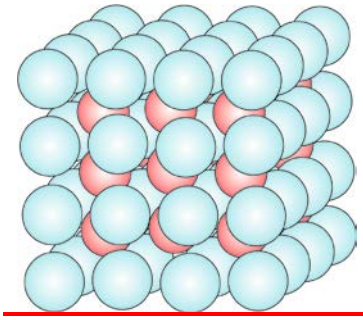

INTERNATIONAL JOURNAL

MATERIALS SCIENCE. NON-EQUILIBRIUM PHASE TRANSFORMATIONS

PUBLISHER:

SCIENTIFIC TECHNICAL UNION OF MECHANICAL ENGINEERING

108, Rakovski Str., 1000 Sofia, Bulgaria
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ISSN 2367-749X
YEAR II, ISSUE 3 / 2016

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TECHNOLOGY LASER MODIFICATION IN MATERIAL SCIENCE NANOCOMPOSITES FOR METAL-POLYMERIC SYSTEMS

ТЕХНОЛОГИИ ЛАЗЕРНОГО МОДИФИЦИРОВАНИЯ В МАТЕРИАЛОВЕДЕНИИ НАНОКОМПОЗИТОВ ДЛЯ МЕТАЛЛОПОЛИМЕРНЫХ СИСТЕМ

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Abstract: A*re investigated mechanisms and kinetics of structural transformations polymeric substrates and of disperse particles fillers and modifiers exposed defocused laser radiation with energy in the range of 1.5 to 6 J. Installed effect of hardening the thermoplastic matrices (polyolefins, polyamides, of polyesters) when exposed to short laser pulses on a film sample thicknesses of 50-200 microns. The methods of structural analysis (IR spectroscopy, X-ray diffraction, DTA) showed, that the predominant mechanism of manifestation hardening effect is the formation of nano-sized structures in the film sample volume due to leakage of recrystallization processes. When exposed to laser radiation to disperse and fibrous particles of silicates, graphite, schungite, carbon fibers is implementing a complex effect of increasing the dispersion and the formation of advanced morphology of the surface layer with an increase in the proportion of nano-sized fragments whisker and lamellar habitus. When laser irradiation of fibers fragments formed developed morphology of the surface layer, due to the occurrence of thermal degradation processes that lead to the appearance of cracks and of globular indentations. Spectroscopy method of thermally stimulated currents (TSC - spectroscopy) established the effect of changing the energy state of the surface layers of substrates and particulate modifiers, which are characterized by extreme values of magnitude TSC - currents in the temperature range 193-523 K. The combined effect of energy and morphological factors provides the effect of increasing the activity of modifying components subjected to the laser processing. Changing the energy state of the surface layer of the polymer substrate has a beneficial bactericidal effect, increases the effectiveness of antiseptic treatment of medical devices used in medical practice. Are presented examples of the practical use of the established laws when creating polymer composites for metal-polymer systems for various applications.*
KEYWORDS*: MODIFICATION, LASER INFLUENCE, MORPHOLOGY, SURFACE LAYER, ENERGY STATE, STRUCTURING MATRICES*

1. Introduction

The development of effective compositions of composite materials with desired performance parameters is one of perspective directions of creation of static (adhesive) and dynamic (tribological) Metal-Polymer Systems [1, 2].

Clearly a statement that the determining criteria for the selection of the functional material components are the degree of their influence on the mechanisms and kinetics of interfacial physico-chemical and tribological processes at the interface of "matrix-filler" and "composite-substrate", which is determined by the activity, assessed by parameters energy characteristics [2].

Among the most promising parameter control technologies and energy morphological characteristics of the metal components and metal-polymer systems include laser radiation with a certain energy and time parameters. Laser irradiation allows not only to carry out the dispersion of semi-finished products as a result of ablation and destruction, but to change the parameters of the structure and energy characteristics of the dispersed particles and substrates directionally adjusting mechanisms of contact interactions [3, 4].

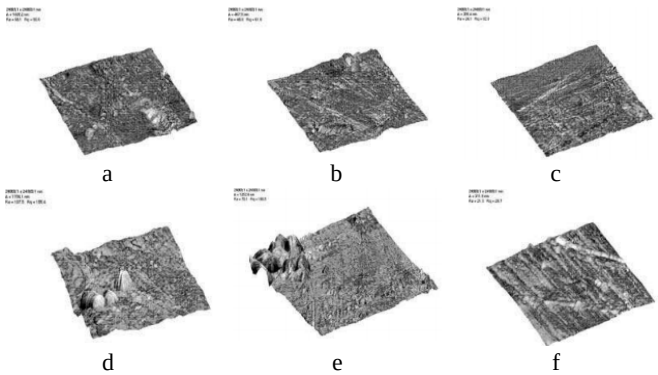
The aim of this work was to study the morphology and energy characteristics of the components Metal-Polymer systems exposed to laser radiation.

1. Materials and methods of research

For the research were chosen components, which widespread in the technology of functional materials based on polymeric matrices - polyolefins (HDPE, LDPE), polyester (PET, PBT), polyamides (PA6, PA6.6), fluoropolymers (PTFE). As used modifiers disperse silicon particles (clay), carbon containing (UFDG, graphite) and combined (shungite) compounds. Modifying components was performed in air or in a liquid medium (aqueous solutions) using a short-pulse laser radiation with energy (0,5 ÷ 0,75) J. and wave length λ_o = 0.532 microns. Modified components used to form the adhesive system and coating producing composite materials.

2. Results and discussion

System analysis of studies on various aspects of the technology of laser exposure on the components of Metal-Polymer Systems of different types [3, 4], indicate multifactorial influence of concentrated streams on the structure and energy parameters of the resulting products. At the same time, irrespective of the flow rate and the method of delivery (concentrated or defocused beams continuous or discrete action), there are structural changes at different levels of organization and energy parameters of the surface layer, which is caused by the occurrence of recrystallization processes, the formation of defects, energy absorption, degradation, ablation in the surface layers of the modified object. Model studies of the morphology of the surface layer films of thermoplastic polymers show a significant relief change with the formation of nano-sized components (Figure 1).

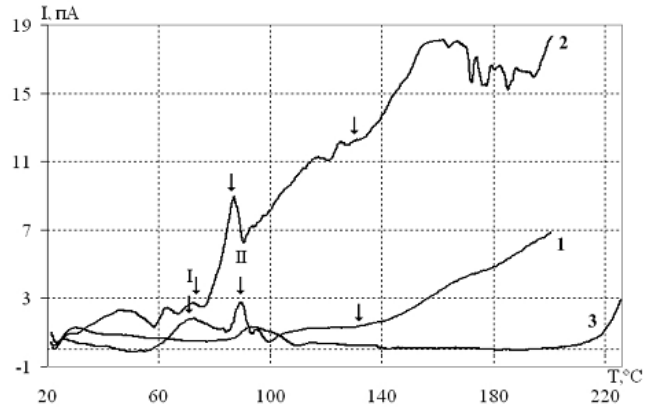


Area scan 24869,1x24869,1 nm

Fig. 1 *The surface morphology of film samples LDPE (a, d), PP (b, e), PET (c, f) the source (a, b, c), treated with pulsed laser light with a 2.0 W/cm^2 power density (d, e, f)*

Formation of nanoscale components in the surface layer characteristic of all types of thermoplastic samples subjected to treatment with pulsed power density (2.0-4.5) W / cm^2.

If the laser beam is not only changing the morphology of the surface layer, but its energy state (Figure 2), as measured by the magnitude of thermally stimulated currents. The probable mechanism of manifestation of the electret state is the formation of radical products of thermal degradation of macromolecules under the action of radiation, the amount of which depends on the amount of energy absorbed by the sample.

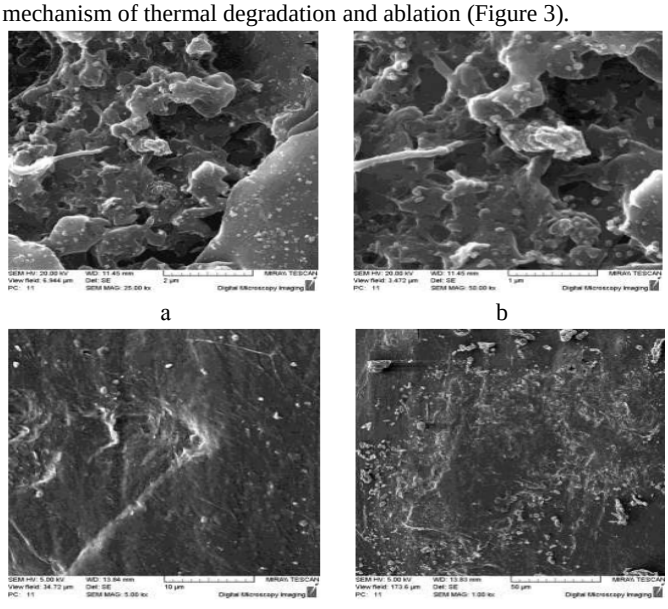


1 - reflective, 2 - light-absorbing substrate, 3 - initial sample

***Fig. 2** Dependence of thermally stimulated currents I on the temperature T in the sample LDPE subjected to a single treatment with laser radiation with an energy E = 0.6 J*

Of particular interest are the processes of functional modifying component materials in liquids of different composition. With such a technology to implement exposure manages modifying surfaces juvenile products laser dispersing functional components introduced into the liquid-phase medium, as electrolytes which can serve for the galvanic coating, solutions of surfactants, solutions of salts of polyvalent metals and etc.

Exposure to the laser pulse on a substrate of different composition causes the destruction of the surface layer by the mechanism of thermal degradation and ablation (Figure 3).



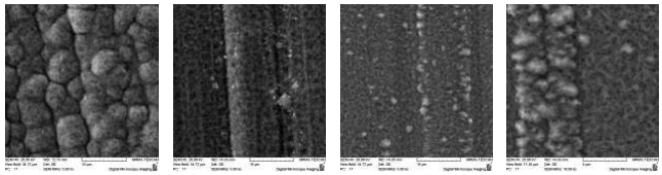
These REM. λ0 = 0,532 micron, τ = 16·10-9 s, the pulse energy of 75 mJ

***Fig. 3** A typical view products of the ablation electrode graphite (a, b) and PTFE in the electrolyte (c, d)*

Have developed the morphology of the surface layer in the ablation of particles ensures the implementation nanostate, which has a significant impact on the mechanisms and kinetics of interfacial interactions in composite materials and metal-polymer systems.

For example, the products of ablation of PTFE and graphite electrode introduced into the electrolyte for the production of coatings based on chromium, can not only change the rate of formation of the coating composition, but also improve its parameters tribological and corrosion resistance.

The characteristic relief of nanocomposite coatings based on modified products ablation chromium (Figure 4) contributes to the formation of sustainable boundary lubrication in heavily loaded friction units. The presence in the structure of the coating of nanoparticles of graphite and PTFE significantly reduces the coefficient of friction during its operation without external supply of lubricant.



a - the initial coating, b - concentration solution FCO in the electrolyte 3% wt%, c - FCO concentration in the electrolyte solution 7 wt%, d - concentration particles of polytetrafluoroethylene obtained by dispersing the laser, 0.1% wt%

***Fig. 4** The morphology of electrolytic chromium coatings modified with fluorine-containing compounds. These SEM*

Of particular interest as a modifier are fluorine-containing oligomers (FCO), which form the structure of the surface layer which is resistant to corrosion and mechanical wear.

3. Conclusions

Systemic investigations of the mechanisms of formation and morphology of the energy state of the components of different composition and structure when exposed to laser light indicate the presence of the general laws, leading to the formation of nanocomponents, which ensure the implementation of the phenomenon nanostate.

The components activated by laser radiation of different energies are effective for modifying polymer and metal matrix composite materials to create a set of performance parameters. A promising area is the use of laser modification optically transparent liquid-phase fluids containing functional modifiers are capable of adsorbing on the surfaces of juvenile dispersion and ablation products.

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