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ABSTRACTS

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Stevens Institute of Technology
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Dr. Chang-Hwan Choi
Conference Chair
Department of Mechanical Engineering
Stevens Institute of Technology, NJ, USA

Dr. K.-C. Kenneth Park Technical Committee Chair
Department of Mechanical Engineering
Northwestern University, IL, USA
Table of Contents

Organizers and Contact Information ................................................................. 10

Industrial Sponsor ............................................................................................. 10

Partnering Journals ........................................................................................... 11

Keynote, June 12, 8:30-9:30 am
Structured Surfaces – from Super-repellency to Drag Reduction
Chang-Jin "CJ" KIM
University of California, Los Angeles (UCLA), USA........................................ 12

Session: Friction & Tribology, June 12, 9:30-10:10 am

SLIPSs with Reduced Skin-Friction Resistance
Federico VERONESI,1 Mariarosa RAIMONDO,1 Elena CIAPPI,2 Boris JACOB,2 Francesco LAGALA2
1 National Research Council – Institute of Science and Technology for Ceramics ISTEC, ITALY
2 National Research Council – Institute of Marine Engineering INM, ITALY ........................................ 13

Tribological Properties of Nature-Inspired Microporous PDMS Surfaces under Physiological Conditions
Yiwen XI1,2, Hans J. KAPER2, Chang-Hwan CHO1, Prashant K. SHARMA*2
1 Stevens Institute of Technology, USA
2 University of Groningen and University Medical Center Groningen, The NETHERLANDS .............. 14

Session: Phase Change I, June 12, 10:30 am-12:00 pm

Invited Talk
Bioinspired Jumping-Droplet Vapor Chambers
Chuan-Hua CHEN
Duke University, USA ............................................................................................. 15

Perfluoropolymer Nanoarrays Enabling Jumping Dropwise Condensation under Subcooling Larger than 70 K
QianFeng XU,1,2 Illya NAYSHEVSKY,2 Alan M. LYONS *,1,2
1 ARL Designs LLC, USA
2 College of Staten Island and the City University of New York, USA ......................... 16

Bioinspired Textured Surfaces to Control Water Condensation: Experimental and Numerical Approaches
Stéphane VALETTE1, N. PIONNIER1, S. Boroomandi BARATI2
1 Univ Lyon, École Centrale de Lyon, France
2 Ecole Nationale Supérieure des Mines de Saint-Etienne, FRANCE ........................................ 17

Effect of Surface Wettability on Fog Collection on a Wire
Youhua JIANG, Christian MACHADO, Kyoo-Chul PARK
Northwestern University, USA ............................................................................. 18

Session: Droplet I, June 12, 2:00-3:50 pm

Invited Talk
Liquid Marbles, Naturally Inspired Elastic Nonstick Droplets: From Mini-reactors to Self-Propulsion
Edward BORMASHENKO
Ariel University, ISRAEL .................................................................................... 19

Physics of Self-assembled Levitating Clusters of Water Droplets
The Effect of Surface Curvature on Coalescence-Induced Jumping of of Nanodroplets on Superhydrophobic Surfaces
Xukun HE, Lei ZHAO, Jiangtao CHENG
Virginia Tech, USA ................................................................. 20

Deposition of Micrometric Water Droplets on Rough Hydrophobic Surfaces
Jeong-Hyun KIM, Ian HO, Daniel M. HARRIS
Brown University, USA ............................................................... 22

Syntheses of Supraparticles on Liquid Repellent Surfaces
Sanghyuk WOOH
Chung-Ang University, SOUTH KOREA ........................................... 23

Session: Droplet II, June 12, 4:10-6:10 pm

Invited Talk
Bioinspired Wettability Gradient Surfaces: from Design to Control Droplet Transport
Yongmei ZHENG
Beihang University (BUAA), CHINA ............................................. 24

Invited Talk
Nature-Inspired Topological Surfaces for Directional Droplet Transport
Zuankai WANG
City University of Hong Kong, CHINA ............................................ 25

Printing Surface Charge as a New Paradigm to Program Droplet Transport
Qiangqiang SUN1, Dehui WANG1, Yanan LI2, Jiaxi CUI1, Longquan CHEN1, Zuankai WANG2, Hans-Jürgen BUTT3*, Vollmer DORIS3, Xu DENG1*
1. University of Electronic Science and Technology of China, CHINA
2. City University of Hong Kong, CHINA
3. Max Planck Institute for Polymer Research, GERMANY .................................................. 26

Nature-inspired Omnidirectional Droplet Transportation using Magnetically Actuated Surface Deformation
Hongbo YUAN, Koen VAN GORKOM, Shuaizhong ZHANG, Ye WANG, Jaap DEN TOONDER
Inst. of Complex Molecular Syst., The NETHERLANDS ......................................................... 27

Droplet Motion on Structured Surfaces
Yahua LIU
Dalian University of Technology, CHINA .......................................... 28

Keynote, June 13, 8:30-9:30 am
Transport-phenomena-based Approaches to Surface Engineering
Howard A. STONE
Princeton University, USA ............................................................ 29

Session: Coating I, June 13, 9:30-10:10 am

Cheap and Non-Fluorinated Superhydrophobic Concrete Coating
Jinlong SONG, Yuxiang LI
Bioinspired Hedgehog Coating with Superomniphobicity
Jyotirmoy SARMA, Xianming DAI
University of Texas at Dallas, USA

Session: Phase Change II, June 13, 10:30 am-12:00 pm

Invited Talk
Experimental Investigations on Bioinspired Hydro/Ice-phobic Coatings for Aircraft Icing Mitigation
Hui HU
Iowa State University, USA

Phase Adaptive Liquids for Exceptional Anti-icing and Anti-Frosting Performance
Rukmava CHATTERJEE,1 Daniel BEYSENS,2 Sushant ANAND*,1
1University of Illinois at Chicago, USA
2Universités Paris, France

Leidenfrost Rotors on Turbine-Like Surfaces
Glen McHALE, Prashant AGRAWAL, Gary G. WELLS, Rodrigo LEDESMA-AGUILAR, Anthony BUCHOUX, Anthony WALTON, Adam STOKES, Khellil SEFIANE
1Northumbria University, UK
2University of Edinburgh, UK
3Kyushu University, JAPAN

Boiling Heat Transfer Enhancement using Micro-nano Hybrid Surfaces
Donghwi LEE,1 Namkyu LEE1, Dong Il SHIM1, Beom Seok KIM2, Hyung Hee CHO*,1
1Yonsei University, REPUBLIC OF KOREA
2National Fusion Research Institute (NFRI), REPUBLIC OF KOREA

Session: Adhesion, June 13, 2:00 am-4:00 pm

Invited Talk
Responsive Surfaces for Reversible Adhesion and Tunable Wetting
Seok KIM
University of Illinois at Urbana-Champaign, USA

Invited Talk
Bioinspired Adhesive Architectures for Versatile Applications
Sang Yu BAIK, Da Wan KIM, Changhyun PANG
1Sungkyunkwan University (SKKU), REPUBLIC OF KOREA

Nature-inspired Removal of Microparticles by Ciliated Surfaces
Shuaizhong ZHANG, Ye WANG, Patrick ONCK, Jaap DEN TOONDER
1Inst. of Complex Molecular Syst., The NETHERLANDS
2University of Groningen, The NETHERLANDS

The Strong Attachment of Tree Frog’s Toe Pads and Its Applications
Liwen ZHANG, Huawei CHEN, Yan WANG, Yurun GUO, Deyuan ZHANG
Beihang University, CHINA

Biomimicking of Wrinkled Finger Phenomenon to Improve Fiber Matrix Adhesion in Fiber-reinforced Polymer Composites
Umesh MARATHE, Meghashree PADHAN, Jayashree BIJWE
Indian Institute of Technology, INDIA
Session: SLIPS, June 13, 4:20 am-6:00 pm

Invited Talk  
Nature-inspired Materials for Health and Water Sustainability  
Tak-Sing WONG  
The Pennsylvania State University, USA ................................................................. 41

Invited Talk  
Controlling Droplets - Thin, Conformal and Gradient SLIP Surfaces  
Glen McHALE, Gaby LAUNAY, Bethany, V. ORME, Gary G. WELLS, Rodrigo LEDESMA-AGUILAR  
Northumbria University, UK .................................................................................. 42

Dynamic Contact Angle Measurements on Lubricant-Infused Surfaces  
Dohyung KIM,¹ Minki LEE,¹ Sole EO,¹ Jeong-Hyun KIM²* and Jinkee LEE¹*  
¹Sungkyunkwan University, REPUBLIC OF KOREA  
²Brown University, USA .......................................................................................... 43

Statics and Dynamics of Wetting on Lubricant-Infused Surfaces  
Lei ZHAO and Jiangtao CHENG  
Virginia Tech, USA .................................................................................................. 44

Keynote, June 14, 8:30-9:30 am  
Butterfly Wing-Inspired Nanoparticle Coatings  
Shu YANG  
University of Pennsylvania, USA .......................................................................... 45

Session: Coating II, June 14, 9:30-10:10 am

Gallium Oxide Coated Surfaces for Liquid Metal Droplets Actuation  
Ziyu CHEN and Jeong-Bong LEE  
The University of Texas at Dallas, USA .................................................................. 46

Carbon Nanotubes and Conjugated Polymer Films for Tunable Surfaces and Flexible Electrodes  
Eui-Hyeok YANG  
Stevens Institute of Technology, USA .................................................................... 47

Session: Laser Machining, June 14, 10:30am-12:10 pm

Invited Talk  
Functionality through Texture - Nature-inspired Surface Engineering using Laser Micromachining  
Anne-Marie KIETZIG  
McGill University, CANADA .................................................................................... 48

Invited Talk  
Femtosecond Laser Tailoring of Surface Wettability for Droplet Control  
Sajan D. GEORGE, Jijo Easo George, Alina Peethan, and Santhosh. C.  
Manipal Academy of Higher Education, INDIA ..................................................... 49

Superhydrophobic and Anti-icing Microstructures on Aluminium utilizing Direct Laser Writing and Direct Laser Interference Patterning  
Stephan MILLES, Bogdan VOISIAT, Andrés Fabián LASAGNI  
Technische Universität Dresden, GERMANY ............................................................ 50

Nanofiber-coated Microstructures for Lab-on-chip Devices  
Ikwuagwu IKWUAGWU, Jana D. ABOU ZIKI, Amirkianoosh KIANI
Invited Talk
Bio-Inspired Design of Mechanochromisms via Surface Engineering
Songshan ZENG, Rui LI, Dianyun ZHANG, Luyi SUN, University of Connecticut, USA

Invited Talk
Biological Surfaces with Simultaneous Mechanical and Optical Functions
Ling LI, Liuni CHEN, Ting YANG, Mathias KOLLE, James C. WEAVER, Matthew M. CONNORS, Christine ORTIZ, Grant ENGLAND, Stefan KOLLE, Daniel SPEISER, Xianghui XIAO, Joanna AIZENBERG, Virginia Tech, USA, MIT, USA, Harvard University, USA, University of South Carolina, USA, Brookhaven National Laboratory, USA

StrC: A Research Tool to Connect Scientific Knowledge of Nature with Biomimetic Design Innovation
Carlos FIORENTINO, Tomislav TERZIN, John NYCHKA, Anne BISSONNETTE, Megan STRICKFADEN, University of Alberta, CANADA

Broadband, Wide-angle, Anti-Reflection, Superhydrophobic Substrate
Prantik MAZUMDER, Juan ROMBAUT, Valerio PRUNERI, Corning Research and Development Corporation, USA, The Barcelona Institute of Science and Technology, SPAIN

Surface Engineering to form Vertical Organic Semiconductor Crystal Arrays
Kai ZONG, Kaustubh ASAWA, Chang-Hwan CHOI, Stephanie S. LEE, Stevens Institute of Technology, USA

Invited Talk
Bioinspired Adaptive Material Systems for Sensing, Sorting, and Harvesting
Ximin HE, University of California, USA

Invited Talk
Humidity-Responsive Soft Machines
Ho-Young KIM, Seoul National University, USA

High Q Factor Meridian Whispering Gallery Modes Sensing in an EWOD-tuned Water Droplet on Nanostructured Surfaces
Weifeng CHENG, Jiangtao CHENG, Meng ZHANG, Jiansheng LIU, Zheng ZHENG, Virginia Tech, USA, Beijing University, CHINA

Integrating Bioinspired Strain-Engineered MEMS Actuators with Breathable Fabric Carriers
Mohammad S. ISLAM, Sushmita CHALLA, Jasmin BEHARIC, Cindy K. HARNETT, University of Louisville, USA

Applications of Surface Engineering in Blood Plasma Separation
Poster Presentations

On the Design of Lignin Derived Nanoparticles by Benign Solution Assisted Processes
Surojit GUPTA, Maharsi DEY, Chandler BORILLO, Saud Abu ALDAM, Sabah JAVAID, Yun JI
University of North Dakota, USA ................................................................. 61

New Investigations of Marangoni-Flow-Driven Self-Propulsion
Edward BORMASHENKO
Ariel University, ISRAEL .............................................................................. 62

Magnetic Displacement of Floating Diamagnetic Bodies: The Moses Effect Drives Diamagnetic Bodies
Edward BORMASHENKO, Mark FRENKEL....................................................... 64
Ariel University, ISRAEL

Block Copolymer-tempanied Hollow n-ZnO/p-Si Nanodiode Arrays using Atomic Layer Deposition
Woojae LEE, Se-Hun KWON
Pusan National University, KOREA.............................................................. 65

Novel Lipid-Hydrogel-Nanostructure Hybrids for Antifouling Applications
Hyun-Ha PARK, Kahyun Sun, Minho Seong, Insol Hwang, Minsu Kang, Hoon Eui Jeong
Ulsan National Institute of Science and Technology (UNIST), REPUBLIC OF KOREA ................................................................. 66

Wetting Simulation by Lattice Boltzmann Method on Bio-inspired Surfaces
Vincent NEYRAND, Jean-Michel BERGHEAU, Stéphane VALETTE
Laboratoire de Tribologie et Dynamique des Systèmes, FRANCE……………… 67

Water harvesting with different wettability
Thanh-Binh Nguyen, Seungchul PARK, Hyuneui LIM
Korea Institute of Machinery and Materials, REPUBLIC OF KOREA ............... 68

Absorption of Water in Nanoporous Anodic Aluminum Oxide
Hyunbin JO1, Hyoung-Seok MOON2, Dong In YU3, Kwonhoo KIM1, Junghoon LEE1
1Pukyong National University, REPUBLIC OF KOREA
2Korea Institute of Industrial Technology, REPUBLIC OF KOREA .................. 69

Controlled Micro-texturing of Glass with Spark Assisted Chemical Engraving
Jana D. ABOU ZIKI
University of Ontario Institute of Technology, CANADA ................................ 70

Visualization Study of Interfacial Behavior and Shapes underneath a Nucleated Bubbles on the Heated Surfaces w/ and w/o Micro-pillars via Synchrotron X-ray Imaging
Dong In YU3, Hyoung-Seok MOON2, Junghoon LEE1
1Pukyong National University, REPUBLIC OF KOREA
2Korea Institute of Industrial Technology, REPUBLIC OF KOREA ................. 71

Biocompatible Transfer Printing Technique with Wet-responsive Film
Hoon YL, Kahyun SUN, Hyunwook KO, Minsu KANG, Hangil KO, Hoon Eui JEONG
Ulsan National Institute of Science and Technology (UNIST), REPUBLIC OF KOREA ............................................................. 72

Actively Controllable Drop Bouncing Behavior and Robust Anti-icing Property of a Magnetic-responsive Hair Array
Sang-Hyeon LEE, Minho SEONG, Hyunwook KO, Minsu KANG, Hoon Eui JEONG
Bioinspired Hairy Surfaces
Stefan MÜLLERS, Jürgen RÜHE
University Freiburg, GERMANY

Elaboration of Model Bio-inspired Surfaces for Robust Super-hygrophobicity
Quentin LEGRAND, Stéphane BENAYOUN, Pauline BREGIGEON, Nan WU, Stéphane VALETTE
École Centrale de Lyon, FRANCE

The Effect of Patterning and Surface Contact on the Sliding Speed over Ice
Ilze KALNINA, Karlis Agris GROSS, Janis LUNGEVICS, Liene PLUDUMA
Institute of Inorganic Chemistry, LATVIA

Durable Anti-Corrosion Performance of Oil-Impregnated Porous Oxide Layer for Magnesium Alloy
Jaehoon JOO1, Donghyun KIM2, Kwonhoo KIM1, Junghoon LEE1
1Pukyong National University, REPUBLIC OF KOREA;
2Korea Institute of Ceramic Engineering and Technology, REPUBLIC OF KOREA

Water-Repellent Multifunctional Edible Oil-Impregnated Surface of Stainless Steel
Minju KANG1, Wangryeol KIM2, Kwonhoo KIM1, Junghoon LEE1
1Pukyong National University, REPUBLIC OF KOREA
2Korea Institute of Industrial Technology, REPUBLIC OF KOREA

Abrasive Wear Resistance of Mole Pelt Inspired Material
Maksim ANTONOV, Yaroslav HOLOVENKO, Rahul KUMAR
Tallinn University of Technology, ESTONIA

The Impact Characteristics of Millimetric Water Droplets on Woven Stainless-Steel Meshes
Michael J. WOOD, Anne-Marie KIETZIG
McGill University, CANADA

Effect of Laser Fabricated Micro-structures on the Wetting of Pure Aluminium
Stephan MILLES, Bogdan VOISIAT, Andrés Fabián LASAGNI
Technische Universität Dresden, GERMANY

Scalable Fabrication of Functional Metallic Surfaces with Hierarchical Surface Morphology
Michal JAMBOR2, Stanislava FINTOVÁ1, Jozef BRONČEK2, Branislav HADZIMA2, Mario GUAGLIANO1 Sara BAGHERIFARD1
1Politecnico di Milano, ITALY
2University of Zilina, SLOVAK REPUBLIC
3Institute of Physics of Materials, CZECH REPUBLIC

Light induced degradation of transport length of CH3NH3PbI3 studied by surface photovoltage spectroscopy after Goodman
Celline Awino OMONDI, Godfrey Barasa OKUMU, and Victor ODARI
Masinde Muliro University of Science and Technology, KENYA

A Highly Drainable, Capillary-enhanced, Organ-attachable Adhesive with Octopus-inspired 3-dimensional Architectures
Sangyul BAIK, Heon Joon LEE, Da Wan KIM, Hyeongho MIN, and Changhyun PANG
Sungkyunkwan University (SKKU), REPUBLIC OF KOREA

Amphibian-like Hierarchical Microchannels Embedded Hydrgel for Drainable Adhesion with Peel Resistance
Da Wan KIM, Sangyul BAIK, Jihyun LEE, Gui Won HWANG, Jiwon KIM, and Changhyun PANG
Sungkyunkwan University, REPUBLIC OF KOREA
Rediscovery of pitch for ideal coating source of Si-based anode materials in Lithium ion batteries
Seong-Hyeon CHOI, Sujong CHAE, Kwonhoo KIM, Minseong KO
1Pukyong National University, REPUBLIC OF KOREA
2Ulsan National Institute of Science and Technology, REPUBLIC OF KOREA

Enhancing Condensation Through Bio-inspired Hybrid Surface Coated with MOF
Xuan CHEN, Zuankai WANG
City university of Hong Kong, CHINA

Efficient Removal of Droplet Inspired by Moss Plants
Yaqi CHENG, Xuehu MA, Zuankai WANG
1Institute of Chemical Engineering, CHINA;
2City University of Hong Kong, CHINA

Spatial Control of Condensation on Cavity Surface
Jing SUN, Zuankai WANG
City University of Hong Kong, CHINA

Directional Droplet Transport at High Temperature
Minjie LIU, Zuankai WANG
City University of Hong Kong, CHINA

Transitions from Amorphous Structures Offer a More Efficient Pathway for Creating Crystalline Allotropes
Karlis Agris GROSS
Riga Technical University, LATVIA

Integration of Nanopores onto Micro Wick Structures for High Performance Flat Heat Pipe
Deyin ZHENG, Jie LI, Xin ZHAO, Chang-Hwan CHOI, Guangyi SUN
1Nankai University, CHINA;
2Stevens Institute of Technology, USA

Bioinspired laser-induced periodic surface structures (LIPSS) on stainless steel and β-Ti alloy for the generation of superhydrophobic and superhydrophilic surfaces
David Garreth WAUGH, J.LAWRENCE
Coventry University, UK

Corrosion Resistance of Superhydrophobic Aluminum 5052 Alloy Surface using Anodizing with Pore-widening Time
Hyejeong JI, Chanyoung JEONG
Dong-eui University, KOREA

Keyword Index
ORGANIZERS AND CONTACT INFORMATION

Dr. Chang-Hwan Choi
Professor, Department of Mechanical Engineering
Stevens Institute of Technology, NJ, USA
Phone: 201.216.5579
Email: cchoi@stevens.edu

Dr. K.-C Kenneth Park
Assistant Professor, Department of Mechanical Engineering
Northwestern University, IL, USA
Phone: +1-847-491-8793
E-mail: kpark@northwestern.edu

Dr, Levent Koch
Director
American Institute of Sciences
New Jersey, USA
Phone: +1-201-497-4362
Email: director@ameriscience.org

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Keynote: Structured Surfaces – from Super-repellency to Drag Reduction

Chang-Jin “CJ” KIM

Mechanical and Aerospace Engineering Department; Bioengineering Department; California NanoSystems Institute
University of California, Los Angeles (UCLA), California, U.S.A.

Keywords: microstructured surface, superomniphobic, superhydrophobic, drag reduction

A solid surface may be geometrically structured in microscale or below, where liquid-gas interfacial tension plays an important role, to exhibit unusual properties to a liquid placed on it. Typical superhydrophobic (SHPo) surfaces are made of a hydrophobic material with microscale roughness to super-repel water drops. However, to super-repel low-energy liquids, such as oils and solvents, which partially wet all materials, the role of the roughness should increase to compensate for the material wettability. To super-repel all available liquids, including fluorinated solvents, which completely wet all materials, the repellency should be accomplished entirely by the roughness. Such superomniphobic surfaces may be considered a “mechanical” surface because the material or chemistry of the surface has no role. Although the apparent contact angle is commonly used to describe SHPo surfaces, different applications require different measures for different types of structured surfaces. Consider, for example, the widely anticipated drag reduction on SHPo surfaces. Unlike the common impression, the large contact angle on SHPo surfaces has not much to do with their ability to reduce the friction drag. Instead, the ability of the surface microstructures to retain air under water and the ability of the surface micropatterns to induce a large slip were found to determine the amount of drag reduction, as supported by many flow experiments including the recent high Reynolds number tests with a motorboat on the ocean water.
SLIPSs with Reduced Skin-Friction Resistance

Federico VERONESI*, 1 Mariarosa RAIMONDO, 1 Elena CIAPPI, 2 Boris JACOB, 2 Francesco LAGALA 2

1 National Research Council – Institute of Science and Technology for Ceramics ISTEC, Faenza, Italy; 2 National Research Council – Institute of Marine Engineering INM, Rome, Italy

Keywords: SLIPS, skin-friction, marine applications

Skin-friction drag is a crucial problem for naval and maritime industries, accounting for over 50% of the total drag of many ships and submarines [1]. Thus, researchers have devoted their efforts to the quest for surfaces with reduced drag to be applied on marine vessels. Bioinspired, liquid-repellent surfaces have been intensively investigated for this application. However, the well-known superhydrophobic surfaces have proven unsuitable for underwater conditions, due to the loss of trapped air pockets. On the other hand, Slippery Liquid-Infused Porous Surfaces (SLIPSs) have provided encouraging results in terms of drag resistance reduction and long-term stability [2]. However, further studies are needed to establish more solid relationships between SLIPS engineering and their drag resistance properties.

In this work, we have fabricated and tested SLIPSs with different infused oils. All these SLIPSs were based on a randomly oriented, nanostructured boehmite coating combined with an organic layer to promote retention of the infused liquid. Perfluoropolyethers, silicone oils and n-hexadecane were used as infused liquids. The drag resistance behavior of SLIPSs has been tested in three experiments involving different scales and flow regimes:

- Visualization of the rolling/sliding motion of a single drop on a tilted surface
- Measurement of the torque in a Couette-like flow apparatus (laminar conditions)
- Measurement of the wall shear force in a high-speed boundary layer over a large flat plate (turbulent conditions).

Preliminary results indicate that a careful design of SLIPSs is necessary to achieve the best compromise between drag reduction and long-term stability, particularly when the more challenging requirements typical of real, high-Reynolds number flows must be considered.

<table>
<thead>
<tr>
<th>Keyword Index</th>
<th>Page Numbers</th>
<th>Related Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-methacryloyloxyethyl phosphorylcholine (MPC)</td>
<td>66</td>
<td>Critical heat flux</td>
</tr>
<tr>
<td>3D Printing</td>
<td>61</td>
<td>Crystal orientation</td>
</tr>
<tr>
<td>3D printing</td>
<td>79</td>
<td>Crystallization</td>
</tr>
<tr>
<td>β-Ti alloy</td>
<td>93</td>
<td>CH$_3$NH$_3$PbI$_3$</td>
</tr>
<tr>
<td>Absorption</td>
<td>69</td>
<td>Diffusiophoresis</td>
</tr>
<tr>
<td>Abrasive wear</td>
<td>79</td>
<td>Drag</td>
</tr>
<tr>
<td>Academic Prototyping</td>
<td>54</td>
<td>Drag reduction</td>
</tr>
<tr>
<td>Actuation</td>
<td>57</td>
<td>Direct laser writing</td>
</tr>
<tr>
<td>Actuating</td>
<td>73</td>
<td>Direct laser interference patterning</td>
</tr>
<tr>
<td>Adaptive</td>
<td>57</td>
<td>Directional droplet transport</td>
</tr>
<tr>
<td>Adhesion</td>
<td>47, 48</td>
<td>Directional liquid transport</td>
</tr>
<tr>
<td>Aircraft icing mitigation</td>
<td>32</td>
<td>Dropwise Condensation</td>
</tr>
<tr>
<td>Aluminum alloy</td>
<td>82, 94</td>
<td>Drop bouncing</td>
</tr>
<tr>
<td>Amorphous calcium phosphate</td>
<td>91</td>
<td>Droplet</td>
</tr>
<tr>
<td>Anodic Aluminum Oxide</td>
<td>69</td>
<td>Droplet cluster</td>
</tr>
<tr>
<td>Anodizing</td>
<td>94</td>
<td>Droplet Impact</td>
</tr>
<tr>
<td>Anodization</td>
<td>82</td>
<td>Droplet transport</td>
</tr>
<tr>
<td>Antifouling</td>
<td>38</td>
<td>Droplet transportation</td>
</tr>
<tr>
<td>Anti-icing</td>
<td>33, 49, 73</td>
<td>Dry adhesive</td>
</tr>
<tr>
<td>Anti-reflection</td>
<td>55</td>
<td>Durable</td>
</tr>
<tr>
<td>Antifouling</td>
<td>66</td>
<td>Dynamic</td>
</tr>
<tr>
<td>Anti-Corrosion</td>
<td>77, 78</td>
<td>Dynamic contact angle</td>
</tr>
<tr>
<td>Atomic Layer Deposition</td>
<td>65</td>
<td>Dynamic optics</td>
</tr>
<tr>
<td>Bactericidal</td>
<td>66</td>
<td>Electrochemical etching</td>
</tr>
<tr>
<td>Beetle-inspired hybrid surface</td>
<td>87</td>
<td>Erosion</td>
</tr>
<tr>
<td>Bio-inspired Surfaces</td>
<td>32, 67, 75</td>
<td>Experimental</td>
</tr>
<tr>
<td>Biomimetics</td>
<td>37, 84</td>
<td>Fabric carriers</td>
</tr>
<tr>
<td>Biomimicry</td>
<td>54</td>
<td>Flat heat pipe</td>
</tr>
<tr>
<td>Bioelectronics</td>
<td>37</td>
<td>Flexibility</td>
</tr>
<tr>
<td>Biocomposites</td>
<td>62</td>
<td>Floating bodies</td>
</tr>
<tr>
<td>Biocompatibility</td>
<td>72</td>
<td>Fluoropolymer</td>
</tr>
<tr>
<td>Bioinspiration</td>
<td>58</td>
<td>Fluorescence</td>
</tr>
<tr>
<td>Blood Separation</td>
<td>61</td>
<td>Fluorescence Microscopy</td>
</tr>
<tr>
<td>Boiling heat transfer</td>
<td>35</td>
<td>Fog collection</td>
</tr>
<tr>
<td>Boehmitization</td>
<td>82</td>
<td>Fog harvesting</td>
</tr>
<tr>
<td>Broadband</td>
<td>55</td>
<td>Formation</td>
</tr>
<tr>
<td>Bubble visualization</td>
<td>35</td>
<td>Friction</td>
</tr>
<tr>
<td>Capillary peeling</td>
<td>29</td>
<td>Functionalization</td>
</tr>
<tr>
<td>Carbon fiber</td>
<td>40</td>
<td>Galinstan</td>
</tr>
<tr>
<td>Carbon nanotubes</td>
<td>47</td>
<td>Glass</td>
</tr>
<tr>
<td>Cassie-Baxter</td>
<td>42</td>
<td>Glass micro-machining</td>
</tr>
<tr>
<td>Cavity</td>
<td>89</td>
<td>Gradient</td>
</tr>
<tr>
<td>Coalescence-induced jumping</td>
<td>21</td>
<td>Hairy</td>
</tr>
<tr>
<td>Colloidal Assembly</td>
<td>23</td>
<td>Half mushroom</td>
</tr>
<tr>
<td>Composite</td>
<td>40</td>
<td>Hedgehog</td>
</tr>
<tr>
<td>Condensation</td>
<td>17, 68, 87, 89</td>
<td>Heat transfer</td>
</tr>
<tr>
<td>Concrete coating</td>
<td>30</td>
<td>Heat engine</td>
</tr>
<tr>
<td>Condensation</td>
<td>33</td>
<td>Hierarchical</td>
</tr>
<tr>
<td>Conjugated polymer</td>
<td>47</td>
<td>High aspect ratio</td>
</tr>
<tr>
<td>Contact line dissipation</td>
<td>21</td>
<td>High temperature</td>
</tr>
<tr>
<td>Contact line dynamics</td>
<td>22</td>
<td>High-speed camera</td>
</tr>
<tr>
<td>Contact time</td>
<td>28</td>
<td>High Energy Anodes</td>
</tr>
<tr>
<td>Contact angle hysteresis</td>
<td>64</td>
<td>Hotspot cooling</td>
</tr>
<tr>
<td>Corrosion resistance</td>
<td>94</td>
<td>Humidity</td>
</tr>
<tr>
<td>Contact line</td>
<td>44</td>
<td>Hydrophobic</td>
</tr>
</tbody>
</table>

The First International Conference on Nature Inspired Surface Engineering (NISE 2019) Abstracts, Vol. 1, no. 1 95
<table>
<thead>
<tr>
<th>Topic</th>
<th>Page Numbers</th>
<th>Related Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrophilic</td>
<td>61</td>
<td>Nanotube</td>
</tr>
<tr>
<td>Hydrogel</td>
<td>57, 66, 72</td>
<td>Nano-lignin</td>
</tr>
<tr>
<td>Hydrophobic</td>
<td>78</td>
<td>Non-stick droplets</td>
</tr>
<tr>
<td>Hybrid Materials</td>
<td>86</td>
<td>Non-wetting</td>
</tr>
<tr>
<td>Icophobic coatings</td>
<td>32</td>
<td>Numerical</td>
</tr>
<tr>
<td>Impact icing physics</td>
<td>32</td>
<td>Nucleation control</td>
</tr>
<tr>
<td>Interface</td>
<td>25, 71</td>
<td>Numerical simulation</td>
</tr>
<tr>
<td>Interface wetting</td>
<td>59</td>
<td>n-ZnO/p-Si nanodiode arrays</td>
</tr>
<tr>
<td>Interfacial tension</td>
<td>47</td>
<td>Octopus sucker</td>
</tr>
<tr>
<td>Jumping</td>
<td>16</td>
<td>Oil-Impregnation</td>
</tr>
<tr>
<td>Lab-on-a-chip</td>
<td>38</td>
<td>Oil-Impregnation</td>
</tr>
<tr>
<td>Laser nano fabrication</td>
<td>50</td>
<td>Omniphobic surface</td>
</tr>
<tr>
<td>Leidenfrost</td>
<td>34</td>
<td>Optical</td>
</tr>
<tr>
<td>Liquid marbles</td>
<td>19, 63</td>
<td>Optical switch</td>
</tr>
<tr>
<td>Liquid Metal</td>
<td>46</td>
<td>Optofluidics</td>
</tr>
<tr>
<td>Liquid Repellent Surface</td>
<td>23</td>
<td>Organic semiconductor</td>
</tr>
<tr>
<td>Liquid-infused surfaces</td>
<td>29, 33</td>
<td>Particle removal</td>
</tr>
<tr>
<td>Li-ion Batteries</td>
<td>86</td>
<td>Patterning</td>
</tr>
<tr>
<td>Lubricant impregnated</td>
<td>42</td>
<td>Phase-change heat transfer</td>
</tr>
<tr>
<td>Lubricant infused surface (LIS)</td>
<td>43, 44</td>
<td>Phase change materials</td>
</tr>
<tr>
<td>LIPSS</td>
<td>93</td>
<td>Pitch-coated Composites</td>
</tr>
<tr>
<td>Magnetic actuation</td>
<td>27</td>
<td>Polymer</td>
</tr>
<tr>
<td>Magnetic artificial cilia</td>
<td>38</td>
<td>Polypyrrole</td>
</tr>
<tr>
<td>Magnetically responsive</td>
<td>73</td>
<td>Polyethylene glycol (PEG)</td>
</tr>
<tr>
<td>Magnesium Alloy</td>
<td>77</td>
<td>Porous silicon</td>
</tr>
<tr>
<td>Marine applications</td>
<td>13</td>
<td>Pool boiling</td>
</tr>
<tr>
<td>Marangoni flow</td>
<td>63</td>
<td>Pore-widening time</td>
</tr>
<tr>
<td>Material surface design</td>
<td>91</td>
<td>Protein lubrication</td>
</tr>
<tr>
<td>Mechanical</td>
<td>53</td>
<td>Pseudocapacitor</td>
</tr>
<tr>
<td>Mechanowetting</td>
<td>27</td>
<td>Repellency</td>
</tr>
<tr>
<td>Mechanical strength</td>
<td>30</td>
<td>Replication</td>
</tr>
<tr>
<td>Mechanochromism</td>
<td>52</td>
<td>Reversible Adhesion</td>
</tr>
<tr>
<td>MEMS</td>
<td>60</td>
<td>Re-entrant structure</td>
</tr>
<tr>
<td>Mesh</td>
<td>80</td>
<td>Rich Prospect Browsing</td>
</tr>
<tr>
<td>Microtexture</td>
<td>14</td>
<td>SACE</td>
</tr>
<tr>
<td>Microstructure</td>
<td>53</td>
<td>Self-assembly Voronoi entropy</td>
</tr>
<tr>
<td>Microstructured surface</td>
<td>12</td>
<td>Self-cleaning</td>
</tr>
<tr>
<td>Micro</td>
<td>71</td>
<td>Self-Healing Membranes</td>
</tr>
<tr>
<td>Microfluidics</td>
<td>61</td>
<td>Self-propulsion</td>
</tr>
<tr>
<td>Microstructure</td>
<td>74</td>
<td>Sensing</td>
</tr>
<tr>
<td>Microwrinkles</td>
<td>84</td>
<td>Shape Memory Polymer</td>
</tr>
<tr>
<td>Micro-capillary bridge</td>
<td>22</td>
<td>Shot peening</td>
</tr>
<tr>
<td>Micro- and nanostructure</td>
<td>24</td>
<td>Si Nano-layer Coating</td>
</tr>
<tr>
<td>Micro-nano hybrid surfaces</td>
<td>35</td>
<td>Skin-friction</td>
</tr>
<tr>
<td>Micro-actuators</td>
<td>60</td>
<td>Skin-patch</td>
</tr>
<tr>
<td>Micro-machining</td>
<td>70</td>
<td>Skin electronics</td>
</tr>
<tr>
<td>MOF</td>
<td>87</td>
<td>SLIP</td>
</tr>
<tr>
<td>Moses effect</td>
<td>64</td>
<td>SLIPS</td>
</tr>
<tr>
<td>Moss plants-inspired surface</td>
<td>88</td>
<td>Sliding speed</td>
</tr>
<tr>
<td>Mucins</td>
<td>14</td>
<td>Slippery Surfaces</td>
</tr>
<tr>
<td>Multifunctionality</td>
<td>53</td>
<td>Soft Matter</td>
</tr>
<tr>
<td>Nanoporous Structure</td>
<td>69</td>
<td>Soft Robots</td>
</tr>
<tr>
<td>Nanoarrays</td>
<td>16</td>
<td>Solution Processing</td>
</tr>
<tr>
<td>Nanofibers</td>
<td>51, 58</td>
<td>Soft surfaces</td>
</tr>
<tr>
<td>Nanoneedle</td>
<td>31</td>
<td>Splashing</td>
</tr>
<tr>
<td>Nanoporous scaffold</td>
<td>56</td>
<td>Spatial control</td>
</tr>
<tr>
<td>Nanostructure</td>
<td>37</td>
<td>Structural color</td>
</tr>
</tbody>
</table>