

# Nanoscale Horizons

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

[rsc.li/nanoscale-horizons](https://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 8(5) 553-706 (2023)



### Cover

See Saptarshi Das  
et al., pp. 603–615.  
Image reproduced  
by permission of Elizabeth  
Floresgomez Murray  
from *Nanoscale Horiz.*,  
2023, 8, 603.

## EDITORIAL

560

### Nanoscale Horizons 2022 Outstanding Paper Award

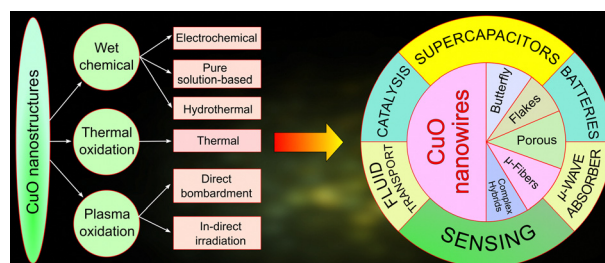


## REVIEW

568

### Recent innovations in the technology and applications of low-dimensional CuO nanostructures for sensing, energy and catalysis

Oleg Baranov,\* Kateryna Bazaka, Thierry Belmonte, Claudia Riccardi, H. Eduardo Roman, Mandhakini Mohandas, Shuyan Xu, Uroš Cvelbar and Igor Levchenko\*



## Editorial Staff

### Executive Editor

Michaela Mühlberg

### Managing Editor

Heather Montgomery

### Editorial Production Manager

Jonathon Watson

### Senior Publishing Editor

Alex Metherell

### Development Editor

Edward Gardner

### Publishing Editors

Blake Baker, Matthew Blow, Chris Dias, Rob Hinde, Ash Hyde, Evie Karkera, Tamara Kosikova, Carole Martin, Kirsty McRoberts, Cat Schofield, Ella White, Tom Williams

### Editorial Assistant

Elizabeth So

### Assistant Editors

Jie Gao, Yu Zhang

### Publisher

Sam Keltie

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

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

For pre-submission queries please contact

Michaela Mühlberg, 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 12 times a year by the

Royal Society of Chemistry, Thomas Graham House,

Science Park, Milton Road, Cambridge, UK CB4 0WF.

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)

2023 Annual (electronic) subscription price: £2727; \$4500.

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)

# Nanoscale Horizons

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

*Nanoscale Horizons* is the home for urgent short reports of exceptionally high quality & innovative nanoscience & nanotechnology



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

## Editorial Board

### Chair

Katharina Landfester, Max Planck Institute for Polymer Research, Germany

### Scientific Editors

Wenlong Cheng, Monash University, Australia

Yves Dufrene, Université Catholique de Louvain, Belgium

Dirk Guldí, Friedrich-Alexander-Universität

Erlangen-Nürnberg, Germany

Anna Fontcuberta i Morral, École

polytechnique fédérale de Lausanne,

Switzerland

Zhiyong Tang, National Center for

Nanoscience and Technology, China

Jinlan Wang, Southeast University, China

### Members

Michael Sailor, University of California,

San Diego, USA

Sarah Tolbert, University of California,

Los Angeles, USA

Miqin Zhang, University of Washington, USA

## Advisory Board

Chunli Bai, Chinese Academy of Sciences,

China

Uri Banin, Hebrew University of Jerusalem,

Israel

Frank Caruso, University of Melbourne,

Australia

Cinzia Casiraghi, The University of

Manchester, UK

Paola Ceroni, University of Bologna, Italy

Chunying Chen, National Center for

Nanoscience and Technology, China

Xiaodong Chen, Nanyang Technological

University, Singapore

Serena Corr, University of Sheffield, UK

Harold Craighead, Cornell University, USA

Qing Dai, National Center for Nanoscience

and Technology, China

Shuai Dong, Southeast University, China

Laura Fabris, Rutgers University, USA

Andrea Ferrari, University of Cambridge, UK

Xingyu Jiang, Southern University of

Science and Technology, China

Rongchao Jin, Carnegie Mellon University,

USA

Dong Ha Kim, Ewha Womans University,

South Korea

Jang-Kyo Kim, University of New South Wales,

Australia

Kostas Kostarelos, University of Manchester,

UK

Yamuna Krishnan, University of Chicago,

USA

Tai Wei David Leong, National University of

Singapore, Singapore

Quan Li, Chinese University of Hong Kong,

Hong Kong

Xing Yi Ling, Nanyang Technological

University, Singapore

Jie Liu, Duke University, USA

Xiaogang Liu, National University of

Singapore, Singapore

Renzhi Ma, National Institute for Materials

Science, Japan

Stefan Maier, Ludwig-Maximilians-

Universität München, Germany

Liberato Manna, Istituto Italiano di

Tecnologia, Italy

Chad Mirkin, Northwestern University, USA

Paul Mulvaney, University of Melbourne,

Australia

Catherine Murphy, University of Illinois at

Urbana-Champaign, USA

Valeria Nicolosi, Trinity College Dublin,

Ireland

Dong Qin, Georgia Institute of Technology,

USA

Sandra Rosenthal, Vanderbilt University, USA

Paolo Samori, Université de Strasbourg,

France

Ester Segal, Technion - Israel Institute of

Technology, Israel

Elena Shevchenko, Argonne National

Laboratory, USA

Hisanori Shinohara, Nagoya University, Japan

Zuzanna Siwy, University of California,

Irvine, USA

Sara Skrabalak, Indiana University, USA

Francesco Stellacci, École polytechnique

fédérale de Lausanne, Switzerland

Ling-Dong Sun, Peking University, China

Shouheng Sun, Brown University, USA

Jonathan Veinot, University of Alberta,

Canada

Umesh Waghmare, Jawaharlal Nehru Centre

for Advanced Scientific Research, India

Jianfang Wang, Chinese University of Hong

Kong, Hong Kong SAR

Sharon Weiss, Vanderbilt University, USA

Benjamin Wiley, Duke University, USA

Stefan Zauscher, Duke University, USA

Xiao Cheng Zeng, University of Nebraska-

Lincoln, USA

Hongjie Zhang, Changchun Institute of

Applied Chemistry, China

Hua Zhang, City University of Hong Kong,

China

Manzhou Zhu, Anhui University, China

Jin Zou, University of Queensland, Australia

## Community Board

Serena Carrara, CNRS Aix-Marseille

Université, France

Arun Richard Chandrasekaran, The RNA

Institute, University at Albany, SUNY, USA

Ying Diao, University of Illinois at Urbana-

Champaign, USA

Qingchen Dong, Shanghai University, China

Yuanxing Fang, Fuzhou University, China

Azhar Fakharuddin, Interuniversity

Microelectronics Centre, Belgium

Calum T. J. Ferguson, Max Planck Institute

for Polymer Research, Germany

Lucas Günter, EPFL, Switzerland

Marilena Hadjideometriou, University of

Manchester, UK

Shumeng Hao, Georgia Institute of

Technology, USA

Samuel S. Hinman, Berkeley Lights, Inc, USA

Nobuhiko Hosono, University of Tokyo, Japan

Jundie Hu, Suzhou University of Science and

Technology, China

Shuaidong Huo, Xiamen University, China

Ignacio Insua, University of Santiago de

Compostela, Spain

Debrina Jana, Indian Institute of Science

Education and Research Mohali, India

Ruibin Jiang, Shaanxi Normal University,

China

Yih Hong Lee, Nanyang Technological

University, Singapore

Sarah Lerch, Chalmers University of

Technology, Sweden

Li Li, Northeastern University, USA

Zhiyuan Liu, Shenzhen Institute of Advanced

Technology, Chinese Academy of Sciences,

China

Saeed Nazemidashtarjandi, The University of

Texas at Austin, USA

Sabina Alexandra Nicolae, Queen Mary

University of London/Imperial College

London, UK

Anamaria Orza, Emory University, USA

Pepita Pla-Vilanova, University of Lleida,

Spain

Amirali Popat, The University of Queensland,

Australia

Kalyan Raidongia, Indian Institute of

Technology Guwahati, India

Satyajit Ratha, Indian Institute of Technology

Bhubaneswar, India

Nathaniel Richey, Stanford University, USA

Jungki Ryu, Ulsan National Institute of

Science and Technology, Korea

Lei Shao, Beijing Computational Science

Research Center, China

Pengzhan Sun, University of Manchester, UK

Jing Tang, The University of Queensland,

Australia

Yanlong Wang, Dalian Institute of Chemical

Physics, China

Jiangxiexing Wu, Tianjin University, China

Tong Wu, Qingdao University, China

Wenzhuo Wu, Purdue University, USA

Xiuqiang Xie, Hunan University, China

Liguang Xu, Jiangnan University, China

Yikai Xu, Queen's University Belfast, UK

Nobuhiro Yanai, Kyushu University, Japan

Fei Zhang, Tianjin University, China

Zishuai Zhang, The University of British

Columbia, Canada

Ya Zhou, Advanced Micro-Fabrication

Equipment Inc., China

Kai Zhu, Harbin Engineering University,

China

Xiaolu Zhuo, CICBiomagnum, Spain

## 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 2023.

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.

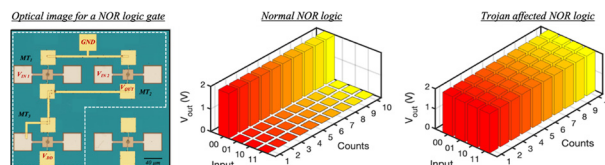
Registered charity number: 207890



603

## Hardware Trojans based on two-dimensional memtransistors

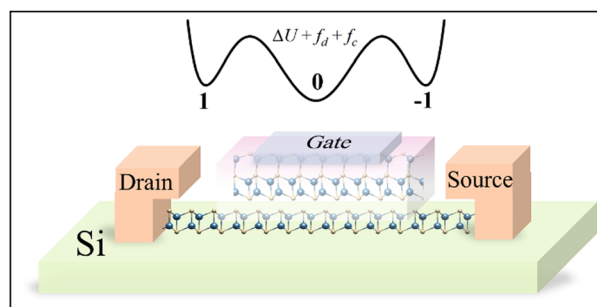
Akshay Wali, Hari Krishnan Ravichandran and Saptarshi Das\*



616

## Depolarization induced III–V triatomic layers with tristable polarization states

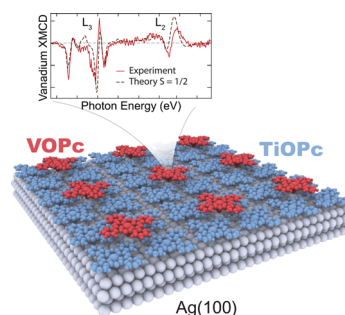
Changming Ke, Yihao Hu and Shi Liu\*



624

## Template-directed 2D nanopatterning of $S = 1/2$ molecular spins

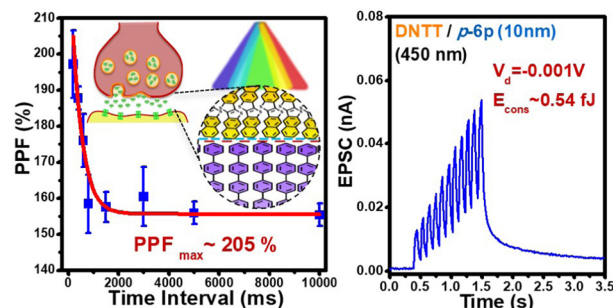
Kyungju Noh, Luciano Colazzo,\* Corina Urdaniz, Jaehyun Lee, Denis Krylov, Parul Devi, Andrin Doll, Andreas J. Heinrich, Christoph Wolf,\* Fabio Donati\* and Yujeong Bae\*



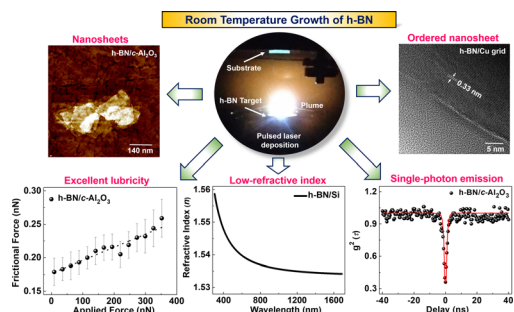
632

## Molecular template growth of organic heterojunctions to tailor visual neuroplasticity for high performance phototransistors with ultralow energy consumption

Ender Ercan,\* Chih-Chien Hung, Guan-Syuan Li, Yun-Fang Yang, Yan-Cheng Lin and Wen-Chang Chen\*



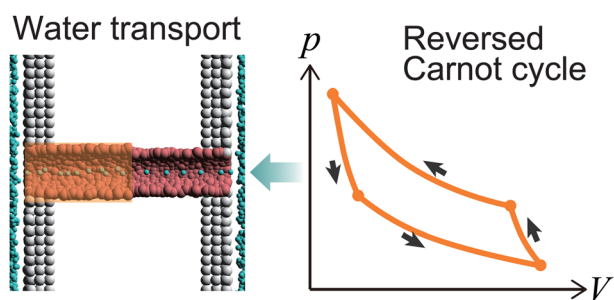
641



### Unravelling the room temperature growth of two-dimensional h-BN nanosheets for multifunctional applications

Abhijit Biswas,\* Rishi Maiti, Frank Lee, Cecilia Y. Chen, Tao Li, Anand B. Puthirath, Sathvik Ajay Iyengar, Chenxi Li, Xiang Zhang, Harikishan Kannan, Tia Gray, Md Abid Shahriar Rahman Saadi, Jacob Elkins, A. Glen Birdwell, Mahesh R. Neupane, Pankaj B. Shah, Dmitry A. Ruzmetov, Tony G. Ivanov, Robert Vajtai, Yuji Zhao, Alexander L. Gaeta,\* Manoj Tripathi,\* Alan Dalton and Pulickel M. Ajayan\*

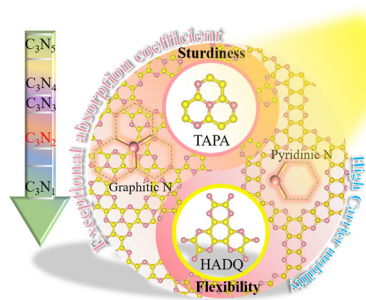
652



### Wetting hysteresis induces effective unidirectional water transport through a fluctuating nanochannel

Noriyoshi Arai,\* Eiji Yamamoto, Takahiro Koishi, Yoshinori Hirano, Kenji Yasuoka and Toshikazu Ebisuzaki

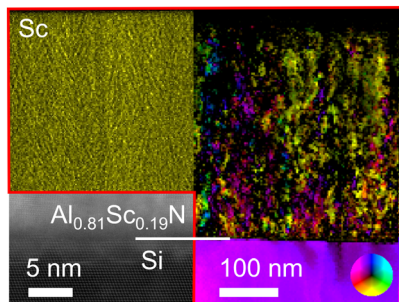
662



### C<sub>3</sub>N<sub>2</sub>: the missing part of highly stable porous graphitic carbon nitride semiconductors

Xinyong Cai, Jiao Chen, Hongyan Wang,\* Yuxiang Ni, Yuanzheng Chen\* and R. Bruce King\*

674



### Nanoscale compositional segregation in epitaxial AlScN on Si (111)

Xiaoman Zhang, Eric A. Stach, W. J. Meng\* and Andrew C. Meng\*

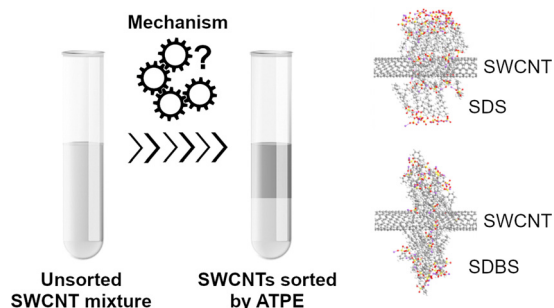


## COMMUNICATIONS

685

### Understanding the partitioning behavior of single-walled carbon nanotubes using an aqueous two-phase extraction system composed of non-ionic surfactants and polymers

Pranjala Tiwari,\* Błażej Podleśny, Maciej Krzywiecki, Karolina Z. Milowska and Dawid Janas\*



695

### Transition metal single atom-optimized g-C<sub>3</sub>N<sub>4</sub> for the highly selective electrosynthesis of H<sub>2</sub>O<sub>2</sub> under neutral electrolytes

Hongcen Yang, Fei Ma, Niandi Lu, Shuhao Tian, Guo Liu, Ying Wang, Zhixia Wang, Di Wang, Kun Tao, Hong Zhang\* and Shanglong Peng\*

