ABSTRACT AND REFERENCES

APPLIED PHYSICS. MATERIALS SCIENCE

DETECTION OF METHANOL VAPOR BY SURFACE PLASMON RESONANCE METHOD (p. 4–7)

Glib Dorozinsky, Mykhaylo Lobanov, Volodymyr Maslov

The possibility of using the device based on the physical phenomenon of surface plasmon resonance to detect the methanol vapor in the air of the working premise was considered in the paper.

Therefore, the PPR method, which has high sensitivity, speed and ability to use small samples of investigated gaseous substance is of interest.

Experimental studies have confirmed the possibility of using the phenomenon of surface plasmon resonance to detect methanol vapor in accordance with the requirements of the MAC (5 mg/m^3, which corresponds approximately to 0.37 vol %). Virtually linear dependence for two sections was determined:

a) at the methanol concentration in the air from 0.05 to 1 vol %, which covers the MAC values for the given substance. An analytical description of the dependence $\Delta\theta = 0{,}1068\ C + 0.0568$, where $\Delta\theta$ is the difference in the SPR angle minima, C is the methanol concentration, and the approximation accuracy is $R^2 = 0{,}992$ was found.

b) at the methanol concentration in the air from 1 to 40 vol %, a graph of the concentration dependence is approximated by the virtually linear dependence $\Delta\theta = 0{,}0128\ C + 0.121$ with the approximation accuracy of $R^2 = 0{,}998$.

Keywords: detection device, surface plasmon resonance, methanol, maximum allowable concentration, sensor element, environmental safety.

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APPLICATION OF THE INTERFEROMETRIC APPROACH FOR THE OPTICAL TOMOGRAPHY OF STATIONARY TORCH (p. 8–12)

Andrey Popov, Aleksandr Tyurin, Vladimir Tkachenko, Aleksandr Bekshaev, Valery Kalinchak, Mikhail Trofimenko

Knowledge on the internal structure of the flame is very important for the study and optimization of the combustion processes. The direct flame probing involves great difficulties because of the usually aggressive nature of the environment studied and due to inevitable perturbation of combustion processes by probing devices. Efficient alternatives are supplied by non-contact optical methods in which the flame structure can be recovered via the spatial distribution of the radiation passed through the flame. In this situation, the phase distribution of the transmitted radiation is especially informative, in particular, for an optically dense (not fully transparent to its own radiation) flame. The paper describes a speckle-interferometry technique for registration of the probe radiation phase and related approaches to extracting information on the spatial inhomogeneity of the torch. Application of the high-speed single-frame measurement techniques and special handling tomographic procedures enable to determine the spatial and temporal distribution of the refractive index in the combustion zone on which basis it is possible to identify the structure of the flame. As an example, results of a study of the stationary combustion of the medical paraffin droplets are presented. The data obtained can be used for increase of the combustion efficiency and reduction of fuel consumption.

Keywords: speckle-interferometry, optically-dense flame, refractive index, temperature distribution, optical tomography.

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A METHOD OF DETERMINING THE MAXIMUM HEIGHT OF LOCALIZED CIRCULAR WAVES IN THE PROXIMITY OF SHALLOW WATER (p. 13–16)

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The paper presents a mathematical model of the expansion of localized circular tsunami-type waves in the proximity ofshallow water. The model is based on special T-profile representations of the waves. Taking into account the relevant profile representations, we have analytically solved the system of shallow water equations for random bottom surface in the absence of azimuthal perturbations. We have suggested a method for studyingover-time changes of the profile of random initial perturbations at a given bottom surface, which allows, in particular, studying over-time changes of the maximum disturbance. The main idea is to studythe changing profile of traveling waves at certain checkpoints and to find appropriate equations for amplitude functions. For each checkpoint,we solve the Cauchy problem for ordinary differential equations. The method can be applied with regard to random initial conditions for the wave profile, the law of its movement,and different initial perturbation velocities.

Keywords: wave, solitary wave, soliton, tsunami, profile of waves, shallow water equation, Lamé's equation, difference scheme, deformation, bathymetry.

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ANALYSIS OF RELATIONSHIP BETWEEN OPTICAL PROPERTIES OF MINERALS AND PORTLAND CEMENT WHITENESS (p. 17–21)

Nataliia Dorogan, Lev Cherniak

The relationship of mineralogical composition and optical properties of rock-forming minerals in the raw mix to the characteristics and phase composition of Portland cement clinker for gray and white cement production was investigated. The dependence of the clinker whiteness on the phase composition and optical properties of individual crystalline phases was considered. The influence of ferrohydroxides in the feedstock on the formation of C_4AF type iron-containing crystalline phases, characterized by optical anisotropy, increased density indexes and refractive index (Ng=3,77) in gray cement clinker (20–25 % whiteness) was confirmed.

The formation of crystalline phases of the $C_{12}A_7$(Ng=2,85–2,90) mayenite type, relating to optically isotropic and transparent, with a relatively lower refractive index, as a factor of increasing the clinker whiteness (70–73 %) in the firing of raw mixes based on the oxide system $CaO – Al_2O_3 – SiO_2$ was shown. An example of obtaining high-whiteness clinker (80–83 %) under the $C_{12}A_7$ synthesis intensification was given.

Keywords: Portland cement, raw mix, mineralogy, optical properties, clinker, phase composition, mayenite.

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SYNTHESIS AND SORPTION PROPERTIES OF COMPOSITE MATERIALS BASED ON NANOSCALE Fe^0 (p. 22–27)

Viktoriia Tobilko, Borys Kornilovych

Physico-chemical production features of composite materials based on natural clay minerals and nanoscale Fe^0 were investigated in the paper. The X-ray phase analysis has shown that the deposition of the finely dispersed iron layer on the surface of layered or layered-band silicates leads to the formation of sorption materials, which contain the crystalline phases α-Fe, FeO and FeOON.

The sorption properties of the synthesized samples with respect to the cobalt compounds were examined. It is shown that the resulting composite materials have a high sorption capacity compared to the initial clay minerals. This is caused by an increase in the number of OH^- groups in thin oxide-hydroxide films on the surface of the Fe^0 nanoparticles.

The studies of rheological properties of dispersions of palygorskite, modified by nanodispersed iron were performed. It was found that at the Fe^0 content that corresponds to the mineral exchange capacity ratio of 1:5, the suspension exhibits pseudoplastic nature and is resistant. The possibility of using finely dispersed adsorbent in the groundwater purification from the metal ions with applying modern environmental technologies, which are based on the direct pumping of aqueous dispersions of nanomaterials in the contaminated soil layers through injection wells was shown.

Keywords: composite materials, nanoscale Fe^0, sorption capacity, cobalt compounds, rheological properties.

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DEVELOPMENT OF TECHNOLOGY OF OBTAINING RAW MATERIALS FOR TITANIUM ALLOYS MADE OF OFF-GRADE TITANIUM SPONGE (p. 28–32)

Oleksandr Osypenko

Simplification and efficiency improvement of the process of obtaining sintered products and semi-finished items made of sparingly alloyed titanium alloys with high mechanical properties are possible using titanium sponge with a given content of iron and oxygen.

To study the method of obtaining titanium sponge with a given iron content in the process of screening and sieving, the pilot plant was designed and built. The iron concentration in titanium sponge was implemented in several ways by screening various sub-fractions of titanium sponge of a small fraction –2+0 mm.

Industrial technology for titanium sponge production with a given iron content on the sponge screening plants was developed. Selection of parameters of the developed process: bulk material flow rate on the screen-table of the plant in the range 0.370...0.380 m/min at the material flow depth 9.0...11.0 mm, which provides the yield of the desired fraction of about 60 % and the iron content of 1.50 % (wt.) was made.

Production technology of titanium sponge with a given chemical composition was implemented at the Zaporozhye Titanium and Magnesium Combine on the pilot plant for titanium sponge sieving, pilot unbalanced-throw screen 290 Gr with performance of 1000 kg/h. Sintered titanium billets of the alloy Ti-0,25O-1,5Fe were made of the manufactured product by hydrogenation, pressing and sintering of titanium sponge with a given chemical composition. The sintered alloy has a level of mechanical properties similar to that of serial sintered titanium alloys of grades 2M2A and PT5-1.

Using titanium sponge with a given composition of alloying elements in combination with the powder metallurgy techniques of titanium alloys as a raw material for the production of sparingly alloyed sintered titanium alloys is economically advantageous and cost-effective due to eliminating a number of process operations and low cost of raw materials used.

Keywords: titanium alloy, titanium sponge, alloying, sintering, chemical composition, impurities, mechanical properties.

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INVESTIGATION OF CORROSION RESISTANCE WELDS METAL HOSE MADE OF STEELS AISI 304 AND AISI 316 (p. 33–39)

Natalia Solidor, Vitaliy Ivanov, Fedor Morgay, Boris Nosovskiy

Despite a large number of available data regarding the causes of damage of steel structures made of stainless steel of AISI 304 and AISI 316 grades, little attention has been paid to the manufacturing and storage conditions of these steel grades, but these conditions may be additional factors promoting pitting corrosion and other types of local corrosion. The article describes the results of researches aiming to increase corrosion resistance of welded steel flexible hoses for transportation of natural gas made of austenite steel. The research determined the controversial influence of the deformation degree on the tendency to corrosion failure of stainless steel; showed the efficiency of heat treatment of AISI 304 and AISI 316 steels to relieve internal stresses in order to increase their corrosion resistance. As a result, in order to reduce propensity for corrosion cracking (pitting) of welded steel flexible hoses is recommended to perform the heat treatment for stress relief at a temperature of 200 °C for 60 minutes. The suggested technology may be used at various enterprises. The results showed in the article may be useful for the specialists engaged in increasing the life of welded steel structures.

Keywords: welded steel flexible hoses, corrosion resistance, pitting, deformation, macrostructure, austenite, heat treatment.

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A STUDY OF FRACTURE TOUGHNESS OF HEAVY-WEIGHT CONCRETE AND FOAM CONCRETE REINFORCED BY POLYPROPYLENE FIBRE FOR ROAD CONSTRUCTION (p. 40–46)

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The study explores fracture toughness of heavy-weight concrete and foam concrete solidified by an autoclave-free method and reinforced vs. non-reinforced with polypropylene fibres. The research was conducted by the criteria of fracture mechanics to determine strength and deformation characteristics as well as power and energy features of fracture toughness of the considered concretes.

It has been discovered that addition of polypropylene fibreto the composition of heavy-weight concrete and foam concrete mainly affects the supercritical phase of deterioration: the fibre inhibited fracture of the samples once there had appeared a backbone crack (from the moment when the maximum breaking load had already been applied) until its complete defragmentation. The indicator characterizing this effect—the specific energy load used for static destruction, G_F—was higher in all series of dispersed concrete reinforcement, which was quite different in the case of non-reinforced concrete and foam concrete. It proved to be the most effective additive in heavy-weight concrete and porous concrete with a density of 700 kg/m^3 (respectively, the indices were 1.5 and 1.8 times higher than in the case of non-reinforced concrete). Besides, adding polypropylene fibre increases, by 22 % on average,the tensile strength of concrete while bending it.

Hence, formation and development of cracks are inhibited by polypropylene fibres, which can be observed in an increase of all indicators of strength and deformability of the studied concretes as well as of power and energy features of fracture toughness.

Keywords: reinforced concrete, crack, fracture mechanics, specific energy consumption, fracture toughness.

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FEATURES OF STRUCTURE FORMATION OF MODIFIED COMPOSITION MATERIALS (p. 46–51)

Irada Nusrat kyzy Shirinzade, Irada Mamedova Hasan gizi

A new method for producing a composition material based on low-grade clays and dolomite was developed. Its essence lies in the fact that the clay-dolomite composition material is made using ceramic technology but hardens as a binder in the subsequent hydraulic conditions. For producing clay-dolomite composition material, fusible clays of the Absheron deposit and dolomites of the Gobustan deposit are used.

The influence of various factors: the degradation kinetics of carbonates during firing, mineralizers, related phases in the rocks used, firing temperature and duration, hydraulic treatment duration, etc. on strengthening of clay-dolomite composition materials was found and their hardening mechanism was revealed. Calcium hydroxide, obtained during clay-dolomite mixture firing in the presence of smaller cations (Mg, Al) forms compounds, having binding properties, with Si_2O_5 radicals. Such calcium silicates have layered structures and become stable only in the presence of water.

It was found that the clay-dolomite composition materials gain sufficient strength after firing due to the formation of silicates, aluminum silicates and calcium and magnesium aluminates, which in their subsequent hardening in water conditions show binding properties, are hydrated to form hydrated compounds, leading to a significant increase in the composition strength.

Keywords: composition material, clay, dolomite, hydrated compound, hardening.

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ROLE OF BORON IN FORMATION OF SECONDARY RADIATION DEFECTS IN SILICON (p. 52–58)

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Influence of boron impurities on electron-transport in crystalline silicon is well known because p-Si – basic semiconducting material of the modern microelectronics – usually is obtained by doping with B. It is too important to understand the mechanism of interaction of B dopants with radiation defects in silicon to (i) develop effective radiation treatment technologies for electronic devices and integrated circuits, (ii) improve their radiation resistance, and (iii) design effective solid-state radiation sensors and detectors.

Based on authors' previous works the role of B-impurities in formation of secondary radiation defects in Si crystals is investigated. Dependences of these processes on isochronous annealing temperature (80–600 °C) are studied by using the Hall measurements of temperature-dependencies (100–300 K) of hole concentration and mobility in silicon before and after irradiation with 8 MeV electrons at the dose of $5{\cdot}10^{15}$ cm^{-2}. Two main conclusions are made: boron atoms in silicon crystals (i) serve as extremely active sinks of radiation defects, and (ii) participate in space-charge-screening of the relatively high-conductive inclusions in form of clusters of radiation defects.

Keywords: silicon, boron-dopant, radiation defects and complexes.

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