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PROSPECTIVES

Paper as a scaffold for cell cultures: teaching an old material new tricks

Xinchen Wu, **Sanika Suvarnapathaki**, **Kierra Walsh**, and **Gulden Camci-Unal**, University of Massachusetts Lowell, USA

Paper-based cell culture platforms have emerged as a promising approach for a myriad of biomedical applications, such as tissue engineering, disease models, cancer research, biotechnology, high-throughput testing, biosensing, and diagnostics. Paper enables the generation of highly flexible, biocompatible, inexpensive, porous, and three-dimensional (3D) constructs and devices. These systems have been used to culture mammalian cells, bacteria, algae, and fungi. Studies have shown that paper is an exceptional material for applications in life sciences, materials sciences, engineering, and medicine. Paper has been employed for creating biomimetic cell culture environments by folding or stacking it into the desired 3D shapes and structures. This review discusses the use of paper-based platforms for cellular applications and provides a diverse range of examples. DOI:10.1557/mrc.2018.8

Temperature-dependent nanoindentation response of materials

Saeed Zare Chavoshi, Imperial College London, London, UK; and **Shuozhi Xu**, University of California, Santa Barbara, USA

It is of the uttermost interest to understand the mechanical performance and deformation mechanisms contributing to small-scale plasticity of materials in micro/nanoelectromechanical systems at their service temperatures, which are usually above room temperature. In recent years, high-temperature nanoindentation experiments have emerged as a reliable approach to characterize the deformation behavior of materials at the nano and submicron scale. In this review, we highlight the role of the temperature in nanoindentation response of a wide variety of materials, with a particular focus on the thermally-activated deformation mechanisms in crystalline and non-crystalline materials under the indenter, e.g., dislocation processes, shear transformation zone, and phase transformations. A brief survey of the temperature-dependent nanoindentation elastic modulus, hardness, and creep behavior of materials is also provided. We also discuss experimental methods for correctly measuring the mechanical properties of materials at high temperatures. DOI:10.1557/mrc.2018.19

COMMENTARY

Water photonics, non-linearity, and anomalously large electro-optic coefficients in poled silica fibers

John Canning, University of Technology, Sydney, Australia, and The University of Sydney, Australia

A review of the literature offers an explanation for the large anomalous electro-optic (e.o.) effect reported by Fujiwara et al. in 1994. It is based on the large e.o. coefficient of ordered water at an interface measured in recent years >1000 pm/V. More broadly, the concept of water-based photonics, where water could be a new platform material for devices and systems, is introduced, suggesting that liquid states of matter can allow ready shaping and exploitation of many processes in ways not previously considered. This paper is a commentary on the significance of this new understanding and the broader interest of water in photonics, particularly its consideration as a new platform material. DOI:10.1557/mrc.2018.15

RESEARCH LETTERS

Silver nanostructures evolution in porous SiO_2/*p*-Si matrices for wide wavelength surface-enhanced Raman scattering applications

Dmitry Yakimchuk, **Egor Kaniukov**, and **Victoria Bundyukova**, Scientific-Practical Materials Research Center NAS of Belarus, Belarus; **Liubov Osminkina**, Lomonosov Moscow State University, Russian Federation; **Steffen Teichert**, Ernst Abbe University of Applied Science, Germany; **Sergey Demyanov**, Scientific-Practical Materials Research Center NAS of Belarus, Belarus; and **Vladimir Sivakov**, Leibniz Institute of Photonic Technology, Germany

The formation of silver nanostructures (AgNSs) with different crystals morphology in porous SiO_2/*p*-Si templates by the electroless wet-chemical method at temperatures between 20 and 50 °C and surface-enhanced Raman scattering (SERS) was investigated. It was found that optimized dendritic silver architectures contain a significant number of localized "hot spots." We show that well-reproducible AgNSs provide a significantly enhanced Raman signal of Nile blue dye molecules up to 10^{-6} M by using different excitation wavelengths (473, 532, and 633 nm). Based on our observations, the well-organized AgNSs can act as efficient surfaces for SERS as well as (bio)-sensor applications. DOI:10.1557/mrc.2018.22

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Colon cancer cells adhesion on polymeric nanostructured surfaces

Angelo Accardo, Université de Toulouse, France; and **Victoria Shalabaeva** and **Rosanna La Rocca**, Istituto Italiano di Tecnologia, Italy

In this work, we report on the adhesion of HCT116 (human colon carcinoma cells) cultured on nanofibrillar polymethylmethacrylate (PMMA) and SU-8 micropillars substrates. Both surfaces enabled a good cell proliferation and promoted the formation of adherent interconnections with the fabricated nano- and microstructures. The three-dimensional immunofluorescence confocal characterization of the cells on nanotextured PMMA highlighted the expression of well-spread F-actin cytoskeletal networks as well as the presence of focal adhesions. This study provides thus interesting perspectives for further investigations on the force/adhesion mechanisms related to cancer cell growth and proliferation. DOI:10.1557/mrc.2017.128

Metal organic framework-modified nitrogen-doped graphene oxygen reduction reaction catalyst synthesized by nanoscale high-energy wet ball-milling structural and electrochemical characterization

Shiqiang Zhuang, **Bharath Babu Nunna**, and **Eon Soo Lee**, New Jersey Institute of Technology, USA

Nitrogen-doped graphene (N-G) is a promising non-platinum group metal catalyst for oxygen reduction reaction. A new N-G/metal organic framework (MOF) catalyst is derived by the modification of MOF on N-G catalysts to enhance the electrochemical performance of N-G by increasing the surface area and porosity in this paper. The characterization confirmed that the Brunauer–Emmett–Teller surface areas of N-G/MOF catalysts are 13–66 times larger than the original N-G catalyst. The highest current density (5.02 mA/cm^2) and electron transfer number (3.93) of N-G/MOFs are higher than the N-G catalyst. The current density of N-G/MOF catalyst is even higher than 10 wt% Pt/C catalyst. DOI:10.1557/mrc.2017.130

Nanostructured substrates for multi-cue investigations of single cells

Joseph A. Christodoulides, **Marc Christophersen**, **Jinny L. Liu**, and **James B. Delehanty**, Naval Research Laboratory, USA; **Deepa Raghu**, Naval Research Laboratory, USA, and BioReliance, Sigma-Aldrich Corp., USA; and **Michael Robitaille**, **Jeff M. Byers**, and **Marc P. Raphael**, Naval Research Laboratory, USA

Cellular adhesion depends on the integration of numerous signaling inputs generated by the chemical and physical properties of the substrate. The complex coupling among inputs makes it challenging experimentally to deconvolve their individual contributions to the adhesion process. To address this roadblock, we have employed a combination of electron beam and optical lithographic techniques to fabricate substrates with independently tunable topographical and chemical signaling cues. Arrays of gold nanostructures were patterned atop quartz substrates, half of which were etched into gold-capped nanopillars. Individual A549 cells exposed simultaneously to Arg-Gly-Asp-functionalized etched and non-etched arrays exhibited strongly preferential adherence to the nanopillars. DOI:10.1557/mrc.2018.2

Effect of the spacer arm on non-specific binding in membrane affinity chromatography

Eleonora Lalli, **Giulio C. Sarti**, and **Cristiana Boi**, Alma Mater Studiorum-Università di Bologna, Italy

The preparation, screening, and characterization of affinity membranes require a deep knowledge of the behavior of all components of the affinity material. Several studies report the effect of different spacers in combination with the ligand molecule, but the effect of the spacer arm "per se" is generally disregarded. The effect of the spacer 1,2-diaminoethane on non-specific protein adsorption was recently investigated and the results were compared with the ones obtained with A2P affinity membranes. The results show that this spacer has indeed an important effect and that similar specific studies need to be performed for every spacer molecule. DOI:10.1557/mrc.2018.4

Synthetic biology with nanomaterials

Sanhita Ray and **Ahana Mukherjee**, University of Calcutta, India; **Pritha Chatterjee**, University of California, Riverside, USA; **Kaushik Chakraborty**, Centre for Research in Nanoscience and Nanotechnology, India; and **Anjan Dasgupta**, University of Calcutta, India

Magnetic field has been used to trigger biofilm formation. Iron oxide nanoparticles were attached to bacterial cells and cells were aggregated by application of magnetic field. Artificial cellular crowding triggered quorum sensing and led to formation of biofilm at sub-threshold population. Aggregation process was monitored by studying temporal dynamics of capacitance and conductance profiles. Capacitive profile exhibited a plateau upon introduction of magnetic field which was retained even after field was removed. This hysteresis property signified biofilm initiation in response to artificial crowding. This work demonstrates how synthetic biology is enabled by including nanoparticles in the interactome. DOI:10.1557/mrc.2018.23

Synthesis of nanosized zirconium dioxide and its solid solutions with titanium dioxide from the CO_2 supercritical fluid

I.E. Sokolov, **I.A. Konovalov**, **R.M. Zakalyukin**, and **D.V. Golubev**, Moscow Technological University, Russia; **A.S. Kumskov**, FRC Crystallography and Photonics, Russia, and National Research Center Kurchatov Institute, Russia; and **V.V. Fomichev**, Moscow Technological University, Russia

In this study, the formation solid solutions of titanium dioxide- zirconium dioxide (TiO_2-ZrO_2) system with the supercritical fluid method is described. The particles of solid solutions in the TiO_2-ZrO_2 system are spherical and form agglomerates, they are amorphous and have a size from 90 to 850 nm. The x-ray patterns of samples calcined above the temperatures of crystallization (450 °C) and phase transition (750 °C) demonstrate the decomposition of the solid solutions above the crystallization temperature and formation of phases in accordance with phase ratios in the TiO_2-ZrO_2 system at these temperatures. The formation solid solutions of the starting materials are observed in all region of concentrations. DOI:10.1557/mrc.2018.3

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Self-patterning of graphene-encapsulated gold nanoparticles for surface-enhanced Raman spectroscopy

Yuan Li, The University of Alabama, USA; **Kelly Burnham**, NSF-REH Fellow, Northridge High School, USA; and **John Dykes** and **Nitin Chopra**, The University of Alabama, USA

The main challenges of developing advanced surface-enhanced Raman spectroscopy (SERS) sensors lie in the poor reproducibility, low uniformity, and the lack of molecular selectivity. In this paper, we report a facile and cost-effective approach for the large-scale patterning of graphene-encapsulated Au nanoparticles on Si substrate as efficient SERS sensors with highly-improved uniformity, reproducibility, and unique selectivity. The materials production was accomplished via an industry-applicable galvanic deposition—annealing—chemical vapor deposition approach, followed by a final plasma treatment. Our study provides a facile approach to the fabrication of uniform SERS substrate and further prompts the practical progress of SERS-based chemical sensors.
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Rapid microwave synthesis and optical activity of highly crystalline platinum nanocubes

Clare Davis-Wheeler Chin, **Sara Akbarian-Tefaghi**, **Juana Reconco-Ramirez**, and **John B. Wiley**, University of New Orleans, USA

We have developed a novel, facile, and reproducible synthesis of highly crystalline oleylamine-capped colloidal platinum nanocubes by microwave (MW) heating. Use of MW heating decreases reaction times, eliminates the need for dangerous reagents [e.g., Fe(CO)5], and gives efficient production of monodispersed 8 nm Pt nanocubes [MW-nanoparticles (NPs)]. We also present a study of the optical properties of these NPs, which to our knowledge has not been previously reported. Absorbance spectra of the MW-NPs show a distinct localized surface plasmon resonance band at 213 nm. This observation could be significant for developments in plasmonic photocatalysis and advanced catalytic materials.
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Fabrication of nickel and nickel carbide thin films by pulsed chemical vapor deposition

Qun Guo, Beijing Institute of Graphic Communication, China; **Zheng Guo**, Peking University, China; **Jianmin Shi**, China Academy of Engineering Physics, China; **Lijun Sang**, **Bo Gao**, **Qiang Chen**, and **Zhongwei Liu**, Beijing Institute of Graphic Communication, China; and **Xinwei Wang**, Peking University, China

We report a new pulsed chemical vapor deposition (PCVD) process to deposit nickel (Ni) and nickel carbide (Ni_3C_x) thin films, using bis(1,4-di-*tert*-butyl-1,3-diazabutadienyl)nickel(II) precursor and either H_2 gas or H_2 plasma as the coreactant, at a temperature from 140 to 250 °C. All the PCVD films are fairly pure with low levels of N and O impurities. The films deposited with H_2 gas at ≤200 °C are faced centered cubic-phase Ni metal films with low C content; but at ≥220 °C, another phase of rhombohedral Ni_3C is formed and the C content increases. However, when H_2 plasma is used, the films are always in rhombohedral Ni_3C phase for the entire temperature range.
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