MRS Communications
2018 • Volume 8, Issue 2
2016 Impact Factor 3.01

To view additional abstracts and gain access to Prospectives Articles, Commentaries and Research Letters, visit www.mrs.org/mrc.

PROSPECTIVES ARTICLES

Carbyne: from the elusive allotrope to stable carbon atom wires

C.S. Casari and **A. Milani**, Department of Energy, Politecnico di Milano via Ponzio, Italy

Besides graphite and diamond, the solid allotropes of carbon in sp^2 and sp^3 hybridization, the possible existence of a third allotrope based on the *sp*-carbon linear chain, the carbyne, has stimulated researchers for a long time. The advent of fullerenes, nanotubes, and graphene has opened new opportunities and nurtured the interest in novel carbon allotropes, including linear structures. The efforts made in this direction produced a number of interesting *sp*-hybridized carbon molecules and nanostructures in the form of carbon-atom wires. Here we discuss some of the new perspectives opened by the recent advancements in the research on *sp*-carbon systems. DOI:10.1557/mrc.2018.48

Bioreplication for optical applications

Raúl J. Martín-Palma and **Akhlesh Lakhtakia**, The Pennsylvania State University, USA

Evolving from the oblique-angle deposition method used industrially for the deposition of thin films, the conformal-evaporated-film-by-rotation (CEFR) technique has been successfully applied to replicate surfaces of biologic origin. The CEFR technique is the first step of the Nano4Bio technique, an industrially scalable bioreplication process, the other three steps being electroforming, plasma ashing, and either stamping or casting. These techniques have found optical applications in diverse fields, including forensic science, pest control, and light sources. DOI:10.1557/mrc.2018.85

New perspectives on nano-engineering by secondary electron spectroscopy in the helium ion and scanning electron microscope

Nicola Stehling and **Robert Masters**, University of Sheffield, UK; **Yangbo Zhou**, Nanchang University, China; **Robert O'Connell**, University of Dublin Trinity College, Ireland; **Chris Holland**, University of Sheffield, UK; **Hongzhou Zhang**, University of Dublin Trinity College, Ireland; and **Cornelia Rodenburg**, University of Sheffield, UK

The helium ion microscope (HeIM) holds immense promise for nano-engineering and imaging with scope for *in situ* chemical analysis. Here we will examine the potential of secondary electron hyperspectral imaging (SEHI) as a new route to exploring chemical variations in both two and three dimensions. We present a range of early applications in the context of image interpretation in wider materials science and process control in ion beam-based nano-engineering. Necessary steps for SEHI in the HeIM to evolve into a reliable technique which can be fully embedded into nano-engineering workflows are considered. DOI:10.1557/mrc.2018.75

RESEARCH LETTERS

Biomimetic protein-harpooning surfaces

G.M.L. Messina, **C. Bonaccorso**, **A. Rapisarda**, **B. Castroflorio**, **D. Sciotto**, and **G. Marletta**, University of Catania, Italy

Properly driving protein interactions with solid surfaces play a very important role in many natural processes, stimulating a great interest for the design of new biomaterials and medical devices. Despite the progress in this field, many further upgrades have to be achieved to better exploit the protein driving, in terms of control of amounts and conformation of the adsorbing proteins. In this paper, new biocompatible amino acid–calix[4]crown-5 bilayers were built as nano-templating surfaces, hosting a controlled number of anchoring sites, able to immobilize proteins in well-defined quantity, and the evaluated footprint data support the idea of oriented protein on analyzed substrates. The efficiency of the setup was tested for the particular case of antibacterial lysozyme adsorption on biocompatible surfaces. DOI:10.1557/mrc.2018.54

Molecular dynamics simulations of montmorillonite reinforcing amylose plasticized by Brazilian Cerrado oils: polymer-clay nanocomposite

Felipe Azevedo Rios Silva and **Maria José Araújo Sales**, Universidade de Brasília, Brazil; **Mohamed Ghoul** and **Latifa Chebil**, Université de Lorraine, France; **Guilherme Duarte Ramos Matos**, University of California, Irvine, USA; and **Elaine Rose Maia**, Universidade de Brasília, Brazil

In this study, we performed computational simulations to extend the behavior knowledge over molecular systems composed by amylose oligomers, three fatty acids often found in Brazilian vegetable oils, water solvent, and montmorillonite. The focus is directed to the molecular movement and to intra and intermolecular interactions, each simulation step being compared with the literature's experimental profile. The calculations were mostly performed by Molecular Mechanics and Dynamics methods. The excellent agreement and complementarities with the literature results indicate, once again, the important contribution offered by the computational simulations to the design of new polymer–clay nanocomposites with biopolymers. DOI:10.1557/mrc.2018.41

Resonant thermoelectric transport in atomic chains with Fano defects

J. Eduardo González, **Chumin Wang**, and **Vicenta Sánchez**, Universidad Nacional Autónoma de México, Mexico

Atomic clusters attached to a low-dimensional system, called Fano defects, produce rich wave interferences. In this work, we analytically found an enhanced thermoelectric figure-of-merit (ZT) in periodic atomic chains with Fano defects, compared with those without such defects. We further study self-assembled DNA-like systems with periodic and quasiperiodically placed Fano defects by using a real-space renormalization method developed for the Kubo–Greenwood formula, in which tight-binding and Born models are respectively used for the electric and lattice thermal conductivities. The results reveal that the quasiperiodicity could be another ZT-improving factor, whose long-range disorder inhibits low-frequency acoustic phonons insensitive to local defects. DOI:10.1557/mrc.2018.84

Assessing failure in epitaxially encapsulated micro-scale sensors using micro and nano x-ray computed tomography

Lizmarie Comenencia Ortiz, **David B. Heinz**, **Ian B. Flader**, **Anne L. Alter**, **Dongsuk D. Shin**, **Yunhan Chen**, and **Thomas W. Kenny**, Stanford University, USA

Millions of micro electro mechanical system sensors are fabricated each year using an ultra-clean process that allows for a vacuum-encapsulated cavity. These devices have a multi-layer structure that contains hidden layers with highly doped silicon, which makes common imaging techniques ineffective. Thus, examining device features post-fabrication, and testing, is a significant challenge. Here, we use a combination of micro- and nano-scale x-ray computed tomography to study device features and assess failure mechanisms in such devices without destroying the ultra-clean cavity. This provides a unique opportunity to examine surfaces and trace failure mechanisms to specific steps in the fabrication process. DOI:10.1557/mrc.2018.70

Automated self-assembly and electrical characterization of nanostructrutured films

Rafael C. Hensel and **Kevin L. Rodrigues**, University of Campinas, Brazil; **Vinicius do L. Pimentel**, Information Technology Center Renato Archer, Brazil; and **Antonio Riul** and **Varlei Rodrigues**, University of Campinas, Brazil

Significant progress in nanoscience was achieved through the development of methods and instruments to better comprehend nanoscale properties. We present here a methodology and automated setup to measure layer-by-layer films capacitance in the air immediately after polyelectrolytes adsorption. It presents high accuracy (~0.01 pF) to check the capacitance stabilization during spontaneous drying process in the air, with sensitivity to show electrical signal alternation accordingly to the outermost polyelectrolyte layer. Besides, a linear trend in capacitance was observed similar to UV–vis measurements. This method allows analyzing films electrical properties, affording better choice of materials, thickness, and molecular architecture. DOI:10.1557/mrc.2018.47

Alkyne modified water stable alkylammonium lead(II) iodide perovskite

Sayantan Sasmal and **Suresh Valiyaveettil**, National University of Singapore, Singapore, and Indian Institute of Technology, India; **Arun P. Upadhyay**, **Raj Ganesh S. Pala**, and **Sri Sivakumar**, Indian Institute of Technology, India; and **Dharmadoss Sornadurai** and **Chakram S. Sundar**, Indira Gandhi Centre for Atomic Research, India

Perovskite materials are sensitive to environmental conditions. Here we report the synthesis and characterization of a hydrophobic alkylammonium lead(II) iodide perovskite with enhanced stability in water. Water stability was achieved by growing a shell of 4-[(N-3-butyne)carboxyamido]anilinium lead(II) iodide over methylammonium lead(II) iodide. As a proof of concept, the water-splitting reaction was performed using our new material coated on TiO_2, and a 7-fold increase in applied bias photon-to-current efficiency was observed as compared with standard p25-TiO_2. Such simple and versatile chemical modification to induce high water stability is useful toward exploring new applications for the perovskite materials. DOI:10.1557/mrc.2018.56

Additive manufacturing of metal matrix composites via nanofunctionalization

John H. Martin, **Brennan D. Yahata**, **Eric C. Clough**, **Justin A. Mayer**, **Jacob M. Hundley**, and **Tobias A. Schaedler**, HRL Laboratories LLC, USA

A novel, alloy-agnostic, nanofunctionalization process has been utilized to produce metal matrix composites (MMCs) via additive manufacturing, providing new geometric freedom for MMC design. MMCs were produced with the addition of tungsten carbide nanoparticles to commercially available AlSi10Mg alloy powder. Tungsten carbide was chosen due to the potential for coherent crystallographic phases that were identified utilizing a lattice-matching approach to promote wetting and increase dislocation interactions. Structures were produced with evenly distributed strengthening phases leading to tensile strengths >385 MPa and a 50% decrease in wear rate over the commercially available AlSi10Mg alloy at only 1 vol% loading of tungsten carbide. DOI:10.1557/mrc.2018.95

Developing fire retardant and water repellent bio-structural panels (BISP) using nanocellulose

Nadir Yildirim, Bursa Technical University, Turkey

The fire-retardant and water-repellent bio-structural panels (BISPs) were successfully developed using cellulose nanofibrils, corn starch, boric acid, and *n*-dodecenyl succinic anhydride with adhesive-free character. Its performance properties were evaluated and compared with other well-known products on the market. The BISP's density (0.1 g/cm^3) and permeance value [41.81 g/day/m^2 with 5.76% coefficient of variation (CV)] were found higher than compared competitor products. The BISPs' contact angle was found 132.13° (1.59% CV) for BISP. The BISP was the only fire-retardant product, and the only one developed almost no smoke 2.20%. DOI:10.1557/mrc.2018.37