental and applied physical knowledge in the educational process of a pedagogical university will contribute to:

- increase of motivation towards studying of physics;
- the increasing methodological orientation of content of the pedagogical physical education;
- integration of training, research and project work of trainees;
- expanding of educational resources of the physical education;
- formation of professional competence of trainees.

Physical education plays a prominent role in the technological and intellectual development. The training of highly qualified scientific pedagogical personnel majoring in physics contributes to the effective implementation of innovational development of economy and society.

5. Conclusion

Our research has demonstrated that the implementation of continuous training in the educational process, including the results of scientific research and methodology of studying the effects of electron irradiation on the mechanical characteristics of certain composites in condensed matter physics, allows the trainees to achieve different levels of professional competence. Thus, the formation of professional competence of trainees in solving professional and pedagogical tasks, as well as a system of value orientations and targets specific to physical science, occurs with regard to the requirements of employers and social society request.

References

Gosudarstvennaya Programma industrial'no-innovatsionnogo razvitiya Respubliki Kazakhstan na 2015-2019 gody [State Program of Industrial-Innovative Development of the Republic of Kazakhstan for 2015-2019]. (2014). Decree of the President of the Republic of Kazakhstan from August 1, 2014 #874, Kazakhstan.

Klein, P.G. Woods, D.W., & Ward, J.M. (1987). The Effect of Electron Irradiation on the Structure and Mechanical Properties of Highly Drawn Polyethylene Fibers. J*ournal of Polymer Science, Part B: Polymer Physics, 25*(7), 1359-1379.

Kozhamkulov, B.A. (1997). *Radiatsionnye effekty izmeneniya mekhanicheskikh svoystv polimerov i kompozitov* [Radiation Effects of changing Mechanical Properties of Polymers and Composites]. Almaty: Ylym.

Kozhamkulov, B.A., & Bitibaeva, Zh.M. (2004). Vliyanie elektronnogo oblucheniya na prochnost' polimerov v nagruzhennom sostoyanii [Influence of Electron Irradiation on the Strength of Polymers under Load]. *Poisk, 3*, 203-206.

Moldabekova, M.S., Asembayeva, M.K., & Akzholova, A.A. (2015). Metodologiya resheniya problem v formirovanii issledovatel'skikh kompetentsiy magistrantov [Methodology for Solving Problems in the Formation of Research Competences of Magistrands]. In Materialy XIII Mezhdunarodnoy konferentsii “Fizika v sisteme sovremennogo obrazovaniya (FSSO-2015)”, Sankt-Peterburg, 1-4 iyunya 2015 [Materials of the XIII International Conference “Physics in the Modern Educational System (FSSO-2015)”, Saint-Petersburg, 1-4 June 2015]. Saint Petersburg: Fora-print.

Moldabekova, M.S., Zhavrin, Ju.I., Poyarkov, I.V., & Mukamedenkyzy, B. (2013). Vnedrenie nauchnykh metodov issledovaniy v spetsial'nyy fizicheskiy praktikum – osnova formirovaniya professional'nykh kompetentnostey studentov [Implementation of Scientific Research Methods in the Special Practical Physics is the Basis of Formation of Professional Competence of Students]. *Fizicheskoe obrazovanie v vuzakh, 19*(2), 110-114.

Tamuzh, V.P., Kozhamkulov, B.A., Moldabekova, M.S., & Bitibaeva, Zh.M. (2016). Issledovanie

dolgovechnosti polimernykh kompozitnykh materialov obluchennykh elektronami [Study on Durability of Polymer Composite Materials Irradiated with Electrons]. *Vestnik KazNPU im. Abaya, 3*, 103-107.

Tamuzh, V.P., Kozhamkulov, B.A., Moldabekova, M.S., & Bitibaeva, Zh.M. (2015). Izuchenie radiatsionnykh effektov izmeneniya mekhanicheskikh svoystv kompozitnykh materialov [Study of Radiation Effects on Changes of Mechanical Properties of Composite Materials]. In *Materialy Mezhdunarodnoy nauchno-prakticheskoy konferentsii "Radiatsionno-termicheskie yavleniya i innovatsionnye tekhnologii" 10 -11 noyabrya 2015 g., Almaty* [Materials of the International Scientific-Practical Conference "Radiation-Thermal Phenomena and Innovative Technologies" 10 -11 November 2015, Almaty]. Almaty: Abai KhazNPU.

Tamužs, V. (2013). Mechanical Behaviour of Concrete Structures Reinforced by Composites. In *IV Annual Meeting of the Georgian Mechanical Union, Book of Abstracts, 8-10 November 2013, Kutaisi*.

Tamužs, V. (2014). Strengthening of Concrete by Fibres and Fibre Reinforced Plastics. In *Proceedings of the XXII Nordic Concrete Research Symposia, 13-15 August 2014*, *Reykjavik, Iceland.*

---

1. Al-Farabi Kazakh National University, 050040, Republic of Kazakhstan, Almaty, al-Farabi Ave., 71

2. Kazakh National Pedagogical University of Abay, 050010, Republic of Kazakhstan, Almaty, Dostyk Ave.13. Email: zhazmar@mail.ru

---

Revista ESPACIOS. ISSN 0798 1015
Vol. 38 (Nº 25) Año 2017

[Índice]