ABSTRACT AND REFERENCES

MATERIALS SCIENCE

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A STUDY OF THE EFFECT OF DEPOSITION CONDITIONS ON THE PHASE-STRUCTURAL STATE OF ION-PLASMA WC – TiC COATINGS (p. 6-13)

Oleg Sobol`
National Technical University "Kharkiv Polytechnic Institute", Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-4497-4419

Osman Dur
Hacettepe University Technopolis, Ankara, Turkey
ORCID: http://orcid.org/0000-0001-5824-2780

Studies of the influence of thermal and radiation factors on the elemental composition and phase-structural state of WC-TiC ion-plasma condensates of a quasibinary system are presented. As a thermal factor, we used different substrate temperatures during deposition and temperatures of high-temperature annealing of coatings after their deposition. The influence of the radiation factor was changed by applying a negative bias potential of different magnitudes to the substrate during coating deposition. It was found that with a change in the substrate temperature during deposition (in the temperature range 80–950 °C), a change occurs in the elemental composition of the coating. With an increase in the deposition temperature, the relative content of heavy metal atoms W increases and the relative content of Ti and C atoms decreases. At the phase-structural level, this leads to a change from the single-phase state ((W, Ti)C supersaturated solid solution at a deposition temperature of less than 700 °C) to two-phase ((W, Ti)C and α-W_2C phases at a deposition temperature of more than 700 °C). The use of high-temperature annealing of coatings after their formation showed a relatively low decay activation efficiency. At an annealing temperature of 800 °C, a noticeable change in the phase-structural state is not observed, and at the highest temperature of 1000 °C and holding for 2 hours, the content of the α-W_2C phase is relatively small and does not exceed 15 vol %. The supply of a bias potential stimulates the formation of a two-phase state from (W, Ti)C and α-W_2C phases with nanometer crystallite size. With an increase in the bias potential from –50 V to –115 V, the average crystallite size decreases from 4.5 nm to 3.8 nm.

The use of structural engineering methods in the work to create two-phase materials based on a quasibinary WC-TiC system is the basis for increasing the strength and crack resistance of coatings of such systems.

Keywords: quasibinary system, elemental composition, substrate temperature, bias potential, supersaturated solid solution.

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IMPROVING CONTACT DURABILITY OF POLYCRYSTALLINE SYSTEMS BY CONTROLLING THE PARAMETERS OF LARGE-ANGLE GRAIN BOUNDARIES (p. 14-22)

Viacheslav Kopylov
National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Kyiv, Ukraine
ORCID: http://orcid.org/0000-0002-1789-3226

Oleg Kuzin
Lviv Polytechnic National University, Lviv, Ukraine
ORCID: http://orcid.org/0000-0003-3669-0237

Nickolay Kuzin
Lviv branch of Dniprovsk National University of Railway Transport named after Academician V. Lazaryan, Lviv, Ukraine
ORCID: http://orcid.org/0000-0002-6032-4598

Polycrystalline metal systems in the samples made of steel 40X with different morphology and parameters of the distribution of large-angle grains boundaries for energy have been examined. The effect of the structural-energy state of grains boundaries on the operational reliability of improved steel 40X has been established. Based on the hierarchical modeling of polycrystals structure, new approaches have been proposed and algorithms have been developed for defining relationships between the structure that is formed in the technological processing of materials and stages in the life cycle of parts. It has been revealed that it is advisable to use, as a digital prototype of the structure of polycrystalline alloys that describes their performance under conditions of contact loads, the matrix representation of a system model that would incorporate the quantitative characteristics of grains. By using the devised procedures, the ways to execute technological control over the energy state of grain boundaries in the structural components have been defined in order to improve durability of parts exposed under contact loads. An estimation-experimental method has been developed to assess the effect of quantitative characteristics of the structure on the parameters of strength of the grains boundaries and their ability to form intragrain damage under external loads. The energy level of grains boundaries and triple joints between the groups of small and large grains is higher than that between grains of the same size. The boundary surfaces with a high level of energy are places where damage occurs at technological processing and under external loads on structural materials. This points to the crucial role of large-angle boundaries placed between triple joints with a high energy gradient in the process of forming microstructurally short cracks and intragrain destruction of polycrystalline systems. The use of hierarchical modeling methods and computational materials science makes it possible to improve the operational reliability of articles by choosing the optimal parameters for internal boundary surfaces. The lower cost of the parts' life cycle is achieved by thermal treatment regimes, which alter the quantitative characteristics of the steel structure.

Keywords: systemic modeling, hierarchical models, computational materials science, polycrystals, energy of grains boundaries, durability.

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EXPERIMENTAL STUDY OF CAVITATION DESTRUCTION OF A PROTECTIVE COMPOSITE POLYURETHANE-BASED MATERIAL (p. 23-28)

Anatoly Ischenko
Pryazovskyi State Technical University, Mariupol, Ukraine
ORCID: http://orcid.org/0000-0002-6189-7830

Dmitry Rassokhin
Pryazovskyi State Technical University, Mariupol, Ukraine
ORCID: http://orcid.org/0000-0002-3479-9485

Elena Nosovskaya
Pryazovskyi State Technical University, Mariupol, Ukraine
ORCID: http://orcid.org/0000-0002-1313-4767

Studying the process of cavitation has remained relevant up to now. The reason for this is the multifactorial causes of cavitation and, as a result, the difficulty to prevent it. One effective way to fight cavitation destruction is to use specialized materials resistant to cavitation erosion in pumping equipment, in order to form a basis, for example, for manufacturing a new impeller.

In order to protect surfaces from cavitation, a specialized material has been developed based on polyurethane (DC-2), which makes it possible to resist cavitation without destroying the protective layer itself. An impact method was chosen to determine the effectiveness of applying the developed material. Its essence implies exposing a prototype to cyclic impact loading. To estimate the capability of the examined material to resist impact loading, we have designed samples in the form of cylinders with the thickness of the examined samples chosen based on the practical conditions for restoring equipment, namely, based on the optimal thickness of the applied material at restoration. Values for the layer's thickness were experimentally set within 2–5 mm. Experimental loading of the examined samples has shown the high efficiency of using the developed material as protection during the cavitation destruction of a part for different loading modes. Given that the polymeric material DC-2 has a high level of liquid fluidity, it was proposed to add a thickener in the form of a glass-containing filler the type of "Orosil". In addition, considering the complex type of wear in pumping equipment, it was suggested to strengthen the polymeric material with finely dispersed abrasive particles. The current work involved an experimental testing of the effect of additional inclusions on the strength of the polymeric layer.

Keywords: protection of surfaces against cavitation, polyurethane-based material, cavitation resistance of materials.

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THE EFFECT OF TEMPLATE RESIDUAL CONTENT ON SUPERCAPACITIVE CHARACTERISTICS OF $Ni(OH)_2$, OBTAINED BY TEMPLATE HOMOGENEOUS PRECIPITATION (p. 29-37)

Valerii Kotok
Ukrainian State University of Chemical Technology, Dnipro, Ukraine
Vyatka State University, Kirov, Russian Federation
ORCID: http://orcid.org/0000-0001-8879-7189

Vadym Kovalenko
Ukrainian State University of Chemical Technology, Dnipro, Ukraine
Vyatka State University, Kirov, Russian Federation
ORCID: http://orcid.org/0000-0002-8012-6732

Nickel hydroxide is widely used in hybrid supercapacitors. High electrochemical activity is demonstrated by α-$Ni(OH)_2$ prepared by template homogeneous precipitation. A possible disadvantage of template synthesis is the inclusion of template into nickel hydroxide and the lack of data on its residual content. Multiple rinsing method was proposed for lowering the content of template residue. The comparative study was conducted for the influence of residual template content and its use without the introduction of external binders. To conduct the study, samples of $Ni(OH)_2$ were prepared by template homogeneous precipitation using ether cellulose template Culminal C8465 with a concentration of 0.5 %. The structural properties of the sample were studied by means of X-ray diffraction analysis and sample morphology – by means of scanning electron microscopy. Electrochemical characteristics were studied by means of galvanostatic charge-discharge cycling of pasted electrode prepared without and with 3 % of the binder in the supercapacitor regime. It was found that with the use of an external binder, the specific capacity of the sample with a high content of template residue is very low because of blocked active surface. When this sample was used without the introduction of an external binder, the specific capacity increases by 1.8–18.4 times. The decrease in the content of template residue due to one-stage rinsing improved the specific capacity of the samples insignificantly. It was found that two- and three-stage rinsing is optimal, in which the specific capacities of the samples improved by 4.3–53.9 times, to 490 F/g and 50.7 mA·h/g. The higher number of rinsing stages (lower content of template residue) results in a decrease of specific characteristics. It is possible that there is an optimal template content, at which the negative effect of the template is balanced with blocking the active surface and the positive effect – with stabilizing the nano-sized hydroxide particles. It is recommended to experimentally establish the optimal number of rinsing stages to form the optimal content of template residue for a specific template.

Keywords: nickel hydroxide, template synthesis, homogeneous precipitation, supercapacitor, binder, residual content.

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STUDYING THE TRIBOLOGICAL PROPERTIES OF CONNECTING MATERIALS C61900 - A48-25BC1.25BNo.25 IN COMPOSITION OILS WITH GEOMODIFICATORS (p. 38-47)

Viktor Aulin
Central Ukrainian National Technical University, Kropyvnytskyi, Ukraine
ORCID: http://orcid.org/0000-0003-2737-120X

Andrii Hrynkiv
Central Ukrainian National Technical University, Kropyvnytskyi, Ukraine
ORCID: http://orcid.org/0000-0002-4478-1940

Sergii Lysenko
Central Ukrainian National Technical University, Kropyvnytskyi, Ukraine
ORCID: http://orcid.org/0000-0003-0845-7817

Oleg Lyashuk
Ternopil Ivan Puluj National Technical University, Ternopil, Ukraine
ORCID: http://orcid.org/0000-0003-4881-8568

Taras Zamota
Volodymyr Dahl East Ukrainian National University, Severodonetsk, Ukraine
ORCID: http://orcid.org/0000-0002-9904-4518

Dmytro Holub
Central Ukrainian National Technical University, Kropyvnytskyi, Ukraine
ORCID: http://orcid.org/0000-0003-4984-1161

With the development of dispersed systems in tribology, there emerged a possibility to use effectively functional additives to lubricants in the form of geomodifiers. When introducing composite oils with geomodifiers, it is not necessary to perform constructive changes in mated machine parts, however, their wear resistance and alignment increase. This requires experimental tribological research.

It was proposed to use geomodifiers KGMF-1+oleic acids as a functional additive to motor oil, fresh oil Monnol TS-5 UHPD 10W40 and composite oil Monnol TS-5 UHPD 10W40+XADO HighWay for Diesel Truck (2.0...2.3 %) were chosen for comparison. An increase in friction momentum of different mated samples in the studied oils was recorded on the friction machine of 2070 CMT-1 model with the additional module "ring – ring". Wear intensity in the samples in the studied oils was determined using the method of measuring the amplitude of the acoustic signal directly from the friction zone with the help of the device produced by Brüel & Kjear company.

It was found that an increase in effectiveness of the oil compositions is observed in the following order: Monnol TS-5 UHPD 10W4, Monnol TS-5 UHPD 10W40, Monnol TS-5 UHPD 10W40+XADO HighWay for Diesel Truck, Monnol TS-5 UHPD 10W4+KGMF-1+oleic acid. The indicator of wear of the metal samples in the medium of modified oil Monnol TS-5 UHPD 10W4+KGMF-1+oleic acid, in comparison with basic oil decreased by 11.5...14.3 %. The value of critical load increased by 17.2 % and welding load increased by 19.3 %, respectively. In turn, it was found that maximum intensity of wear of the sample when using modified oil Monnol TS-5 UHPD 10W4+KGMF-1+oleic acid decreased by 3.4...6.0 times.

The obtained data are necessary for the formation of composite oils and substantiation of conditions of their further operation during the period of forced alignment of parts tribojunction.

Keywords: tribojunction of samples, geomodifier, composite oil, friction momentum, wear resistance, acoustic emission, zone of friction, additive, bronze, gray cast iron.

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