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AI-powered low-dimensional nanomaterials-based hydrogen gas sensors

Speaker： Prof. Gianaurelio Cuniberti

(Dresden University of Technology, Germany)

AI-enabled advanced nanomaterials-based electronic olfaction

Speaker：Dr. Shirong Huang

(Dresden University of Technology, Germany)

报告时间：2026 年 05 月 15 日（星期五）09:00-12:00

报告地点：长宁园区 4 号楼 14 楼第一会议室

联系人：吴成铁 研究员（52412249）

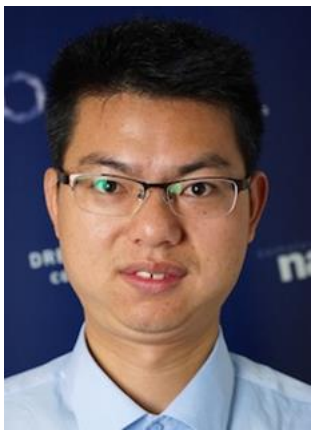
欢迎广大科研人员和研究生参加！

Personal information:

Professor Gianaurelio Cuniberti holds since 2007 the Chair of Materials Science and Nanotechnology at the Technische Universität Dresden (TU Dresden) and the Max Bergmann Center of Biomaterials in Dresden, Germany. He is a member of the TU Dresden School of Engineering Sciences (Materials Science) and of the School Science (Physics). He studied Physics at the University of Genoa, Italy (where he got his B.Sc. and M.Sc.) and obtained his Ph.D. in 1997 at the age of 27 in a collaboration between the University of Genoa and the University of Hamburg, Germany. He was visiting scientist at MIT and the Max Planck Institute for the Physics of Complex Systems Dresden. From 2003 to 2007, he was the head of a Volkswagen Foundation Research Group at the University of Regensburg, Germany. His research activity is internationally recognized in more than 400 scientific journal papers to date. He initiated and organized numerous workshops, schools, and conferences and took part in international research training networks, offering extensive opportunities for young scientists. He has given plenary and invited talks at numerous international meetings. He serves as a referee for numerous high-impact journals, and for several funding research institutions including among others the EU, the German Science Foundation (DFG), the USA National Science Foundation (NSF), the German Israeli Foundation (GIF), and the Alexander von Humboldt Foundation. He received several talent scholarships and awards including the Max Planck Society Schloeßmann award (2001) and the VolkswagenStiftung Research Group Individual Grant (2003). He is a member of several scientific organizations and a corresponding member of the Umbrian Academy of Sciences. Gianaurelio Cuniberti is an Honorary Professor at the Division of IT Convergence Engineering of POSTECH, the Pohang University of Science and Technology since 2009, since 2011 Adjunct Professor for the Department of Chemistry at the University of Alabama, and since 2019 Guest Professor at SJTU. In 2018 he became a faculty member of the transcampus between TU Dresden and King's College London. He recently got the special medal for natural science of the Academia of the XL (one of the oldest science academies limited to 40 scientists) and the prestigious *Ehrennadel* of TU Dresden. Professor Gianaurelio Cuniberti is an elected member of the European Academy of Sciences, of the Academia Europaea and of the Germany National Academy of Science and Engineering (acatech).

ABSTRACT:

Hydrogen is increasingly viewed as a cornerstone of the clean energy economy thanks to its high energy density, renewability, and zero-carbon emissions at the point of use. Yet, its small molecular size, high diffusivity, and wide flammability range (4–75% in air) make safe handling a critical challenge. Because hydrogen is colorless and odorless, its reliable and rapid detection is essential for production, storage, and utilization in emerging energy systems. Conventional sensors such as optical, acoustic, catalytic, and electrochemical types face limitations in complexity, power consumption, selectivity, and stability. Chemiresistive sensors offer a simpler and more scalable route but often require high operating temperatures and show limited sensitivity. Low-dimensional materials (LDMs) such as carbon nanotubes, MXenes, and transition metal dichalcogenides address these challenges through high surface area, tunable electronic properties, and room-temperature operation. We present hydrogen sensors based on single-walled carbon nanotubes functionalized with Pd nanoparticles and hybridized with MXenes, achieving parts-per-billion detection, fast response, and humidity stability. Integrating these nanomaterials with AI-driven signal interpretation enables adaptive, distributed hydrogen monitoring networks, an essential step toward a safe and intelligent hydrogen infrastructure.



Personal information:

Dr. Shirong Huang is a Group Leader of Digital Olfaction Sensors at the Chair of Materials Science and Nanotechnology at Dresden University of Technology (TU Dresden) since 2024. He received his Ph.D. in Materials Science in 2022 under the supervision of Prof. Gianaurelio Cuniberti at TU Dresden. Prior to that, he obtained his M.Sc. degree from Shanghai University, China, in 2014, where he conducted research under Prof. Johan Liu on the synthesis of carbon nanomaterials and their applications in thermal management for high-power electronic packaging.

Dr. Huang is an IEEE Senior Member and the winner of the China–Europe Outstanding Young Scientist Award. He actively contributes to the professional community, serving as a Young Professional Member of the IEEE Sensors Council Young Professionals Committee, YP Chair of the IEEE Biosensors Conference 2026, and Technical Program Committee (TPC) Member for both International Symposium on Olfaction and Electronic Nose (ISOEN) 2024/2026 and the Digital Olfaction Society (DOS) 2024 Conference. He also serves on the Youth Editorial Board of Applied Research and Brain-X, and as Guest Editor for Small, Analysis & Sensing, and Advanced Sensor Research, among others. He also serves as reviewer for numerous peer-reviewed journals, including Nature Communications, Sensors and Actuators B: Chemical, Biosensors and Bioelectronics, ACS Sensors, ACS Applied Materials & Interfaces, Carbon, Small, IEEE Sensors Journal, Advanced Intelligent Systems, Advanced Engineering Materials, Journal of Hazardous Materials, and Artificial Intelligence in Agriculture, etc.

To date, Dr. Huang has authored over 50 peer-reviewed publications in leading journals and international conference proceedings, including Applied Physics Reviews, Angewandte Chemie International Edition, ACS Sensors, Carbon, Small, ACS Applied Materials & Interfaces, Advanced Intelligent Systems, and IEEE Sensors Journal, etc., as well as four book chapters. Currently, he also serves as the vice president of the Society of Chinese Chemists and Chemical Engineers in Germany (GCCCD).

ABSTRACT:

Among our five human senses, sight, hearing, and touch have been highly digitized, while smell and taste remain in the nascent stages of digitization. Inspired by the biological example, gas sensors in combination with efficient machine learning algorithms aim to achieve similar performance and thus to digitize the sense of smell. Despite the significant progress of e-noses, their compactness still remains challenging due to the complex layout design of sensor arrays with a multitude of receptor types or sensor materials, and the high working temperature. In this talk, we present the development of machine learning-enabled graphene-based single-channel electronic olfaction (e-olfaction) sensors and propose a methodology to evaluate their olfactory performance. We selected four VOC-based odors, namely eucalyptol, 2-nonanone, eugenol, and 2-phenylethanol, which are widely used in human olfactory performance assessment. We achieved a low odor detection limit of 4.4 ppm (for 2Phe) and high odor discrimination (83.3%) and identification (97.5%) accuracies. Both molecular dynamics simulations (MDS) and density functional theory (DFT) were employed to elucidate the adsorption interaction between odorant molecules and sensing materials. Our work demonstrates that the developed e-olfaction exhibits excellent olfactory performance in sniffing out VOC-based odors. This work could facilitate miniaturization of e-noses, digitization of odors, and distinction of volatile organic compounds (VOCs) in various emerging applications, such as molecular discrimination, food quality identification, disease diagnosis, etc.