ABSTRACT AND REFERENCES

APPLIED PHYSICS. MATERIALS SCIENCE

DEVELOPMENT OF HEAT-MASS EXCHANGE OPTIMIZATION METHODS USING FRACTAL CONVOLUTIONS OF COMPUTER TOMOGRAMS (p. 4-9)

Alexandr Stanovskyi, Oksana Saveleva, Igor Prokopovich, Alla Toropenko, Marianna Dukhanina

It was shown that designing heat-mass exchange processes and devices requires the methods of non-destructive measurement of the real surface area of such an exchange. Since this surface is, usually, very complicated, convolutions of images, obtained in the computer tomograph were proposed. Tomograms of synthetic granite, confirming the technical feasibility of such analysis method and its informativeness in terms of further heterogeneous structure investigation were obtained.

Three types of convolutions: convolution in the form of Hausdorff dimensions of the section boundaries, convolution using contraction mapping and convolution using parabolic transformation were considered. The presence of a maximum on the dependence of the heat-mass exchange rate on the working surface convolution results, which allows to formulate and solve the problems of optimizing the parameters of technological processes and designs of heat-mass exchange devices was theoretically justified and experimentally confirmed.

Practical testing of the proposed optimization method in designing the packed absorber was performed. As a result of using the proposed method, an increase in the absorber performance by 16–23 % without increasing its size was achieved.

Keywords: heat-mass exchange, heat-mass exchange surface, heterogeneous flows, computer tomogram, fractal convolution.

Referenses

1. prEN ISO 13790. Thermal performance of buildings (2002). Calculation of energy use for space heating, 10–31.
2. Valancius, K., Skrinska, A. (2002). Transient heat conduction process in the multilayer wall under the influence of solar radiation. Improving human potential program, 179–185.
3. Kavetskiy, G. D., Kasyanenko, V. P. (2008). Protsessy i apparaty pishchevoy tekhnologii, 591.
4. Realnaya struktura tverdogo tela (2006). Available at: http://www.fnm.msu.ru/documents/15real15.pdf (Last accessed: 12.07.2014).
5. Dytnerskiy, Yu. I. (1995). Protsessy i apparaty khimicheskoy tekhnologii, 1, 2.
6. Kostrova, G. V., Saveleva, O. S., Stanovskiy, O. L. (2011). Obladnannya naftogazovoi ta khimichnoi galuzi, 145.
7. Levin, G. G., Vishnyakov, G. N. (1989). Opticheskaya tomografiya, 224.
8. Natterer, F. (1990). Matematicheskiye aspekty kompyuternoy tomografii, 288.
9. Canny, J. (1986). A Computational Approach to Edge Detection. Transactions on pattern analysis and machine intelligence, IEEE, 6, 679–698.
10. Aizenberg, I., Butakoff, C. (2002). Image Processing Using Cellular Neural Networks Based on Multi-Valued and Universal Binary Neurons. Journal of VLSI Signal Processing Systems for Signal, Image and Video Technology, 32, 169–188.
11. Feder, Ye. (1991). Fraktaly, 254.
12. Nomoyev, A. V., Vikulina, L. S. (2012). Fraktalnaya razmernost granits zeren keramiki s nanodispersnymi dobavkami. Zhurnal tekhnicheskoy fiziki, 82 (12), 139–142.
13. Bozhokin, S. V., Parshin, D. A. (2001). Fraktaly i multifraktaly. NITs «Regulyarnaya i khaoticheskaya dinamika», 128.
14. Izmerov, M. A. (2006). Metody opredeleniya fraktalnoy razmernosti inzhenernykh poverkhnostey. Vestnik Bryanskogo gosudarstvennogo tekhnicheskogo universiteta, 3 (11), 10–19.
15. Mandelbrot, B. (2002). Fraktalnaya geometriya prirody, 656.
16. Lauwerier, H. A., Kaandorp, J. A. (1987). Fractals (Mathematics, Programming and Applications). Report CS-R8762, 1–33.
17. Lin, H., Venetsanopoulos, A. N. (1996). Fast pyramidal search for perceptually based fractal image compression. Department of Electrical and Computer Engineering, 1–4. doi: http://dx.doi.org/10.1109/icip.1996.559461
18. Fisher, Y., Prusinkiewicz, P. (1992). Fractal image compression. SIGGRAPH'92 Course Notes: From Folk Art to Hyperreality, 1–21.
19. Vostrov, G. N., Abu Ayash, T. A. (2001). Printsip szhimayushchikh otobrazheniy i ego primeneniye dlya fraktalnogo szhatiya izobrazheniy. Trudy Odesskogo politekhnicheskogo universiteta, 2 (14), 96–99.
20. Kronover, P. M. (2000). Fraktaly i khaos v dinamicheskikh sistemakh, 198.
21. Kolmogorov, A. N., Fomin, S. V. (1989). Elementy teorii funktsiy i funktsionalnogo analiza, 267.
22. Vostrov, G. M., Abu Ayash, T. A., Stanovskiy, P. O. (2005). Do pitannya pro fraktalne koduvannya videopotokiv. Naukovi noa tatki. Mizhvuzivskiy zbirnik, 17, 41–48.
23. Tonkonogiy, V. M., Stanovskiy, P. A. (2005). Videoobrabotka izobrazheniy v sisteme avtomaticheskogo izmereniya defektnosti iznosostoykikh pokrytiy na rezhushchem instrumente. Trudy Odesskogo politekhnicheskogo universiteta, 1 (23), 112–115.
24. Stanovskiy, P. O., Malakhov, E. V., Arsiriy, O. O. (2007). Rozrobka metodu fraktalnogo koduvannya-dekoduvannya videopotokiv. Trudy Odesskogo politekhnicheskogo univerk siteta, 2 (28), 113–116.
25. Laptev, A. G., Farahov, M. I., Mineev, N. G. (2010). Osnovy rascheta i modernizatsiya teplomassoobmennyh ustanovok v neftekhimii, 574.
26. Laptev, A. G., Nikolaev, N. A., Basharov, M. M. (2011). Metody intensifikatsii i modelirovanie teplomassoobmennyh protsessov, 335.
27. Skoblo, A. I., Molokanov, Yu. K., Vladimirov, A. I., Shchelkunov, V. A. (2000). Protsessy i apparaty neftegazopererabotki i neftekhimii, 677.

INCREASING OPERATING DURABILITY OF FINE-SIZE TOOL BY THE METHOD OF LOW-TEMPERATURE ION IMPLANTATION (p. 10-13)

Larisa Vasetskaya

The paper deals with increasing the operating durability of a fine-size tool. Applying this tool has economic benefits for producers since it leads to lower costs of the tool purchased. Using the method of low-temperature implantation, modified coatings of titanium and chromium nitride on tool steel substrates were obtained. Structure and physicomechanical properties of these coatings and their use as protective coatings on fine-size tools were investigated in the paper. Due to properly selected modes (U discharge=400 V, I discharge=0.5 a, U target=2 Q, I target=50 mA, U substrate=25 kV, 35 mA=I substrate, r gas=3.32–10–2 Pa) introduced ion dose (5.73–1016––6.73–1017 ion/cm^2), materials of the target (Ti and Cr) and substrate (R18 and HVG) as a result of experimental researches, high-quality protective coatings were produced, microhardness increased by 2.2–2.5 times. Practical use of research results has revealed an increase in operating durability of fine-size steel tool by 1.5–2 times. Applying ion-plasma treatment allows to produce steels with modified protective coatings and increase the operating durability of fine-size steel tools and small, but those that are key machine parts.

Keywords: ion implantation, titanium, chromium, modified coating, operating durability.

References

1. Krasilnikov, L. A., Krasilnikov, S. A. (1977). Volochilshchik provoloki. Moscow: Metallurgija, 240.
2. Chejlyah, A. P., Prekrasnyj, S. V., Shchetinin, S. D., Sushchenko, V. P. (2003). Povyshenie dolgovechnosti filyer s ispolzovaniem metastabilnyh sostoyanij v hromistyh instrumentalnyh stalyah. Metall I lityo Ukrainy, 33–35.
3. Vladimirov, V. I. (1988). Fizika iznosostojkosti poverhnosti metallov. Lviv: FTI, 230.
4. Jushchenko, K. A., Borisov, Ju. S., Kuznecov, V. D., Korzh V. M. (2007). Inzhenerija poverhni. Kiev: Naukova dumka, 558.
5. Pogrebnjak, A. D., Bratushka, S. N., Malikov L. V. (2009). Vlijanie vysokih doz ionov N+ , N+ + Ni+ , Mo+ + W+ na fiziko-mehanicheskie svojstva TiNi. Zhurnal tehnicheskoj fiziki, 79 (5), 65–72.
6. Shulaev, V. M., Andreev, A. A. (2007). O vlijanii atomarnogo azota na process sinteza vakuumno-dugovyh pokrytij Mo-N. ФІП ФИП PSE, 5, 1-2, 75–78.
7. Sergeeva, M. H., Kohanovskij, V. A. (2008). Nanostrukturnaja modifikacija poverhnosti. Vestnik DGTU, 8 (2), 192–195.
8. Sergeev, V. P., Fedorishheva M. V., Voronov, A. V. (2006). Mehanicheskie svojstva i struktura nanokompozitnyh pokrytij Ti1-xAlxN. Izvestija Tomskogo politehnicheskogo un-ta, 309 (2), 149–153.
9. Poleshchenko, K. N., Voloshina, I. G., Povoroznjuk, S. N., Remnev, G. E., Grinberg, P. B. Sposob uprochnenija tverdosplavnogo rezhushchego instrumenta. Patent 2167216 Ros. Federacija, MPK7 S 23 S 14/48. Zajavitel i patentoobladatel Omsk, gos. un-t, 99120890/02, 05.10.99, 20.05.01.
10. Remnev, G. E., Tarbokov, V. A. (2004). Povyshenie stojkosti tverdosplavnogo instrumenta metodom predvaritelnoj obrabotki moshchnym ionnym puchkom i osazhdenija nitrid-titanovogo pokrytija. Fizicheskaja mezomehanika, 329–332.
11. Ignatenko, P. I., Kljahina, N. A., Badekin, M. Ju. (2005). Struktura i svojstva plenok nitridov razlichnyh metallov, poluchennyh metodom ionnoj implantacii. Neorganicheskie materialy, 41 (1), 40–45.
12. Danilin, B. S. (1989). Primenenie nizkotemperaturnoj plazmy dlja nanesenija tonkih plenok. Moscow: Jenergoatomizdat, 324.

BASIC REGULARITIES OF THE FILTRATION DRYING OF WHEAT GRAIN (p. 14-18)

Iryna Matkivska, Volodymyr Atamanyuk, Dmitry Symak

This paper discusses the results of experimental investigations into the hydrodynamics and heat exchange specific to the filtration drying of wheat grain. The result of experimental investigations into the hydrodynamics has been generalized based on the inner problem, exterior problem and a mixed problem of hydrodynamics. The experimental data representations in the form of dimensionless numbers are easy-to-use in practice and enable determine the energy cost and the economic feasibility of the process. Determining the optimal parameters of filtration drying process was ensure by the investigation into heat exchange specificities and their generalization in the form of dimensionless numbers that would enable to compute the heat rejection factors, with the filtration modes and physical parameters of the heating medium being known. Obtained are the design dependences to determine the internal diffusion coefficients against the temperature of a heating medium and the initial moisture content of grains. The resulting design dependency may be used to predict the duration of the wheat grain filtration drying. Determined are the rational modes of drying for seed grain and food grain.

Keywords: wheat grains, moisture content, hydrodynamics, heat exchange, diffusion, drying kinetics.

References

1. Burlaka, N. I. (2012). Ukraine as a world exporter of grains. Scientific works VNAU, № 3(69), 36-41.
2. Voziyan, V. V., Lubich, V. V, Suhomud, O. H. (2013). Technological properties of grain of winter wheat varieties of different eco-heohafichnoho origin. Scientific works VNAU, № 1(71), 121-125.
3. Mujumdar, A. S., Kudre, T. (2001). Progress in drying technologies, Vol. 7, 459.
4. Snyezhkin, Y. F., Pazyuk, J. O., Petrova, Zh. O., Chalayev, D. M. (2012). Heat pump grain dryer for seed grain: monograph. Kyiv, 154.
5. Atamanyuk, V. M., Humnytskyy, Y. M. (2013). Scientific basis of filtration drying of dispersed materials. Lviv: Lviv Polytechnic National University Publishing House, 276.
6. Jayas, D. S., Ghosh, P. K. (2006). Preserving quality during grain drying and techniques for measuring grain quality. 9 th International Working Conference on Stored Product Protection, 969-980.
7. Fesenko, A. V. (2006). Improving tehnolohycheskoho of the effectiveness of the process of drying grain crop. Lugansk, 170.
8. Pronychev, S. A. (2007). Ympulsnaya ynfrakrasnaya semennoho grain drying. Moskov, 21.
9. Burdo, A. H., Bezbakh, I. V., Donkhlov, V. I. (2009). Kinetics of drying wheat in devices based on termosyfoniv. Collected Works ONAFT, Vol. 36, Issue 1, 297-302.
10. Vinokurov, K. V., Nikonorov, S. N., Sedelkina, V. M. (2005). Road intensification of the process of grain drying in the dryer drum. Materials II Intern. scientific-practical. conf. Modern energy-saving heating technology SETT-2005 (Moscow, 11-14 October. 2005), 1, 233-236.
11. Atamanyuk, V. M., Matkivska, I. Ja., Mosiuk, M. I. (2013). Hydrodynamic features filtration drying wheat. Collected Works ONAFT, Vol. 2, Issue 43, 10-16.
12. Atamaniuk, V. M., Huzova, I. A., Matkivska, I. Ja., Mazyar, G. O. (03.25.2013). Declaration. pat. a utility model UA-78453, IPC 2006.01. Installation of filtration dry bulk materials. u 2012 08120, Bull № 6, 4.
13. Matkivska, I. Ja., Symak, D. M., Atamanyuk, V. M. (2013). Heat and Mass Transfer during filtration drying wheat. Chemical Industry of Ukraine, №2, 55-59.
14. Matkivska, I. Ja., Atamanyuk, V. M., Barna, I. R. (2014). Kinetics of drying wheat filtration method. Bulletin of the National Technical University "KPI", №17, 130-138.
15. Lykov, A. V. (1967). The theory of heat conduction. M.: High School, 600.
16. DSTU 2240-1993. Crop seeds. Varietal and sowing qualities. Technical conditions. (1993). K.: State Standard of Ukraine, 74.

THE INFLUENCE OF ABSOLUTE MINIMUM ($L_1-\Delta_1$) TYPE INVERSION ON THE IONIZATION ENERGY OF THE GROUND STATE OF SHALLOW DONORS IN n-Ge SINGLE CRYSTALS (p. 18-21)

Sergiy Luniov

Based on the Ritz variational method and perturbation theory, ionization energy of shallow donors for the cases of L_1 and Δ_1 model of the conduction band of germanium single crystals was calculated. It was shown that the absolute minimum ($L_1-\Delta_1$) type inversion in n-Ge leads to a significant increase in ionization energy of shallow donors. Using the Ritz variational method allows more accurately describe the experimental results with respect to the calculation based on perturbation theory. Comparison of theoretical calculations with experimental data shows that the hydrogenlike impurity model is approximate and may be used only for Sb impurity in germanium. For impurities, such as, P and As chemical shift, that is "personality" of the ion field potential of each impurity, which is not Coulomb must be considered.

Keywords: perturbation theory, Ritz variational method, germanium single crystals, ionization energy, absolute minimum ($L_1-\Delta_1$) type inversion in n-Ge.

References

1. Selezenev, A. A., Aleinikov, A. Y., Ermakov, P. V., Ganchuk, N. S., Ganchuk, S. N., Jones, R. E. (2012). Molecular-dynamics calculation of the thermal conductivity coefficient of the germa-

nium single crystal. Physics of the Solid State, 54(3), 462–467. doi:10.1134/s1063783412030286
2. Baranskii, P. I., Fedosov, A. V., Gaidar, G. P. (2000). Physical properties of crystals of silicon and germanium in the fields of effective external influence. – Lutsk: Nadstyr'ya, 280.
3. Bir, G. L., Picus, G. L. (1972). Symmetry and Deformation Effects in Semiconductors. Moscow: Science, 584.
4. Baranskii, P. I., Ermakov, V. N., Kolomoets, V. V., Nazarchuk, P. F. (1987). Inversion of the energy bands under the influence of extremely large uniaxial elastic strain in n-Ge in conditions of transition metal-semiconductor (Mott transition). Abstracts of the XI International Conference MARIVD, Kiev. Proc. High pressure in science and technology, 127.
5. Luniov, S. V, Nazarchuk, P. F., Burban, O. V. (2013). Parameters of the high – energy Δ_1 – minimum of the conduction band in n-Ge. Journal of Physical Studies, 17 (3), 1–5.
6. Kobayashi, M., Irisawa, T., Magyari-Kope, B., Saraswat, K., Wong, H.-S. P., Nishi, Y. (2010). Uniaxial Stress Engineering for High-Performance Ge NMOSFETs. IEEE Transactions on Electron Devices, 57 (5), 1037–1046. doi:10.1109/ted.2010.2042767
7. Kobayashi, M., Irisawa, T., Kope, B., Yun Sun, Saraswat, K., Wong, H., Pianetta, S., Nishi, Y. (2009). GeO2/Ge interface formed by SPA radical oxidation and uniaxial stress engineering for high performance Ge NMOSFETs. Presented at VLSI Technology, 76–77.
8. Choi, Y. S., Lim, J.-S., Numata, T., Nishida, T., Thompson, S. E. (2007). Mechanical stress altered electron gate tunneling current and extraction of conduction band deformation potentials for germanium. Journal of Applied Physics, 102 (10), 104507. doi:10.1063/1.2809374
9. Peleshchak, R. M., Kuzyk, O. V., Dan'kiv, O. O. (2012). Energy Spectrum of Electrons in a Three-Layer Heterosystem with Self-Organized Defect-Deformation Structures. Ukr. J. Phys, 57 (8), 838–843.
10. Murphy-Armando, F., Fahy, S. (2011). Giant enhancement of n-type carrier mobility in highly strained germanium nanostructures. Journal of Applied Physics, 109 (11), 113–703. doi:10.1063/1.3590334
11. Kogan, Sh. M., Taskinboev, R. (1983). Spectra of shallow donors in germanium and silicon. Fizika i Tekhnika Poluprovodnikov, 17 (9), 1583–1586.
12. Wheeler, R., Dimmock, J. (1962). Exciton Structure and Zeeman Effects in Cadmium Selenide. Phys. Rev., 125 (6), 1805–1815. doi:10.1103/physrev.125.1805
13. Kohn, W. (1957). Shallow Impurity States in Si and Ge. Sol. St. Phys., 5, 257–320.
14. Baidakov, V. V., Ermakov, V. N., Grigorev, N. N., Kolomoets, V. V., Kudykina, T. A. (1984). Breakdown of Impurity States of As and Sb in Germanium at Uniaxial Compression. Phys. Stat. Sol. (b), 122 (2), K163–K167. doi:10.1002/pssb.2221220259
15. Gorin, A. E., Ermakov, V. N., Kolomoets, V. V. (1995). Intervalley redistribution of electrons due to impact ionization of shallow donors in uniaxially deformed Ge. Fizika i Tekhnika Poluprovodnikov, 29 (4), 1147–1151.

ABOUT FORMATION OF STRATUM HETEROGENEITY IN THE SILICON SINGLE-CRYSTALS (p. 22-25)

Anna Iakymenko, Ivan Chervony

The analysis of the impurity accumulation in the melt at the crystallization front during the silicon single crystal growing was performed, and the model of rapid crystallization in this melt region was considered. The following impurity redistribution model was applied: during the crystallization of a single layer of silicon, one impurity part is absorbed by the growing crystal, while the other part remains in the melt, enriching its frontal area. During the crystallization of the second silicon layer, the growing crystal absorbs impurity from the impurity-enriched melt after crystallization of the first atomic layer, etc. Thus, in the frontal region of the melt, stepwise impurity accumulation and concentration supercooling region formation take place, including a possible increase in its concentration to the critical value – achieving the occurrence of independent second phase. According to calculations by the equation, growing rate increases by 5...7 times, and conditions for the abrupt change in the growing rate and crystallization of the impurity-enriched melt layer are ensured. After abrupt crystallization, the impurity accumulation to a certain value and accelerated crystallization mode are repeated in the frontal area. To eliminate or significantly reduce the strata characteristics, it is proposed to apply high-rate single crystal growing modes, which eliminates the impurity accumulation at the crystallization front and ensure its homogenous distribution by a single crystal volume.

Keywords: silicon, crystallization front, single crystal, impurity, heterogeneity, strata, chip, concentration, supercooling, phase.

References

1. Lektsiya 17. Osnovnyie printsipyi nanotehnologii. Perspektivyi nanoteh-nologii v sistemah zapisi i hraneniya informatsii. Available at: http://rudocs.exdat.com/docs/index-247352.html (Last accesed: 10.09.2014).
2. Zakon Mura i ego vliyanie na mikroprotsessoryi. Sozdaem svoy protsessor. Available at: http://www.igropolis.com/articles/46496/Zakon_Mura_i_ego_vliyanie_na_mikroprocessory.htm] (Last accesed: 12.09.2014)
3. Friedrich, J., Stockmeier, L., Muller, G. (2013). Constitutional Supercooling in Czochralski Growth of Heavily Doped Silicon Crystals. Acta Physica Polonica, 124 (2), 219. Available at: http://connection.ebscohost.com/c/articles/89750179/constitutional-supercooling-czochralski-growth-heavily-doped-silicon-crystals (last accessed:10.09.2014).
4. 5th International Workshop on Crystal Growth Technology (2011). Berlin, Germany, 32. Available at: http://iwcgt5.ikz-berlin.de/fileadmin/pdf/IWCGT5_Abstractbook.pdf (Last accessed: 01.09.2014).
5. Patent RU 2257428. Byivalyiy. Sposob polucheniya odnorodnyih mono-kristallov. pulished 27.07.2005. Byul. № 2. Available at: http://www.freepatent.ru/images/patents/211/2257428/patent-2257428.pdf (Last accessed: 15.09.2014).
6. 5th International Workshop on Crystal Growth Technology (2011). Berlin, Germany, 79. Available at: http://iwcgt5.ikz-berlin.de/fileadmin/pdf/IWCGT5_Abstractbook.pdf (Last accessed: 15.08.2014).
7. Nashelskiy, A. Ya. (1972). Tehnologiya poluprovodnikovyih materialov. Moscow: Metallurgiya, 432.
8. Falkevich, E. S., Pulner, E. O., Chervonyiy, I. F., Shvartsman, L. Ya., Yarkim, V. N., Salli, I. V., Pulner, E. O., Chervonyiy, I. F. (1992). Tehnologiya poluprovodnikovogo kremniya. Moscow: Metallurgiya, 408.
9. Glazov, V. M., Zemskov, V. S. (1967). Fiziko-himicheskie osnovyi legirovaniya poluprovodnikov. Moscow: Nauka, 367.
10. Sluchinskaya, I. A. (2002). Osnovyi materialovedeniya i tehnologii polupro-vodnikov. Moscow: Nauka, 376. Available at: http://www.twirpx.com/file/96095/ (Last accessed: 17.08.2014).

CIRCUIT, TECHNOLOGICAL, PHYSICAL AND TOPOLOGICAL METHODS IMPROVE PERFORMANCE INTEGRAL COMPARATOR (p. 25-33)

Stepan Novosyadlyy

Performance comparators defined as circuit solutions and topological and technological improvements. This article aims to study existing integrated comparators, which held copyright modernization circuitry, topologies and technologies that improve their performance at least 2 times, which determines the feasibility of the article.

As a result of investigations by the original Schematic technological solutions to improve performance integrated comparators.

Its input stage must have high attenuation of commonmode component and the ability to withstand large commonmode and differential input signals which are not saturating, ie not getting into profiles from which the comparator will go long.

These solutions are implemented with technology integrated comparators as on mono-Si, and the gallium arsenide and thereby increase the reliability of integrated circuits and simplify the production process.

Such studies will be useful in the construction of high-speed VLSI structures where elements act as analogue and digital comparators.

Keywords: operational amplifier, one threshold analog comparator and hysteresis comparator, Schmitt comparator.

References

1. Koledov, J. A., Volkov, V. A., Dokuchaeva, N. K. (1992). Design and technology mikroschem. M.: Higher School, 231.
2. Chistyakov, Y. D. (1986). VLSI technology. M.: Mir, 453.
3. Aynspruk, N. U. (1988). Gallium arsenide microelectronics. M.: Mir, 554.
4. Di Lorenzo, A. V., Kandeluola, D. D. (1988). Field-effect transistors on gallium arsenide. M.: Radio and Communications, 489.
5. Watanabe, N., Asada, K., Kani, K., Otsuki, T. (1988). VLSI Design. M: Mir, 304.
6. Novosyadlyy, S. P. (2010). Sub-nanomykron technology structures LSI. Ivano-Frankivsk: City NV, 456.
7. Novosyadlyy, S. P. (2003). Physical and technological bases submicron VLSI. Ivano-Frankivsk: Simyk, 52-54.
8. Novosyadlyy, S. P. (2002). Radiation technology in the formation, submicron VLSI structures. Metal-physics and new technologies, 7, 1003-1013.
9. Novosyadlyy, S. P. (2002). Formation of silicon epitaxial structures for the combined VLSI. Metal-physics and new technologies, 24/3, 353-365.
10. Berezin, A. S., Mogalkin, A. R. (1992). Technology design IC. M.: Dis, 254.
11. Alexeenko, A. G. (2002). Bases microcircuitry. M.: Lab. knowledge bases, 286.
12. Pavlov, V. M., Nochin, V. M. (2001). Circuitry analog circuits. M.: Gor. mic appliances, 320.

A SIMULATION APPROACH TO STUDY OF ENTROPIC ELASTICITY PROPERTIES OF POLYMER CHAIN MOLECULES USING ATOMIC SCALE MONTE-CARLO (p. 34-39)

Michael Grankin, Anatoliy Kargin, Eduard Karpov

This paper describes atomic scale Monte–Carlo studies of entropic elasticity properties of individual polymer chain molecules. An efficient numerical Monte –Carlo sampling approach is outlined and used to evaluate the entropic contribution to the total elastic force.Theoretic predictions of mechanical properties of polymer molecules, particularly complex bio-molecules (proteins, lipids, etc.), are difficult due to effects of entropic elasticity. Entropic elastic force can be a significant contributor to the free energy F of the polymer chain and can even exceed interatomic potential energy U under external mechanical load. Monte-Carlo based approach allows to achieve atomic resolution for molecular structure in contrast to analytical methods. Specific load-extension curves are obtained numerically for a group of molecules with degenerate potential energy profiles. Results of the atomistic modeling are compared with the limiting continuum model of the same type of polymers. The extent of the linear and nonlinear elastic regimes and dependence on the molecular weight and geometric parameters of the molecules are discussed. A significant divergence with the continuummodel behavior is observed at smaller bond angles for all elongationsof the molecule. Linearity of the entropic force exists in a wide range ofthe elongations, however, molecules with low gyration radii(densely packedpolymers) are linear mostly in extensionor unfolding, while very sparsely packed molecules are linear mostly in thecontraction mode. The achieved result cannot be reproduced withinthe settings of the continuum model and required an application of atomic scale Monte-Carlo approach developed by our group.

Keywords: Monte-Carlo, model, simulation, entropy, elasticity, polymers, monomers, properties, radius, gyration.

References

1. Zuckerman, D. M. (2010).Statistical Physics of Biomolecules: An Introduction. CRC Press, 356.
2. Bhutani, S. P. (2010). Chemistry of Biomolecules. CRC Press, 304.
3. Stroble, G. (2007). The Physics of Polymers: Concepts for Understanding Their Structures and Behavior. Springer, 518.
4. Broedersz, C. P., Storm, C., MacKintosh, F. C. (2008). Nonlinear elasticity of composite networks of stiff biopolymers with flexible linkers. Phys. Rev. Lett., 101(11), 118103–118107. doi: 10.1103/PhysRevLett.101.118103
5. Landau, L. D., Lifshitz E. M. (1980). Statistical Physics. 3rd ed. (Course of TheoreticalPhysics, Vol. 5). Butterworth-Heinemann, 544.
6. Laurendeau, N. (2005). Statistical Thermodynamics for Ideal Gas Mixtures. Fundamentals and Applications, 205–222. doi:10.1017/cbo9780511815928.015
7. Strick, T. R., Dessinges, M. N., Charvin, G. (2003). Stretching of macromolecules and proteins.Reports on Progress in Physics, 66, 1–45. doi: 10.1088/0034-4885/66/1/201.
8. Gardiner, C. W. (2004). Handbook of Stochastic Methods. Springer, 442.
9. Karpov, E. G., Chaichenets, S., Liu, W. K. (2010).Mechano-kinetic coupling approach for functional materials with dynamic internal structure.Philosoph. Mag. Lett. 90(7), 471–480. doi: 10.1080/09500831003761933
10. Borsali, R., Pecora, R. (2008). Soft-Matter Characterization. Springer, 1452.
11. Karpov, E. G., Grankin. M. V. (2012). Atomic Scale Monte-Carlo Studies of Entropic Elasticity Properties of Polymer Chain Molecules.Adv. inSoftMatterMech., 147–163. doi: 10.1007/978-3-642-19373-6_5.

THE EFFECT OF THE HEAT TREATMENT ON THE STRUCTURE AND PROPERTIES OF SINTERED TiC-Ti-Ni, TiC-Ni-Fe ALLOYS (p. 39-45)

Vladimir Pashynsky, Mariia Subbotina

The features of heat treatment effect on the phase composition and crack resistance of sintered tool metastable-bunch alloys, hardened with TiC, were considered in the paper. Due to the fact that one of the major failure mechanisms of the tool, for the manufacture of which these alloys (forming rolls, bandages) were designed, is the crack network formation, the problem of decreasing brittleness of materials is of great scientific and practical value. Alloys with compositions 23 % Ti-27 % Ni and 39 % Ti-11 % Ni (+50 % TiC); as well as 19 % Ni+46 % Fe (+35 % TiC); 10%Ni+40 % Fe (+50 % TiC) and 40 % i+10 % Fe (+50 % TiC) were considered. Crack resistance indicators of alloys along the length of the radial crack from hardness indentations in the as-sintered and as-annealed condition at t=800...1100 °C were defined. It was shown that the reduction in crack resistance parameters provokes annealing at t=800..1000 °C for the alloy 19 % Ni+46 % Fe (+35 % TiC), t=800 °C, 900 °C and 1100 °C for 40 % Ni+10 % Fe (+50 % TiC), 1100 ˚C – 10 % Ni+40 % Fe (+50 % TiC), respectively. This condition is accompanied by the presence of intermetallic compounds in the microstructure. The data obtained allow to recommend the use of alloys in the as-sintered condition, and avoid prolonged exposure of embrittlement temperatures during operation of products from them.

Keywords: powder alloy, titanium carbide, sintering, phase composition, brittleness, indentation.

References

1. Pashinskiy, V. V., Lisovskiy, A. I., Manshilin, A. G., et. al. (2010). Teoriya, tekhnologiya i praktika proizvodstva tverdosplavnykh

prokatnykh valkov. Metallurgicheskie protsessy i oborudovanie, 1 (19), 4–10.
2. Lyakishev, N. P. (Ed.) (1997). Diagrammy sostoyaniya dvoynykh metallicheskikh sistem. Spravochnik. Vol. 2. Moscow: Mashinostroenie, 1024.
3. Kitsai, A. A. (1999). Change in porosity of TiC-(Fe, Ni) composite on reaction with molten iron-Nickel. Powder Metallurgy and Metal Ceramics, 38, 1–2. doi: 10.1007/BF02675880
4. Ye, Y. Z., Liu, R., Li, D. Y., Eadie, R. (1999). Development of a new wear-resistant material: TiC/TiNi composite. Scripta Materialia, 41 (10), 1039–1045. doi: 10.1016/S1359-6462(99)00236-5
5. Yan, Y., Zheng, Y., Yu, H., Bu, H., Cheng, X., Zhao, N. (2007). Effect of sintering temperature on the microstructure and mechanical properties of Ti(C, N)-based cermets. Powder Metallurgy and Metal Ceramics, 46 (9-10), 449–453. doi: 10.1007/s11106-007-0070-0
6. Li, Y., Luo, Y. C. (2001). Effects of TiN nano-particles on porosity and wear behavior of TiC/TiNi tribo composite. Journal of Materials Science. Letters, 20, 2249–2252.
7. Pashinskiy, V. V., Babenko, M. A., Manshilin, A. G., Sidorenko, D. G. (2004). Analiz opyta ekspluatatsii i povyshenie effektivnosti ispol'zovaniya tverdosplavnykh prokatnykh valkov diskovogo tipa. Metall i lit'e Ukrainy, 8-10, 68–70.
8. Liu, Y, Blanc, M., Tan, G., Kim, J. I., Miyazaki, S. (2006). Effect of ageing on the transformation behaviour of Ti–49.5 at. % Ni. Materials Science and Engineering A, 438-440, 617–621. doi: 10.1016/j.msea.2006.02.165
9. Vaidyanathan, R., Dunand, D. C., Ramamurty, U. (2000). Fatigue crack-growth in shape-memory NiTi and NiTi-TiC composites. Materials Science and Engineering A, 289 (1-2), 208–216. doi: 10.1016/S0921-5093(00)00882-0
10. Ren, Y. L., Qi, L., Fu, L. M., et. al. (2002). Microstructural chaM racteristics of TiC and (TiW)C iron matrix composites. Journal of Materials Science, 37 (23), 5129–5133.
11. Choi, Y. (2014). Characterization of quasi-nano-sized TiC_x-Ni-Fe thin composite sheet prepared by using self-propagating high-temperature synthesis reaction and electroforming. Metals and Materials International, 20 (3), 531–535. doi: 10.1007/s12540-014-3019-0
12. Burkes, D. B., Gottoli, G., Yi, H. C., Moore, J. J. (2006). Combustion synthesis and mechanical properties of dense NiTi-TiC intermetallic-ceramic composites. Metallurgical and Materials Transactions A, 37 (1), 235–242. doi: 10.1007/s11661-006-0168-x
13. Burkes, D. B., Gottoli, G., Yi, H. C., Moore, J. J. (2006). Production of Ni_3Ti-TiC_x intermetallic-ceramic composites employing combustion synthesis reactions. Metallurgical and Materials Transactions A, 37 (3), 1045–1053. doi: 10.1007/s11661-006-0077-z
14. Dub, S. N., Ignatusha, A. I. (1991). Tverdost' i treshchinostoykost' materialov na osnove plotnykh modifikatsiy BN. Sverkhtverdye materialy, 1, 34–36.
15. Novikov, N. V., Dub, S. N., Bulychev, S. I. (1987). Metody miroispytaniy na treshchinostoykost'. Zavodskaya laboratoriya, 7, 60–67.
16. Pashynsky, V., Subbotina, M., Sidorenko, D. (2013). Research of the structure and phase composition of the powder alloy based on titanium carbide. XIV International Scientific Conference "New technologies and achievements in metallurgy and material engineering", Chenstohowa, Poland, 2, 151–156.
17. Ye, H. Z., Liu, R., Li, D. Y., Eadie, R. (1999). Development of a new wear-resistant material: TiC/TiNi composite. Scripta Materialia, 41 (10), 1039–1045. doi: 10.1016/S1359-6462(99)00236-5
18. Gupta, K. P. (2001). The Fe-Ni-Ti System Update (Iron-Nickel-Titanium). J. Phase Equil., 22, 171–175. doi: 10.1361/105497101770339148
20. Raghavan, V. (2012). Fe-Ni-Ti (Iron-Nickel-Titanium). J. Phase Equil. and Dif., 33 (3), 238–239. doi: 10.1007/s11669-012-0071-7

ELECTRICAL CONTACT RESISTANCE RESEARCH OF GRAPHITE WITH COPPER AND TERMO-EXPANDED GRAPHITE (p. 45-49)

Anton Karvatskii, Serhii Leleka, Igor Pulinets, Taras Lazarev, Anatoliy Pedchenko

The experimental setup for measuring the specific electrical contact resistance (SECR) of solids contact pairs, depending on the compression pressure and temperature, has been developed.

In the development of graphitization furnaces numerical models the electrical properties of the contact interaction of copper-graphite, graphite-graphite, using a gasket of thermo-expanded graphite, are important. Resistance of the contact portions is always greater than the contacting elements, thus, there are additional losses of energy in these regions. This affects the thermoelectric state of furnaces. The relevance of this study is determined by the absence of data concerning the contact resistance of graphite-gasket- graphite in the literature.

The most difficult task in the investigation of the contact resistance transition is to determine the actual contact area, the value of which depends on the nature of the microscopic bulge deformation. The theoretical solution to the problem concerning the actual contact area of real surfaces is very difficult, that is why experimental methods have become widespread in the study of the electrical solids contact resistance.

As a result of research, the following experimental data was observed: SECR of the copper-graphite at compression pressure of 1–7 MPa and under the temperature 16 °C; SECR of the graphite-gasket-graphite at constant pressure of 1,7 MPa under the temperature range 16–250 °C with subsee quent extrapolation to 3000 °C.

The experimental data of the SECR contact pairs of copper-graphite and graphite-gasket-graphite is necessary for the priori estimation of graphitization furnace thermoelectric state during their development, modernization and also for electrothermal equipment of other industries.

Keywords: specific electric contact resistance, copper, graphite, thermo-expanded graphite, pressure, temperature.

References

1. Ionov, S. H., Pavlov, A. A., Savchenko, D. V., Seleznev, A. N., Avdeev, V. V., Fokin, V. P., Obidennaya, N. P. (2009). RU Patent No. 2,343,112. Moscow: Rospatent, 11.
2. Chalykh, Ye. F. (1990). Equipment of electrode plants. M.: Metallurgy, 238.
3. Lutkov, A. I. (1990). Thermal and electrical properties of carbon materials. M.: Metallurgy, 175.
4. Shlykov, Yu. P., Hanin, E. A., Tsarevskiy, S. N. (1977). Contact thermal resistance. Moscow: Energy, 328.
5. Slade, P. G. (2014) Electrical Contacts: Principles and Applications, 2nd ed. Florida, USA.: CRC Press, 1268. . doi: 0.1201/b15640
6. Yovanovich, M. M. (2005). Four decades of research on thermal contact, gap, and joint resistance in microelectronics. IEEE Trans. Comp. Packag. Technol., 28 (2), 182–206. doi:10.1109/tcapt.2005.848483
7. Richard, D., Fafard, M., Lacroix, R., Cléry, P., Maltais, Y. (2003). Carbon to cast iron electrical contact resistance constitutive model for finite element analysis. Journal of Materials Processing Technology, 132 (1-3), 119–131. doi:10.1016/s0924-0136(02)00430-2
8. Pradille, C., Bay, F., Mocellin, K. (2010). An Experimental Study to Determine Electrical Contact Resistance. 2010 Proceedings of the 56th IEEE Holm Conference on Electrical Contacts, 1–5. doi:10.1109/holm.2010.5619522
9. Song, Q., Zhang, W., Niels, B. (2005). An experimental study determines the electrical contact resistance in resistance welding. Welding Journal, 92 (2), 73–76.
10. Panov, E. N., Leleka, S. V., Korzhik, M. V. (2005). Complex collection of data for high-temperature industrial units. Kiev: PiCAD, 2, 28–30.
11. Myshkin, N. K., Konchyts, V. V., Braunovitch, M. (2008). Electrical contacts. Moscow: Intelekt, 560.

REGULATION OF THE STRUCTURE FORMATION OF CERAMIC MASSES OF THE SYSTEM MULTIMINERAL CLAY– KAOLIN-FELDSPAR RAW MATERIALS (p. 49-55)

Tat'yana Oksamyt

Polymineral clay raw materials with absent sintering interval was selected as the main raw material for the synthesis

of ceramic masses, production of ceramic clinker for various purposes using the plastic extrusion method.

Kaolin and pegmatite from the Khmelivskyi deposit that may act as fluxing agents were selected as kaolinite-feldspar raw materials.

Methods of directed structure formation regulation of ceramic masses based on polymineral clay raw materials using kaolinite-natural feldspar raw materials were investigated.

Using mathematical planning, mathematical models of interaction and influence of various technological factors on the properties of experimental masses were developed. Using the correlation analysis method, the relationships in the system polymineral clay-kaolinite-natural feldspar raw materials were examined.

Based on the ceramic mass 9 and 11 of the system polymineral clay-montmorillonite-substandard kaolin-pegmatite of the Khmelivskyi deposit, possibility to produce ceramic clinker by optimizing the chemical-mineralogical composition, and masses with a wide sintering interval was shown.

Keywords: structure formation, chemical-mineralogical composition, mathematical model, fusible clay, substandard kaolin, pegmatite, sintering interval, ceramic clinker, composition, properties.

References

1. Butt, Y. M., Dudarev, G. N., Matveeva, M. A. (1962). General technology of silicates. Gostroyizdat, 457.
2. Budnikov, P. P., Gentle, A. S., Bulavin, I. A. (1950). Technology keramiki and refractories. State. Ed. Lita. by stroit.mater, 575.
3. Frost, I. I. (1961). The technology of building ceramics. Gostroyizdat USSR, 464.
4. Avgustinik, A. I. (1975). Ceramics. Stroyizdat, 560.
5. Sokolov, Y. A (1973) Clinker and its production. Publ gueosdor.
6. Dudarev, I. G, Matveev, G. M., Sukhanov, V. B. (1987). General technology sylikatov. Stroyizdat, 560.
7. Hodakovska, T. V., Ogorodnik, I. V., Dimitrenko, N. D. (2006). Keramichny klinker for oblichkuvannya fasadiv i brukuvannya dorig s vikoristannyam polovoshpatvmisnoï sirovini. Construction materials and sanitary equipment, 22, 60–67.
8. Yakimchuk, T. V., Ogorodnik, I. V., Doniy, O. M., Dimitrenko, N. D. (2008). Mathematical, modelyuvannya skladiv weight for virobnitstva keramichnoï klinkernoï tsegla on osnovi clay Kiïvskoï of Region. Budivelni that meriali that virobi, 1, 23–27.
9. Pavlov, V. F. (1977). Physico-chemical basis of constructed firing keramiki. Stroyizdat, 270.
10. Kruglitsky, N. N., Nichiporenko, S. P., Granovsky, I. G. (1976). Physico-chemical mechanics of disperse structures in magnetic fields. Sciences. Dumka, 193.

INFLUENCE OF GRINDING-POLISHING OF NATURAL STONE ON ITS SHINE AND LIGHTNESS SHADES (p. 56-60)

Volodymyr Shamray, Valentyn Korobiychuk

An important problem of stone processing enterprises is decorativeness control of natural stone products. Among many different methods that allow to change natural stone decorativeness parameters, textured surface finishing is the most common. In the study of products from Pokostivske granodiorite, color and lightness classification was proposed. Depending on the stone surface roughness, a change in the stone lightness and shine was investigated. Using the fine-grained diamond tool, stone sample darkening is achieved by reducing the stone surface roughness. Stone lightness can be adjusted to ensure minimum differences in their future use. Ensuring minimum differences of the polished stone surface is possible for species with the same color and adjusted for a stone with red and blue color (from light to dark); for a stone with blue color (from dark to very dark). In the future, it is important to solve the problem of labeling different types of blocks that will ensure their recognition and selection of the grinding-polishing procedure to provide the desired lightness shade.

Keywords: stone lightness, Pokostivske granodiorite, grinding-polishing, stone glitter, stone color, stone surface roughness.

References

1. Dawei, W., Xianhua, C., Markus, O., Helge, S., Bernhard, S. (2014). Study of micro-texture and skid resistance change of granite slabs during the polishing with the Aachen Polishing Machine. Wear, 318 (1-2), 1–11. doi: 10.1016/j.wear.2014.06.005
2. Hideo, A., Hidetoshi, T., Seong-Woo, K., Natsuko, A., Koji, K., Tsutomu, Y., Toshiro, D. (2014). Evaluation of subsurface damage in GaN substrate induced by mechanical polishing with diamond abrasives. Applied Surface Science, 292, 531–536. doi: 10.1016/j.apsusc.2013.12.005
3. Xie, J., Tamaki, J. (2007). Parameterization of Micro-Hardness Distribution in Granite Related to Abrasive Machining Performance. Journal of Materials Processing Technology, 186 (1-3), 253-258. doi: 10.1016/j.jmatprotec.2006.12.041
4. Yavuz, H., Ozkahraman, T., Demirdag, S. (2011). Polishing experiments on surface quality of building stone tiles. Construction and Building Materials, 25 (4), 1707–1711. doi: 10.1016/j.conbuildmat.2010.10.016
5. Ozguven, A., Ozcelik, Y. (2013). Investigation of some property changes of natural building stones exposed to fire and high heat. Construction and Building Materials, 38, 813–821. doi: 10.1016/j.conbuildmat.2012.09.072
6. Vazquez, M., Galan, E., Guerrero, M., Ortiz, P. (2011). Digital image processing of weathered stone caused by efflorescences: A fool for mapping and evaluation of stone decay. Construction and Building Materials, 25 (4), 1603–1611.
7. Kalchuk, S. V., Kamskikh, O. V., Chehuta, S. O. (2009). Research of influencing of aggressive environment on change of saturation of colour of surface of decorative stone. News of ZSTU. Technical sciences, 1 (48), 196–201.
8. Bakka, M. T., Korobiichuk, V. V., Zubchenko, E. A. (2006). Processing of natural stone: study guide. Zhytomyr, ZSTU, 438.
9. Kryvoruchko, A. A., Kamskikh, O. V., Lomakov, G. M. (2011). Research of influencing of textured finishes on decorativeness of natural stone products. News of ZSTU. Technical sciences, 2 (57), 141–145.
10. Kryvoruchko, A. A., Iskov, S. S., Lomakov, G. M. (2009). Formation of ornamental stone coloration. Part 1. Natural coloration of stones. News of ZSTU. Technical sciences, 2 (49), 122–130.

ANALYSIS OF IMPACT OF LEIKONAT HARDENER AND MICROWAVE ENERGY ON THE ADHESIVE JOINT STRENGTH (p. 61-65)

Olesya Medvid, Valentyna Oliynykova, Lydmila Svistunova

A new polychloroprene adhesive composition with increased adhesion strength for gluing bottom parts of footwear was theoretically developed and practically created. The dependence of its holding strength on the content of fillers: modified kaolin, diphenyl guanidine, carbon black DG-100 and leikonat hardener and its benefits in terms of physicomechanical and chemical indicators was proved.

As a result of the research, an increase in the adhesion strength of polychloroprene adhesives for footwear manufacture was achieved. The main components of the polychloroprene adhesive composition are nairit NT, gasoline BR1 or BR2, ethyl acetate of the grade A, modified kaolin, diphenyl guanidine, carbon black DG-100 and leikonat. Adding 5 % leikonat and microwave energy irradiation increases adhesion strength by 59 %. Modified adhesive composition can be recommended for the manufacture of special footwear.

The technological standards and modes of assembly of uppers and footwear using microwave energy and modified adhesives in the footwear industry to improve the physicomechanical properties of ready shoes were determined.

Keywords: polychloroprene, adhesive composition, leyconate, microwave energy, adhesion strength, ethyl acetate, hardener, adhesion.

References

1. Fomchenkova L. N. (2006). Sovremennye obuvnye klei otechestvennogo proizvodstva. Kozhevenno-Obuvnaya Promishlennost, 2, 30–34.
2. Danilova, Yu., Gvozdev, Yu. (2006). Issledovanie kleevyh podoshvennyh soedineniy v dinamicheskih usloviyah. Kozhevenno-Obuvnaya Promishlennost, 5, 42–43.
3. Kozar, O. P., Mokrousova, O. R., Konoval, V. P. (2013). Deformation characteristics of genuine leather, manufactured using natural minerals. Programme and adstracts of Baltic Polymer Symposium. Vilnius University, 141.
4. Kozar, O. P., Oliynykova, V. V., Konoval, V. P. (2013). Improvement of Thermal Polyurethane Adhesive Compositions Parameters by Modification with Zeolite. Key Engineering Materials, 559, 81–85. doi: 10.4028/www.scientific.net/kem.559.81
5. Kozar, O., Mokrousova, O. (2013). Eco-friendly technologies of leather manufacturing with using natural minerals montmorilonite and zeolite. Technology audit and production reserves, 6/2(14), 11–15. Available at: http://journals.uran.ua/tarp/article/view/19499/17168
6. Kozar, O., Mokrousova, O., Woznyak, B. (2014). Deformation characteristics of leather for shoe upper, filled with natural minerals. Journal of Chemistry and Chemical Engineering, 8 (1), 47–53.
7. Morozov, O., Kargin, A., Savenko, G., Trebuh, V., Vorobjev, I. (2010). Promishlennoe primenenie SVCH-nagreva. Elektronika: Nauka, Technologia, Biznes, 3, 2–6.
8. Standard ISO20234:2012 (E). Requirements for clothing and footwear of special purpose.
9. Medvid, O., Oliynikova, V. V. (2013). Patent UA 81312. Department of Intellectual Property of Kyiv National University of technology and design.
10. ТУ 6-14-95-85 (1985). Adhesive Leikonat. Specifications Intr. 01.08.1985 to 01.08.1990. Standards Press. Moscow.
11. State Standard 22307-77 (1976). Shoe adhesives. The strength of adhesive bonds test in shear and peel. Part 1; Intr. 01.07.77 to 01.07.90. Prolonged 01.07.91 to 01.07.04. - Standards Press. Moscow.