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BOOK OF ABSTRACTS

THE SECOND SINO-RUSSIAN BILATERAL SYMPOSIUM ON NANO SURFACE TECHNOLOGY AND SURFACE EFFECT

INTERNATIONAL SYMPOSIUM

BOOK OF ABSTRACTS

The second sino-russian bilateral symposium on nano surface technology and surface effect

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Organizations:

- Kutateladze Institute of Thermophysics SB RAS (Novosibirsk, Russia)
- School of Materials Science and Engineering, Dalian University of Technology (Dalian, China)

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CONTENS

Bioinspired Nanostructures with Long-term mechano-biocidal Activities

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Abstract

Increased usage of antibiotics and related emergence of antibiotic-resistant bacteria call for the development of novel treatment approaches in which pathogenic bacteria cannot develop resistance. As an alternative, natural or bio-inspired nanostructured surfaces can effectively kill bacteria through mechanical rupture of bacterial cells without the risk of causing antibacterial resistance, but these surfaces are prone to be severely shielded by the residual debris and lose their efficacy. To address this issue, we developed a series of bio-inspired nanostructures with long-term mechano-bactericidal activities, including super-repellent mechano-biocidal surface, SLIPS based mechano-biocidal surface and Stimuli-responsive mechano-biocidal surface.

For Super-repellent mechano-biocidal surface, the bio-inspired surface has displayed remarkable synergistic antimicrobial activity against Escherichia coli: while the majority of the bacteria (>99%) were repelled from the surface, very few bacteria that managed to be in touch of the surface were physically killed completely to get a 100% bacterial killing rato.

For SLIPS based mechano-biocidal surface, the synergistic effect of anti-biofouling and supplementary function of structured sterilization via purely physical actions, stimulating the exploration of novel and green SLIPS with multifunctional and improved antibacterial properties in a non-chemotherapeutic way.

For stimuli-responsive mechano-biocidal surface, the thermo-responsive property of the grafted layer on the nanostructures can be well regulated from collapsed to swollen states, rendering surface with temperature-modulated antibacterial properties from bacterial repellency, mechano-bactericidal performance, to dead bacteria release.

All the bacteria-killing and bacteria-releasing actions above-mentioned are completely attributed to physical mechanisms. Therefore, it opens an avenue for the rational design of nanostructured bactericidal surfaces with repeatable and long-term effective antibacterial performances, without triggering antibiotic resistance.

Keywords: bio-inspired, nanostructures, mechano-bactericidal, bacteria-releasing, bacteria-repelling.

Effect of Au film mask on antiwetting and antireflection properties of nanostructural polymer by plasma nanotexturing

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Abstract

Plasma nanotexturing is a surface modification technique to construct nanostructures on polymer substrates and even offers excellent surface properties such as antiwetting and antireflection. In this work, the plasma nanotexturing was carried out to fabricate the bundles of fluorocarbon-film decorated nanowires on the PMMA substrates. The oxygen plasma treatment (OPT) was used to etch the PMMA substrates using the Au film masks which were sputtering deposited with the thinner and thicker Au film. The fluorocarbon-films were sequently deposited by the plasma polymerization using C_4F_8 monomer. The spacing distance between nanowires in a bundle was adjusted by the thicker and thinner Au film masks on PMMA substrate. The thicker Au mask preserved the narrower spacing distance and the larger height of nanowires in bundle than those with the thinner Au mask. The antiwetting property of the nanotextured and PMMA substrates was observed when the water droplets bounced off completely at a high speed of 4.5 m/s on the bundles of nanowires with a contact angle above 150°, which was depended on the narrower spacing distance between the nanowires in bundles. The stability of complete rebound on the polymer substrates with the thicker Au film mask under OPT was outstanding. The antireflection property was obtained as a low reflectivity of 0.2% for the visible and near-infrared light in a broad wavelength range of 400-2000 nm and a wide incidence angle range of 8°-68°, which was related to the larger height of the nanowires in bundles. The reflectivity obtained on the polymer substrates with Au film mask was insensitive to the wavelengths and AoI of light. The plasma nanotexturing provided an antiwetting and antireflection properties of the polymer substrates.

Keywords: Plasma nanotexturing, Au film masks, antiwetting, antireflection.

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The thermal stability and radiation tolerance of Cu-Nb nanocomposite thin films

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Abstract

Nuclear energy utilization is very important for future energy development. However, the structural and functional parts of nuclear power equipment are unavoidably affected by the nuclear radiation damage, and the material performance gradually degrades due to the defect aggregation caused by the irradiation. Immiscible Cu-Nb system is a potential candidate material for obtaining both thermal stable and radiation tolerant nanomaterial due to its thermodynamic characteristics. The as-deposited Cu-Nb thin films were designed to show a typical nanocomposite structure with Cu and Nb nanocrystals embedded in a Cu-riched phase. The thermal stability of Cu-Nb nanocomposite thin films which mostly relies on the segregation mixing enthalpy is enhanced by highly dispersed Nb nanoprecipitates, while the radiation tolerance of the films is mainly driven by the mixing enthalpy. The pinning effect of nanoscale Nb precipitate should be responsible for the enhanced properties of Cu-Nb nanocomposite thin films.

Keywords: Thermal stability, radiation tolerance, Cu-Nb nanocomposite thin films, Nb nanoprecipitates.

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Antiwetting Behaviors of Biomimetic Nanopillars and Nanocones

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Abstract

The presence of random arrays of elongated nanostructures with dimensional nonuniformity on the cuticular surfaces of insects endows them with antiwetting characteristics, as exemplified by nanopillar arrays on dragonfly wings and nanocone arrays on cicada wings. But the roles of the nanostructure shape and dimensional nonuniformity, as well as of the randomness of placement, on antiwetting characteristics are difficult to delineate because of the different chemical compositions of the surfaces of dragonfly and cicada wings. Two-step technique based on a capacitatively coupled radiofrequency plasma (CCRP) were utilized to modify the polypropylene (PP) surfaces. First oxygen-plasma treatment (OPT) is implemented to grow arrays of vertical elongated nanostructures with almost uniform cross-sectional diameter, and then fluorocarbon polymer deposition (FPD) is carried out so that the nanostructures evolve into nanocones with small apex angle. The surface nanotexture transition from the nanopillars into the nanocones was achieved by FPD of octafluorocyclobutane monomer with the duration time. The biomimetic nanopillars and nanocones with the fluorocarbon polymer film on nanotextured PP substrates preserve the similar tip diameter, placement irregularity, and chemical composition, which is well utilized to study the effects of dimensional variability and irregularity of placement on the antiwettability characteristics. The evaporation behaviors and mechanisms of water droplets were investigated on the superhydrophobic surfaces with biomimetic nanopillars and nanocones. During the initial evaporation process, the surfaces with biomimetic nanopillars and nanocones showed the droplet evaporation in constant contact angle (CCA) model due to the prominent heat transfer of the interfaces between the vapor and the droplets in the superhydrophobicity with Cassie state. The evaporation of water droplets which transited into Marmur and Wenzel state became the mixed model due to the enhanced heat transfer between the interfaces of the nanotexturs and the droplets with the increase of evaporation time. The increased width and aggregation of nanocones in FPD for the increased duration time led to the reduced proportion of vapor between the droplets and the nanotextured surfaces and the enhanced heat transfer between the interfaces of the nanotexturs and the droplets, which caused the increase of the area-average evaporation flux over the droplet surfaces. The transformation from CCA evaporation model to mixed evaporation mode of water droplets became easy on the biomimetic nanocones.

Keywords: Biomimetic surface, plasma nanotexturing, superhydrophobicity, droplet evaporation, wetting state.

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Creating biphilic surfaces using a combination of methods HW CVD and pulsed laser treatment

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Abstract

The control of the surface wettability of materials used in high-efficiency power engineering, microelectronics, micromechanics, high-precision instrumentation, manufacturing of diagnostic and analysis devices, production of medical equipment, aircraft and rocket engineering, etc., can significantly improve their performance. The wettability significantly influences the surface processes, for example, the heat exchange, boiling, condensation, evaporation, liquid flow dynamic, etc. Surfaces with contrast wettability at the micro- and nanoscale are particularly interested. For example, materials with such surfaces allow increase the critical heat flux at boiling due to the superhydrophilicity and, at the same time, preventing deposition of contaminating impurities onto the heat exchange surface due to the superhydrophobicity. The manufacturing of such materials by the existing technologies is rather difficult, labor-consuming and sometimes impossible. Thus, there is a need to develop inexpensive, universal and scalable methods for modifying surfaces of different materials to achieve the effect of contrast wettability. In the present work, the fundamental principles of hybrid technology for creation surfaces with contrasting wettability were developed. It is shown that preliminary treatment with laser radiation not only ensures the achievement of superhydrophilic properties of the material, but also increases its adhesion characteristics when applying a superhydrophobic fluoropolymer coating. Fluoropolymer coatings were deposited by Hot Wire CVD method.

Keywords: Contrast wettability, superhydrophilicity, superhydrophobicity, fluoropolymer, microstructuring, laser treatment.

Water drops spread on superhydrophilic and superhydrophobic surfaces

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Abstract

The modern biomimetic technologies allow accurately control wettability of different material. It is very promising for different applications. In present work we analyzed the influence of surfaces wetting properties on spread dynamic of falling droplet for different size and velocity. The surface energy of using material was changed by method developed in IT SB RAS. Briefly, the initial single crystalline silicon was treated to obtained superhydrophilicity by nanosecond laser in regimes of special microstructure formation. Then treated surfaces were covered by fluoropolymer thin films of different thicknesses by hot wire chemical vapor deposition. The contact angle dependence on fluoropolymer thicknesses in range 0-170^o. The process of water droplet spread was registered by high speed camera with frequency of 10000 frames per second. The dynamic of droplet detachment on weber number were analyzed in range We = 3-40. The experimental data compared results of calculation by lattice Boltzman method and the agreement was founds. The special time parameter t* referring to inertial stage of droplet spread was introduced. It was found that t* does not depend on surface wettability. It allows generalization of obtained experimental and calculation results. The data are in good agreement with other works.

Keywords: Superhydrophilicity, superhydrophobicity, fluoropolymer, microstructuring, laser treatment, droplet spread.

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Evaporation of water and nanofluid droplets on micro/nano-structured surfaces with contrasting wettability

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Abstract

The study of the deposition process from a drop of a colloidal solution is based on a variety of data on the dynamic behavior of a lying drop. Research in the field of evaporation of liquid droplets has been going on for decades and, nevertheless, is currently of great interest. This is due to the important role that this object plays in technological processes, for example, when spraying ink in inkjet printers, drop cooling of surfaces, growth of biological crystals, in heat and mass transfer devices, etc. At the same time, there are much fewer works in which the evaporation of drops of colloidal solutions on superbiphilic surfaces (with a sharp transition from superhydrophobic to superhydrophilicity) was considered, although such surfaces themselves are very attractive for many applications and are considered, for example, in problems of vapor condensation. Within the framework of this work, unique biphilic substrates were prepared with a sharp spatial gradient of the contact angle of wetting. Experimental studies of the evaporation process of liquid droplets lying on structured surfaces are carried out depending on the orientation of the droplet. It was found that suspended nanofluid droplets have a higher temperature and evaporation rate compared to sessile droplets of the same liquid.

Keywords: Evaporation, droplet, nanofluid, heat and mass transfer, nanoparticle, superhydrophilicity, superhydrophobicity.

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Lattice Boltzmann modelling of droplet impact on hydrophobic and hydrophilic surfaces

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Abstract

The Lattice Boltzmann Method is a rapidly developing approach to simulation of gas and fluid flows. It has been successfully used to solve different problems including heat transfer, porous media flows, multiphase and multicomponent flows.

In this work, the LBM was applied to modelling of droplet impingement on a surface, to understand the physical mechanism of droplet impact. This problem is highly associated with ink printing, spray cooling, anti-icing etc. and has been intensively studied in recent years. It was shown that pseudopotential multiphase LBM demonstrates good quality predictions and excellent computational efficiency. 2D and 3D simulations of droplet impact on superhydrophobic and superhydrophilic surfaces were in good agreement with the experimental data. Numerical modelling results allow us to obtain additional information on droplet impact dynamics, such as velocity distribution.

Keywords: Lattice Boltzmann method, droplet impact, hydrophobic and hydrophilic surfaces.

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