HARBIN INSTITUTE OF TECHNOLOGY
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HIT TIMES

HIT RANKED 5TH OF BEST GLOBAL UNIVERSITIES FOR ENGINEERING

ACADEMICIAN HAN JIECAI NAMED HIT'S NEW PRESIDENT

HIT TIMES

Harbin Institute of Technology Newsletter
2021 ISSUE 2

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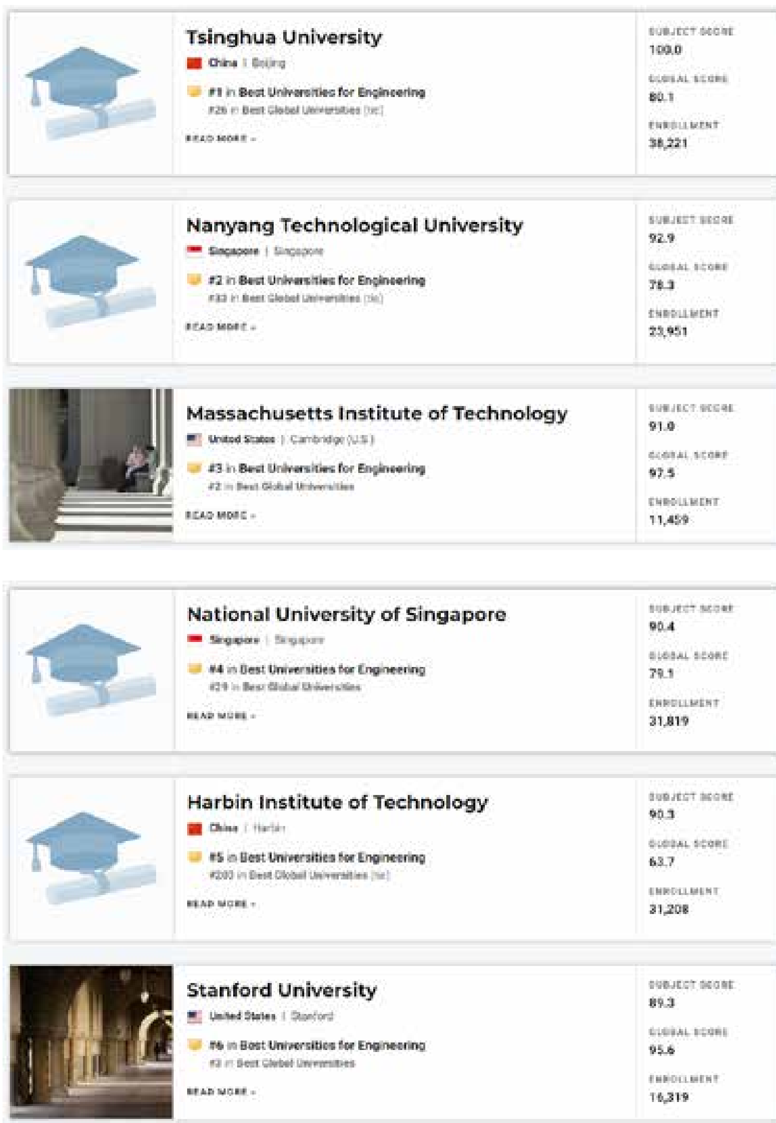
AWARDS & HONORS

ACADEMICIAN HAN JIECAI NAMED HIT'S NEW PRESIDENT

On July 15th, 2021, Li Xiaoxin, Vice Minister of the Organization Department of the CPC Central Committee, announced Han Jiecai as the new president of Harbin Institute of Technology.

Han Jiecai is a professor, doctoral supervisor, and academician of Chinese Academy of Sciences. He serves as Regional Editor of *Composites Science and Technology*, Editorial Board Member of *Composites Part B*, and Deputy Editor of *Science China Technological Sciences* and *Acta Aeronautica et Astronautica Sinica*. As an expert in composite materials and optical materials, he has long been dedicated to the teaching and research of composite materials and mechanics in extreme environments. He was awarded the "Ten Major Scientific and Technological Progresses of China's Colleges and Universities" in 2020. He has also won the 2nd prize of the National Natural Science Award, the 2nd prize of the National Technological Invention Award twice, and the 2nd prize of the National Scientific and Technological Progress Award. He holds more than 70 national patents and has published four academic monographs and over 400 articles in international journals.

HIT RANKED 5TH OF BEST GLOBAL UNIVERSITIES FOR ENGINEERING



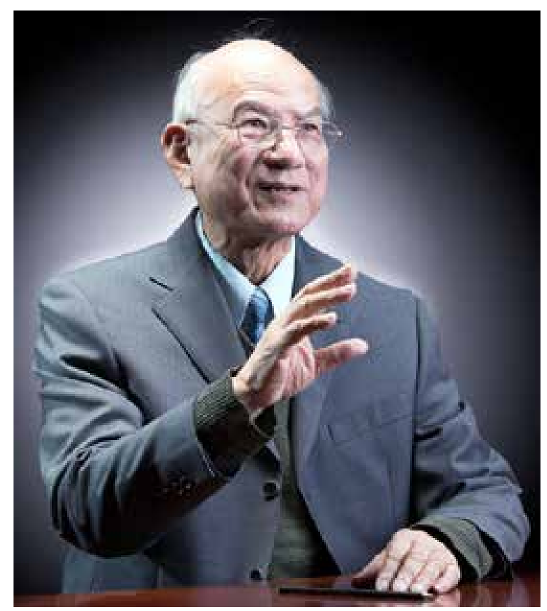
Recently, U.S. News & World Report announced the Best Global Universities for Engineering 2021. Harbin Institute of Technology (HIT) was ranked 5th on the list.

These well-regarded universities from around the world have shown strength in producing research related to a variety of engineering topics. They include aerospace engineering, mechanical engineering, electrical engineering and civil engineering. All rely on the basic engineering concept of using math and science to solve problems. These are the world's best universities for engineering.

(https://www.usnews.com/education/best-global-universities/engineering)

Awards & Honors
HIT TIMES 2021

ACADEMICIAN LIU YONGTAN HONOURED WITH THE TITLE OF "MODEL OF THE TIMES"



On September 29th, the Publicity Department of the Communist Party of China Central Committee announced the decision of conferring the title "Model of the Times" to Academician Liu Yongtan.

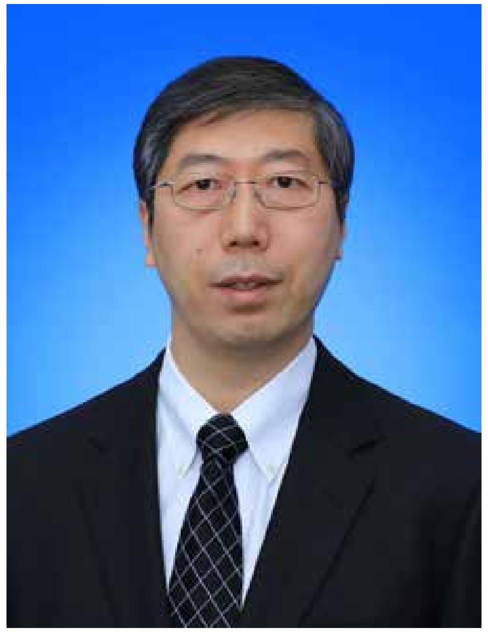
Liu Yongtan was born in December 1936, in Nanjing, Jiangsu Province. From 1953 to 1958, he studied in the Department of Electrical Engineering of Harbin Institute of Technology and the Radio Department of Tsinghua University. He joined Harbin Institute of Technology as a faculty member in 1958. Currently, he is a professor and doctoral tutor at Harbin Institute of Technology. In 1991, he was elected as an academician of the Chinese Academy of Sciences. In 1994, he was elected as an academician of the Chinese Academy of Engineering.

Academician Liu Yongtan is a well-known expert in radar and signal processing technology in China. He is the founder of the sea surface target detection theory of a new radar type in China and a leader in the development of remote detection technology.

To implement the spirit of General Secretary Xi Jinping's important remarks at the Central Talent Work Conference, the Publicity Department of the Communist Party of China Central Committee publicized the meritorious deeds of Liu Yongtan and conferred the title of "Model of the Times" to him.

THREE PROFESSORS ELECTED AS ACADEMICIANS OF CAS, CAE

On November 18th, the Chinese Academy of Sciences (CAS) and the Chinese Academy of Engineering (CAE) announced the list of elected academicians in 2021. Professor Leng Jinsong was elected as an academician of Chinese Academy of Sciences. Professor Liu Hong and Professor Mei Hongyuan were elected as academicians of Chinese Academy of Engineering.



Leng Jinsong is a Cheung Kong Chair Professor and a winner of the National Science Foundation for Distinguished Young Scholars. His research fields include smart materials and structures, sensors and actuators, stimulus-responsive polymers (shape memory and electro-active polymers) and their composites, multifunctional nanocomposites, 4D printing, etc. The shape memory polymer composite structures designed by his group have been applied and successfully deployed in the Tianwen-1 Mars rover. He currently serves as vice president of the International Committee on Composite Materials (ICCM), vice president of the Chinese Society for Composite Materials (CSCM), and editor-in-chief of the International Journal of Smart and Nano Materials (IJSNM). He was elected as a foreign member of Academia Europaea, a member of the European Academy of Sciences and Arts, a world fellow of ICCM, a fellow of American Association for the Advancement of Science (AAAS), a fellow of the SPIE, a fellow of Institute of Physics (IOP), a fellow of Royal Aeronautical Society (RAeS), a fellow of Institute of Materials, Minerals, and Mining (IMMM) and an associate fellow of AIAA. He has published over 350 peer-reviewed papers and holds over 140 issued patents.

Liu Hong, born in 1966, is a professor and doctoral supervisor. He is vice president of Harbin Institute of Technology, a director of the State Key Laboratory of Robotics and Systems, a winner of the National Major Talent Project, and head of the innovation group of the National Natural Science Foundation of China. He has long been engaged in the research of the basic theory and dexterous control technology of space robots, presided over the development of China's first space robot, and his relevant achievements have been successfully applied to the Experimental Satellite No.7 and Tiangong-2 space laboratory, making outstanding contributions to space robotics and on-orbit services. He won four 2nd prizes of the National Technological Invention Award, one 1st prize of the euRobotics Technology Transfer Award, one "Ten Major Scientific and Technological Progress of China's Colleges and Universities", the prize for Scientific and Technological Progress from the Ho Leung Ho Lee Foundation, and the first National Innovation Award. He has published three monographs and registered 42 Chinese patents, five German patents, and one American patent.

Mei Hongyuan, born in 1958, is a national master of engineering investigation and design, vice president of the Architectural Society of China, chairman of the Academic Committee of the Cold Region Architecture, and Honorary Fellow of American Institute of Architects. He is an academic leader in the field of cold region architectural design in China. He has been engaged in cold region architectural design and theoretical research for a long time and has established cold region architectural collaborative design theory and cold region architectural integrated design method system, making outstanding contributions to promoting the development of cold region architecture in China. He has created major engineering projects, such as the 2022 Winter Olympic snow-villa exhibition and hotel area, New Museum of Heilongjiang Province, Zhengzhou Grand Theater, etc. His design works have won more than 30 professional design awards, 2nd prize of the National Teaching Achievement Award, 1st prize of the China Award for Science and Technology in Construction, two 1st prizes of the Scientific and Technological Progress Award of Heilongjiang Province, and one special award issued by the Heilongjiang governor. ■

HIT WON SEVEN NATIONAL SCIENCE AND TECHNOLOGY AWARDS

On November 3rd, the annual "National Science and Technology Awards" ceremony was held in Beijing. Harbin Institute of Technology won seven awards, including five National Technological Invention Awards and two National Scientific and Technological Progress Awards.

A project led by Professor Wang Aijie from the School of Environment, a project led by Professor Liu Jian from the School of Instrumentation Science and Engineering, a project led by Professor Yuan Shijian from the School of Materials Science and Engineering, a project led by Professor Qi Naiming from the School of Astronautics, and a project led by Professor Ye Feng from the School of Materials Science and Engineering won the 2nd prizes of the National Technological Invention Award. A project led by Professor Du Chunyu from the School of Chemistry and Chemical Engineering and a project led by Professor Lu Lihua from the School of Mechatronics Engineering won the 2nd prizes of the National Scientific and Technological Progress Award.

The ceremony was attended by approximately 3,000 people and honored 264 projects, with 46 winning the National Natural Science Award, 61 the National Technological Invention Award, and 157 the National Scientific and Technological Progress Award.

Eight foreign experts and one international organization won the International Science and Technology Cooperation Award for their collaboration with Chinese scientists.

Awards & Honors
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HIT'S 14 PROJECTS WON THE 1ST PRIZES OF HEILONGJIANG SCIENCE AND TECHNOLOGY AWARD

On September 8th, the Heilongjiang Provincial Party Committee and the Heilongjiang Provincial Government held a ceremony in Harbin to commend and reward the winners of the Heilongjiang Science and Technology Award, present awards to Academician Deng Zongquan, the highest winner of the Heilongjiang Provincial Science and Technology Award, and the first-prize winner representatives, and mobilize the whole province to deeply implement the innovation-driven development strategy, accelerate the construction of a strong province through science and technology.

Academician Deng Zongquan

Professor Li Zhengqi

Professor Xing Defeng

Zhang Qingwei, Secretary of the Provincial Party Committee and Director of the Standing Committee of the Provincial People's Congress, issued a certificate to Academician Deng Zongquan. Professor Li Zhengqi and Professor Xing Defeng received the award as the representatives.

There are a total of 278 award-winning achievements, including 39 first prizes, 140 second prizes and 99 third prizes. In terms of award categories, there are 84 natural sciences awards, 18 technological inventions awards and 176 scientific and technological progress awards. There are 14 projects led by Harbin Institute of Technology won the first prizes of Heilongjiang Science and Technology Award.

PROFESSOR GAO HUIJUN WON THE 2021 XPLORER PRIZE

On September 13th, the winners of the 2021 XPLORER PRIZE were announced. There were 50 outstanding scientists on the list. Professor Gao Huijun, from the School of Astronautics, Harbin Institute of Technology (HIT), won the award in the field of Information and Electronics Technologies, becoming HIT's second scientist to win this award.

Gao Huijun is a professor and a doctoral supervisor of the School of Astronautics, Director of the Research Institute of Intelligent Control and Systems, and an IEEE Fellow. He has long been engaged in automatic control theory and application research and has made a series of innovative achievements in the fields of network control, robot intelligent system, and intelligent equipment. He has won a number of honours, such as the second prize of the National Natural Science Award, Tan Kah Kee Young Scientist Awards, China Youth Science and Technology

Award, National Youth May 4th Medal, and National Advanced Worker. He serves as the vice president of IEEE Industrial Electronics Society, IFAC (International Federation of Automatic Control) Council Member. He also serves as co-editor and editorial board member of several international journals, such as *IEEE Transactions on Industrial Electronics* and *Automatica*.

The XPLORER PRIZE is a leading independent, non-governmental, merit-based public-interest award, developed and evaluated by prominent scientists. The award is also one of the most generous talent funding programs for young scientists in China. Adhering to the principle of being future-oriented and focused on basic sciences and frontier technologies, the XPLORER PRIZE is awarded to young scientists who are aged 45 and under and working full-time in Mainland China, Hong Kong, and/or Macao, in the fields of Mathematics and Physics, Astronomy and Geoscience, Information and Electronics

Technologies, Chemistry and New Materials, Life Science, etc. Up to 50 eligible recipients every year will receive a no-strings-attached fund totalling RMB 3,000,000 over a five-year period. Rather than judging research proposals on their prospects of commercial returns, the XPLORER PRIZE makes assessments based on public-interest criteria and pledges long-term funding. ■

PROFESSOR CHEN YIMU SELECTED IN "INNOVATORS UNDER 35"

In the award ceremony of MIT Technology Review "Innovators Under 35" Asia Pacific, held on October 28th in Hangzhou, Professor Chen Yimu from Harbin Institute of Technology (Shenzhen) was on the list, due to his contribution in developing single-crystal metal halide perovskite optoelectronics.

Since 1999, MIT Technology Review has identified young innovators doing exciting work that could shape their fields for decades. It gathers the young scientists who could revolutionize our lifestyles and shape the future of technology and industry. Each year, brilliant talents are recognized for their advancements in diverse technical fields, including biotechnology and medicine, computer and electronics hardware, software, internet, artificial intelligence, robotics, telecommunications, nanotechnology and materials, energy, and transportation. The list of "Innovators Under 35" has been appreciated by scientists worldwide.

Professor Chen has been focusing on the single-crystal of the novel semiconductor material called metal halide perovskites since 2015, aiming at the development of single-crystal perovskite optoeletronics. His studies include the controllable growth of single-crystal perovskite thin films and micro/nano-arrays, the fabrication methods for single-crystal perovskite optoelectronics, the compatibility between the water-sensitive perovskites, and the conventional semiconductor micro/nano-fabrication techniques. These works have a huge impact on the development of the single-crystal perovskite optoelectronics community. ■

HIT TEAM WON THE FIRST PRIZE IN THE 12TH CHINA UNDERGRADUATE PHYSICS TOURNAMENT

From August 21st to 24th, the 12th China Undergraduate Physics Tournament (CUPT) was held online, and 63 teams from 62 Chinese universities participated in the competition. The team from Harbin Institute of Technology (HIT) once again won the national championship and won the first place grand prize in the final.

The team was composed of six undergraduate students: Luo Quanxin, Cheng Zhanbo, Li Yanzhen, Huang Xinnuo, Yue Congyuan, and Yu Donghui. The instructors were Professor Zhang Yu, Professor Wang Yuxiao, Professor Hou Chunfeng, Professor Lv Zhe, and Associate Professor Ren Yanyu from the School of Physics. After the five round-robin competitions, the HIT team entered finals in first place. Through fierce competition, the HIT team ultimately won the national championship and the grand prize. Cheng Zhanbo won the best player award.

Since 2010, the CUPT has been held for 12 times. HIT has been participating in this competition since 2012 and has won eight grand prizes with six first places.

The CUPT is a national research discipline competition for university students based on the model of the International Young Physicists' Tournament (IYPT). The contestants conduct theoretical analysis and experimental research and result discussion on practical problems, aiming to improve the students' ability to comprehensively use their knowledge to analyze and solve practical physical problems, cultivate creative thinking, teamwork spirit and communication and expressiveness, so as to instill within students' knowledge, sharpen their ability, and develop comprehensive capabilities. At present, the competition has become an important platform and window for the freshmen and sophomores of HIT to participate in academic research. ■

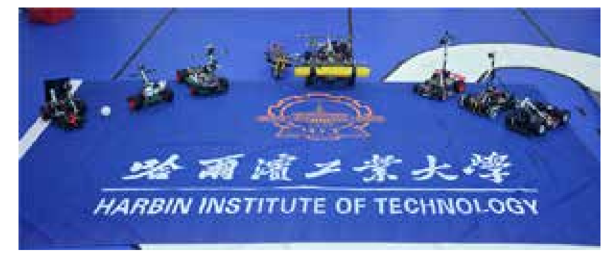
HIT STUDENTS WON THE CHAMPIONSHIP IN THE NATIONAL UNIVERSITY STUDENTS INTELLIGENT CAR RACE

Recently, in the 16th National University Students Intelligent Car Race (NUSICR), the Lilac Intelligent Car Teams from HIT reached a new high, winning all 10 national awards in this competition, including four national top three awards (one national champion and three national 3rd prizes), seven national 1st prizes, two national 2nd prizes, one national 3rd prize and 13 provincial awards.

The No.5 Lilac Intelligent Car Team, composed of three undergraduates Ma Mingcheng, Rong Zhenshuai, and Cao Guangxu, won the energy-saving beacon championship for the third time since 2016. The No.3 Lilac Intelligent Car Team, composed of three undergraduates Zhou Jing, Wei Bo, and Sun Yuxin, won third place in the electromagnetic cross-country. The No.4 Lilac Intelligent Car Team, composed of three undergraduates, Shang Shidi, Xu Xiangrui, and Liu Xinyuan, won third place in the Omnidirectional March. The No.6 Lilac Intelligent Car Team, composed of four undergraduates Wu Xin'ao, Xie Jianshan, Cheng Ruosi, and Zhang Jiashan, won third place in the double car relay.

Since 2006, the NUSICR has been held 16 times. Since 2010, HIT Intelligent Car Innovation Club, guided by the School of Electrical Engineering and Automation, has won 37 national first prizes (including five national champions), 22 national second prizes and several provincial prizes. In the past 11 years, HIT Intelligent Car Innovation Club has gradually become one of the important training bases of HIT for innovative and entrepreneurial talents. Most of the members from the Intelligent Car Innovation Club have gradually grown into industry elites, academic backbones, and entrepreneurial pioneers.

The NUSICR is a creative science and technology competition with smart cars as the research object. It is an exploratory engineering practice for college students all over the country, advocated by the Ministry of Education. The concept of the competition is "based on training, focusing on participation, encouraging exploration, and pursuing excellence". It aims to promote quality education in colleges and universities, cultivate college students' comprehensive knowledge application ability, basic engineering practice ability and innovation consciousness, stimulate college students' interest and potential in scientific research and exploration, and advocate the integration of theory with practice. ■



RESEARCH & ACADEMIA

RU/VACANCY-RICH CARBON DOTS BOOST PERFORMANCE OF HYDROGEN EVOLUTION REACTION

A team led by Professor Li Baoqiang, a core member of Professor Zhou Yu's group from the School of Materials Science and Engineering, published a paper titled "Strong Electron Coupling of Ru and Vacancy-Rich Carbon Dots for Synergistically Enhanced Hydrogen Evolution Reaction" in *Small*, the top journal in the field of engineering technology. The research team has proposed and realized the construction of Ru/vacancy-rich carbon dots electrocatalysts (Ru@CDs) by combining Ru with vacancy-rich CDs. The material not only subtly introduced vacancies in the Ru composite structure, which effectively reduced the instability and agglomeration of Ru nanoparticles, but also significantly improved their electrocatalytic activity.

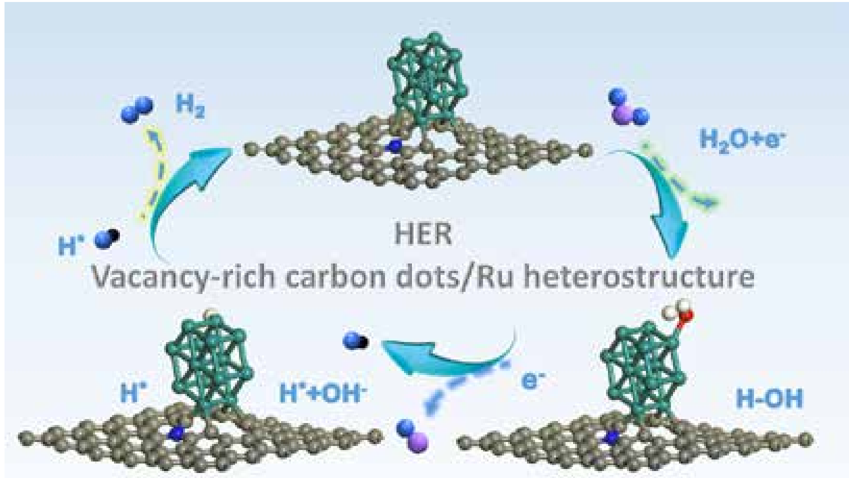
New energy is a hot research topic in both industrial and academic fields, among which hydrogen energy is currently recognized as a clean energy source. The selection of suitable catalysts to improve the efficiency of hydrogen evolution reaction (HER) and reduce the overpotential is important for the efficient use of hydrogen energy. Ruthenium (Ru) has been considered an ideal alternative for catalyzing hydrogen generation from water electrolysis because of its similar hydrogen bond strength as Pt and low price (about 5% of Pt). However, its actual electrocatalytic activity is still not so satisfactory because the high cohesive energy makes the Ru facile agglomerate and thus leads to degradation of the performance. Therefore, it is highly necessary to explore ingenious strategies to alleviate the dilemma of Ru and achieve elevated activity and stability.

Carbon dots (CDs) with accessible vacancies, rapid electron-transfer properties, high stability and large surface area could be a sort of ideal candidates for combining with Ru. Specifically, the abundant intrinsic vacancies and the affluent functional groups would provide favorable sites for achieving stabilized metal-CDs structures by anchoring and the coordination. Furthermore, the confinement of

CDs can also avoid the agglomeration of Ru nanoparticles and thus improve their stabilities. Inspired by these appropriate properties, associating CDs with Ru to form vacancy-rich Ru@CDs structures could provide a potential route for the engineering of Ru-based HER electrocatalysts.

Specifically, Ru@CDs exhibits excellent catalytic performance with a low overpotential (30 mV at 10 mA cm^{-2} in 1 M KOH) and a low Tafel slope of 22 mV dec^{-1} which are all comparable to that of Pt/C catalyst and most recently reported Ru-based electrocatalysts. Both experimental and theoretical studies demonstrate that rich vacancies and the electron interaction between Ru and CDs synergistically facilitate to lower the intermediate energy barrier and therefore maximize the activities of the Ru@CDs. These findings will broaden the application of CDs and shed new light on the design of novel and efficient HER electrocatalysts. The goal realized in the preparation and research of vacancy-rich electrocatalysts will bring more fundamental insights into the design of advanced catalysts.

The paper was highlighted by *Heilongjiang Daily*, *China Science &Technology Network*, *HIT News*, *China Youth Online* and *Materials Views*. It was also reprinted by *Peoples Network*, *Sina* and other media. ■



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Liu Z, Li B, Feng Y, Jia D, Li C, Sun Q, Zhou Y. Strong electron coupling of Ru and vacancy-rich carbon dots for synergistically enhanced hydrogen evolution reaction. Small, 2021, 17(41): 2102496.

4D PIXEL MECHANICAL METAMATERIALS WITH PROGRAMMABLE AND RECONFIGURABLE PROPERTIES

Mechanical metamaterials were artificial materials consisting of periodic optimized microstructures, which gained their extraordinary mechanical properties from structure rather than composition, such as auxetic behavior, negative stiffness, and reconfigurability, etc. Generally, the metamaterials consisted of periodically interconnected microstructures that maintained the inherent configuration and exhibited macroscopic constitutive behavior. However, the interconnected microstructures were mutually restricted and highly coupled in kinematics, limiting the potential deformation and reducing the reusability and maintainability of the metamaterials. Additionally, the mechanical properties of the metamaterials were controlled by the configuration of the microstructures, meaning that the mechanical properties were fixed and irreversible after fabrication.

Recently, a group led by Professor Leng Jinsong, from the Center for Composite Materials and Structures at Harbin Institute of Technology, published a paper titled “4D Pixel Mechanical Metamaterials with Programmable and Reconfigurable Properties” in *Advanced Functional Materials*.

The pixel mechanical metamaterial (PMM) was developed by the array of uncoupled constrained mechanical pixel (MP), which exhibited a great degree of design freedom, modularity, and diversity of mechanical properties. Similar to adjusting the screen image by pixel colors, the PMM adjusted mechanical properties by changing the configuration of the MPs. Inspired by the microstructural configuration of collagen fibers of biological tissues, helical ligaments were introduced into the 3D chiral structure and combined with 4D printing to develop tension-torsion coupled MP (Figure 1a) and PMM (Figure 1b) with adjustable and reconfigurable mechanical properties.

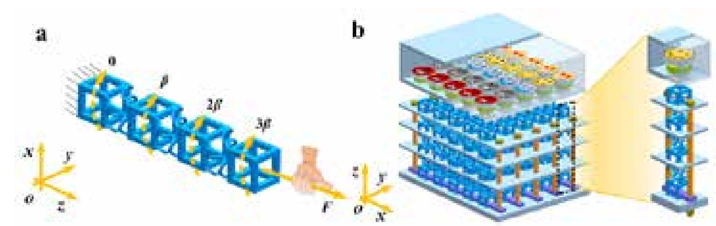

Figure 1 (a) Developed MP with tensile-torsional coupling deformation properties and (b) PMM.

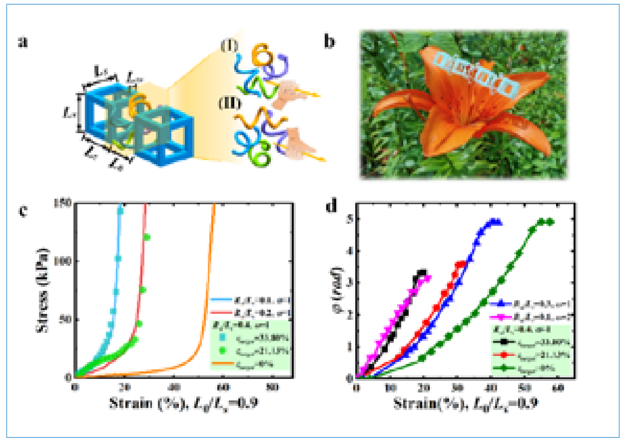

Figure 2 (a) Different chiral modes of ligaments; (b) MPs with lightweight characteristics; Reconfigurable properties of (c) stress-strain curves and (d) torsional angle-strain curves.

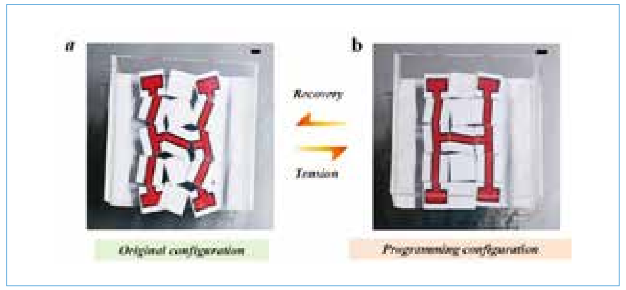

Figure 3 The information encryption device: (a) encrypted state (b) decrypted state.

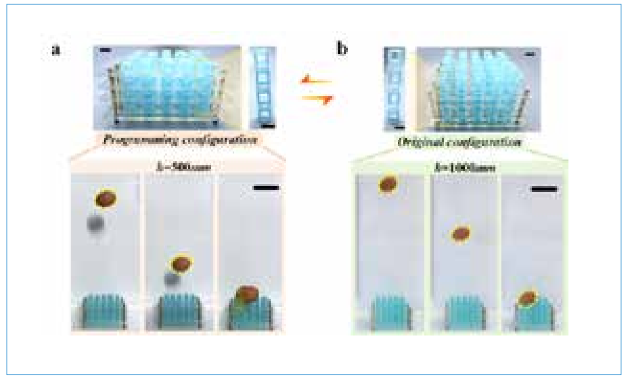

Figure 4 Dynamic impact experiments of the eggs freely falling to the buffer device: (a) programmed state (b) unprogrammed state.

The unit cell of the MP, composed of a hollow cubic node and helical ligaments, was obtained by removing the lateral constraints of the 3D chiral structure with cubic symmetry (Figure 1a). The distribution of ligaments was divided into the right-handed chiral mode (Figure 2a) and the left-handed chiral mode (Figure 2a). The geometrical parameters of the microstructure determined the configuration and mechanical properties of the MP, creating an opportunity to design the mechanical behavior of the MP. The deformation mechanism of the MP from bending-dominated deformation mode to the stretching-dominated deformation mode was revealed, and the reconfigurable properties of the nonlinear mechanical behavior of the MP were verified (Figure 2c~2d).

The torsion angle and direction of the MP can be adjusted by changing geometric parameters and chiral modes. The MPs with different chiral modes were arranged periodically to fabricate an information encryption device. When the device was heated and mechanically deformed, the torsion of the MPs enabled the information to transform from an encrypted state to a decrypted state (i.e. "H").

The ligament configuration and node spacing of MPs created an opportunity for the fabrication of buffer devices. During impact, the node spacing allowed the ligament to deform in a large space, thus providing sufficient buffer for the fragile objects. Due to the shape memory characteristics, the node spacing and configuration of MPs in the buffer device can be adjusted to achieve different buffer effects. For example, the egg fell from a height of 500 mm on the programmed buffer device and broke immediately (Figure 4a), while the egg remained intact when it fell from 1000 mm on the unprogrammed buffer device (Figure 4b). ■

REFERENCE

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Research & Academia
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SHAPE MEMORY EPOXY RESINS AND THEIR COMPOSITES WITH A NARROW TRANSITION TEMPERATURE RANGE

Shape memory epoxy resins are one of the most widely used smart polymers, mainly used in aerospace, intelligent bionics, and other fields of active deformation structures. Recently, Professor Leng Jinsong's group from the Center for Composite Materials and Structures at Harbin Institute of Technology published a paper "Multi-Performance Shape Memory Epoxy Resins and Their Composites with Narrow Transition Temperature Range" in *Composites Science and Technology*.

This study developed and synthesized a series of shape memory epoxy resins with a narrow glass transition temperature range, strong inter-segment forces, and uniform crosslinked networks. By adjusting the stoichiometric ratio and crosslinking density, the length of the chain segment was controlled uniformly (Figure 1a). The glass transition temperature range was from 14°C to 23°C (Figure 1b), which improved the efficiency of shape memory action. In addition, the multi-amines crosslinking agents were used to adjust the

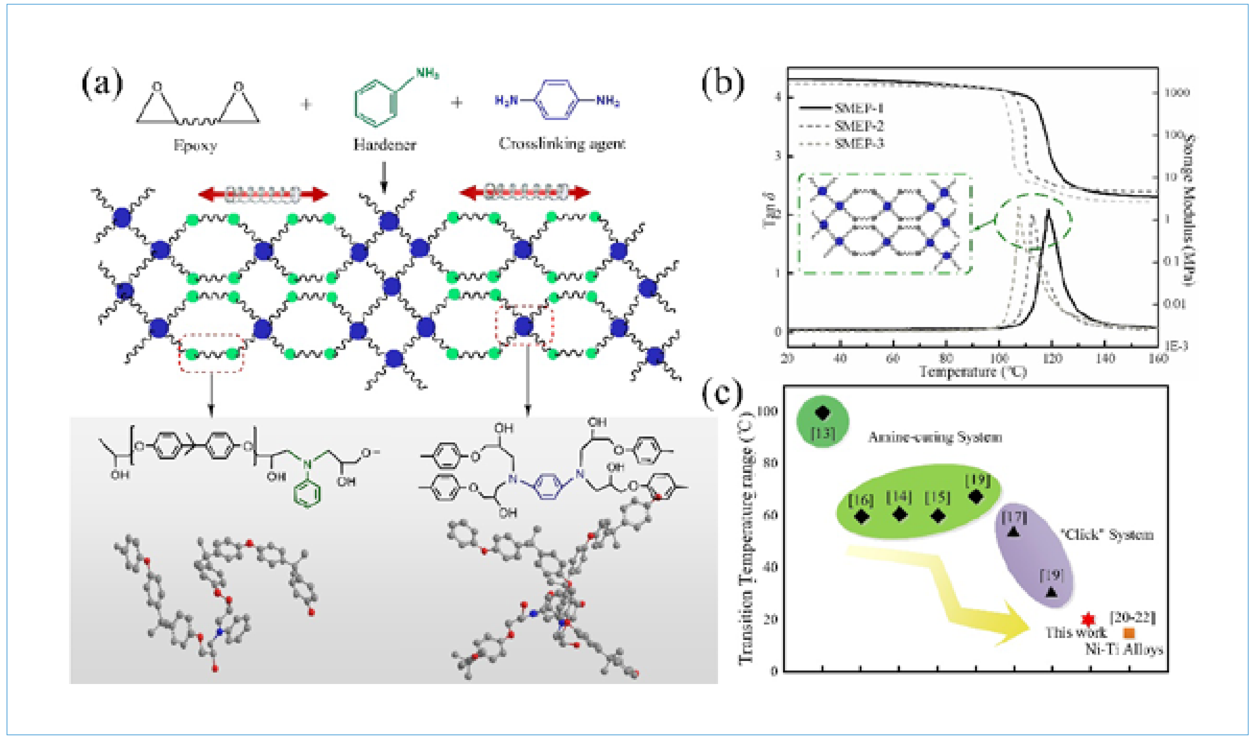

Figure 1 (a) Schematic illustration of the regular and uniform crosslinked network of SMEP. (b) The DMA curves of systems. (c) The transition temperature range performance is compared with other literature.

distribution of the chain segment and achieve the effect of regulating the glass transition temperature (Tg).

Moreover, the additions of epoxy-terminated liquid nitrile rubber (ETBN) composites enabled toughen of systems. The elongation at break could be increased by four times. Furthermore, Tg, modulus and strength of composites were improved by adding high-temperature latent hardener based on the ETBN toughening system combined with a two-stage curing method. The composites with a narrow transition temperature range were more suitable for shape fixation and recovery temperature with higher precision and closer spacing, which meet the higher requirements in the aerospace field. This work reported a series of SMEPs with a narrow transition range up to 20℃ and excellent shape memory properties (Figure 1c).

This work was financially supported by the National Natural Science Foundation of China. ■

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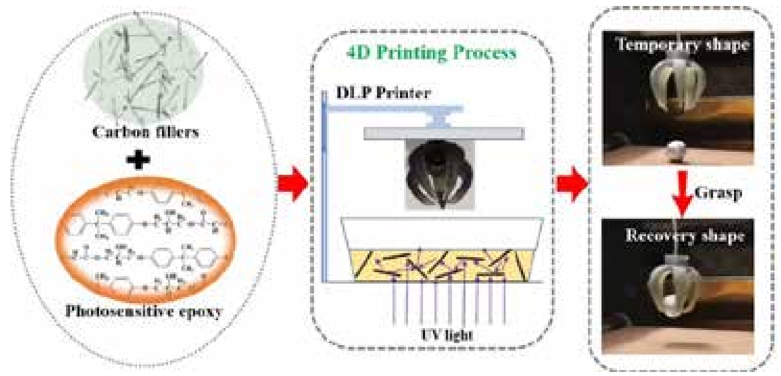
Luo Lan, Zhang Fenghua, LengJinsong. Multi-performance shape memory epoxy resins and their composites with narrow transition temperature range. Composites Science and Technology, 2021, 108899. DOI: https://doi.org/10.1016/j.compscitech.2021.108899

PHOTOSENSITIVE COMPOSITE INKS FOR DIGITAL LIGHT PROCESSING FOUR-DIMENSIONAL PRINTING OF SHAPE MEMORY CAPTURE DEVICES

In 2021, Professor Leng Jinsong's group from the Centre for Composite Materials and Structures published a paper titled "Photosensitive Composite Inks for Digital Light Processing Four-Dimensional Printing of Shape Memory Capture Devices" in *ACS Applied Materials & Interfaces*.

Shape memory epoxy resin has been widely used in a variety of fields because of its excellent thermodynamic and electrical insulation properties, bonding properties with various materials, and process molding. Printable shape memory resins have attracted widespread attention with three-dimensional (3D) printing development. There are two main ways to print thermosetting resin. One is to add fillers into the resin, which plays a supporting role in the printing process to ensure that the printed structure will not collapse. The other method is to mix the resin with acrylics, and the mixture is light-cured



during the printing process and then heat-cured after printing. Herein, we report two black inks suitable for photocuring 4D printing, which were synthesized via addition esterification. The advantages advantages were mild conditions, high yield and low cost, benefiting to more manufacturing technologies.

The pristine resin is not sufficient for most engineering applications, especially in aerospace. Therefore, the printable performances of nanoscale multi-wall carbon nanotubes (CNTs) and micron-sized short carbon fibers (CFs) filled inks are investigated. And printing parameters are adjusted to optimize layer structure and improve the printing efficiency. We investigated the effect of the carbon fillers on rheological properties, crosslinking degree and molding properties of the black inks from the perspective of the two scales. The black composite inks with photosensitive performance were used to realize rapid and complex structure manufacturing. Because the length of the CFs is greater than the thickness of a printing layer, the CFs were oriented in the X-Y plane, which can increase the mechanical properties of cured resin in the X-Y plane, but does not affect the Z direction. Moreover, the addition of the CNTs and CFs significantly improves the shape memory recovery efficiency of the printed capture structure. 4D printing opens up a new portal for manufacturing thermoset epoxy composites and complex structures, which make the shape memory thermosetting epoxy resins and their composites possess excellent properties and good engineering application prospects.

REFERENCE

Linlin Wang, Fenghua Zhang, Yanju Liu, Shanyi Du, and Jinsong Leng. Photosensitive composite inks for digital light processing four-dimensional printing of shape memory capture devices. ACS Applied Materials & Interfaces, 2021, 13, 18110-18119. DOI: https://doi.org/10.1021/acsami.1c02624

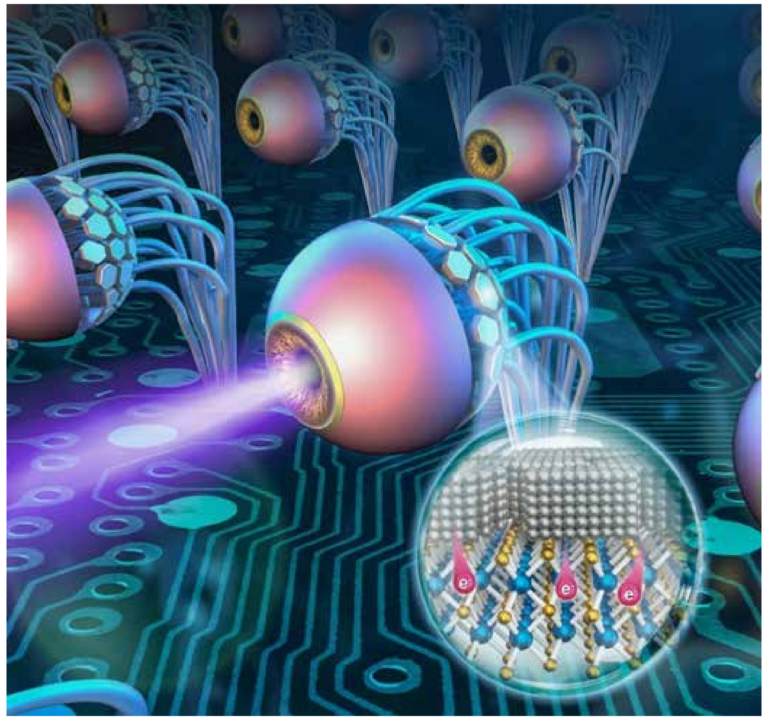
ULTRALOW POWER OPTICAL SYNAPSES AND THE APPLICATION IN BIOMIMETIC EYES

Recently, Professor Hu PingAn's group from the Institute for Advanced Ceramics, School of Materials Science and Engineering at HIT, reported the important progress in the field of ultra-low power biomimetic optical synaptic devices and chips. The paper "Ultralow Power Optical Synapses Based on MoS_2 Layers by Indium-Induced Surface Charge Doping for Biomimetic Eyes" was published in *Advanced Materials*. The first author is Hu Yunxia.

Inspired by the biological eyes, biomimetic eyes with their excellent imaging functions, such as large fields of view and low aberrations, have shown great potentials in the fields of visual prostheses and robotics. However, the current visual systems are based on conventional von Neumann architecture with physically separated sensors, memories and processing units, which induce power consumption wall and memory wall, resulting in high energy consumption and difficulties of performing complex image learning and processing tasks. Therefore, it is of great significance to develop artificial visual systems, based on non von Neumann architectures. Particularly, optical synaptic systems can respond to the optical stimuli and show a typical synaptic plasticity, which combine the visual systems and brain functions. However, high power consumption and difficulties in surface machining integration become critical issues for the rapid development of the current synaptic devices.

To solve the above problems, Hu PingAn's research group designed an artificial synaptic device in which the channel material of MoS_2 film is covered with an electron injection enhanced indium (In) layer, resulting in a significant reduction of power consumption of the optical synapse down to 68.9 aJ per spike, which is much lower than those of the currently developed optical synapses (>1 pJ per spike). Furthermore, this research overcomes the problems of 2D material growth and device integration on the curved substrates, constructs a hemispherical electronic retina composed of a synaptic device array, and exhibits high performance image sensing and learning functions. This work opens up a new route to regulate the performance of synaptic devices based on the 2D materials and the construction of curved vision chip.

Hu PingAn's research group is engaged in large-scale two-dimensional single wafer growth (graphene, hexagonal boron nitride, etc.) and optoelectronic devices. Recently, the papers "High-Performance van der Waals Metal-Insulator Semiconductor Photodetector Optimized with Valence Band Matching" and "Low Optical Writing Energy Multibit Optoelectronic Memory Based on SnS_2/h-BN/Graphene Heterostructure" were published online in *Advanced Functional Materials* and *Small* respectively. He was invited to publish a comment paper "A Vertical Transistor with a Sub-1-nm Channel" in *Nature Electronics*. ■



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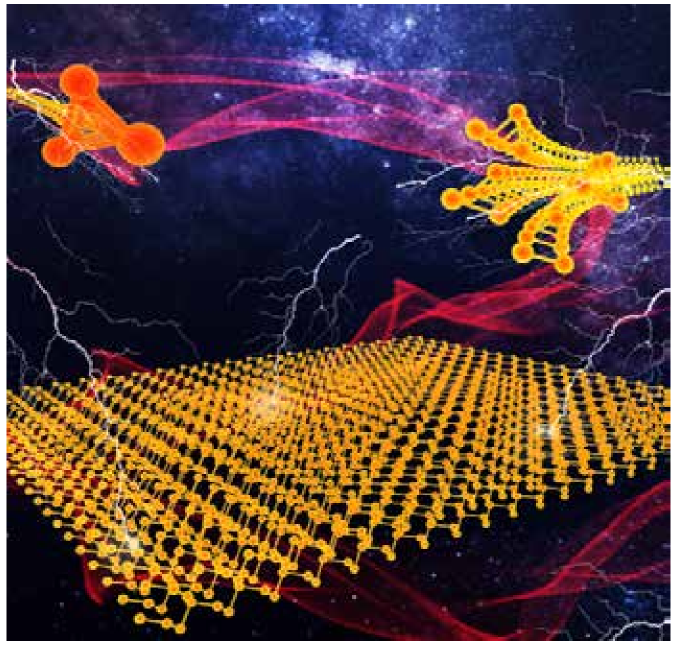
Research & Academia
HIT TIMES 2021

HIT RESEARCH TEAM REVEALS THE MECHANICAL ANISOTROPY IN 2D SELENIUM ATOMIC LAYERS

Recently, Professor He Xiaodong and Associate Professor Wang Chao, from the School of Astronautics, revealed the anisotropic tensile mechanical behaviours of 2D selenium (Se) nanomaterial with atomic-level thickness by advanced *in-situ* mechanical testing technique. Meanwhile, the van der Waals (vdW) interaction strength between Se atomic chains was quantified for the first time. This work lays experimental foundation for designing new multi-functional 2D nanomaterials. The related results were published on the authoritative journal of *Nano Letters* in the field of nanomechanics. Harbin Institute of Technology is the first corresponding unit, Ph.D Qin Jingkai and Associate Professor Sui Chao are the co-first authors, and Professor He Xiaodong and Associate Professor Wang Chao are the co-corresponding authors.

In recent years, Se 2D nanomaterial has become research focus, owing to its excellent optical and electrical properties. It is well-known that the mechanical properties of materials play critical roles in their actual applications. However, it is very difficult to directly measure the mechanical performances by



traditional mechanical testing methods because of the nano-scale of Se nanomaterials. On the other hand, as the Se 2D nanomaterial is assembled by vdW interaction among special highly-aligned 1D Se atomic chains, it possesses remarkable orthogonal anisotropy structure. So far, the tensile mechanical behaviour correlated with this kind of anisotropic 2D structure has yet to be understood.

In order to address these issues, the researchers achieved the *in-situ* loading of Se 2D nanomaterial along different directions by combining transferring technique with SEM *in-situ* mechanical testing technique. With this kind of testing technique, the "zig-zag" fracture mode along the atomic chain axis and "flat" fracture mode along the direction perpendicular to atomic chain axis were revealed. More importantly, the vdW interaction strength between Se atomic chains was determined for the first time, which indirectly demonstrates that the dominated vdW interaction at nano-scale can be utilized to assemble 2D nanomaterial. This work provides new structural design routes for advanced multi-functional 2D nanomaterials. ■

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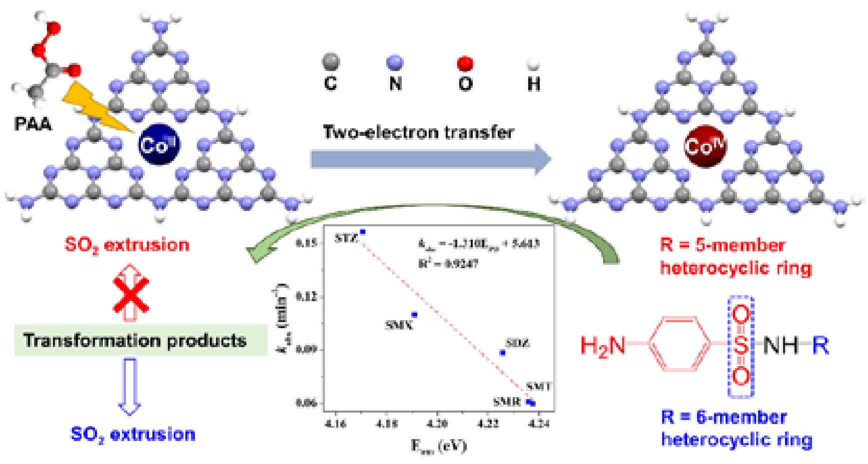
SIGNIFICANT ROLE OF HIGH-VALENT COBALT-OXO SPECIES IN COBALT-BASED FENTON-LIKE REACTION

Recently, a team led by Professor Guo Wanqian, from the State Key Laboratory of Urban Water Resource and Environment, Harbin Institute of Technology, published a research paper titled "Novel Nonradical Oxidation of Sulfonamide Antibiotics with Co(II)-Doped g-C_3N_4-Activated Peracetic Acid: Role of High-Valent Cobalt-Oxo Species" in *Environmental Science & Technology*.

In the bulk phase, radical species from the one-electron transfer have been widely accepted as the main reactive oxidant in the cobalt-based Fenton-liked reactions. In the heterogeneous processes, however, the behavior of the cobalt-related reaction is elusive. Up to now, the proposed catalytic mechanisms include foregoing radical-generating and well-reported nonradical-involved (i.e., singlet oxygenation or mediated electron transfer) routes. Herein, we report a novel nonradical pathway with unprecedented high-valent cobalt-oxo species [Co(IV)] as the dominant reactive species occurred in the Co(II)-doped g-C_3N_4-activated peracetic acid process, quite different from the conventional



activation mechanism. The established oxidative system exhibits exotic catalytic activities, selectivity, and pH stability for the oxidation of various sulfonamides. More importantly, benefiting from this unique mechanism, the developed oxidation technology also shows excellent anti-interference capacity and realizes the target-oriented elimination of sulfonamides from actual water. The results of this study can advance the understanding of reactive cobalt species generation in a heterogeneous system and the application of cobalt-based Fenton-like reaction.

Professor Guo Wanqian, from HIT, and Professor Jiang Jin, from Guangdong University of Technology, are the corresponding authors. The Ph.D. student, Dr. Liu Banghai, is the first-author. This work was financially supported by the National Natural Science Foundation of China and the State Key Laboratory of Urban Water Resource and Environment. ■

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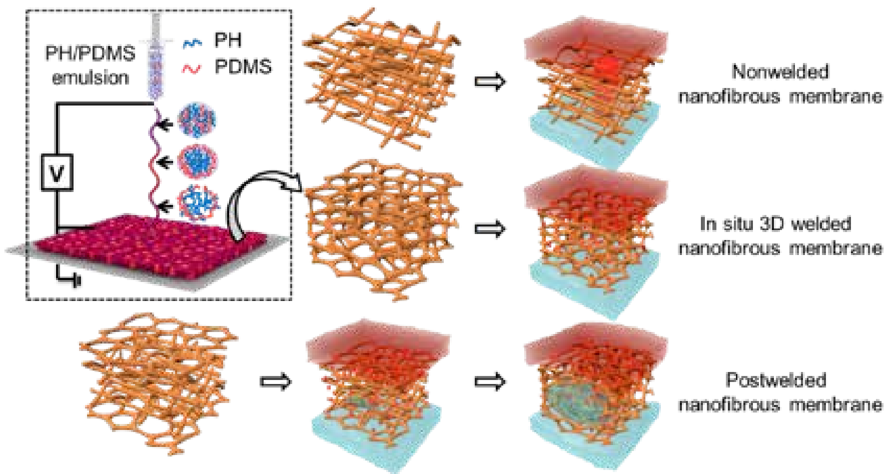
IN SITU THREE-DIMENSIONAL WELDED NANOFIBROUS MEMBRANES FOR MEMBRANE DISTILLATION

Professor Wang Wei, from the State Key Laboratory of Urban Water Resource and Environment, recently published a paper titled "In Situ Three-Dimensional Welded Nanofibrous Membranes for Robust Membrane Distillation of Concentrated Seawater" in the top journal, *Environmental Science & Technology*. The first author is Zhong Lingling.

Membrane distillation (MD), which holds the advantage of using waste heat to treat the challenging hypersaline water steams, is a suitable candidate to concentrate the concentrated seawater for zero liquid discharge (ZLD). Maintaining high water vapor permeability and hydrophobic durability is critical for the success of the MD process. Recently, electrospun membranes, fabricated by additive manufacturing, have proven to be more permeable than the conventional phase-inversion membranes because of their higher porosity and lower pore tortuosity. However, these characteristics lead to poor structural stability of electrospun membranes, which constrains their hydrophobic durability. To overcome this issue,



the research group developed an in situ 3D welding method by one-step emulsion electrospinning to fabricate an MD membrane with excellent 3D hydrophobic durability. This 3D hydrophobic stability, even without superhydrophobicity, could avoid internal and external wetting at the same time. The mechanism of internal wetting caused by the difference in the structural stability in cross-section was first proposed. The results showed that the in situ 3D welded nanofibrous membrane exhibited a long-term hydrophobic durability and high water recovery rate, which was much better than those of the nonwelded and postwelded (superhydrophobic) nanofibrous membrane. More significantly, the in situ 3D welded nanofibrous membrane could achieve the crystallization of actual concentrated seawater, which is of great practical significance for treating hypersaline water streams.

This work was financially supported by the National Natural Science Foundation of China and the Natural Science Foundation of Heilongjiang Province. ■

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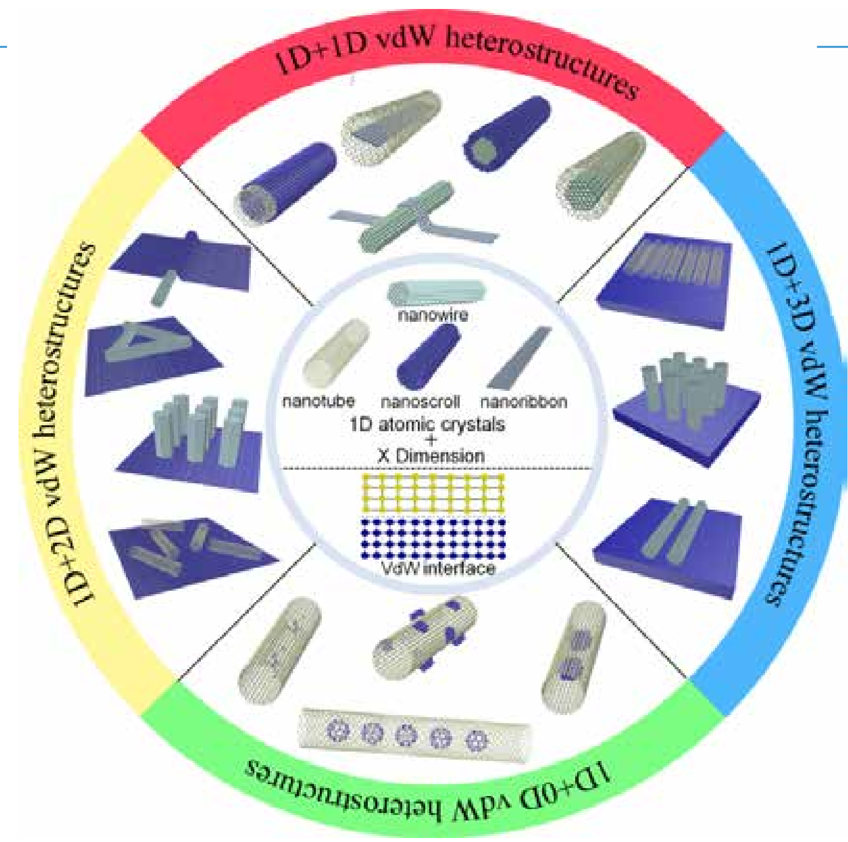
VAN DER WAALS HETEROSTRUCTURES WITH ONE-DIMENSIONAL ATOMIC CRYSTALS

Van der Waals (vdW) heterostructures represent an important category of artificial materials, where atomic crystals with different dimensionalities are integrated via weak vdW interaction. Without the strict requirement on the symmetry and lattice matching, the components can be manipulated like LEGO® pieces to create various designed artificial materials. The strategy of vdW integration has been quite successful in two-dimensional (2D) atomic crystals (including graphene, *h*-BN, and transition metal dichalcogenides), and it can be further extended to one-dimensional (1D) materials such as nanotubes, nanowires, and nanobelts. Due to the weak vdW interaction and loose requirements on lattice matching at heterointerface, a large number of materials with different configurations (0D organic molecules/quantum dots, 1D nanowires/nanotubes, 2D nanosheets, 3D bulks) and physical properties (metallic, semiconducting and insulating) can be integrated into 1D backbones to create vdW heterostructures. A selective set of recipes enable such vdW heterostructures with a wealth of intriguing physics including quantum confinement effect, phase transition, directional mass transport, *etc*. These properties make the hybrid materials system a good candidate for exploring multifunctional applications such as solid-state devices, energy storage, and drug delivery.



Schematic illustration and structural characteristics of 1D vdW heterostructures

Recently, Professor Xu Chengyan and his colleagues from the School of Materials Science and Engineering at Harbin Institute of Technology (Shenzhen) published a comprehensive review article "Van der Waals Heterostructures with One-Dimensional Atomic Crystals" in *Progress in Materials Science*, a prestigious journal that publishes authoritative and critical reviews of recent advances in the science of materials and their use in engineering and other applications. In this review, the authors introduced typical structures of 1D materials, their synthesis techniques, their physical properties that can be controlled by their dimensions, and new applications of 1D van der Waals heterostructures such as field-effect transistor, optoelectronic devices, energy storage, and drug delivery. The authors also provided their prospects on new directions in this field. ■

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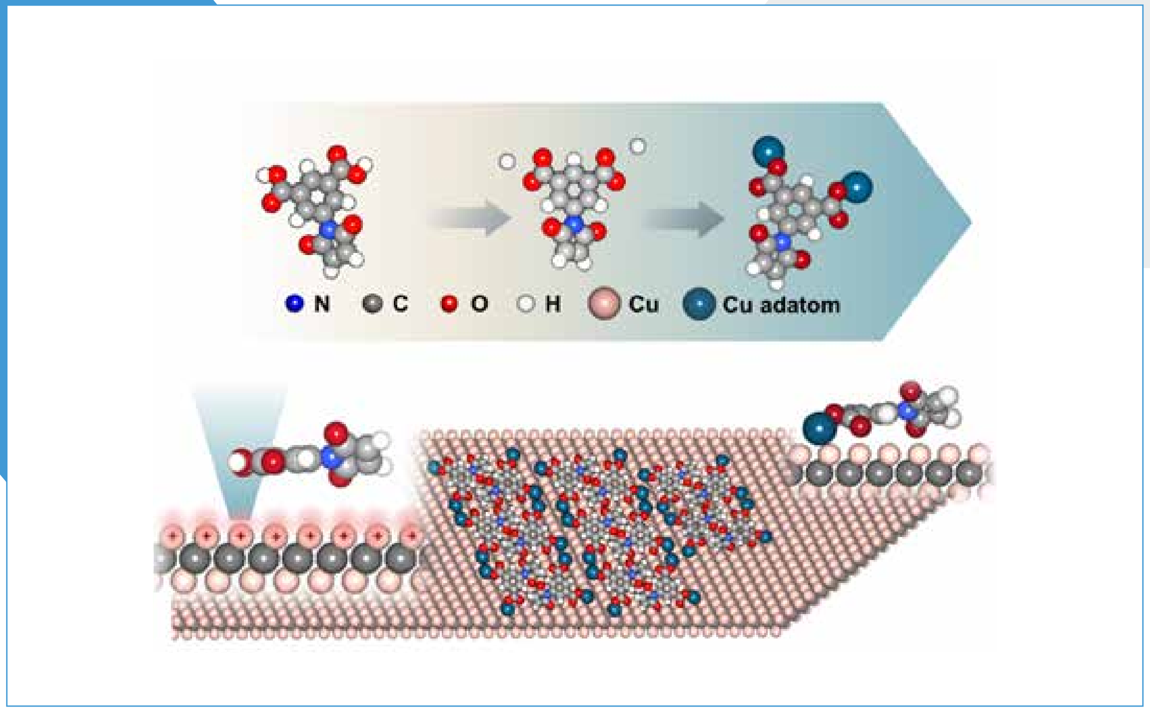
SUBSURFACE CARBON-INDUCED LOCAL CHARGE FOR HIGH-PERFORMANCE CATALYSIS

Professor Yu Miao, from the School of Chemistry and Chemical Engineering, recently published a research paper titled "Subsurface Carbon-Induced Local Charge of Copper for On-Surface Displacement Reaction" in *Angewandte Chemie International Edition*.

A big challenge for the whole field of on-surface synthesis is the lack of robust, smooth and isotropic platform with high catalytic capability, so that only very limited reaction types hence product can be achieved.

Copper (Cu), as one of the most classical catalysts, has been applied extensively in selective oxidation, coupling reaction, carbon dioxide reduction, *etc.* Since the extrinsic species on top of a Cu surface have a high probability of being removed or modified upon chemical reactions, which results in the reduction of $Cu^{\delta+}$ to Cu^0, subsurface doping is believed to be advantageous for long-term, stable catalytic performance. In regard to compatibility with Cu, carbon (C), one of the typical minorities in natural Cu bulk, certainly holds advantages over other elements. However, local charge of Cu surface induced by C-doping and the catalytic properties of Cu carbide or C-doped Cu are still unexplored.

In this work, Yu's group introduces subsurface C to Cu(111); displacement reaction of proton in carboxyl acid group with single Cu atom is demonstrated at the atomic scale and room temperature, which does not occur on pristine Cu(111) even at elevated temperatures until complete desorption of the adsorbate. Its occurrence is attributed to the C-doping induced local charge of surface Cu atoms (up to +0.30 e/atom), which accelerates the rate of on-surface deprotonation via reduction of the corresponding energy barrier, thus enabling the instant displacement of a proton with a Cu atom when the



molecules land on the surface.

Not only does this work reveal the catalytic performance of C-doped copper for the first time, it provides the direct experimental demonstration at the sub-molecular scale, indicating that the new catalytic platform can trigger reactions that cannot occur in the parent metal. Superior to the commonly-used high surface-energy metal crystal planes or doped metal surfaces (that are significantly roughened with various islands/holes), the well-defined *C-Cu*$^{\delta+}$ surface offers a much less anisotropic platform for long-range ordered synthesis. Moreover, given the high-temperature and subsurface doping, the platform is robust upon thermal excitation and avoids the reduction to Cu^0 by the on-surface reactions. Such locally charged transition metal surfaces therefore hold great promise for on-surface synthesis and high-performance catalysis. As the first story on this direction, this new strategy may provide a fertile ground for developing various advance catalytic platforms. ■

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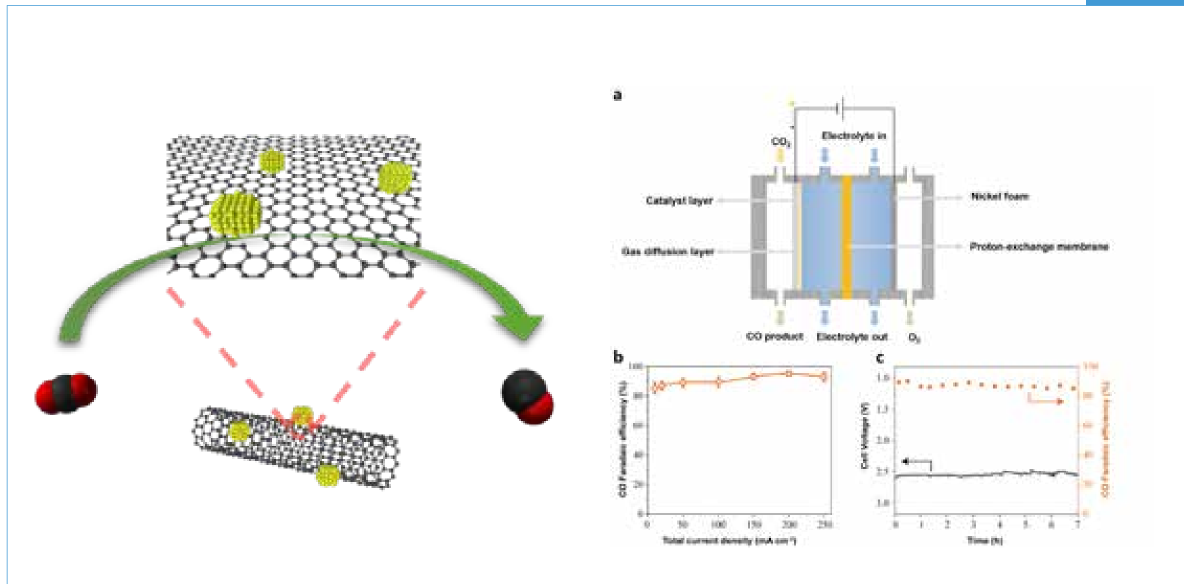
BREAKTHROUGH IN EFFICIENT CO_2 REDUCTION VIA AU-COMPLEX DERIVED CARBON NANOTUBE SUPPORTED AU NANOCLUSTERS

Recently, a team led by Professor Wang Zhijiang from the School of Chemistry and Chemical Engineering, Harbin Institute of Technology, has made important progress in CO_2 electroreduction. The research article titled "Efficient CO_2 Electroreduction via Au-Complex Derived Carbon Nanotube Supported Au Nanoclusters" was published in *ChemSusChem*.

The overuse of fossil fuels to meet the energy demand of human beings has led to the rapid growth of atmospheric CO_2 concentration, that severely threatens the survival of mankind. It is of great urgency to achieve carbon neutrality for sustainable development. Despite being one of the culprits of the greenhouse effect, CO_2 is also a cheap source of carbon. Considering the wide application of renewable electricity from solar, wind, and tide energy, electrochemical reduction of CO_2 to value-added molecular energy is the most promising technology to tackle the current predicament.

Professor Wang and his co-authors developed a facile and mild synthesis method to fabricate a novel Au-based catalyst. They found that a novel carbon nanotube supported Au nanoclusters with diameters about 4 nm can be formed by the



electrochemical activation of an Au-complex material with CNT. The fabricated electrocatalyst possesses impressive performances toward CO production in both H-cell and flow cell reactors. They found the charge transfer happened between Au nanoclusters and CNT support using this synthesis method. The interaction between metal and CNT support gives rise to the formation of electron rich Au active sites, in which CO_2 reduction reaction can be greatly enhanced by altering the mechanism pathway. The facile method reported in this work effectively utilizes the dispersion effect and electronic modulation effect induced by support materials for the active metal components in catalysis. This work constitutes a breakthrough in developing practical CO_2 reduction catalysts.

This research was financially supported by the National Natural Science Foundation of China. ■

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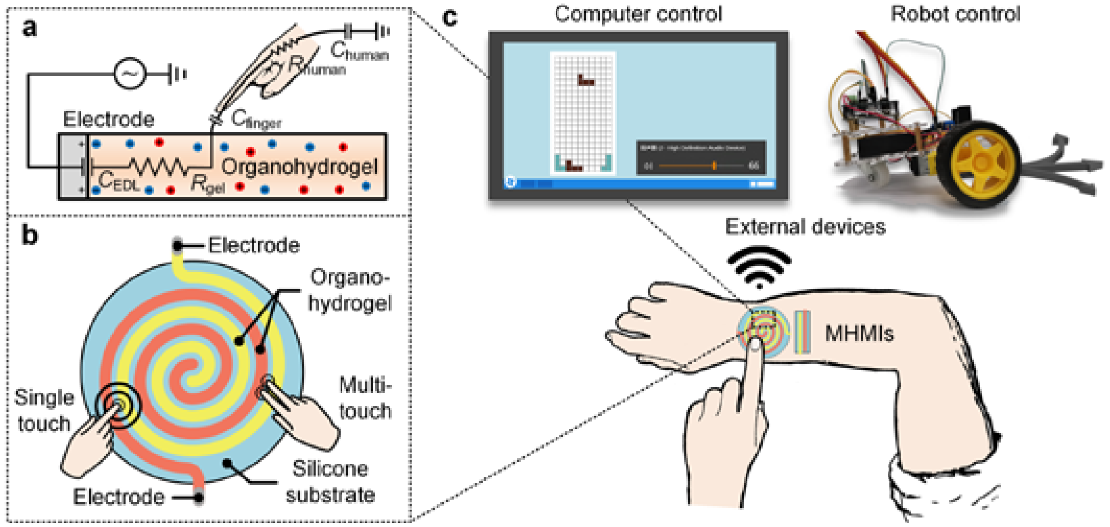
NOVEL MULTIFUNCTIONAL HUMAN-MACHINE INTERFACES USING ANTI-DRYING, ION-CONDUCTING ORGANOHYDROGELS

Recently, a team led by Professor Jiang Hongyuan, from the School of Mechatronics Engineering, Harbin Institute of Technology, published a research paper titled "Anti-Drying, Transparent, Ion-Conducting, and Tough Organohydrogels for Wearable Multifunctional Human-Machine Interfaces" in *Chemical Engineering Journal*.

There is increasing interest in the "Internet of Things" (IoT) and the development of wearable intelligent devices with human–machine interfaces (HMIs). Flexible touch panels have received wide attention due to their use as intuitive HMIs. However, most existing flexible touch panels can only detect a single touch or rely on massive electrodes and complex sensor arrays for multi-touch detection. This limitation undoubtedly hinders the further development of wearable HMIs.

In this study, a long service life (>5 months), wearable multifunctional HMI (MHMI) with only two electrodes was developed. MHMIs were manufactured using a novel anti-drying, transparent, resilient, and tough double-network ion-conducting organohydrogel as a sensing material, which is produced using the solvent substitution method. The present organohydrogel shows satisfactory



conductivity (0.33 S m^{-1}), mechanical property (>450%), and a long service life (>5 months). We use the organohydrogel as an example to illustrate the sensing principle of the flexible ion conductor and present the corresponding electrical circuit diagram. A parallel mutual inspection structure is proposed based on the sensing principle. A pair of organohydrogel strips is embedded in a flexible substrate in a horizontal or spiral form to construct one-dimensional (1D) and two-dimensional (2D) MHMIs. Owing to their special structure, the MHMIs only need two electrodes to detect a single touch and recognize multi-touch accurately and sensitively. 1D-MHMIs can be used as linear controllers to continuously control external devices through a slide or tap with a single finger, and 2D-MHMIs can accurately control the movement of external devices in a 2D coordinate system through a single touch. Furthermore, the multi-touch recognition function confers greater operability on the 1D-MHMI and 2D-MHMIs, which can be used in control centers to achieve multi-device switching and multiple function selection through programming.

Taken together, the anti-drying organohydrogel-based MHMIs proposed herein have a simple structure, a long service life, outstanding sensitivity, and satisfactory deformability, making the interaction between humans and machines more efficient and fascinating, further promoting the development of the "Internet of Things." ■

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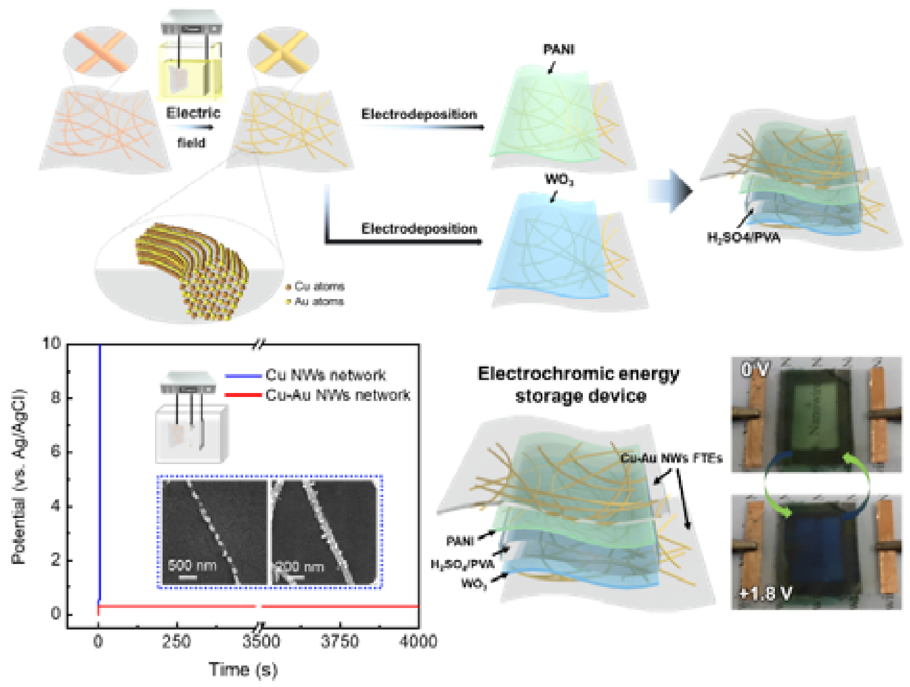
FABRICATION OF HIGHLY STABLE COPPER NANOWIRES ELECTRODE FOR FLEXIBLE ELECTROCHROMIC DEVICE

Recently, a highly conductive and stable copper nanowire (CuNW) based flexible transparent electrode (FTE) was proposed by Professor Tian Yanhong's team from the State Key Laboratory of Advanced Welding and Joining, Harbin Institute of Technology, and the results titled "Robust Cu-Au Alloy Nanowires Flexible Transparent Electrode for Asymmetric Electrochromic Energy Storage Device" was published in *Chemical Engineering Journal*.

In past five years, Professor Tian's team has made a series progress in the nano-joining of flexible electronics. One-dimension nanomaterials (such as silver nanowires, copper nanowires, carbon nanofibers, etc.) have attracted increasing attentions due to their excellent electrical conductivity, mechanical flexibility, and cost-effectiveness. These unique advantages give it potential to replace conventional indium tin oxide (ITO) for the applications in next-generation flexible and wearable electronics, including wearable stain sensor, transparent heaters, organic light emitting diodes, etc. However, they



always suffer from inadequate conductivity and poor stability against electrochemical corrosion in practical usage. To address these issues, Professor Tian's team developed a novel and effective method — inducing passive Au atoms, which can join stacked CuNWs together to decrease the wire-to-wire contact resistance, as well as increase the anti-corrosion performance of CuNWs. Based on these improvements, a bifunctional color-changing and energy-storage device was fabricated by integrating complementary polyaniline and tungsten oxide. This result demonstrates that CuNWs FTE will have significant future impact in many electrochemical fields, such as electrochromic smart windows, supercapacitors, etc.

These works were supported by the National Natural Science Foundation of China, the New Century Excellent Researcher Award Program from the Ministry of Education of China and Heilongjiang Touyan Team. ■

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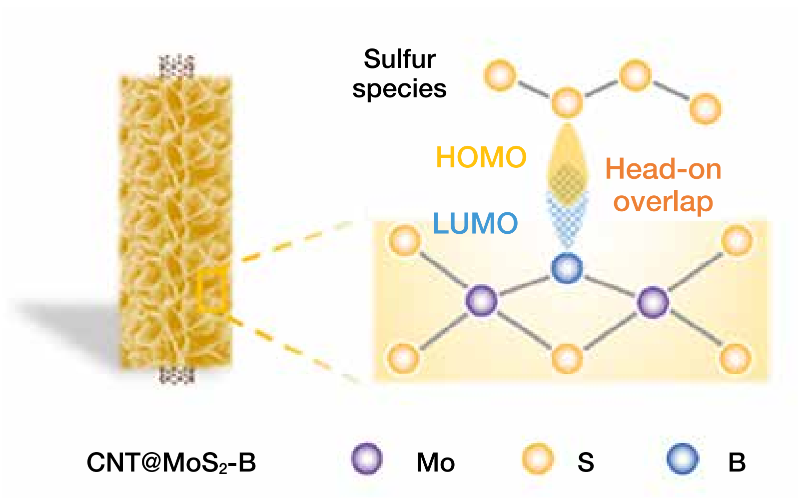
BASAL-PLANE-ACTIVATED MOLYBDENUM SULFIDE NANOSHEETS WITH SUITABLE ORBITAL ORIENTATION

In 2021, Professor Zhang Naiqing's group from the State Key Laboratory of Urban Water Resource and Environment published a research paper titled "Basal-Plane-Activated Molybdenum Sulfide Nanosheets with Suitable Orbital Orientation as Efficient Electrocatalysts for Lithium-Sulfur Batteries" in *ACS Nano*.

The shuttling behavior and sluggish conversion kinetics of lithium polysulfides (LiPSs) limit the practical application of lithium-sulfur (Li-S) batteries. Employing electrocatalysts has been recognized as an effective approach to accelerate sulfur redox reactions. Transition metal chalcogenides such as molybdenum disulfide (MoS_2) have attracted a lot of attention because of the large surface area and low cost. Unfortunately, the active sites are limited to a small number of edge sites only, while the majority part (the basal plane) is catalytically inert.



The researchers revealed that the poor catalytic performance of MoS_2 basal plane is related to its unsuitable orbital orientation, which obstructs the orbital overlap with sulfur species. They further presented an orbital engineering strategy by fabricating B-doped MoS_2 supported on carbon nanotube (denoted as CNT@MoS_2-B) as a Li-S electrocatalyst. B in CNT@MoS_2-B is sp^3 hybridized, and it has a vacant σ orbital perpendicular to the basal plane, which allows for maximal orbital overlap with sulfur species. Consequently, the basal plane is efficiently activated and excellent electrochemical performances of Li-S battery have been demonstrated with the CNT@MoS_2-B host.

This work was financially supported by the National Natural Science Foundation of China.

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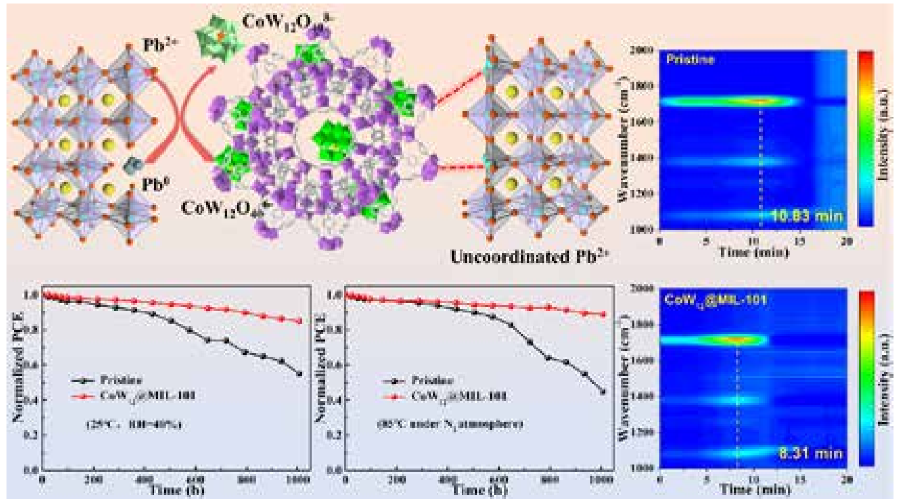
D. Tian, X. Song, Y. Qiu, et al. Basal-plane-activated molybdenum sulfide nanosheets with suitable orbital orientation as efficient electrocatalysts for lithium-sulfur batteries. ACS Nano, 2021, DOI: 10.1021/acsnano.1c06067

PASSIVATING MULTIPLE LEAD DEFECTS USING POM@MOFS FOR HIGHLY STABLE PEROVSKITE SOLAR CELLS

In 2021, Professor Lin Kaifeng, Professor Yang Yulin, and Dr. Zhang Jian from the School of Chemistry and Chemical Engineering published a research paper titled "Construction of Polyoxometalate-Based Material for Eliminating Multiple Pb-Based Defects and Enhancing Thermal Stability of Perovskite Solar Cells" in *Advanced Functional Materials*.

Perovskite solar cells (PSCs) have recently achieved dramatic enhancement in the power conversion efficiency (PCE). However, the industrialization process is still limited by the long-term stability of device. The uncoordinated Pb^{2+} defects on the surface and grain boundary of perovskite film not only act as non-radiative recombination center but also contact with water and oxygen and cause the reduced charge extraction efficiency and accelerated degradation of PSCs. In particular, uncoordinated Pb^{2+} ions will transform to metallic Pb^0 when heated or illuminated and produce a deep defect, which seriously affects the moisture and thermal stability of the device.

In view of the above problems, Professor Lin's



research team proposed an efficient strategy to eliminate Pb^0 and passivate Pb^{2+} simultaneously by employing a stable polyoxometalate-based material CoW_{12}@MIL-101(Cr) in the precursor solution of perovskite. The controllable oxidation ability of CoW_{12} was optimized through the interaction with the MOFs, therefore, the hybrid material could control oxidate Pb^0 without reacting with I^- ions. Meanwhile, electron-rich atoms, such as O, in MOFs further passivate uncoordinated Pb^{2+} ions by forming Lewis acid-base adducts. Benefiting from the high-quality perovskite film, the champion doped-device shows enhanced PCE to 21.39% and excellent stability, maintaining 85% and 89% of the original PCE after heating at 85℃ in N_2 atmosphere and stored in ambient conditions (25℃, 40% humidity) for 1000 h, respectively. In addition, the solvent vapor overflow process in the precursor solution was real-time monitored by an in-situ TG-FT-IR analysis for the first time, which will inspire new ideas on how to prepare high-quality perovskite films.

The first author is PhD candidate Wang Wei. This work was financially supported by the National Natural Science Foundation of China, the China Postdoctoral Science Foundation, the Postdoctoral Foundation of Heilongjiang Province, and the Natural Science Foundation of Heilongjiang Youth Fund. ■

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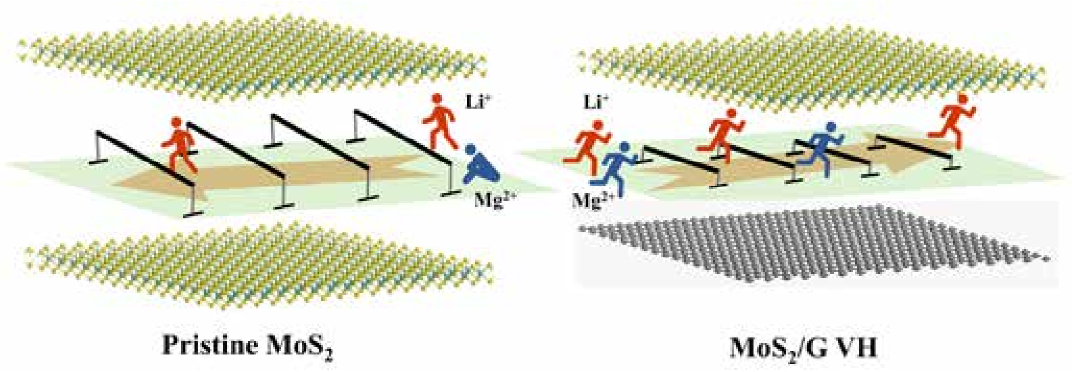
Research & Academia
HIT TIMES 2021

A MoS_2 AND GRAPHENE ALTERNATELY STACKING VAN DER WAALS HETEROSTRUCTURE FOR Li^+/Mg^{2+} CO-INTERCALATION

In 2021, Professor Zhang Naiqing's group from the State Key Laboratory of Urban Water Resource and Environment published a research paper titled "A MoS_2 and Graphene Alternately Stacking van der Waals Heterostructure for Li^+/Mg^{2+} Co-Intercalation" in *Advanced Functional Materials*.

Constructing a Li^+/Mg^{2+} hybrid-ion battery (LMIB) with a Mg metal anode and a Li^+ host cathode is an attracting strategy to circumvent the intrinsic issue and release the huge potential of Mg metal secondary batteries. Nevertheless, the "Daniell Type" LMIBs inevitably suffer from the limitation of energy density which results from the limited solubility amounts of Li^+ in the electrolyte. Furthermore, the severe Li^+ concentration polarization along with the discharge proceeding causes the rapid deterioration of battery performances. Currently, "Rock-Chair Type" LMIBs based on Li^+/Mg^{2+} co-intercalating into cathode materials in discharge are designed and constructed. The unique construction of "Rock-Chair Type" LMIBs



can settle well the issues of "Daniell Type" batteries.

In the present work, a new construction of ion transport channels built in MoS_2/graphene van der Waals heterostructures (MoS_2/G VH) are designed and prepared. The channels possess weaker electrostatic force toward metal ions compared with pristine MoS_2 by transforming the channel construction from pristine interlamination of two MoS_2 monolayers to the interlamination of MoS_2 monolayer with graphene monolayer. The density functional theory (DFT) calculations demonstrated that, compared with the pristine MoS_2, the MoS_2/G VH can greatly reduce the migration energy barriers of Li^+ (from 0.67 eV to 0.09 eV) and Mg^{2+} (from 1.01 eV to 0.21 eV). Moreover, they also demonstrated that MoS_2/G VH can not only allow the Mg^{2+} and Li^+ intercalation/deintercalation into/from the host material simultaneously even at a current density of 1000 mA g^{-1} but also enhance the structural stability, verified by the DFT calculations, galvanostatic intermittent titration technique, *ex-situ* X-ray diffraction, *etc.*

This work was financially supported by the National Natural Science Foundation of China.■

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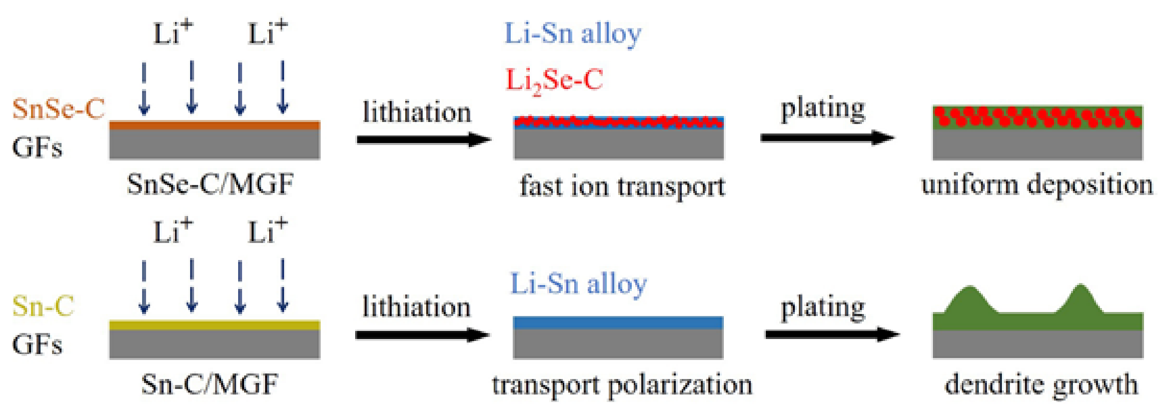
X. Yu, G. Zhao, C. Liu, et al. A MoS_2 and graphene alternately stacking van der Waals heterostructure for Li^+/Mg^{2+} Co-Intercalation. Advanced Functional Materials, 2021, 31, 2103214. DOI: 10.1002/adfm.202103214

MULTIFUNCTIONAL SnSe-C COMPOSITE MODIFIED 3D SCAFFOLDS TO REGULATE LITHIUM NUCLEATION AND FAST TRANSPORT FOR DENDRITE-FREE LITHIUM METAL ANODE

In 2021, Professor Zhang Naiqing's group from the State Key Laboratory of Urban Water Resource and Environment published a research paper titled "Multifunctional SnSe-C Composite Modified 3D Scaffolds to Regulate Lithium Nucleation and Fast Transport for Dendrite-Free Lithium Metal Anode" in *Journal of Materials Chemistry A*.

Undesirable lithium dendrite growth limits the application of lithium metal anode in high-energy storage batteries. 3D scaffold is a promising approach that can provide enough room to accommodate the volume change and lower local current density. Several lithiophilic materials such as MnO_2, NiO, CuO and Co_3O_4 have been decorated onto the surfaces of conductive scaffolds to lower the energy barrier for nucleation and direct uniform lithium deposition. Good lithium affinity ensures the initially uniform deposition on the surface of the material, and at the same time, highly reductive lithium reacts with these oxides to form Li_2O with high ion conductivity and various metal sites. However, the relatively high heterogeneous nucleation barrier of Mn, Ni, Cu and



Co metal causes inhomogeneous lithium nucleation in the subsequent cycling process, which accelerates the growth of lithium dendrites.

In this work, the researchers design and construct multifunctional SnSe-C composite modified 3D glass fiber films (GFs) scaffolds to achieve homogeneous lithium deposition. During the first discharge cycling, the porous SnSe-C composite in-situ converts into Sn-Li alloy and Li_2Se. First of all, the lithiophilic Sn-Li alloy layer exhibits a fast charge transfer kinetics and offers plenty of electrochemically active sites to guide homogeneous lithium nucleation. The process of Sn-Li alloying shows good reversibility and guarantees the continuous homogeneous lithium nucleation during the subsequent cycles. Secondly, the in-situ formed Li_2Se ion-conducting network facilitates fast lithium ion transport kinetics, which is favorable for fast lithium ion diffusion and uniform lithium growth. Benefitting from synergistic effect of the Sn-Li alloy and Li_2Se, the Li/SnSe-C anode exhibits an ultralong lifespan over 1100 h with a low overpotential of 18 mV.

This work was financially supported by the National Natural Science Foundation of China.

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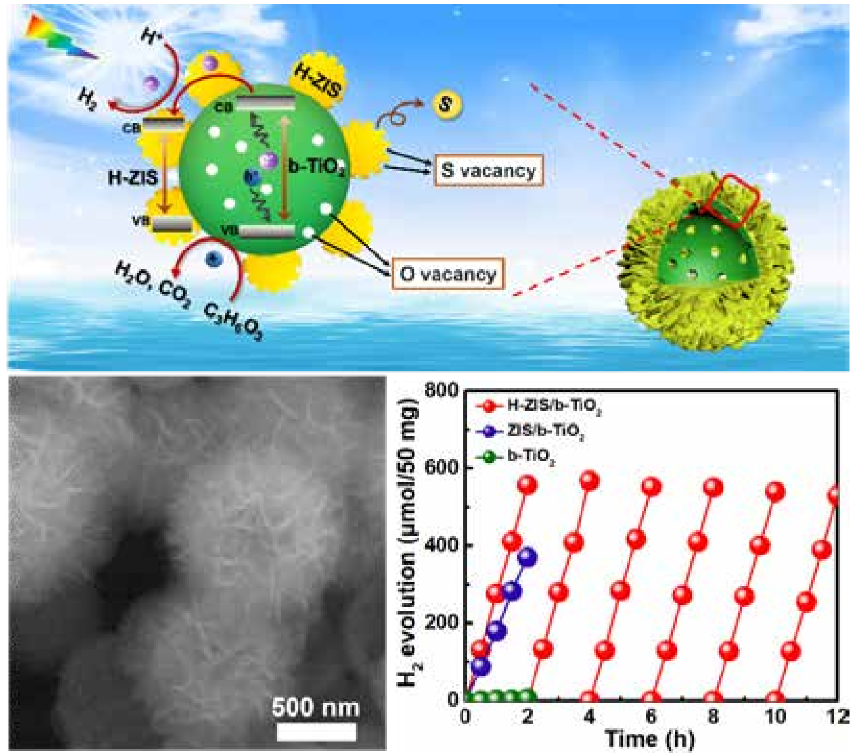
X. J. Shen, G. Y. Zhao, X. B. Yu, et al. Multifunctional SnSe-C composite modified 3D scaffolds to regulate lithium nucleation and fast transport for dendrite-free lithium metal anode. Journal of Materials Chemistry A, 2021, 9: 21695-21702. DOI: 10.1039/D1TA06836A

A HETEROJUNCTION PHOTOCATALYST WITH O, S-DUAL VACANCY DEFECTS SPLIT WATER TO PRODUCE HYDROGEN

In 2021, Professor Du Yunchen's group from the School of Chemistry and Chemical Engineering published a research paper titled "O, S-Dual Vacancy Defects Mediated Efficient Charge Separation in $ZnIn_2S_4$/Black TiO_2 Heterojunction Hollow Spheres for Boosting Photocatalytic Hydrogen Production" in *ACS Applied Materials & Interfaces.*

With the rapid development of technology and economy after the industrial revolution, environmental pollution and energy shortages have gradually been exposed to the public and become one of the problems that can no longer be ignored. Solar energy, as the largest source of energy, is inexhaustible, and thus the split of water into clean hydrogen energy by solar energy has recently been an area of interest. The development of semiconductor photocatalysts with high efficiency and low cost is the key to realizing the solar-driven photocatalytic water splitting.

In this work, the researchers demonstrate rational design and successful synthesis of flower-like $ZnIn_2S_4$ nanosheets/black TiO_2 heterojunction hollow spheres with O, S-dual vacancy defects (H-ZIS/b-TiO_2). The hollow structure of b-TiO_2 cannot only achieve multiple reflections within the cavity to improve the utilization of light but also be used as a substrate with high surface area



for the vertical growth of ZIS nanosheets. Moreover, ZIS nanosheets have abundant active sites due to the presence of abundant unsaturated S atoms on the edge by surface hydrogenation at low temperature. The heterojunction structures and O, S-dual vacancies of H-ZIS/b-TiO_2 greatly facilitate the separation efficiency of photogenerated electrons and holes. Therefore, flower-like H-ZIS/b-TiO_2 heterojunction hollow spheres exhibit excellent photocatalytic hydrogen evolution rate of 278 μmol h^{-1} 50 mg^{-1}. This novel flower-like heterojunction hollow spheres photocatalyst without noble metal cocatalyst will have a wide application prospect in the energy field.

This work was financially supported by the National Natural Science Foundation of China.■

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Bojing Sun, Jiaqi Bu, Yunchen Du, et al. O, S-dual vacancy defects mediated efficient charge separation in $ZnIn_2S_4$/black TiO_2 heterojunction hollow spheres for boosting photocatalytic hydrogen production. ACS Applied Materials & Interfaces, 2021, 13, 37545-37552. DOI: 10.1021/acsami.1c10943

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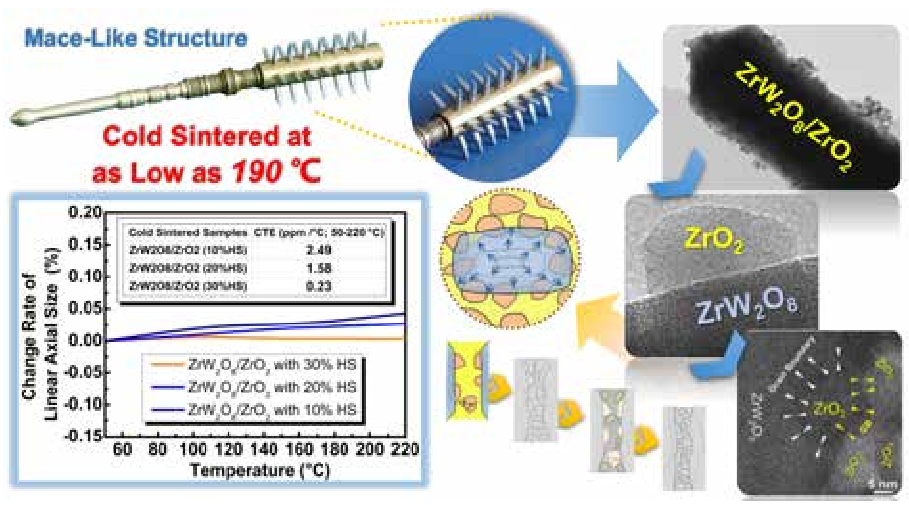
HIT TIMES 2021

ZrW_2O_8/ZrO_2 COMPOSITES WITH LOW/NEAR-ZERO COEFFICIENTS OF THERMAL EXPANSION FABRICATED AT ULTRALOW TEMPERATURE

In 2021, Professor Meng Songhe's group from the National Key Laboratory of Science and Technology on Advanced Composites in Special Environments at Harbin Institute of Technology published a research paper titled "ZrW_2O_8/ZrO_2 Composites with Low/Near-Zero Coefficients of Thermal Expansion Fabricated at Ultralow Temperature: An Integration of Hydrothermal Assembly and a Cold Sintering Process" in *ACS Applied Materials & Interfaces*.

Materials with low or even near-zero coefficients of thermal expansion (CTE) are particularly significant in solving the effect of thermal expansion in the fields of aerospace, precision manufacturing and measurement, optical fiber communication, electronic circuit, etc. ZrW_2O_8/ZrO_2 composite has been a promising candidate owing to the relatively good compatibility, similar absolute values of CTE, excellent corrosion resistance and designability between the two phases. However, bottleneck issues caused by conventional high-temperature sintering impede the development and application of this composite.

The researchers reported a methodology of integration of the hydrothermal assembly with a cold sintering process



(CSP) to fabricate ZrW_2O_8/ZrO_2 composite with excellent low/near-zero CTE. The ZrW_2O_8/ZrO_2 composite powders with a mace-like structure are hydrothermally assembled, in which the spherical ZrO_2 nanoparticles peripherally embed on the rod-like ZrW_2O_8 matrix particles. Then, the relatively dense ZrW_2O_8/ZrO_2 composite is successfully achieved by CSP (as low as 190°C) with a post annealing treatment (550°C). The CTE of the composite is detected as $\bar{\alpha}$= 0.23 × 10^{-6} °C^{-1} [50-220°C] without the decomposition of ZrW_2O_8 phase.

This novel methodology has contributed to overcoming the bottleneck issues and promoting the engineering application in the field of ZrW_2O_8/ZrO_2.

Professor Li Jinping is the corresponding author of this research paper. PhD Yang Cheng is the first authors. Professor Meng Songhe and other authors also made important contributions to this study. This research is financially supported by the National Natural Science Foundation of China.■

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Research & Academia
HIT TIMES 2021

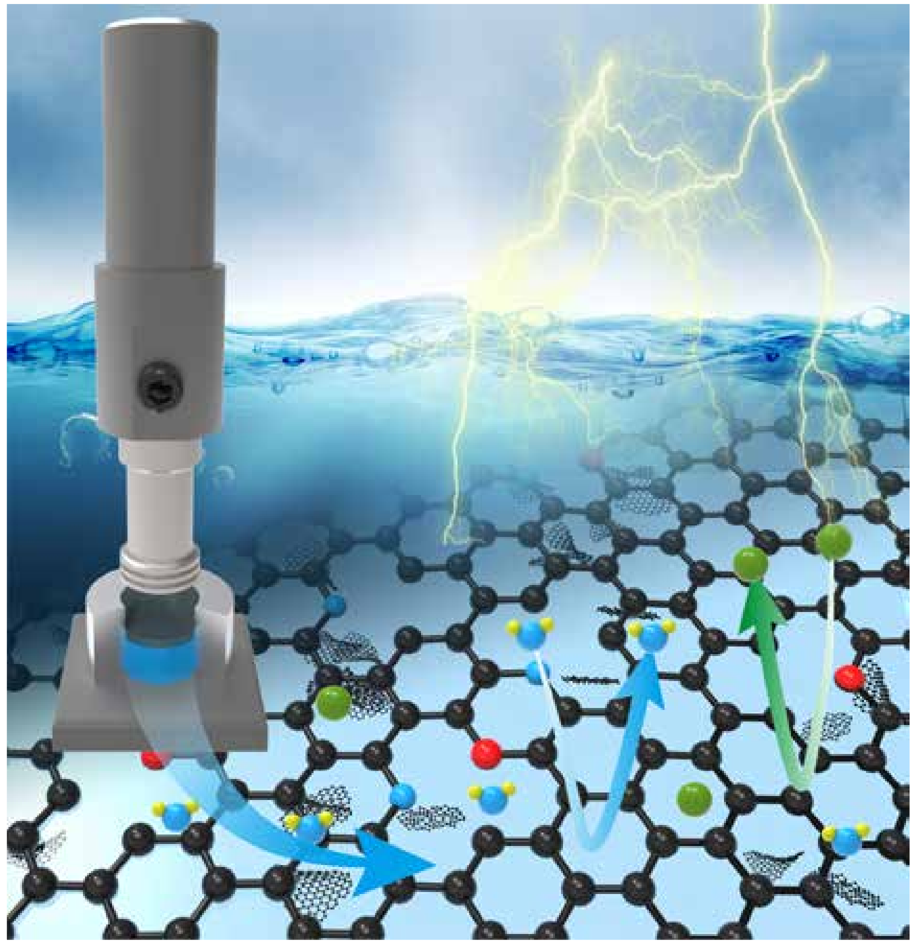
DEFORMATION-DRIVEN METALLURGY: THE NEXT-GENERATION PREPARATION TECHNIQUE FOR ALUMINUM MATRIX COMPOSITES

Professor Huang Yongxian's group from the State Key Laboratory of Advanced Welding and Joining, Harbin Institute of Technology, proposed a revolutionary solid-state sintering technique, deformation-driven metallurgy, to prepare aluminum matrix composites with better strength-ductility balance and corrosion durability. The research article titled "Homogeneously Dispersed Graphene Nanoplatelets as Long-Term Corrosion Inhibitor for Aluminum Matrix Composites" was recently published in the high impact international journal *ACS Applied Materials and Interfaces*.

Sparked with unprecedented physical and mechanical properties, nanoparticle-reinforced aluminum matrix composites have obtained huge industrial application potential, especially in high-value engineering structures, such as lightweight aerospace components, etc. Deformation-Driven Metallurgy (DDM), based on the principle of severe plastic deformation, was proposed to obtain ultrafine-grained microstructures with homogeneous dispersion of the nano-reinforcements via mechanical stirring and dynamic recrystallization. Fragmentation, thinning, and re-dispersion of the reinforcements accelerated the nucleation of recrystallized grains and inhibited the migration of grain boundaries. The synergy grain refinement mechanism led to a greatly refined microstructure. The ultimate tensile strength and elongation of graphene nanoplatelet-reinforced aluminum matrix composites reached 468±7 MPa and 19.9±0.6%, respectively, showing an enhancement of ultimate strength by 293.3% with almost no loss in ductility. And the homogeneously dispersed graphene nanoplatelets showed great corrosion inhibition mechanism in a chloride-containing environment, ascribed to the formation of carbon-doped protective film via diffusion and chemical bonding between graphene nanoplatelets and surface oxide film. The novel DDM strategy broadens the horizon for anti-corrosion engineering, which is indeed critical for the design of carbonaceous nanomaterial-reinforced composites to realize desired performances for practical applications. This paper will further promote the international impact of the State Key Laboratory of Advanced Welding and Joining.

Professor Huang Yongxian from HIT is the corresponding author. Xie Yuming and Dr. Meng Xiangchen from HIT are the co-first authors. Mao Dongxin, Qin Zhiwei, and Professor Wan Long from HIT are the co-authors.

The paper was jointly supported by the National Natural Science Foundation of China, the Heilongjiang Postdoctoral Foundation, and the Outstanding Youth Program of the Heilongjiang Natural Science Foundation.■



DDM: The next-generation preparation technique for composites

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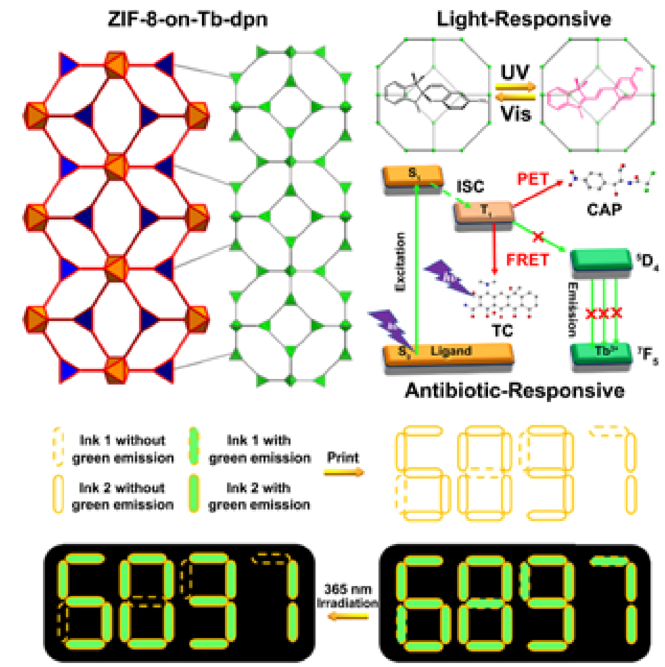
Yuming Xie, Xiangchen Meng, Yongxian Huang, Junchen Li, Jian Cao. Deformation-driven metallurgy of graphene nanoplatelets reinforced aluminum composite for the balance between strength and ductility. Composites Part B: Engineering, 2019, 177: 107413. https://doi.org/10.1016/j.compositesb.2019.107413

STIMULI-RESPONSIVE MOF ON MOF HETEROSTRUCTURE FOR ANTIBIOTIC DETECTION AND ANTICOUNTERFEITING

In 2021, Professor Yang Yulin, Professor Fan Ruiqing and Dr. Zhang Jian, from the School of Chemistry and Chemical Engineering, published a paper titled "Stimuli-Responsive Metal-Organic Framework on a Metal-Organic Framework Heterostructure for Efficient Antibiotic Detection and Anticounterfeiting" in *ACS Applied Materials & Interfaces*.

Stimuli-responsive photoluminescent materials possess attractive emission response towards environmental change (light, temperature, pressure, solvent, pH, organic molecule, and ion) and thus play vital roles in many fields, especially the luminescent sensing and the information anti-counterfeiting. Among various photoluminescent materials, lanthanide metal-organic frameworks (Ln-MOFs) become the first choice in many luminescence stimuli-responsive applications for fascinating luminescence performance and unique "antenna effect" processes. Especially, MOF-on-MOF heterostructure material inherits from the characteristics of multiple compositions as well as the synergy effect and thus is regarded as the ideal material in the stimuli-responsive field.

In this work, a novel MOF-on-MOF heterostructure is synthesized based on designed Tb-dpn (H_3dpn = 5-(2′, 4′-dicarboxylphenyl)nicotic acid) and porous ZIF-8 framework. A layer-by-layer (LBL) approach is utilized to generate a uniform ZIF-8 layer on the surface of Tb-dpn with the assistance of reserved pyridine nitrogen sites, which overcomes the limit of lattice mismatch in most



heterostructures. Via the competitive absorption, Förster resonance energy transfer (FRET) and photoinduced electron transfer (PET) process, the designed luminescent platform exhibits antibiotic-responsive ability towards tetracyclines (TC) and chloramphenicol (CAP), respectively, in water. The Tb-dpn and outer ZIF-8 respectively act as detection components and pre-concentration layer to improve detection performance. In addition, a classic optical switch 1′,3′,3′-trimethyl-6-nitrospiro [chromene-2,2′-indoline] is encapsulated into the ZIF-8 nanocage (11.6 Å) to control the emission of luminescent material. Under the ultraviolet light excitation, a photochromic spirogyran (SP) molecule is gradually transferred into merocyanine (MC) form and achieves a strong adsorption bond at around 555 nm. Combining the Tb^{3+} emission (543 nm) and optical trigger absorption of SP ⊂ ZIF-8-on-Tb-dpn material, invisible anti-counterfeiting patterns are designed for information anti-counterfeiting. The fascinating stimuli-responsive behavior in antibiotics detection and information anti-counterfeiting make the novel ZIF-8-on-Tb-dpn heterostructure a promising material in luminescence application.

Professor Yang Yulin and Professor Fan Ruiqing from HIT are the corresponding authors. Dr. Sun Tiancheng is the first author. This work was supported by the National Natural Science Foundation of China.

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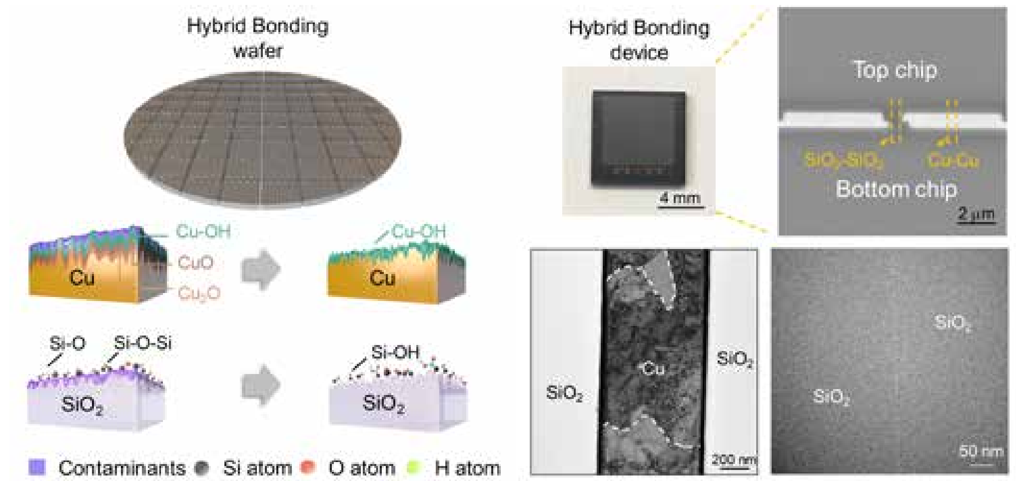
Sun Tiancheng, Fan Ruiqing, Jian Zhang, Yulin Yang, et al. Stimuli-responsive metal-organic framework on a metal-organic framework heterostructure for efficient antibiotic detection and anticounterfeiting. ACS Applied Materials & Interfaces, 2021, 13, 35689-35699. DOI: 10.1021/acsami.1c08078

LOW –TEMPERATURE BUMPLESS HYBRID BONDING FOR HETEROGENEOUS INTEGRATION AND 3D CHIP ARCHITECTURE

In 2021, Professor Wang Chenxi's group, from the State Key Laboratory of Advanced Welding and Joining, Harbin Institute of Technology, published a paper titled "Low-Temperature Co-Hydroxylated Cu/SiO_2 Hybrid Bonding Strategy for a Memory-Centric Chip Architecture" in the journal of *ACS Applied Materials & Interfaces*.

For decades, von Neumann architecture has laid the foundation for computing and still plays a leading role in computing architecture today. Due to the physical separation of the memory and processor, the conventional processor-centric architecture cannot fulfill the urgent requirement for high-bandwidth, low-latency, energy-efficient chips. Therefore, the emerging memory-centric chip architecture came into being based on three-dimensional chip stacking technology, minimizing the gap between the memory and computing logic. As the important stacking structure, through-silicon via (TSV) cannot break through the limitation of vertical interconnection pitch less than 1μm owing to the inevitable use of microbump and underfill. Thus, the ultra-dense bumpless bonding technology is successfully achieved via Cu/SiO_2 hybrid bonding.

Bumpless Cu/SiO_2 hybrid bonding replaces microbump and underfill via Cu-Cu and SiO_2-SiO_2 bonding to realize the electrical connection and mechanical supports, achieving ultra-fine pitch inter-die connection (even less than 1 m). However, the hybrid bonding is usually realized at 400℃ currently, which could degrade the performance of stacked chips. To reduce the operating temperature, the essence lies in the low-temperature bonding of Cu-Cu and SiO_2-SiO_2. Nevertheless, there is a contradiction of low-temperature bonding that the desirable surface chemical states for Cu-Cu (oxide-free) and SiO_2-SiO_2 (-OH terminated) are incompatible.



Co-hydroxylated Cu/SiO_2 surfaces and hybrid bonding interfaces

Herein, Professor Wang and his group developed a co-hydroxylated strategy to circumvent the contradiction, which established –OH groups on Cu and SiO_2 surfaces simultaneously and achieved hybrid bonding at 200℃. By designing a cooperative surface activation based on plasma activation and formic acid treatment, the total surface area increased, which provided adequate adsorption sites for –OH groups. Thanks to the hydroxyl layer, the seamless Cu-Cu interface with sufficient grain growth and improved electrical property was achieved, and a robust SiO_2-SiO_2 interface was also obtained successfully at low temperature. This co-hydroxylated strategy inspires the development of memory-centric chip architecture in the future hyper-scaling era.

Professor Wang Chenxi is the corresponding author of this research paper, and PhD student Kang Qiushi is the first author. Also, this paper was highlighted as a cover image of the journal. This work was supported by the National Natural Science Foundation of China, the Heilongjiang Provincial Natural Science Foundation of China, and Heilongjiang Touyan Team.

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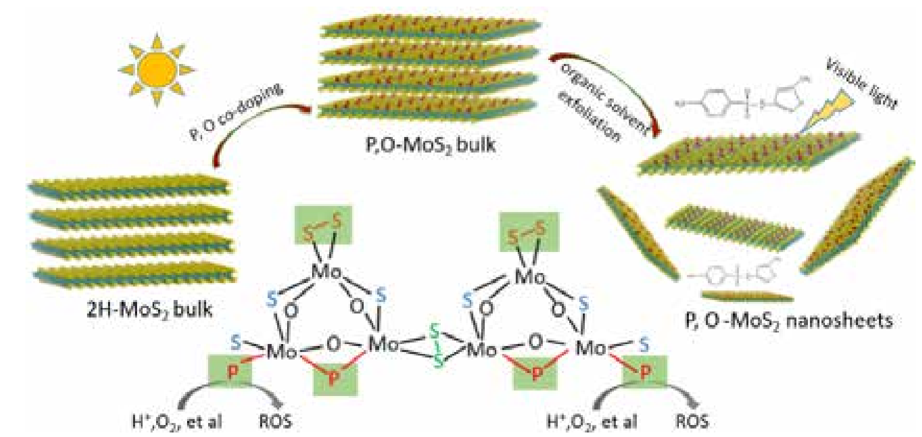
Qiushi Kang, Chenxi Wang, Shicheng Zhou, Ge Li, Tian Lu, Yanhong Tian, Peng He. Low-temperature co-hydroxylated Cu/SiO_2 hybrid bonding strategy for a memory-centric chip architecture. ACS Applied Materials & Interfaces, 2021, 13(32): 38866-38876. DOI: https://doi.org/10.1021/acsami.1c09796

UNCOVERING THE ACTIVATION PRINCIPLE OF INERT BASE SURFACE OF NANO-CATALYST

Recently, Professor Shi Wenxin, Professor Yuan Yixing and the co-authors, from the School of Environment, Harbin Institute of Technology, reported their new progress on revealing the activation mechanism of the inert base plane of 2H-MoS_2 via P substitution combined with the optical properties to photocatalytic degradation organics. The article, titled "Activating the Basal Plane of 2H-MoS_2 by Doping Phosphor for Enhancement in the Photocatalytic Degradation of Organic Contaminant", was published in *ACS Applied Materials & Interfaces*, a top multidisciplinary journal focusing on how newly-discovered materials and interfacial processes can be developed and used for specific applications.

Advanced oxidation processes have exceptional advantages in treating trace emerging organic pollutants in water through the generation of strong oxidation radicals (·OH, ·O_2^-). In particular, the photocatalytic technology centered on semiconductor photocatalysts (SPs) aims to replicate the same process with minimalism and sustainability. Still, research on SPs has always been subject to dual constraints of the defects of visible light response capability and insufficient active sites. To overcome these constraints, abundant research has been devoted to the development of SPs that have excellent light-responsive and sufficient active sites. In this regard, single-layer MoS_2 has recently gained great attention thanks to its photo-induced catalyzing abilities and excellent charge carrier mobility, which can reach 200 $cm^2\ V^{-1}\ s^{-1}$.

Since the edge active site of 2H-MoS_2 was first identified in 2007, its inert base surface has been expected to be activated to release superior catalytic properties. It is also timely and necessary to explore the greater catalytic performance of 2H-MoS_2. Importantly, a large number of



scholars have carried out extensive research on the inert base surface of monolayer 2H-MoS_2. While most of the strategies are difficult-to-operate, some works have achieved results on the technological level. However, the detailed mechanism of action of doped atoms remains ambiguous.

In this study, the photocatalytic property of 2H-MoS_2 (POMS) was successfully activated by doping phosphorus with the assistance of oxygen and exfoliation strategies. The DFT calculation showed that the spreading of the charge distribution and hybridizations over the basal planes induced by P-doping successfully expanded the bandgap to 1.95 eV, accelerating the band extension and light absorption of 2H-MoS_2. The actual treatment effect of POMS was evaluated on SMX, which could be completely degraded within 20 minutes. Molecular structural tests and analyses shed light on the origin of the active sites of the transformed POMS crystals in molecular details, that the 2H-MoS_2 inert substrates were activated through transformation from the crystal phase to amorphous phase in the P-substitution process. Moreover, POMS remained stable during the photo-reaction course in water environments. Therefore, 2H-MoS_2 with its activated inert base surface can potentially realize a fit-for-purpose solution toward the photocatalytic treatment of water environments. Uncovering these operational principles provides a theoretical basis for designing effective catalysts.■

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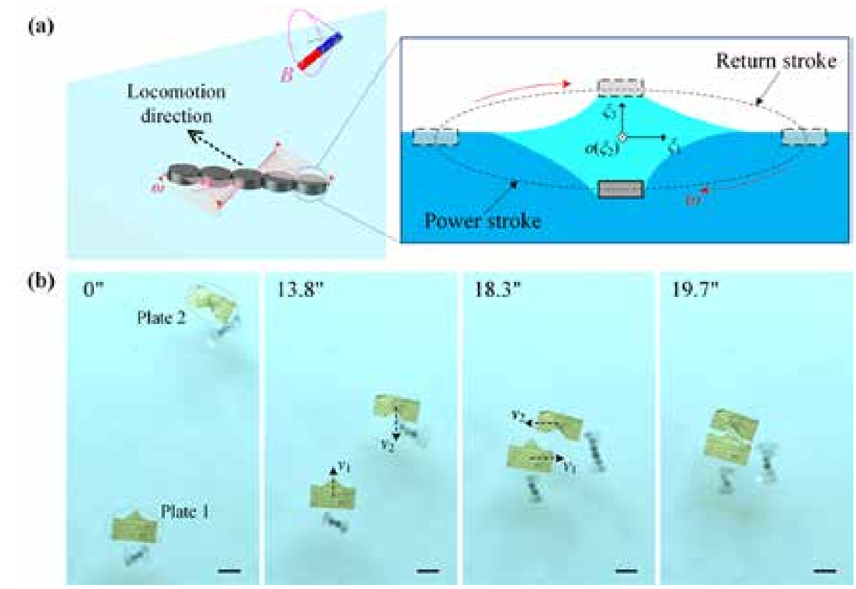
COOPERATIVE SELF-ASSEMBLED MAGNETIC MICROPADDLES FOR THE MICROMANIPULATION AT LIQUID SURFACES

Associate Professor Wang Lefeng's group, from the State Key Laboratory of Robotics and System, recently published an article titled "Cooperative Self-Assembled Magnetic Micropaddles at Liquid Surfaces" in *ACS Applied Materials & Interfaces*. The research group developed magnetic micropaddles capable of creating complicated micromanipulation tasks on liquid surfaces.

Self-assembled magnetic micro-swimmers with programmable shapes present immense potential for various micromanipulation tasks, and the cooperation between these micro-swimmers becomes essential for complex micromanipulation cases. However, the cooperative control of magnetic micro-swimmers is a great challenge because most of them just present similar locomotion under the same magnetic external field.

To deal with this issue, the research group developed novel chain-like micropaddles assembled by micro-disks floating on liquid surfaces. The proposed micropaddles gained controlled propulsion through paddling under the precessing magnetic field. The micropaddle locomotion presents a distinct characteristic in that micropaddles with different lengths reverse directions at distinguishing frequencies. Based on this characteristic, parallel and cooperative controls of several micropaddles were realized by just modulating parameters of the precessing magnetic field. The micropaddles could cooperate to accomplish micro-assembly tasks efficiently, which is a great progress for micro-swimmers.



(A) Moving micropaddle actuated by a precessing magnetic field
(B) Assembly of two small plates based on the cooperation between micropaddles

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Yuanzhe He, Lefeng Wang, Kai Yang, Xi Wang, Weibin Rong, Lining Sun. Cooperative self-assembled magnetic micropaddles at liquid surfaces. ACS Applied Materials & Interfaces, 2021, 13(38): 46180–46191.

Research & Academia
HIT TIMES 2021

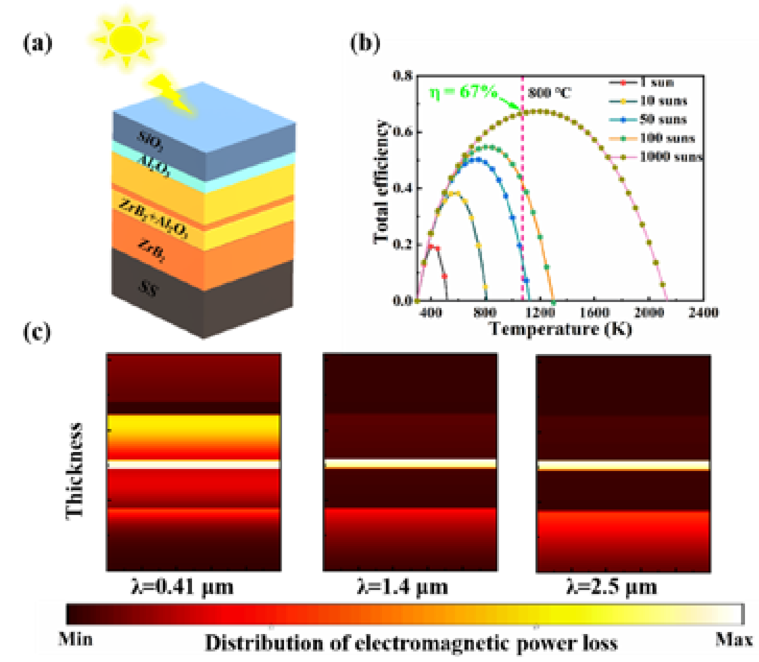
HIGH PERFORMANCE SPECTRALLY SELECTIVE ABSORBER USING THE ZrB_2 BASED ALL-CERAMIC COATINGS

Enhancing the spectral selectivity and thermal stability of the spectrally selective absorber used in the concentrated solar power (CSP) system would boost the conversion efficiency of solar energy to electricity. However, developing the absorbers with an ultra-high absorptance and superior thermal stability under strict environments, such as higher temperatures or in air, still poses a considerable challenge.

Recently, Associate Professor Cao Feng's team from the School of Science at HITSZ published a paper titled "High Performance Spectrally Selective Absorber Using the ZrB_2 Based All-Ceramic" in *ACS Applied Materials & Interfaces*.

In this work, a high-performance ZrB_2-Al_2O_3 ceramic-based solar selective absorption coating (SSAC) with quasi-optical microcavity (QOM) structure is deposited via magnetron sputtering on a mechanically polished stainless substrate, which demonstrates a high spectral selectivity of 0.965/0.16 (82°C). The pretty high absorptance is due to the design of QOM inducing the multi absorption mechanisms comprised of the intrinsic cermet absorption, the surface plasmon polaritons, and localized surface plasmon resonance proved by the electromagnetic power loss. The structure also demonstrates well-matched impedance with free space in solar spectrum range, ensuring a high solar absorptance. The proposed QOM structure possesses high stability even upon annealing whether in vacuum (800°C) or in air (500°C), which is ascribed to the superior thermal stability of the selective materials including ZrB_2, Al_2O_3 and SiO_2 and the novel QOM structural design. The spectrally selective solar absorber designed by the authors demonstrates the record high solar absorption of over 0.96 at 800°C, and the total conversion efficiency can reach around 67% (1000 suns).

Finally, combined with the morphology characterization and phase analysis, it can be concluded that with the increase of working temperature, the optical performance degradation may be attributed to the increase of the roughness and particle size and the aggravation of dissociation of simple substance carbon from the substrate. It is possible to further enhance the thermal stability of the absorber through choosing a more stable substrate. This work paves a new and feasible way for the design of high-performance spectrally selective absorbers and inspires novel ideas and development in spectral controlling.



(a) Schematic illustration of the absorber
(b) Temperature-dependent total efficiency with different optical concentrations
(c) Distribution of electromagnetic power loss of the absorber at different wavelengths

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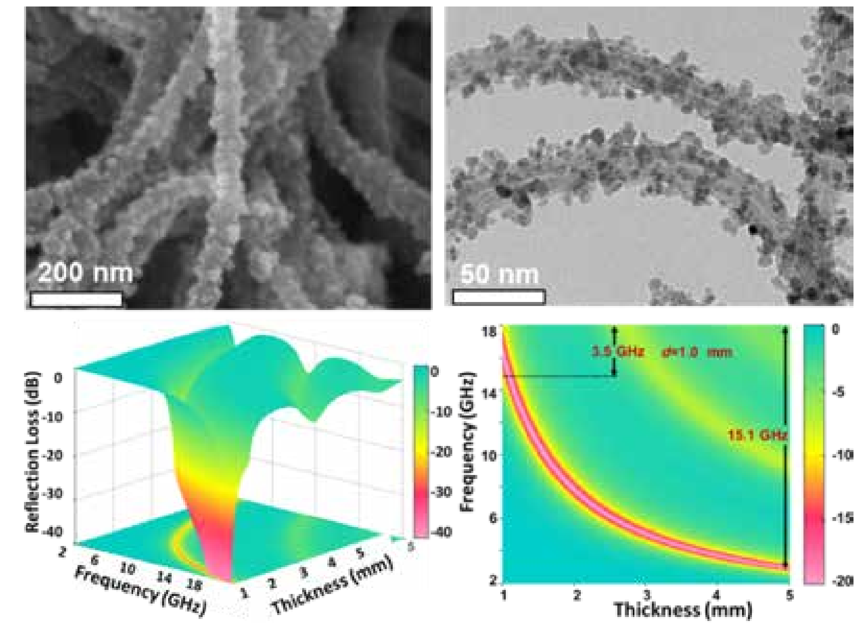
Jian Wang, Zhikun Ren, Yi Luo, Zuoxu Wu, Yijie Liu, Shuaihang Hou, Xingjun Liu, Qian Zhang, and Feng Cao. High-performance spectrally selective absorber using the ZrB_2 based all-ceramic coatings. ACS Applied Materials & Interfaces, 2021, 13, 40522-40530.

NANOCOMPOSITE CARBON MICROWAVE ABSORBOR FOR ELECTROMAGNETIC POLLUTION PRECAUTION

Professor Du Yunchen and Professor Han Xijiang, from the School of Chemistry and Chemical Engineering, Harbin Institute of Technology, recently published a research paper titled "Anchoring Porous Carbon Nanoparticles on Carbon Nanotubes as High-Performance Composite with a Unique Core-Sheath Structure for Electromagnetic Pollution Precaution" in *Journal of Materials Chemistry A*.

Electromagnetic (EM) pollution has been regarded as one of the most concerning environmental problems that should be tackled effectively due to its potential threat to human health and information security. Microwave absorbers pave a possible way of overcoming this problem through sustainable conversion of EM energy. Carbon/carbon composites are always considered qualified candidates for lightweight and durable microwave absorbers, while their EM performance still suffers from the unbalance between characteristic impedance and loss capability.

In this work, with carbon nanotubes (CNTs) as the scaffold, the researchers direct in situ growth of ZIF-8 nanocrystals on CNTs surface and then convert the intermediate into final porous carbon nanoparticles/



CNTs (PCNs/CNTs) composites. EM analysis reveals that the combination of PCNs and CNTs can indeed create a positive synergistic effect on overall EM properties. On one hand, graphitic CNTs can maintain their powerful intrinsic loss toward incident EM waves, and on the other hand, amorphous PCNs anchored on CNTs can regulate the impedance matching effectively and create sufficient favorable interfacial polarization for the consumption of EM energy. By manipulating the relative contents of PCNs and CNTs, the optimal PCNs/CNTs composite produces excellent EM absorption performance, whose strongest reflection loss can reach up to -71.5 dB with the absorber thickness of only 1.1 mm and the integrated effective absorption bandwidth is as broad as 15.1 GHz.

This work was financially supported by the National Natural Science Foundation of China.

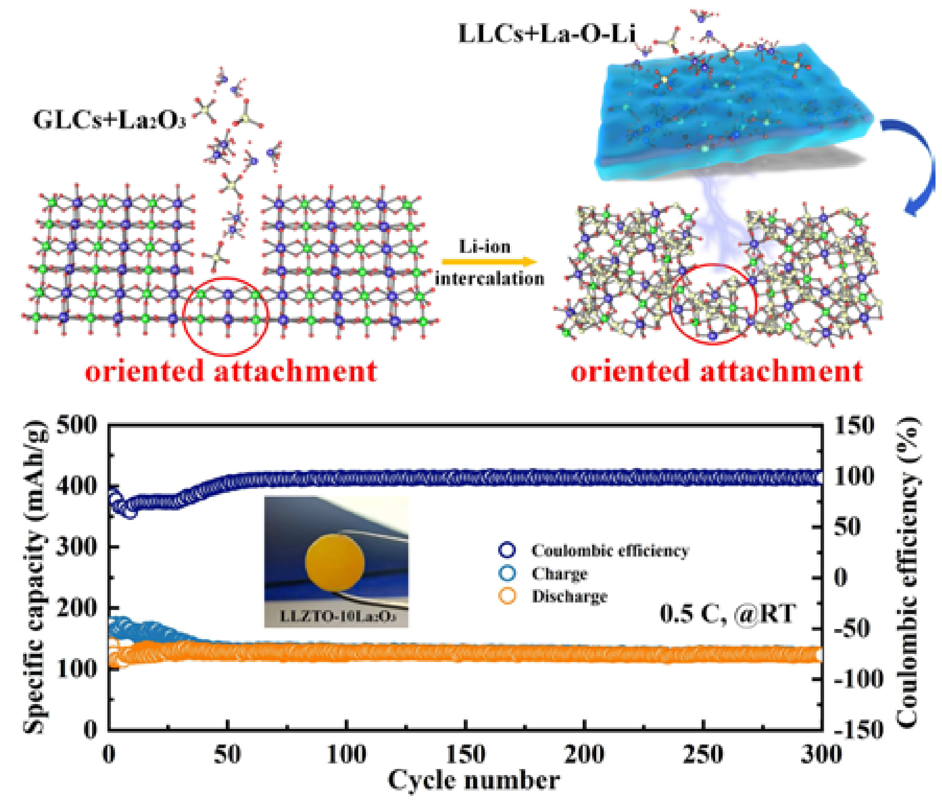
REFERENCE

Honghong Zhao, Xijiang Han, Yunchen Du, et al. Anchoring porous carbon nanoparticles on carbon nanotubes as a high-performance composite with a unique core-sheath structure for electromagnetic pollution precaution. Journal of Materials Chemistry A, 2021, 9, 22489. DOI: 10.1039/d1ta06147j

ORIENTED ATTACHMENT STRATEGY TOWARD ENHANCING IONIC CONDUCTIVITY IN GARNET-TYPE ELECTROLYTES FOR SOLID-STATE LITHIUM BATTERIES

Professor Huang Yongxian's group from the State Key Laboratory of Advanced Welding and Joining, Harbin Institute of Technology, proposed a novel solid-state sintering method, oriented attachment strategy, to prepare garnet-type solid-state electrolyte with high ionic conductivity. The research article titled "Oriented Attachment Strategy Toward Enhancing Ionic Conductivity in Garnet-Type Electrolytes for Solid-State Lithium Batteries" was recently published in a high impact international journal, *ACS Applied Materials and Interfaces*.

Solid-state lithium batteries (SSLBs) based on garnet-type solid-state electrolytes (SSEs) have attracted much attention due to their high energy density and chemical stability. However, poor room-temperature ionic conductivity and low density of SSEs induced by conventional preparation routes limit their potential future applications. An oriented attachment strategy was employed to enhance the Li-ion conductivity and density of garnet-type SSE $Li_{6.5}La_3Zr_{1.5}Ta_{0.5}O_{12}$ by introducing La_2O_3 nanoparticles. Oriented attachment of the ZrO_2 (Ta_2O_5) matrix mediated the epitaxial growth of La-Zr(Ta)-O intermediate phase due to the addition of La_2O_3 nanoparticles. Continuous Li-ion transport pathways along grain boundaries are produced by the combination of residual La_2O_3 and gas Li_2O. A densification interface is obtained when 10 wt.% La_2O_3 is doped. The maximum value of Li-ion conductivity reached 8.20×10^{-4} $S\cdot cm^{-1}$ with a relative density of 97.3%. SSLBs with $LiFePO_4$ cathode show a stable cycling performance with a discharge capacity of 123.1 $mA\cdot h\cdot g^{-1}$ and Coulombic efficiency of 99.2% after 300 cycles (0.5 C) at room temperature. The oriented attachment strategy is comparable to the state-of-the-art methodology, which provides a feasible approach to creating SSEs with high performances for SSLBs. This paper will further promote the international impact of the State Key Laboratory of Advanced Welding and Joining.



Oriented attachment strategy for solid-state lithium batteries

Professor Huang Yongxian from HIT is the corresponding author. Qin Zhiwei, Xie Yuming and Dr. Meng Xiangchen from HIT are the co-first authors. Qian Delai, Li Junchen, Dr. Li Chun, Professor Cao Jian, and Professor Wan Long from HIT are the co-authors.

The paper was jointly supported by the National Natural Science Foundation of China, the Heilongjiang Postdoctoral Foundation, and the Outstanding Youth Program of the Heilongjiang Natural Science Foundation.

REFERENCE

Zhiwei Qin, Yuming Xie, Xiangchen Meng, Delai Qian, Junchen Li, Chun Li, Jian Cao, Long Wan, Yongxian Huang. Oriented attachment strategy towards enhancing ionic conductivity in garnet-type electrolyte for solid-state lithium batteries. ACS Applied Materials & Interfaces, 2021, 13: 32161–32174. https://doi.org/10.1021/acsami.1c08729

Research & Academia
HIT TIMES 2021

A NOVEL WAY TO IMPROVE THE MECHANICAL PROPERTIES OF TITANIUM ALUMINIDE ALLOYS

A team led by Professor Su Yanqing from the National Key Laboratory for Precision Hot Processing of Metals, the School of Materials Science and Engineering at HIT, recently published a research paper titled "In-Situ Synthesis of Al_2O_3-Reinforced High Nb-TiAl Laminated Composite with an Enhanced Strength-Toughness Performance" in *Ceramics International*. Aiming at the excellent mechanical performances, this research takes structural design, microstructure control and material formation into consideration, which provides a totally new idea in the pursuit of engineering applications of TiAl alloys.

TiAl alloy is a promising candidate for aerospace and automotive industries, owing to its low density, high specific yield strength and good high-temperature performances. However, the intrinsic brittleness and poor formability have extremely limited its commercial applications. Inspired by the nacre, the TiAl-based laminated composite is one of the solutions to improving mechanical performances of TiAl alloys.

Professor Su's team created a novel Al_2O_3-reinforced high Nb–TiAl laminated composite sheet by using an innovative method of direct-current magnetron sputtering combined with foil-foil metallurgy and the assistance of vacuum hot-pressed sintering (Figure 1). As-prepared composite sheet (~2 mm thickness) is composed of the alternating high Nb–TiAl alloy (Nb, ~6.5 at. %) layer with fully lamellar (FL) microstructure and the Al_2O_3-rich high Nb–TiAl layer. The multi-scale Al_2O_3 particles have an average grain size of 3.87μm and

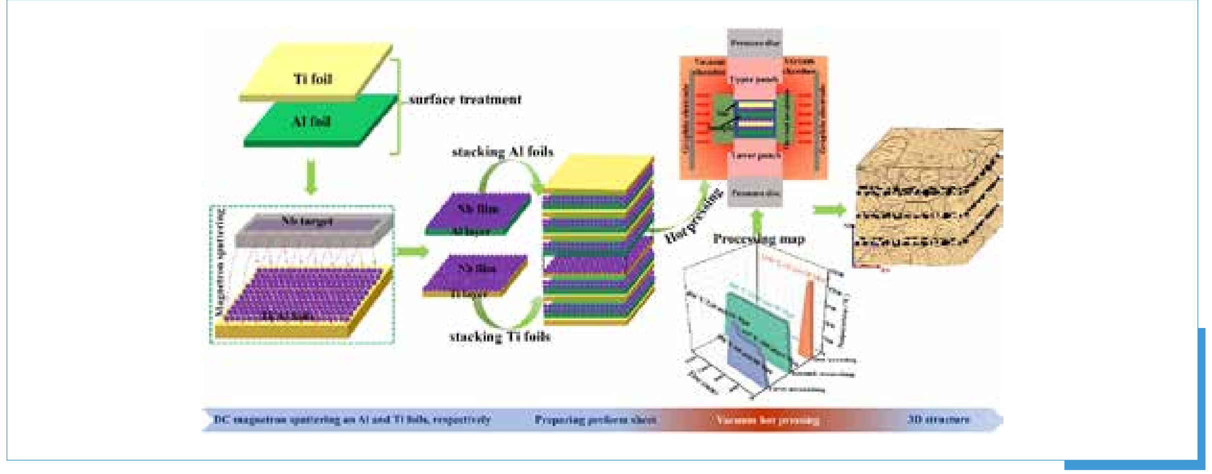


Figure 1 The schematical diagram illustrating the fabrication of the Al_2O_3-reinforced high Nb-TiAl laminated composites

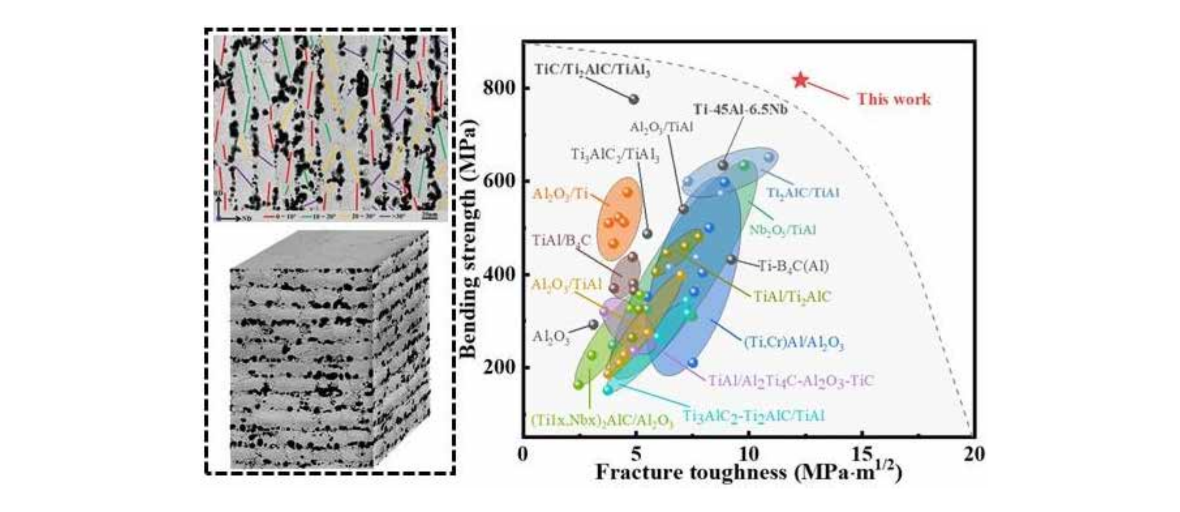


Figure 2 Three-dimensional laminated composite sheet and the corresponding mechanical performances

the lamellar plane distribution in the high Nb-TiAl alloy is also regulated. Consequently, the composite achieved a high bending strength of 817 MPa and good fracture toughness of 12.41 $MPa.m^{1/2}$ (Figure 2). In addition, the composite possesses a great potential in further enhancing the strength retention and oxidation resistance at a higher service temperature.

The paper was financially supported by the Major Special Science and Technology Project of Yunnan Province, the National Natural Science Foundation of China, and the Fundamental Research and Development Program of China.

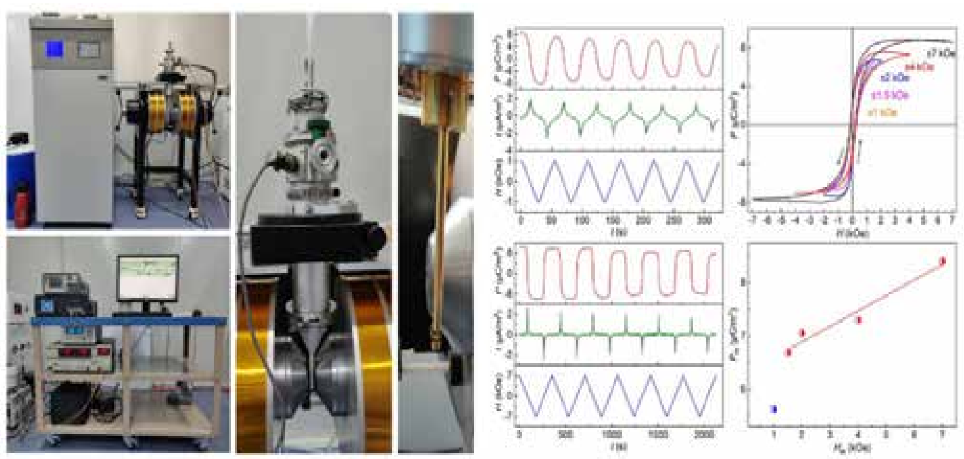
REFERENCE

D. Li, B. Wang, L. Luo, X. Li, J. Yu, L. Wang, Y. Xu, Y. Su, J. Guo, H. Fu. In-situ synthesis of Al_2O_3-reinforced high Nb-TiAl laminated composite with an enhanced strength-toughness performance. Ceramics International, 2021, DOI: https://doi.org/10.1016/j.ceramint.2021.09.238

DYNAMIC MAGNETOELECTRIC COUPLING EFFECT OF HEXAGONAL FERRITE

In 2021, the laboratory of Professor Zhou Zhongxiang and Associate Professor Li Jun from the School of Physics at Harbin Institute of Technology (HIT) published a research paper titled "Mutual Transformation of Reversible and Bound Polarization in Y-Type $BaSrCo_2Fe_{11}AlO_{22}$ Ceramics" in *Ceramics International*.

The research team mainly investigated the quasi-static magnetoelectric coupling and dynamic magnetoelectric coupling effects of hexagonal ferrites. Hexaferrites with helical spin structures are promising candidates to obtain strong magnetoelectric coupling properties, which has broadened the applicable prospects in next-generation electric devices including multibit memory, novel spintronics apparatus, four-state memory prototypes, and so on. According to the stacking sequences of basic blocks, the hexaferrites' structures can be divided into the types of X, Y, Z, W, U, etc. Types of Y and Z hexaferrites are mainly investigated model for their better magnetoelectric performances under low and room temperatures respectively.



Schematic diagrams of magnetoelectric measurements system and electric polarization testing results

All the measurements for magnetoelectric performances can be realized by the self-built systems with the instruments of water-cooled electromagnets (EM5, Dongfang Chenjing Technology Co., Ltd); B2985A Ampereter (Keysight Technologies); E4980Al LCR instrument (Keysight Technologies); SR830 lock-in amplifiers (Standard Research Systems); DAQ6510 on-off systems (Keithley); Model 335 temperature-controlled meters (Keithley). The system can build the relationship among magnetic fields, electric fields and temperatures to harvest the magnetoelectric properties of investigated dielectric materials.

The research team recently investigated the continuously reversed polarization of Y-type $BaSrCo_2Fe_{11}AlO_{22}$ induced by non-collinear conical magnetic structures. The electrical polarization induced by the non-collinear magnetic structures was categorized as reversible polarization and bound polarization. When the range of a circulating magnetic field $H \geq \pm 1.5$ kOe, the *P–H* loops reached a saturated state and the saturated polarization increased linearly as the circulating magnetic field increased, which was ascribed to the bound polarization. During the continuous magnetic field cycle, a portion of the reversible polarization transformed into bound polarization and only the poling process can achieve inverse transformation. Therefore, the polarization attenuated exponentially as the number of the *H* cycles increased. In conclusion, this paper illustrates the magnetoelectric performance of Y-type $BaSrCo_2Fe_{11}AlO_{22}$ and widens its applicable regions in next-generation magnetoelectric information storage devices.

The research group led by Professor Zhou Zhongxiang and Associate Professor Li Jun also has been engaged in the research about the preparation and electromagnetic properties of microwave functional materials. The research was financially supported by the National Natural Science Foundation of China and other projects.

REFERENCE

Han Bai, Jun Li, Tongtong Xu, Yu Zhang, Zhi Yuan, Lulu Liu, Zhenyu Shen, Zhongxiang Zhou. Mutual transformation of reversible and bound polarization in Y-type $BaSrCo_2Fe_{11}AlO_{22}$ ceramics. Ceramics International, 2021, DOI: 10.1016/j.ceramint.2021.08.013

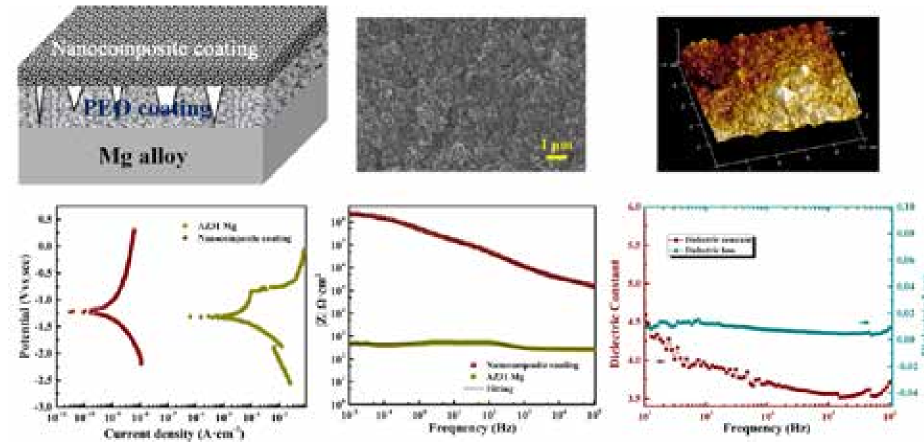
Research & Academia
HIT TIMES 2021

HIGHLY RELIABLE DOUBLE-LAYER COATINGS ON MAGNESIUM ALLOY SURFACE FOR ROBUST SUPERHYDROPHOBICITY, CHEMICAL DURABILITY AND ELECTRICAL PROPERTY

In 2021, Professor Wang Yaming's group from the School of Materials Science and Engineering published a research paper titled "Highly Reliable Double-Layer Coatings on Magnesium Alloy Surfaces for Robust Superhydrophobicity, Chemical Durability and Electrical Property" in *Ceramics International*.

Ultra-lightweight magnesium alloys with high tenacity, shock resistance, and superior thermal conductivity greatly meet the requirements of aerospace and weapons and are expected to become the components of radar antennas. Unfortunately, it has poor corrosion resistance. Simultaneously, the wave-transmitting materials for protecting radars require a low dielectric constant, low dielectric loss and high insulation. Hence, it is hoped that combining a magnesium alloy with lightweight composite materials through innovative design will create the effective integration of multiple functions.

In this work, firstly, to reduce the dielectric constant by the introduction of porous structures and ensure the adhesion strength of the coating simultaneously, the PEO porous bottom ceramic layer as rough template was prepared by Plasma Electrolytic Oxidation. Subsequently, to introduce a superhydrophobic coating as top sealing layer, the organic layer was modified by nano-ceramic particles to form a multilayer organic-inorganic nanocomposite coating, achieving multi-functional characteristics. The coating exhibits superior antiwater surfaces with a barrier layer isolating the underlying substrate from the external environment, rendering a long-term active corrosion protection for magnesium alloy. Noticeably, the coating is capable of withstanding various kinds of physical destruction (>50 cycles), chemical scenarios, and complicated temperature environments. More importantly, the electrical properties of the coating achieve high insulation with dielectric strength (>40 V/μm) and volume resistivity (>10^{12} Ω·cm), low dielectric constant ($\varepsilon < 3.75$) and low dielectric loss ($\tan\delta < 0.0058$). These results may provide a feasible pathway for the rational design and fabrication of advanced protective coating for applications of sensitive electronic devices.



This work was supported by the "Young Scientist Studio" of Harbin Institute of Technology, the National Natural Science Foundation of China, the Advanced Space Propulsion Laboratory of BICE and Beijing Engineering Research Center of Efficient and Green Aerospace Propulsion Technology, and the Heilongjiang Touyan Team Program.

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Shuqi Wang, Yaming Wang, Gui Cao, Junchen Chen, Yongchun Zou, Bo Yang, Jiahu Ouyang, Dechang Jia, Yu Zhou. Highly reliable double-layer coatings on magnesium alloy surfaces for robust superhydrophobicity, chemical durability and electrical property. Ceramics International, 2021. https://doi.org/10.1016/j.ceramint.2021.09.045

"THREE-STEP" APPROACH TO PROTON DIFFUSION IN GRAIN BOUNDARY

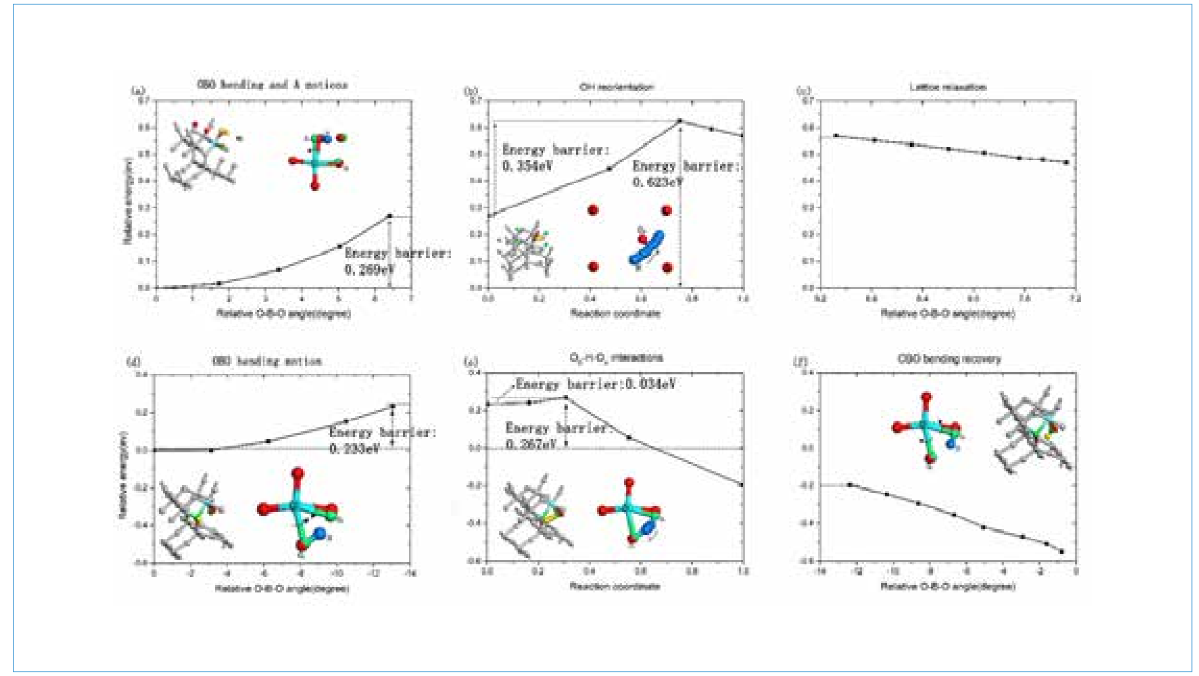
In 2021, a team led by Professor Jing Yuhang, from the Department of Astronautical Science and Mechanics, published a research paper titled "Mechanistic Insights into Proton Diffusion in Σ3 $BaZrO_3$ (210)[001] Tilt Grain Boundary" in *Ceramics International*.

Acceptor-doped barium zirconate ($BaZrO_3$) has remarkable proton conductivity and good chemical and mechanical stability, making them highly promising electrolyte candidates for intermediate-temperature solid oxide fuel cells and electrolytic cells. However, due to the high activation energy of $BaZrO_3$ in the grain boundary (GB), its proton conductivity is significantly lower, which seriously hinders its wide application.

To reveal the underlying mechanism, the team performed density functional theory (DFT) calculations to investigate the process and mechanism of proton diffusion across GB in perovskite oxides. By analyzing the lattice deformations between initial and saddle structures, three elementary steps underlying the proton transfer are suggested: (1) inward O-B-O bending motion, (2) O_D-H-O_A interactions, (3) recovery of the O-B-O bending motion. The three elementary steps underlying the hydroxide ion rotation are the following: (1) outward O-B-O bending motion, (2) hydroxide ion reorientation in the AO plane, (3) lattice relaxation.

Calculations of the proton diffusion process show that there is an obvious proton capture effect in GB, and the O–H bonds formed by protons and oxygen tend to be at positions with larger free space to reduce the rejection of nearby cations. At the same time, the stronger the hydrogen bonding effect, the more stable the O–H bond formed and the easier the proton is trapped. For the proton rotation process, although there is more free space around the proton in GB, which facilitates small-angle rotation of the hydroxide ion, the bonds' strength between the oxygen and adjacent A ions are relatively strong, and the proton must overcome these bonds to achieve proton rotation, thus inhibiting the reorienting motion of the hydroxide ion for large-angle rotation. For the proton transfer process, the increase in the number of interacting bonds between the oxygen donor and B ions lead to a greater bond strength for the oxygen donor, which hinders the transfer of protons from the oxygen donor to the oxygen acceptor.

The breakthrough research not only illustrates a detailed physical picture of proton diffusion in GB in perovskite oxides but also provides useful guidance for the design and discovery of novel materials with improved proton diffusion properties.



Relative energies of three decomposition processes of the proton rotation and transfer in BZY-GB

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Shaofeng Yue, Yuhang Jing, Yi Sun, Junqing Zhao, N.R. Aluru. Mechanistic insights into proton diffusion in Σ3 $BaZrO_3$ (210)[001] tilt grain boundary. Ceramics International, 2021, 0272-8842. DOI: 10.1016/j.ceramint.2021.09.297

Research & Academia
HIT TIMES 2021

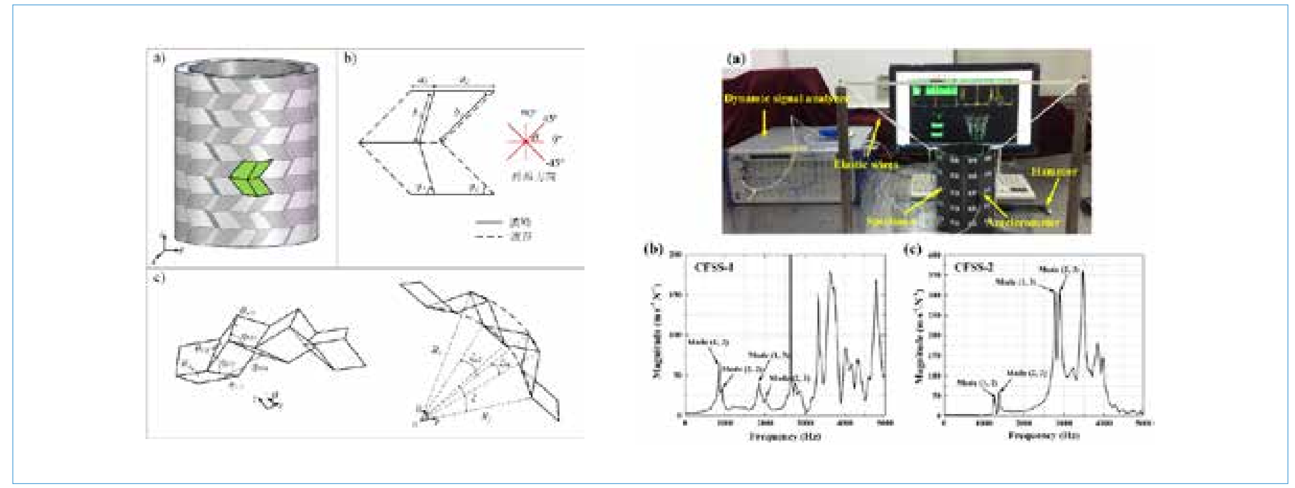
AN INNOVATION-TYPE CFRP CYLINDRICAL FOLDCORE SANDWICH STRUCTURES OF HIGHER STIFFNESS

In 2021, Professor Sun Yugo, from the Center of Composite Materials and Structures, Harbin Institute of Technology, and his Ph.D. student reported their recent progress on the free vibration behavior of an innovation-type CFRP composited cylindrical sandwich structure and published a research paper titled "Prediction and Experiment on the Free Vibration Behavior of Carbon-Fiber-Reinforced Cylindrical Foldcore Sandwich Structure" in *Composite Structures.*

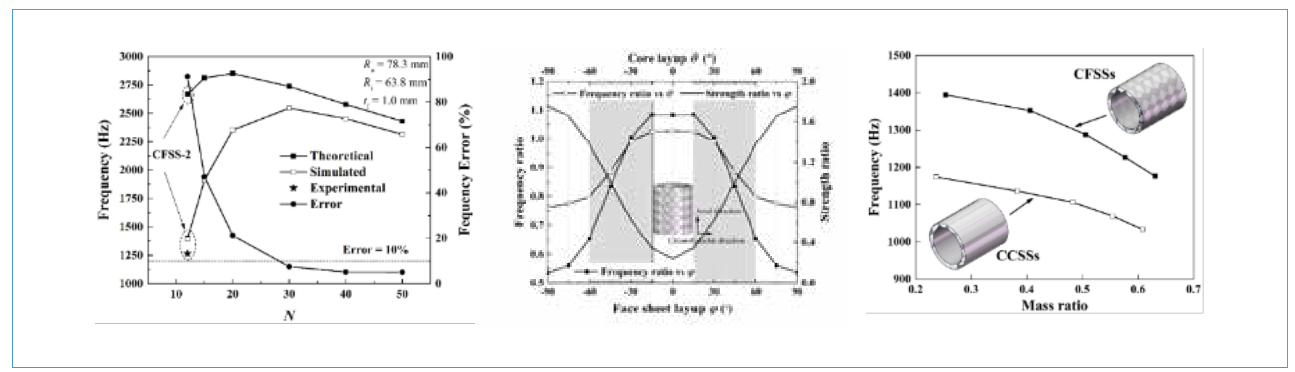
The weight-cost reduction issue is becoming a more important factor for designing larger passenger airlines in the future. The weight of the airplane fuselage takes approximately 40% of the airframe weight. Lightweight and high strength and fuselage stiffness allows the considerable reduction in weight of airframe on the whole. Sandwich structure, consisting of two thin and stiff face sheets and an ultra-low-density core, is one of the most promising alternatives to meeting this requirement. However, the application is restricted to the secondary structures of an airplane. Until now, there are no sandwich materials applied to an airplane fuselage. Foldcore (an origami-like core), as a potential sandwich core, has been supposed to be applied in the airplane fuselage thanks to the internal open and continuous channels and excellent mechanical performance. The merit of adopting origami technique is obvious, because it can preserve the continuity of based materials during the formation of the structural core rather than the requirement of secondary processing treatment and such like, particularly for the case of employing the fiber-reinforced composites.

Structural stiffness is one of the most critical mechanical properties for airplane fuselage, even more than structural strength under some circumstances. If the vibration frequency produced by engines is consistent with the natural frequency of the fuselage, the resonance effect would occur and eventually fail. To solve this issue, a team led by Professor Sun designed and fabricated an innovation-type carbon-fiber-reinforced cylindrical foldcore sandwich structures (CFSSs), their free vibration behaviors investigated through theoretical, numerical, and experimental methods. The governing equations of motion are developed by adopting the first-order shear deformation theory. To obtain the eigenfrequencies, the equivalent shear moduli of CFRP cylindrical foldcore are derived by an energy approach for the first time. When the number of circumferential cells is more than 30, the error of the theoretical results concerning the numerical ones can be well controlled within 10%, which is considered acceptable for engineering designs. The layup sequences and geometrical parameters of CFSSs provide significant references for the design and practical application of advanced performance cylindrical shells. CFSSs always possess higher fundamental frequency compared with other traditional sandwich cylinders under the condition of the same size and mass, indicating the CFSSs are much stiffer and could be designed even lighter in aerospace applications.

Professor Sun Yuguo is the corresponding author. His Ph.D. student, Dr. Liu Biao, is the first author. This work was supported by the National Natural Science Foundation of China.



Schematics of cylindrical foldcore and free vibration experiment



Theoretical, simulated and experimental results and comparison with traditional cylindrical foldcore sandwich structures

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Biao Liu, Yuguo Sun. Prediction and experiment on the free vibration of carbon-fiber-reinforced cylindrical foldcore sandwich structure. Composite Structures, 2021, 277, 114620.

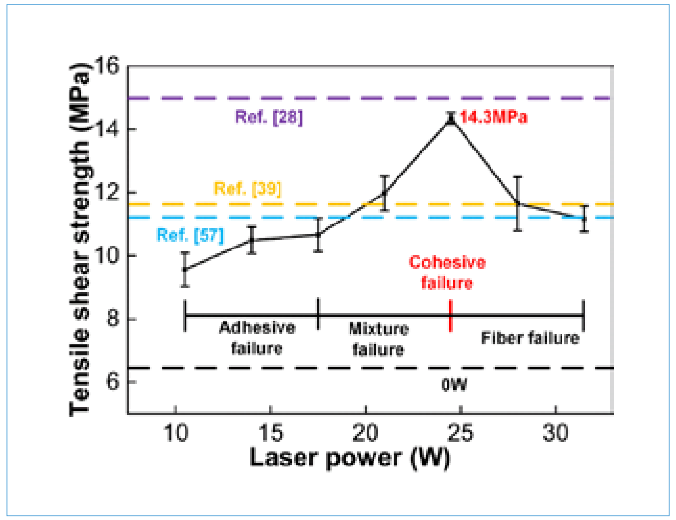
NANOSECOND LASER ABLATION FOR IMPROVING THE STRENGTH OF CFRTP AND ALUMINUM ALLOY ADHESIVELY BONDED JOINTS

In 2021, the laboratory of Professor Tan Caiwang, from Harbin Institute of Technology in Weihai, published a research paper titled "Nanosecond Laser Ablation for Improving the Strength of CFRTP and Aluminum Alloy Adhesively Bonded Joints" in the journal of *Composite Structures*. The research team reported an interesting result for improving the strength of carbon fiber reinforced thermoplastic (CFRTP) and aluminum alloy, the highest strength of joints reaching approximately 2.2 times those without ablation treatment. This study clarifies the effect of nanosecond laser ablation on the characteristics of CFRTP and the adhesive strength of CFRTP and aluminum alloy bonded joints and provides a new approach for enhancing the bonding strength between other metal and thermoplastic composites.

Joining CFRTP and aluminum alloy, these two excellent lightweight materials become a promising method of reducing emission and saving resources. However, the high strength of the adhesively bonded joints is still a big challenge due to inert surfaces with low surface free energy. How to improve the bonding strength between the CFRTP and adhesive has been as a necessary task in this research field.

Various methods have been adopted, such as sanding, chemical etching, grit-blasting, and plasma treatment. Nanosecond lasers, as a new laser source, provide a higher absorptivity to fibers and can achieve a direct bonding between the adhesive and fibers by removing the upper resin. However, previous studies focused on improving the joining of thermoset polymer matrix-based CFRP and metal. The elaboration of bonding mechanisms for joining thermoplastic composites after laser ablation and aluminum alloy is still unclear.

To investigate the effect of nanosecond laser ablation on the adhesively bonded joints of aluminum alloy and CFRTP, the team first treated the CFRTP surface by nanosecond laser with different powers and analyzed the characteristics of substrates, including surface morphology, roughness, wettability, and chemical composition. In the subsequent tensile-shear tests for those adhesively bonded joints prepared by aluminum alloy and CFRTP, a trend of first increasing and then decreasing for the tensile-shear strength was found as the laser power increased. When the CFRTP was treated, the upper resin was removed and underlying fibers were thus exposed, which increased the surface roughness and contact area, improving the strength of adhesive joints. However, excessive heat input would destroy the CFRTP decreasing the strength. The wettability of CFRTP became worse due to rough surfaces and fewer polar chemical bonds, but this adverse effect had been neutralized by the pressure applied during the adhesive bonding. Finally, the highest strength of joints was 14.3 MPa when the laser power was 24.5 W, and a cohesive failure was obtained at the same time.



Tensile-shear strength of joints using nanosecond ablation for CFRTP

In conclusion, this paper effectively enhances the strength of adhesively bonded joints of aluminum alloy and CFRTP by nanosecond laser ablation and provides a new mind to broaden the application range of this technology.

Professor Tan Caiwang is the corresponding author of this research paper; PhD student Feng Ziwei is the first author. This research was financially supported by the National Natural Science Foundation of China. ■

REFERENCE

Ziwei Feng, Hongyun Zhao, Caiwang Tan, Xueyan Zhang, Bo Chen, Xiaoguo Song. Nanosecond laser ablation for improving the strength of CFRTP and aluminum alloy adhesively bonded joints. Composite Structures, 2021, 274: 114369. DOI: 10.1016/j.compstruct.2021.114369

MECHANIC PROPERTIES AND FAILURE MECHANISM OF OVERLAP STRUCTURE FOR CORD-RUBBER COMPOSITE

In 2021, Professor Wang Youshan, from the Center for Composite Materials and Structures at Harbin Institute of Technology, and Associate Professor Wu Jian, from the Rubber Center for Composite Materials and Structures at Harbin Institute of Technology (Weihai), published a paper titled "Mechanical Properties and Failure Mechanism of Overlap Structure for Cord-Rubber Composite" in *Composite Structures*.

As a typical engineering material, cord-rubber composite is widely used in tire, conveyor belt, track, and other rubber products. Overlap structure of cord-rubber composite is a common connection form at present. And the overlap structure is important for the mechanical properties of the cord-rubber composite, affecting the safety performances of the rubber products directly. Therefore, there are important theoretical significances and engineering application values for the research on the mechanical properties and failure mechanism of the overlap structure. However, the mechanical properties and failure mechanism of the overlap structure of the cord-rubber composite are still not clear.

In this work, the mechanical properties and failure mechanism of the overlap structure are studied systematically. Based on uniaxial tensile test of cord and rubber, constitutive models of cord and rubber are established respectively. And then, the mechanical properties of the overlap structure of the cord-rubber composite under the uniaxial tensile test, the real cord model and the rebar layer model on are compared and studied. Last but not least, the overlap length and damage evolution of the overlap structure of the cord-rubber composite are analyzed by the cohesion zone model. The errors of both real cord model and rebar layer model simulated the limit load of the overlap structure at about 5%. An interlaminar damage evolution plays a key role in the strength of the overlap structure. Simultaneously, this work can provide a theoretical basis for the design of the cord-rubber composite.

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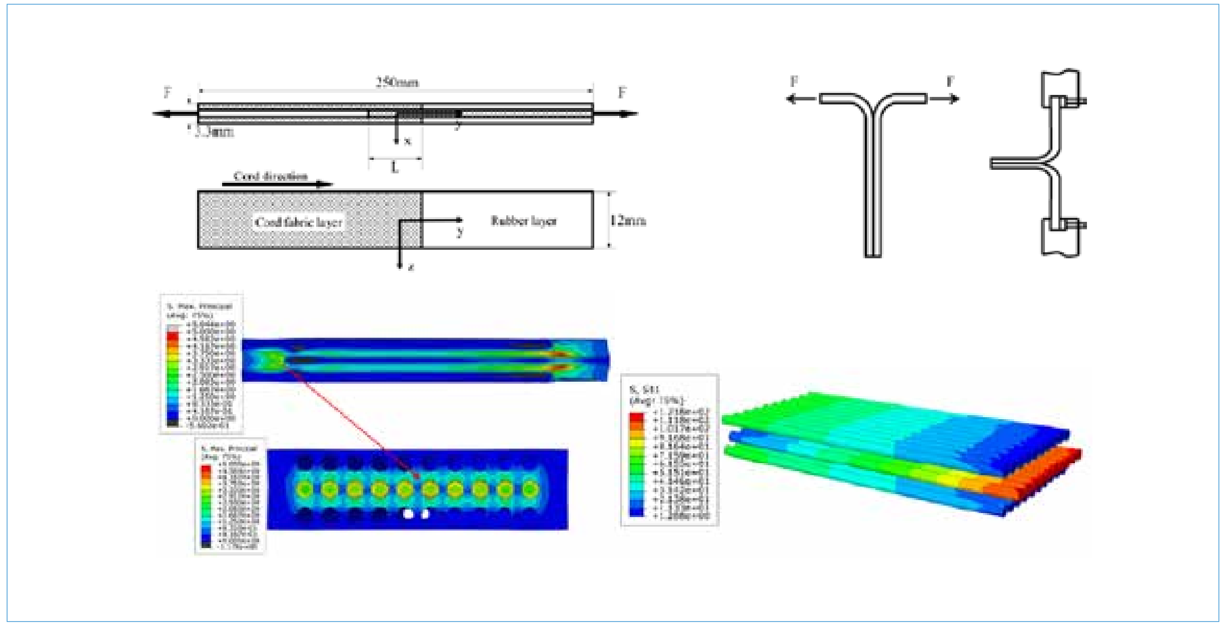

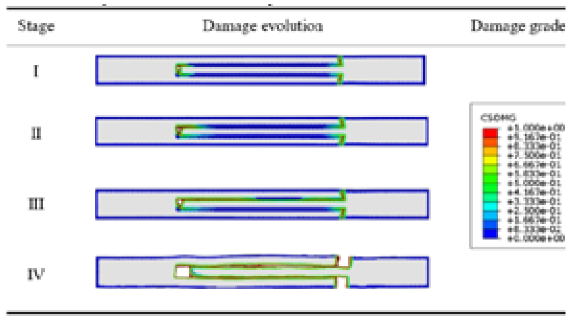

Stage I: the ultimate load of 90%; Stage II: the ultimate load of 100%; Stage III: th carrying load capacity decreased by 4%; Stage IV: the complete failure of the overla specimen

Lecturer Su Benlong and Dr. Liu Shouyao are the first and second authors, respectively. This work was supported by the National Natural Science Foundation of China, the Major Program of National Natural Science Foundation of China and the Shandong Provincial Key R&D Program.

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Benlong Su, Shouyao Liu, Peng Zhang, Jian Wu Youshan Wang. Mechanical properties and failure mechanism of overlap structure for cord-rubber composite. Composite Structures, 2021, 274: 114350.

NEWS & EVENTS

HIT PRESIDENT HAN JIECAI ATTENDED THE 2021 INTERNATIONAL CONFERENCE ON THE COOPERATION AND INTEGRATION OF INDUSTRY, EDUCATION, RESEARCH AND APPLICATION

On September 7th, 2021, the International Conference on the Cooperation and Integration of Industry, Education, Research and Application was held in Changchun. HIT President Han Jiecai was invited to attend the meeting and related exchange activities.

Tian Xuejun, Vice Minister of the Ministry of Education, An Lijia, Vice Governor of Jilin Province, Dmitry Afanasyev, Deputy Minister of the Ministry of Science and Higher Education of the Russian Federation, attended the opening ceremony and delivered a speech. Sergiy Pyrozhkov, Vice President of the National Academy of Sciences of Ukraine, delivered a video speech. During the conference, Chinese and foreign universities reached 10 goals, focusing on scientific research, construction of high-level scientific and technological R&D platforms, transformation and industrialization of high-tech achievements.

During the event, the 21st Meeting of the Education Cooperation Sub-Committee Sino-Russian Humanistic Cooperation Committee was held online. Tian Xuejun and Dmitry Afanasyev chaired the conference. The two sides reviewed the achievements of Sino-Russian education cooperation in the past year, fully exchanged views on the signing of the new education agreements as well as issues such as higher education, studying abroad, language teaching, basic education, supplementary education, institutionalized projects and multilateral cooperation, and reached broad consensus. HIT President Han Jiecai made a report on the construction of the Sino-Russian joint campus of HIT at the meeting.

HIT PRESIDENT HAN JIECAI ATTENDED THE ANNUAL PRESIDENTS' MEETING ON BUILDING WORLD-CLASS UNIVERSITIES

On October 15th and 16th, the 19th Annual Presidents' Meeting on Building World-Class Universities, hosted by Fudan University, was held in Shanghai. The meeting has been aimed at facilitating the development of top Chinese universities into world-class ones through exchange and cooperation since its initiation in 2003. HIT President Han Jiecai attended the meeting and made a report.

President Han made a report themed "HIT's Confidence in Taking the Road of Running a School with Characteristics: From 'China's Top Aerospace School' to 'World's Top Aerospace School'." He pointed out that Harbin Institute of Technology aims at the common cause of mankind and dedicates itself to the shared dream of exploring the vast universe. We adhere to the principle of innovation, pragmatism, and cooperation to strengthen our advantageous disciplines and participate in China's strategic planning for the aerospace industry by producing professional personnel and developing key space technologies. HIT will transform itself from a top university in aerospace in China into a world leader in this field. ■

HIT HELD A FLAG RAISING CEREMONY TO CELEBRATE THE NATIONAL DAY

On the morning of October 1st, a flag raising ceremony was held at Harbin Institute of Technology to celebrate the 72nd anniversary of the founding of new China. During the activity, teachers and students waved the national flag in their hands and sang "My Motherland and I" together to express their patriotic feelings. ■

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