BUILDING ON FIRM FOUNDATIONS

Basic science underpins all engineering advances. At Central South University (CSU), strong physical science programmes drive its many breakthroughs in nonferrous metals and railroad transportation research. They integrate research, application, teaching and talent cultivation, with established strengths in new energy materials, surface and interface physics, probability theories, and advanced computing technologies.

NEW ENERGY MATERIALS
Organic solar cells, which are lightweight and low-cost, are an emerging photovoltaic technology with great promise. Non-fullerene acceptors, potentially with high power conversion efficiencies, have drawn much attention. A CSU research team, led by Zou Yingping, designed a novel non-fullerene acceptor, Y6, based on a fused-ring structure containing an electron-deficient core for adjusting the optoelectronic properties of resulting molecules. Organic solar cells based on this acceptor showed a record high conversion efficiency of 15.7%. The work has opens a new door to the molecular design of high-performance acceptors for photovoltaic applications.

CSU's Ji Xiaobo led a team working on low-cost and long-life sodium ion batteries. They were the first to propose a novel strategy for mass production of carbon quantum dots via the aldol condensation reaction for sodium storage. Furthermore, they have developed low-cost, iron-based electrodes and systematically investigated the kinetic behaviours of the sodiation/desodiation process. Their studies demonstrate the bright future of sodium ion batteries in large-scale energy storage.

Developing high-energy rechargeable batteries, CSU's Lai Yanqing and colleagues came up with a novel technology to fabricate lithium anodes by spraying a graphene oxide layer on to the lithium metal surface, enabling large-scale production of lithium metal cells. His team has also developed other electrode materials and is now collaborating internationally to design flexible photovoltaic power systems with high specific energy that integrates conversion and storage.

SURFACE AND INTERFACE PHYSICS
CSU research on surface and interface sciences has application for electronic and optoelectronic devices, as well as flexible and printed electronics. Researchers are exploring the links between materials, devices and fabrication technologies, accelerating their commercialization.

He Jun, a professor from CSU's School of Physics and Electronics, along with his collaborators, developed two-photon photoelectron spectroscopy for surface analysis, which offers high energy and momentum resolution, probes electronic states with femtosecond time resolution, and is 3D spin-resolved. This multifunctional surface analysis system provides a useful tool for studying polyatomic molecules, clusters and nanostructures, potentially improving designs of novel electronic components and devices.

MATHEMATICS AND COMPUTER SCIENCE
The Markov process, integral to the study of probability, provides a useful tool for control engineers and operation researchers, as it keeps track of changes in a system over time. CSU's Hou Zhenting made breakthroughs in the theoretical study of the time-homogeneous Markov process in the early 1980s, and was the first Chinese mathematician to win the Rollo Davidson Prize. More recently, a CSU undergraduate, Liu Lu, provided the solution to Seetapun's conjecture, a classical mathematical logic problem, in 2016. A team led by Jiao Yong resolved a long-standing open problem in noncommutative analysis—noncommutative good-lambda inequalities.

In computer science, a CSU team, led by Zhang Yaoxue, proposed a promising network computing paradigm to achieve cross-platform, scalable and secure service provision for lightweight terminals. Zhang's transparent computing enables lightweight terminals to load on-demand operating systems and software from the network-connected devices via a streaming method.

Through more than 10 years of collaboration with Intel and local companies, Zhang and his team have successfully promoted commercialization of this technology and developed many commercial software solutions and products. ∎