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PROSPECTIVES

A perspective on bio-inspired interfacial systems for solar clean-water generation

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With rapid growth of human population and decreasing labefaction of our environment, the usable fresh water is facing severe pollution and global shortage. Bio-inspired engineering and biotemplate-directed engineering thus offer great promise in clean water generation, including desalination, decontamination, and disinfection. This Prospective begins with an introduction of solar energy-based interfacial evaporation system inspired by the natural systems of organisms, and then provides a review of the development and recent progress of the interfacial evaporation system for clean water generation. The long-term outlook in this field of clean water generation using bio-inspired interfacial systems is also discussed. DOI:10.1557/mrc.2019.17

Nanoscale magnetization reversal by electric field-induced ion migration

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Nanoscale magnetization modulation by electric field enables the construction of low-power spintronic devices for information storage applications. Electric field-induced ion migration can introduce desired changes in the material's stoichiometry, defect profile, and lattice structure, which, in turn, provides a versatile and convenient means to modify the materials' chemical-physical properties at the nanoscale and *in situ*. In this review, we provide a brief overview on the recent study on nanoscale magnetization modulation driven by electric field-induced migration of ionic species either within the switching material or from external sources. The formation of magnetic conductive filaments that exhibit magnetoresistance behaviors in resistive switching memory via foreign metal ion migration and redox activities is also discussed. Combining the magnetoresistance and quantized conductance switching of the magnetic nanopoint contact structure may provide a future high-performance device for non von Neumann computing architectures. DOI:10.1557/mrc.2018.191

Graphene nanohybrids for enhanced catalytic activity and large surface area

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Nanohybrids containing graphene and bismuth ferrite have been actively employed as efficient photo-catalysts these days owing to the low rate of charge carrier's (e^-–h^+) recombination, moderate surface area with a suitable range of bandgaps. We have synthesized nanohybrids of graphene oxide (GO) and doped $BiFeO_3$ using a co-precipitation method and the doping elements were lanthanum and manganese, hence called BLFMO/GO nanohybrids. The surface area of BLFMO [La = 15% increased from 6.8 m^2/g (for pure) to 62.68 m^2/g (in nanohybrid)]. Also, the bandgap of the BLFMO/GO nanohybrid reduced significantly up to 1.75 eV. The resulting BLFMO/GO nanohybrid represents significantly higher catalytic activity (96% in 30 min) than the pure $BiFeO_3$ (30% in 30 min). DOI:10.1557/mrc.2018.194

3D models of the bone marrow in health and disease: Yesterday, today and tomorrow

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The complex interaction between hematopoietic stem cells (HSCs) and their microenvironment in the human bone marrow ensures a life-long blood production by balancing stem cell maintenance and differentiation. This so-called HSC niche can be disturbed by malignant diseases.

Investigating their consequences on hematopoiesis requires a deep understanding of how the niches function in health and disease. To facilitate this, biomimetic models of the bone marrow are needed to analyze HSC maintenance and hematopoiesis under steady state and diseased conditions. Here, 3D bone marrow models, their fabrication methods (including 3D bioprinting), and implementations recapturing bone marrow functions in health and diseases are presented. DOI:10.1557/mrc.2018.203

The 'Rock of Randomness'— A physical oracle for securing data off the digital grid

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The authors propose a device to secure random data in analog format, so that it is taken off the digital grid. Such action will turn off the means by which remote hackers violate security. A physical "rock" is manufactured through 3D-printing technology, constructed on the basis of high-grade randomness, which is packed into the comprising materials of that rock. The rock functions as an oracle, and does not allow any massive copy of its content. Thus, a major claim of this Prospective is that materials science and engineering may hold the keys to the future of cryptography. DOI:10.1557/mrc.2019.8

RESEARCH LETTERS

Effect of excessive Pb on the stability and performance of Pb-halide perovskite solar cells against photo-induced degradation

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Perovskite solar cells have evolved significantly since their inception. However, stability is still a major concern. We fabricated devices using a glass/ITO/PEDOT:PSS/$MAPbI_3$/PCBM/Ag device configuration. Devices fabricated using the Pb-acetate precursors showed an efficiency of 13%. This work reports the effect of adding excess lead to the precursor and its impact on the light-induced degradation of efficiency. It is found that 5% excess lead is best for devices regarding the performance and stability and devices retained greater than 50% of the initial efficiency after 2 h of prolonged irradiation. We attribute this phenomenon to the formation of PbI_2, which induces passivation in the grain boundaries. DOI:10.1557/mrc.2018.231

Interfacial properties of morpholine-2,5-dione based oligodepsipeptides and multiblock copolymers

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Oligodepsipeptides (ODPs) with alternating amide and ester bonds prepared by ring-opening polymerization of morpholine-2,5-dione derivatives are promising matrices for drug delivery systems and building blocks for multifunctional biomaterials. Here, we elucidate the behavior of three telechelic ODPs and one multiblock copolymer containing ODP blocks at the air–water interface. Surprisingly, whereas the oligomers and multiblock copolymers crystallize in bulk, no crystallization is observed at the air–water interface. Furthermore, polarization modulation infrared reflection absorption spectroscopy is used to elucidate hydrogen bonding and secondary structures in ODP monolayers. The results will direct the development of the next ODP-based biomaterial generation with tailored properties for highly sophisticated applications. DOI:10.1557/mrc.2019.21

3D Printing of poly(vinylidene fluoride-trifluoroethylene): A poling-free technique to manufacture flexible and transparent piezoelectric generators

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Flexible piezoelectric generators (PEGs) present a unique opportunity for renewable and sustainable energy harvesting. Here, we present a low-temperature and low-energy deposition method using solvent evaporation-assisted three-dimensional printing to deposit electroactive poly(vinylidene fluoride) (PVDF)-trifluoroethylene (TrFE) up to 19 structured layers. Visible-wavelength transmittance was above 92%, while ATR-FTIR spectroscopy showed little change in the electroactive phase fraction between layer depositions. Electroactivity from the fabricated PVDF-TrFE PEGs showed that a single structured layer gave the greatest output at 289.3 mV peak-to-peak voltage. This was proposed to be due to shear-induced polarization affording the alignment of the fluoropolymer dipoles without an electric field or high temperature. DOI:10.1557/mrc.2019.19

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Self-healing liquid-infused surfaces with high transparency for optical devices

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The glass surfaces used for optical devices are necessary to have high transparency. Here we propose to take advantage of tube-like SiO_2 textures to trap lubricant liquid inside aiming to prepare novel slippery liquid-infused porous surfaces (SLIPS). As a consequence, SLIPS with high transparency were synthesized on glass substrate successfully. The capillary action of unique tubular structure induces the ion migration of adjacent Krytox 100, thus endowing SLIPS with the self-healing property. Moreover, the remarkable slip behavior enables these surfaces to possess the self-cleaning and anti-biofouling performances. The current work might provide a promising candidate for long-term transparent optical devices. DOI:10.1557/mrc.2018.241

Deciphering charge-storage mechanisms in 3D MnO*x*@carbon electrode nanoarchitectures for rechargeable zinc-ion cells

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The authors previously demonstrated that electrode architectures comprising nanoscale birnessite-like MnO*x* affixed to three-dimensional carbon nanofoam (CNF) scaffolds offer performance advantages when used as cathodes in rechargeable zinc-ion cells. To discern chemical and physical changes at the MnO*x*@CNF electrode upon deep charge/discharge in aqueous Zn^{2+}-containing electrolytes, the authors deploy electroanalytical methods and *ex situ* characterization by microscopy, elemental analysis, x-ray photoelectron spectroscopy, x-ray diffraction, and x-ray pair distribution function analyses. Our findings verify that redox processes at the MnO*x* are accompanied by reversible precipitation/dissolution of crystalline zinc hydroxide sulfate ($Zn_4(OH)_6(SO_4)\bullet xH_2O$), mediated by the more uniformly reactive electrode structure inherent to the CNF scaffold. DOI:10.1557/mrc.2019.3

Reliability of inkjet printed silver nanoparticle interconnects on deformable substrates tested through an electromechanical *in situ* technique

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Inkjet printing is a promising technology providing cost-effective method for processing various materials on deformable substrates. In this work, linear and serpentine inkjet printed interconnects on two different substrates were fabricated and electromechanically characterized. A particular attention was given to the optimization of the process parameters; high quality can be achieved only printing slowly in vertical direction and optimizing the drop spacing to the specific pattern. The electromechanical results showed that the geometrical layout and printing direction strongly affect the printing quality and the electromechanical response; serpentine shapes should be preferred to straight interconnects as better gauge factors are obtained. DOI:10.1557/mrc.2019.10

Phase separation of a nematic liquid crystal in the self-assembly of lysozyme in a drying aqu eous solution drop

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This paper discusses the unique patterns evolved through phase separation of a bulk liquid crystal (LC) from the self-assembly of lysozyme induced by evaporation of de-ionized water only. Each domain shows a central dark region surrounded by bright regions (randomly oriented LC droplets). The birefringence intensity reveals three regimes (a slow increase, rapid rise, then saturation) not seen without LC droplets. The textural study exhibits a simple exponential behavior that changes as a function of LC concentration. Furthermore, in the presence of LC, the crack patterns are found to be different near the drop edge than those in the central region. DOI:10.1557/mrc.2019.18

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