

# Nanoscale Horizons

The home for rapid reports of exceptional significance in nanoscience and nanotechnology

[rsc.li/nanoscale-horizons](http://rsc.li/nanoscale-horizons)

The Royal Society of Chemistry is the world's leading chemistry community. Through our high impact journals and publications we connect the world with the chemical sciences and invest the profits back into the chemistry community.

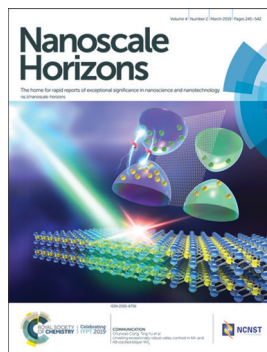
## IN THIS ISSUE

ISSN 2055-6756 CODEN NHAOAW 4(2) 245-542 (2019)



### Cover

See Songnan Qu *et al.*, pp. 388–395.  
Image reproduced by permission of Songnan Qu from *Nanoscale Horiz.*, 2019, 4, 388.



### Inside cover

See Chunxiao Cong, Ting Yu *et al.*, pp. 396–403.  
Image reproduced by permission of Yanlong Wang from *Nanoscale Horiz.*, 2019, 4, 396.

## EDITORIAL

256

### Horizons Community Board Collection – Nanobiomedicine

Chandra Kumar Dixit\* and Christopher M. Proctor\*

A themed collection on nanobiomedicine, guest edited by *Nanoscale Horizons* Community Board Member Chandra Kumar Dixit and *Materials Horizons* Community Board Member Christopher M. Proctor.



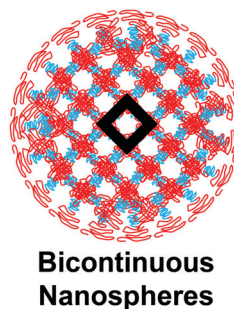
## REVIEWS

258

### On the advancement of polymeric bicontinuous nanospheres toward biomedical applications

Sean D. Allen, Sharan Bobbala, Nicholas B. Karabin and Evan A. Scott\*

Recent advancements in bicontinuous nanosphere research have demonstrated the key design considerations and preliminary work necessary for *in vivo* applications.



Design  
↓  
Characterization  
↓  
Biomedical Applications

## Editorial Staff

### Executive Editor

Sam Keltie

### Deputy Editor

Michaela Muehlberg

### Editorial Production Manager

Gisela Scott

### Development Editor

Hannah Kerr

### Publishing Editors

Lucy Balshaw, Emma Durham, Ed Gardner, Ella Wren, Alexander Whiteside

### Administrative Assistants

Ruoxuan Guo, Jinjing Liu, Ying Liu

### Publisher

Jamie Humphrey

For queries about submitted papers, please contact Gisela Scott, Editorial Production Manager in the first instance.

E-mail: [nanoscalehorizons@rsc.org](mailto:nanoscalehorizons@rsc.org)

For pre-submission queries please contact

Sam Keltie, Executive Editor.

E-mail: [nanoscalehorizons-rsc@rsc.org](mailto:nanoscalehorizons-rsc@rsc.org)

Nanoscale Horizons (print: ISSN 2055-6756 electronic: ISSN 2055-6764) is published 6 times a year by the Royal Society of Chemistry, Thomas Graham House, Science Park, Milton Road, Cambridge, CB4 0WF, UK Tel +44 (0)1223 432398; E-mail [orders@rsc.org](mailto:orders@rsc.org)

All orders, with cheques made payable to the Royal Society of Chemistry, should be sent to the Royal Society of Chemistry Order Department, Royal Society of Chemistry, Thomas Graham House, Science Park, Milton Road, Cambridge, CB4 0WF, UK Tel +44 (0)1223 432398; E-mail [orders@rsc.org](mailto:orders@rsc.org)

2019 Annual (print + electronic) subscription price: £2501; \$4128\*. 2019 Annual (electronic) subscription price: £2382; \$3931\*. Customers in Canada will be subject to a surcharge to cover GST. Customers in the EU subscribing to the electronic version only will be charged VAT.

If you take an institutional subscription to any Royal Society of Chemistry journal you are entitled to free, site-wide web access to that journal. You can arrange access via Internet Protocol (IP) address at [www.rsc.org/ip](http://www.rsc.org/ip)

Customers should make payments by cheque in sterling payable on a UK clearing bank or in US dollars payable on a US clearing bank.

Whilst this material has been produced with all due care, the Royal Society of Chemistry cannot be held responsible or liable for its accuracy and completeness, nor for any consequences arising from any errors or the use of the information contained in this publication. The publication of advertisements does not constitute any endorsement by the Royal Society of Chemistry or Authors of any products advertised. The views and opinions advanced by contributors do not necessarily reflect those of the Royal Society of Chemistry which shall not be liable for any resulting loss or damage arising as a result of reliance upon this material. The Royal Society of Chemistry is a charity, registered in England and Wales, Number 207890, and a company incorporated in England by Royal Charter (Registered No. RC000524), registered office: Burlington House, Piccadilly, London W1J 0BA, UK, Telephone: +44 (0) 207 4378 6556.

Advertisement sales:

Tel +44 (0) 1223 432246; Fax +44 (0) 1223 426017;

E-mail [advertising@rsc.org](mailto:advertising@rsc.org)

For marketing opportunities relating to this journal, contact [marketing@rsc.org](mailto:marketing@rsc.org)

\* Free online access to the entire 2016 and 2017 content of the journal will be provided to all institutions/organisations with registered IP addresses.

Access is available to institutions/organisations who are not Royal Society of Chemistry customers following a simple registration process at [http://www.rsc.org/Publishing/Journals/free\\_access\\_registration.asp](http://www.rsc.org/Publishing/Journals/free_access_registration.asp)

Individuals registered for a Royal Society of Chemistry publishing personal account will also have access to all 2016 and 2017 free access content.



# Nanoscale Horizons

## rsc.li/nanoscale-horizons

*Nanoscale Horizons* is the home for first reports of exceptional significance in nanoscience and nanotechnology.



Published in collaboration with the National Centre for Nanoscience and Technology, Beijing, China

## Editorial Board

### Chair

Harold Craighead, Cornell University, USA

### Scientific Editors

Xiaodong Chen, Nanyang Technological University, Singapore

Yves Dufrene, Universite Catholique de Louvain, Belgium

Dirk Guldi, Friedrich-Alexander University Erlangen-Nürnberg, Germany

### Members

Jang-Kyo Kim, Hong Kong University of Science and Technology, Hong Kong

Stefan Maier, Ludwig-Maximilians-Universität München, Germany

Anna Fontcuberta i Morral, Ecole Polytechnique Federale de Lausanne, Switzerland

Michael Sailor, University of California, San Diego, USA

Zhiyong Tang, National Center for Nanoscience and Technology, China

Sarah Tolbert, University of California, Los Angeles, USA

Miqin Zhang, University of Washington, USA

## Advisory Board

Takuzo Aida, University of Tokyo, Japan

Chunli Bai, Chinese Academy of Sciences, China

Jinwoo Cheon, University of Yonsei, South Korea

Serena Corr, University of Sheffield, UK

Rebekah Drezek, Rice University, USA

Andrea Ferrari, University of Cambridge, UK

Xingyu Jiang, National Center for Nanoscience and Technology, China

Rongchao Jin, Carnegie Mellon University, USA

Kostas Kostarelos, University of Manchester, UK

Yamuna Krishnan, University of Chicago, USA

Katharina Landfester, Max Planck Institute for Polymer Research, Germany

Jie Liu, Duke University, USA

Minghua Liu, National Center for Nanoscience and Technology, China

Xiaogang Liu, National University of Singapore, Singapore

Wei Lu, University of Michigan, USA

Chad Mirkin, Northwestern University, USA

Catherine Murphy, University of Illinois at Urbana-Champaign, USA

Valeria Nicolosi, Trinity College Dublin, Ireland

Sandra Rosenthal, Vanderbilt University, USA

Rodney Ruoff, Ulsan National Institute of Science and Technology, South Korea

Hisanori Shinohara, Nagoya University, Japan

Zuzanna Siwy, University of California, Irvine, USA

Francesco Stellacci, Swiss Federal Institute of Technology in Lausanne, Switzerland

Shouheng Sun, Brown University, USA

Jianfang Wang, Chinese University of Hong Kong, Hong Kong

Horst Weller, University of Hamburg, Germany

Hongxing Xu, Wuhan University, China

Xiao Cheng Zeng, University of Nebraska-Lincoln, USA

Hongjie Zhang, Changchun Institute of Applied Chemistry, China

Hua Zhang, Nanyang Technological University, Singapore

## Community Board

Julian Bergueiro Alvarez, Freie Universität Berlin, Germany

Simone Bertolazzi, Université de Strasbourg & CNRS, France

Randy Carney, University of California, Davis, USA

Jerry Chang, Rockefeller University, USA

Ciro Chiappini, King's College London, UK

Qing Dai, National Center for Nanoscience and Technology, China

Jonathan De Roo, Ghent University, Belgium

Eric Detsi, University of Pennsylvania, USA

Chandra Dixit, University of Connecticut, USA

Qingliang Feng, Northwestern Polytechnical University, China

Chunxian Guo, Suzhou University of Science and Technology, China

Marilena Hadjide metriou, Manchester University, UK

Liangliang Hao, Massachusetts Institute of Technology, USA

Shuaidong Huo, National Center for Nanoscience and Technology, China

Johannes Jobst, Leiden University, The Netherlands

Debin Kong, Tianjin University & National Center for Nanoscience and Technology, China

Sachin Kumar, Indian Institute of Science, Bangalore, India

Kohei Kusada, Kyoto University, Japan

Bo Li, University of Illinois at Urbana-Champaign, USA

Li Li, GlobalFoundries, USA

Xueqin Liu, China University of Geosciences, China

Jia Liu, Stanford University, USA

Robert Macfarlane, Massachusetts Institute of Technology, USA

J. Scott Niezgoda, Saint Joseph's University, USA

Anamaria Orza, Emory University, USA

Baichuan Sun, CSIRO, Australia

Chenyu Wang, University of Wisconsin-Madison, USA

Hai Wang, Jilin University, China

Kai Xu, National Center for Nanoscience and Technology, China

Kangyi Zhang, Institute of Materials Research and Engineering, Singapore

Yao Zheng, University of Adelaide, Australia

Kai Zhu, Harbin Engineering University, China

Xiaolu Zhuo, The Chinese University of Hong Kong, Hong Kong

## Information for Authors

Full details on how to submit material for publication in *Nanoscale Horizons* are given in the Instructions for Authors (available from <http://www.rsc.org/authors>). Submissions should be made via the journal's homepage: [rsc.li/nanoscale-horizons](http://rsc.li/nanoscale-horizons)

Authors may reproduce/republish portions of their published contribution without seeking permission from the Royal Society of Chemistry, provided that any such republication is accompanied by an acknowledgement in the form: (Original Citation)–Reproduced by permission of the Royal Society of Chemistry.

This journal is © The Royal Society of Chemistry 2019. Apart from fair dealing for the purposes of research or private study for non-commercial purposes, or criticism or review, as

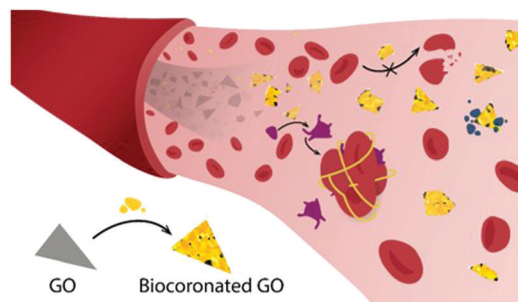
permitted under the Copyright, Designs and Patents Act 1988 and the Copyright and Related Rights Regulation 2003, this publication may only be reproduced, stored or transmitted, in any form or by any means, with the prior permission in writing of the Publishers or in the case of reprographic reproduction in accordance with the terms of licences issued by the Copyright Licensing Agency in the UK. US copyright law is applicable to users in the USA.

Ⓢ The paper used in this publication meets the requirements of ANSI/NISO Z39.48–1992 (Permanence of Paper).

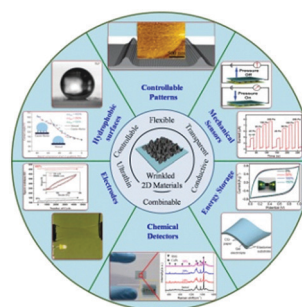
Registered charity number: 207890

## 273

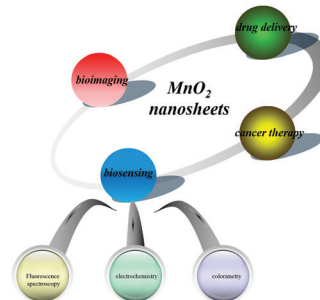
## The impact of graphene oxide biomolecular corona on blood components.



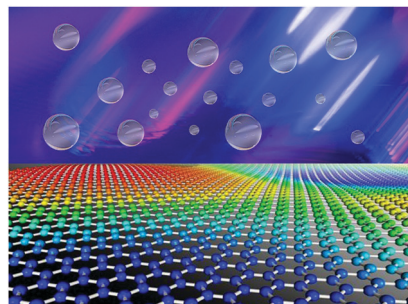
This review addresses the formation, fabrication methods, properties and applications of wrinkled patterns in 2D materials.



Schematic illustration of MnO<sub>2</sub> nanosheets for applications in biosensing, bioimaging, drug delivery and cancer therapy.

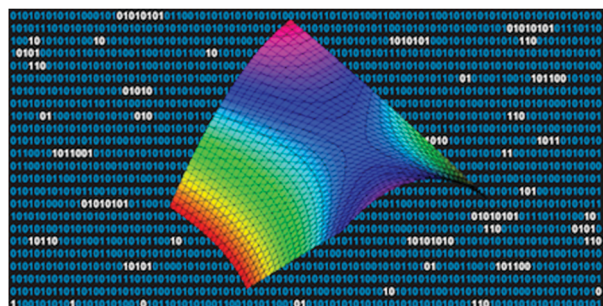


A comprehensive insight into the wettability of graphene with respect to water droplets, specifically including the influencing factors and reversible transformation, is presented in this review.



## MINIREVIEWS

365

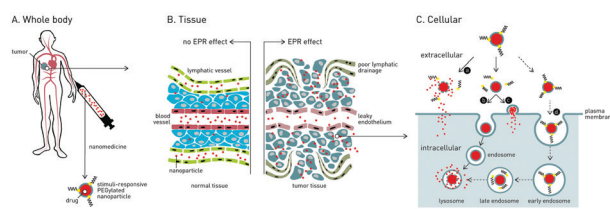


## Artificial intelligence in nanomedicine

Dean Ho,\* Peter Wang and Theodore Kee

Artificial intelligence is poised to substantially enhance the efficacy and safety of nanomedicine.

378



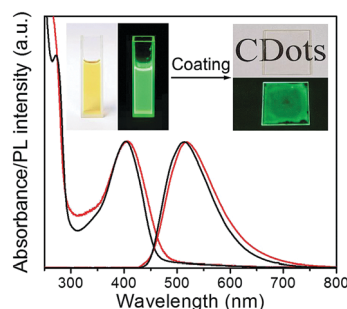
## DePEGylation strategies to increase cancer nanomedicine efficacy

Li Kong, Frederick Campbell and Alexander Kros\*

PEGylation of nanoparticles prolongs circulation lifetimes and maximizes nanoparticle accumulation in target tumors. However, PEGylation comes at the cost of reduced cellular uptake of nanoparticles and concomitant drug delivery. This review discusses the various stimuli-responsive dePEGylation strategies that have been employed to overcome this "PEG dilemma".

## COMMUNICATIONS

388

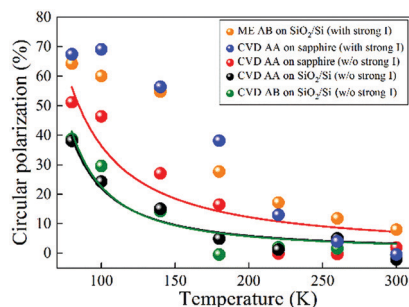


## Carbon dots produced via space-confined vacuum heating: maintaining efficient luminescence in both dispersed and aggregated states

Ding Zhou, Pengtao Jing, Yi Wang, Yuechen Zhai, Di Li, Yuan Xiong, Alexander V. Baranov, Songnan Qu\* and Andrey L. Rogach

A space-confined vacuum heating method has been developed to produce carbon dots which do not experience aggregation-induced luminescence quenching.

396

Unveiling exceptionally robust valley contrast in AA- and AB-stacked bilayer WS<sub>2</sub>

Yanlong Wang, Chunxiao Cong,\* Jingzhi Shang, Mustafa Eginligil, Yuqi Jin, Gang Li, Yu Chen, Namphung Peimyoo and Ting Yu\*

Phonon depletion in the indirect recombination process of bilayer WS<sub>2</sub> has been proposed to unveil exceptionally robust valley polarization.

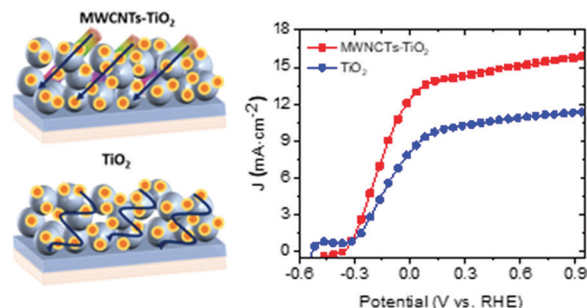


404

### A colloidal heterostructured quantum dot sensitized carbon nanotube–TiO<sub>2</sub> hybrid photoanode for high efficiency hydrogen generation

Gurpreet Singh Selopal, Mahyar Mohammadnezhad, Fabiola Navarro-Pardo, François Vidal, Haiguang Zhao,\* Zhiming M. Wang\* and Federico Rosei\*

A photoelectrochemical device based on a TiO<sub>2</sub>/QD–MWCNT (0.015 wt%) hybrid photoanode yields 40% higher photocurrent density than the control device.

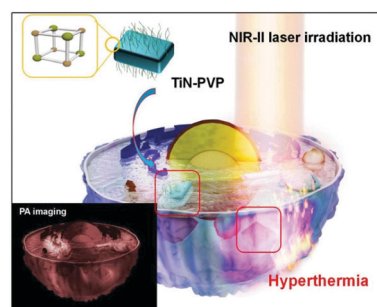


415

### Photonic cancer nanomedicine using the near infrared-II biowindow enabled by biocompatible titanium nitride nanoplateforms

Chunmei Wang, Chen Dai, Zhongqian Hu,\* Hongqiang Li, Luodan Yu, Han Lin, Jianwen Bai\* and Yu Chen\*

Titanium nitride nanoparticles with high photothermal-conversion efficiency and desirable biocompatibility have been constructed as an alternative theranostic agent for NIR-II laser-excited photoacoustic imaging-guided photothermal tumor hyperthermia.

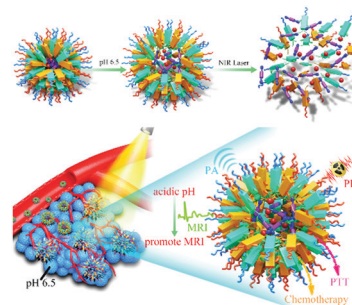


426

### Tumour microenvironment-responsive semiconducting polymer-based self-assembling nanotheranostics

Zhen Yang, Yunlu Dai,\* Lingling Shan, Zheyu Shen, Zhantong Wang, Bryant C. Yung, Orit Jacobson, Yijing Liu, Wei Tang, Sheng Wang, Lisen Lin, Gang Niu, Pintong Huang\* and Xiaoyuan Chen\*

The nanoparticles exhibit excellent tumor accumulation and lead to complete tumor eradication with low power NIR laser irradiation.

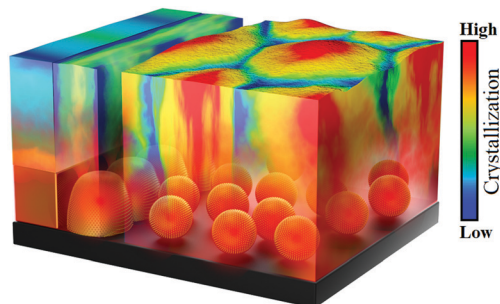


434

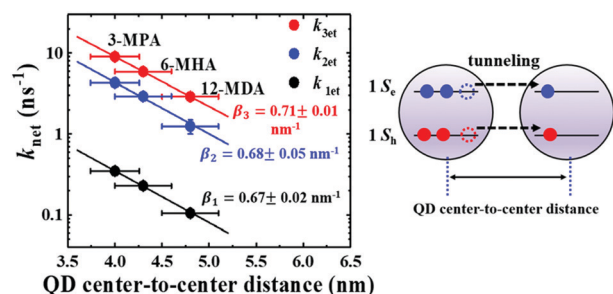
### Au quantum dots engineered room temperature crystallization and magnetic anisotropy in CoFe<sub>2</sub>O<sub>4</sub> thin films

Sagar E. Shirsath,\* Xiaoxi Liu, M. H. N. Assadi, Adnan Younis, Yukiko Yasukawa, Sumanta Kumar Karan, Ji Zhang, Jeonghun Kim, Danyang Wang,\* Akimitsu Morisako, Yusuke Yamauchi\* and Sean Li

For the first time, this work presents a novel room temperature time-effective concept to manipulate the crystallization kinetics and magnetic responses of thin films grown on amorphous substrates.



445

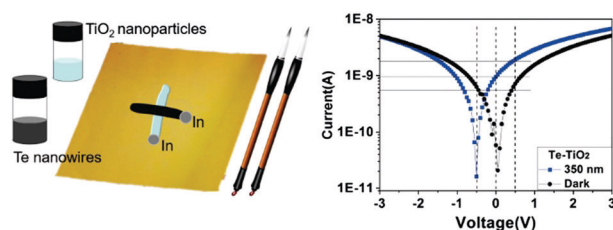


### The interparticle distance limit for multiple exciton dissociation in PbS quantum dot solid films

Naoki Nakazawa, Yaohong Zhang,\* Feng Liu, Chao Ding, Kanae Hori, Taro Toyoda, Yingfang Yao, Yong Zhou, Shuzi Hayase, Ruixiang Wang, Zhigang Zou and Qing Shen\*

The charge transfer rate constant  $k_{\text{net}}$  of single exciton, biexciton and triexciton within the QD solid film is exponentially enhanced as the interparticle distance between the QDs decreases, in which the charge transfer occurs via tunneling of charges between the neighboring QDs.

452

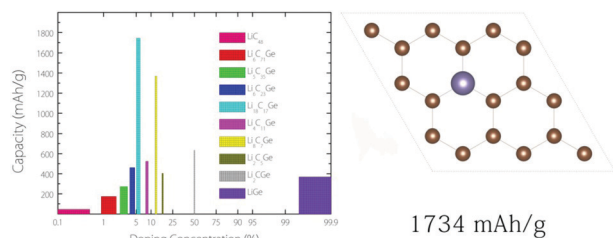


### Low-cost writing method for self-powered paper-based UV photodetectors utilizing Te/TiO<sub>2</sub> and Te/ZnO heterojunctions

Yong Zhang, Wenxin Xu, Xiaojie Xu, Wei Yang, Siyuan Li, Jiaxin Chen and Xiaosheng Fang\*

A low-cost, facile and green writing method to fabricate self-powered paper-based UV photodetectors utilizing Te/TiO<sub>2</sub> and Te/ZnO heterojunctions was achieved.

457

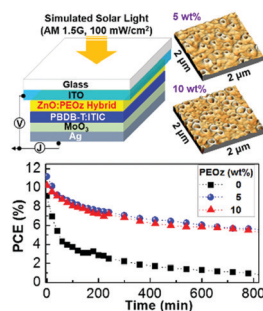


### Germagraphene as a promising anode material for lithium-ion batteries predicted from first-principles calculations

Junping Hu, Chuying Ouyang, Shengyuan A. Yang\* and Hui Ying Yang\*

We predict that germanium doping can help to turn graphene into an ideal LIB anode material with an extremely high capacity.

464



### Nano-crater morphology in hybrid electron-collecting buffer layers for high efficiency polymer:nonfullerene solar cells with enhanced stability

Jooyeok Seo, Sungho Nam, Hwajeong Kim,\* Donal D. C. Bradley and Youngkyoo Kim\*

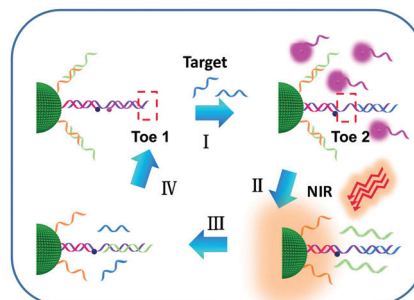
The nano-crater morphology, which is created in the ZnO:PEOz hybrid layers at 150 °C, improves the efficiency and stability of polymer:nonfullerene solar cells.

472

### Intracellular low-abundance microRNA imaging by a NIR-assisted entropy-driven DNA system

Huiting Lu, Fan Yang, Benhan Liu, Kai Zhang, Yu Cao, Wenhao Dai, Wenjun Li\* and Haifeng Dong\*

A NIR-assisted elegant entropy-driven DNA probe for highly sensitive catalytic imaging of low-abundance miRNA in living cells and *in vivo*.

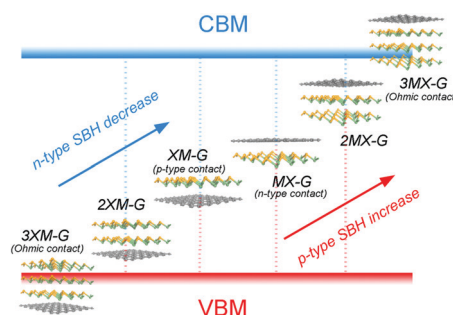


480

### Dipole controlled Schottky barrier in the blue-phosphorene-phase of GeSe based van der Waals heterostructures

Lei Peng, Yu Cui, Liping Sun, Jinyan Du, Sufan Wang, Shengli Zhang\* and Yucheng Huang\*

Intrinsic dipole of blue-phosphorene-phase GeSe can be used to modulate the Schottky barrier height of graphene/GeSe van der Waals heterostructures by stacking in different patterns.

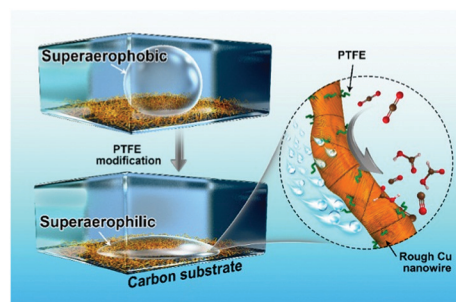


490

### Superaerophilic copper nanowires for efficient and switchable CO<sub>2</sub> electroreduction

Yusheng Zhang, Zhao Cai, Yuxin Zhao, Xuemei Wen, Wenwen Xu, Yang Zhong, Lu Bai, Wen Liu, Ying Zhang, Ying Zhang,\* Yun Kuang\* and Xiaoming Sun\*

A facile polytetrafluoroethylene treated strategy is used to modify Cu nanowire electrocatalyst to achieve high CO<sub>2</sub> reduction selectivity and suppress H<sub>2</sub> evolution simultaneously.

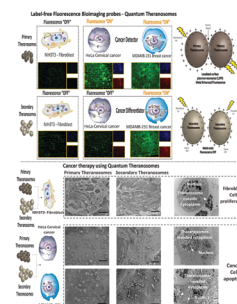


495

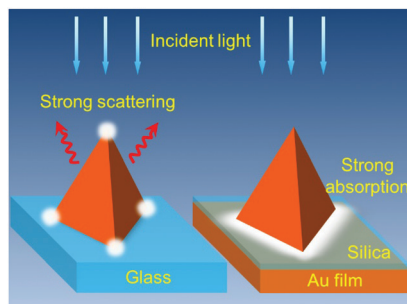
### 3D quantum theranosomes: a new direction for label-free theranostics

Sivaprasad Chinnakkannu Vijayakumar, Krishnan Venkatakrishnan\* and Bo Tan

Quantum-scale materials offer great potential in the field of cancer theranostics.



516

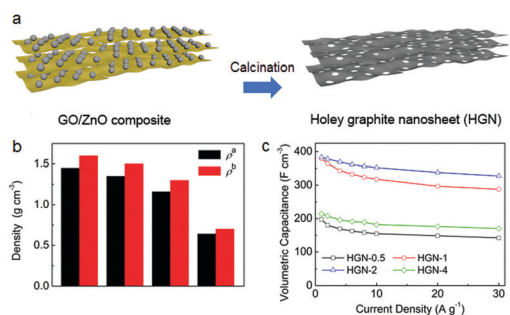


### Converting plasmonic light scattering to confined light absorption and creating plexitons by coupling a gold nano-pyramid array onto a silica–gold film

Peng Zheng, Sujan Kasani and Nianqiang Wu\*

This report presents a facile microfabrication-compatible approach to fabricate a large area of plasmonic nano-pyramid array-based antennas and demonstrates effective light management by tailoring the architecture.

526

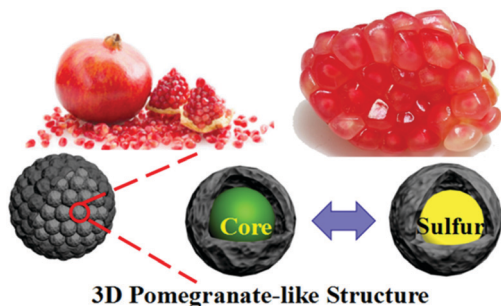


### Scalable synthesis of holey graphite nanosheets for supercapacitors with high volumetric capacitance

Jie Wang, Teahoon Park, Jin Woo Yi, Bing Ding, Joel Henzie, Zhi Chang, Hui Dou, Xiaogang Zhang\* and Yusuke Yamauchi\*

We developed a simple and scalable method to fabricate holey graphite nanosheets (HGNs) using GO as the carbon source and ZnO as an etching agent.

531



### 3D pomegranate-like TiN@graphene composites with electrochemical reaction chambers as sulfur hosts for ultralong-life lithium–sulfur batteries

Rongjie Luo, Qiuhong Yu, Yang Lu, Mengjie Zhang, Tao Peng, Hailong Yan, Xianming Liu, Jang-Kyo Kim and Yongsong Luo\*

3D pomegranate-like TiN@graphene composites as novel sulfur host materials can effectively improve the electrochemical properties of Li–S systems.





# 14<sup>th</sup> International Symposium on Functional $\pi$ -Electron Systems

2 - 7 June 2019 | Berlin, Germany | [www.fpi14.de](http://www.fpi14.de)

## Scientific Scope of the Symposium:

- design and synthesis of new  $\pi$ -conjugated molecules and polymers
- organic and polymeric semiconducting materials for thin film transistors
- organic and polymeric photovoltaic and photo-responsive materials and devices
- organic light-emitting materials for display and lighting application
- hybrid and perovskite materials and devices
- conjugated polymers and oligomers in chemo/bio-sensors
- bioelectronic

Please find more information on our website: [www.fpi14.de](http://www.fpi14.de)

**HZB** Helmholtz  
Zentrum Berlin

## Up-to-date and authoritative books from the Royal Society of Chemistry



**35%** off for Royal Society of  
Chemistry members

Shop online at [rsc.li/books](http://rsc.li/books)

Registered charity number: 207890

ROYAL SOCIETY  
OF CHEMISTRY