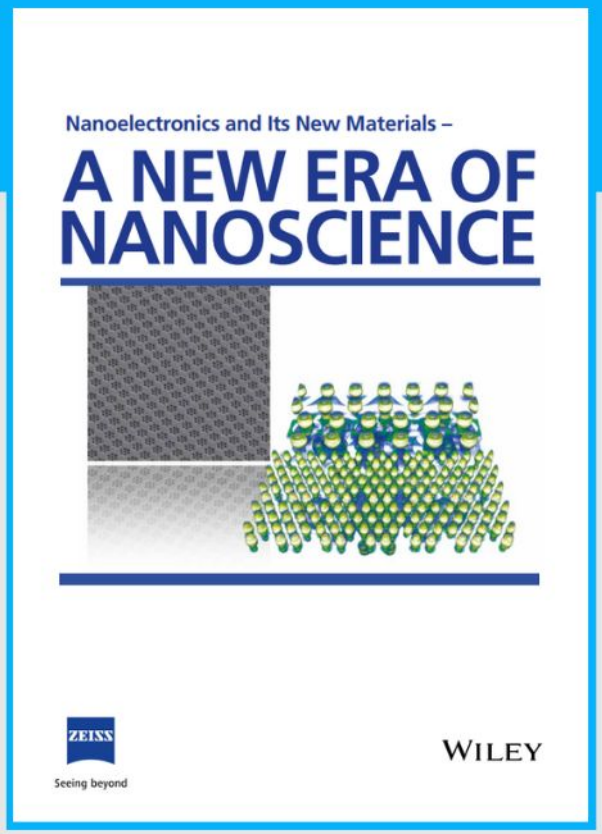
Nanoelectronics and Its New Materials – A NEW ERA OF NANOSCIENCE



Discover the recent advances in electronics research and fundamental nanoscience.

Nanotechnology has become the driving force behind breakthroughs in engineering, materials science, physics, chemistry, and biological sciences. In this compendium, we delve into a wide range of novel applications that highlight recent advances in electronics research and fundamental nanoscience. From surface analysis and defect detection to tailored optical functionality and transparent nanowire electrodes, this eBook covers key topics that will revolutionize the future of electronics.

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Carbon Nanodots: Nanolights Illuminating a Bright Future

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The field of Carbon Nanodots, Carbon Quantum Dots or Carbon Polymer Dots (generally abbreviated CNDs) is a new, emerging and fascinating research area with many potential applications. The spectacular luminescence properties of these novel materials, coupled with the possibility of producing large amounts of CNDs from inexpensive and readily accessible starting materials, has generated great expectations. The field is growing exponentially, and more and more CNDs are synthesized with improved features, such as extended absorption and emission, higher quality, chirality and tunable redox properties.

Thus, it is timely to present a special issue collecting the most recent progress in emerging CNDs, while trying to shape the future perspectives of this dynamic field. Many multidisciplinary areas of chemistry, physics, materials science, medicine and biology are involved in this research topic, from fundamental studies to potential applications. This special issue of Small focuses on current developments, milestones achieved and future research topics regarding CNDs, contributed by leading scientists, covering key aspects of emerging CNDs.

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In this special issue (7 reviews, 2 perspectives and 25 research papers), recent advances have been reported with many interesting properties, some of which have demonstrated potential practical applications and others that may address key challenges at the heart of physical sciences.

Three topical reviews deal with the synthesis, mechanism of formation and applications of CNDs by Su Chen et al. (2206671), Guqiao Ding et al. (2205957), and Zaicheng Sun et al. (2206180), whereas Luka Dordevic et al. (2300906) illustrate the rich supramolecular chemistry of CNDs. The luminescence properties have been reviewed in terms of phosphorescence and afterglow performances by Chaolong Yang et al. (2206429) and Zhongfu An et al. (2207104) respectively. A review on the antibacterial properties of CNDs by Jun-Jie Zhu et al. (2207385) highlights the potential use of CNDs in biological applications.

Two perspectives, by Ya-Ping Sun et al. (2206680) and Maurizio Prato et al. (2206714) address the critical issue of the related formal definitions of CNDs and especially CND purification, a necessary step not only for fundamental studies but also for applications.

The 25 research articles analyze the use of CNDs in many fields of application.

In the field of biology, several researchers have made significant contributions to various applications. Maurizio Prato et al. (2206442) introduce gadolinium doped CND as multifunctional probes for Magnetic Resonance Imaging. Zhigang Xie et al. (2206683) develop an efficient tumor antigen-based nano-vaccine by combining CND with the tumor cell-derived antigens, offering promising potential for cancer treatment. Songnan Qu et al. (2206667) devise a functionalization strategy to protect the emission of the CNDs and enhance the intracellular uptake of L-Arg to inhibit obesity. Fu-Gen Wu et al. (2205890) create fluorescent CNDs for visualizing the structures and dynamic behaviors of organisms. Louzhen Fan et al. (2207204) design amino acids mimicking CNDs with guanidinium functionalization, exhibiting a high tumor inhibition rate. Hengwei Lin et al. (2207868) utilize hemin-modified CNDs to achieve specific chemiluminescence imaging and enhance photodynamic therapy of bacterial infections.

CNDs also show potential applications in the microelectronic device field, which can address the challenges in opto-electronics, photonics, imaging, anti-counterfeiting and information encryption. Large-scale preparation is the prerequisite to promote applications. Zhan'ao Tan et al. (2206715) and Cheng-Long Shen et al. (2205916) introduce massive synthetic strategy of CNDs with solid-state-fluorescence and full-color phosphorescence. Raz Jelinek et al. (2206519) employ CNDs to comprise an array of polymerized-anthraquinone photodetector films. Wei Feng et al. (2204365) broaden the application of hydrogels for realizing flexible electronics by CNDs with luminescent properties. Chong-Xin Shan et al. (2302504), Alberto Bianco et al. (2207046) and

Siyu Lu et al. (2206080) investigate the structure control methods to enhance the intensity and wavelength of phosphorescence of CNDs. These works provide concrete and feasible avenues for advancing the commercialization of CND-based microelectronic devices.

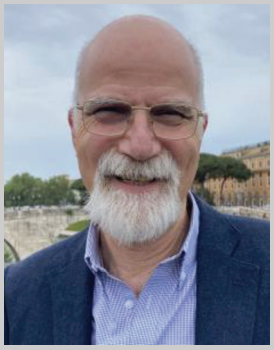
In the field of energy catalysis and conversion, CNDs play a dual role as active sites and effective promoters for co-catalytic components. Bingfu Lei et al. (2206222) emphasize the significant role of CND in improving photosynthesis, a crucial process for all life on the earth. Zhenhui Kang et al. (2300883) uncover the synergistic effect of functional groups and metal coordination structures on peroxide-like activity of CND. In non-metal catalysis, Nikos Tagmatarchis et al. (2208285) and Rafik Naccache et al. (2300541) combine the advantages of CND with other carbon materials to achieve high activity in hydrogen evolution reaction and transesterification reaction. Prashanth Menezes et al. (2206723) and Hong Bi et al. (2205234) report the situ coordination of CND with metal ions, leading to enhanced performance in oxygen evolution reaction and urea oxidation. Hai-Zhu Sun et al. (2206597) introduce CNDs as electrolyte additives to stabilize the high performance of Li metal batteries. Bai Yang et al. (2205291) demonstrate the use of functional CND to optimize polymer membranes for fuel cells. Huan-Ming Xiong et al. (2205558) incorporate heteroatom doped CNDs into the electrolyte for aqueous zinc ion batteries. These works demonstrate the applicability of CNDs in promoting green energy and catalysis.

Dirk M. Guldi et al. (2207238) and Andrey L. Rogach et al. (2204158) provide valuable insights into the photochemical properties of CNDs, deepening our understanding of their structure and mechanisms. Their research sheds light on the intricate relationship between these factors, expanding our knowledge in this area. Takeharu Haino et al. (2207475) focuse on controlling the aggregation of CNDs by manipulating solvent polarity, resulting in intriguing morphologies and unlocking their potential for various functions based on their unique structures.

These papers are expected to pave the way for new developments and advancements in the field of CNDs. Researchers will find inspiration and new avenues of exploration, forging connections with CNDs in diverse areas. We anticipate that this collection of articles will contribute significantly to the comprehensive study of the fundamental properties of CNDs and foster further advancements in their application across various fields.

Zhenhui Kang received his Ph.D. in Chemistry from Northeast Normal University, China in 2005. Now he is currently a professor in the Soochow University. Dr. Kang's research interest is in the fabrication, properties and catalytic- and bio- application of carbon dots (C-Dots).

Bai Yang is currently a professor of the State Key Lab of Supramolecular Structure and Materials, College of Chemistry at Jilin University. He received his PhD in polymer chemistry and physics in 1991 at Jilin University. His research interests are related with polymer nano-hybrid functional materials, including optical, photonic, photo-electric and photo-responsive materials, and focus on Carbon Dots especially Carbonized Polymer Dots in recent years.



Maurizio Prato was Assistant Professor at the Department of Organic Chemistry of the University of Padova since 1983, moving to the University of Trieste in 1992. He did research at Yale University, New Haven (1986-87), and at the University of California, Santa Barbara (1991-92). He was Professeur Invité at the Departments of Chemistry of the Ecole Normale Supérieure in Paris in 2001, at the University of Namur, Belgium in 2010, at ISIS, University of Strasbourg in 2014, and at the University of Mons in 2018. He obtained an ERC grant in 2008 and one in 2020, was appointed Member of the Accademia dei Lincei in 2010, of the National Academy of Inventors, USA in 2021, and Foreign Member of the Royal Spanish Academy of Sciences in 2022. His research focuses on the synthesis of innovative carbon-based functional materials, for applications in materials science, nanomedicine and catalysis.