HUMBLE BEGINNINGS, BRIGHT FUTURE Institute of Physics (CAS) at 90



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Color photos on the second line: Building A (built in 1958, remodeled in 2013), Building D (2002), Building M (2012).

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Xiaoying Chu

Director, Global Collaboration and Business Development, Asia xchu@aaas.org +86-131-6136-3212

Danny Zhao

Regional Sales Manager, Asia dzhao@aaas.org +86-131-4114-0012

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Extreme Science: Celebrating 90 years of cuttingedge research at IOP CAS hysics is a field of extremes. It studies the microworld, including subatomic particles, and the macroworld, including magnetic fields and plasma found in space. It explores the lowest and highest limits of temperature, pressure, and speed. These seemingly disparate subfields are all housed at the Institute of Physics, Chinese Academy of Sciences (IOP CAS), which is commemorating its 90th year.

At the nexus of all these extremes is superconductivity, or the ability of an element, intermetallic alloy, or compound to conduct electricity without resistance or energy loss below a certain temperature. Magnets and very cold temperatures– on the order of 39 K (-234°C, -389°F)–are used to control the flow of electricity. Remarkably, an electrical current will flow forever in a closed loop of superconducting material, which makes it the closest thing to perpetual motion–a sort of Rube Goldberg machine for electricity.

These near-magical materials are employed in devices that have revolutionized theoretical physics; for example, particle accelerators probe the inner workings of atoms, while tokamaks contain hot plasma that could one day be used in thermonuclear fusion. Superconductors are also an important factor in other technological breakthroughs, including magnetic resonance imaging machines that reduce the need for exploratory surgery, digital and quantum computers that store and transmit ever-increasing amounts of data, and Maglev trains that carry people over long distances in a much shorter time than conventional trains.

Inside this supplement is a sampling of the variety of cutting-edge research that is taking place at IOP. This prestigious institute is extensively pursuing superconductivity as well as the physics of condensed and soft matter, optics, subatomic particles, plasma, magnets, and computers. Join us in celebrating IOP's long history and its incredible contributions not just to science, but to humankind.

Jackie Oberst, Ph.D. Sean Sanders, Ph.D. Science/AAAS Custom Publishing Office

Technical Support Services at the Institute of Physics

Junjie Li*, Xiunian Jing, and Changzhi Gu

he Division of Technical Support (DTS), a public platform, provides technical services related to condensed matter physics for Institute of Physics (IOP) research groups. The DTS consists of five departments– the Laboratory of Microfabrication (LMF), Electronics Service and Scientific Instruments (ESSI), Materials

Laboratory of Microfabrication, Division of Technical Support *Corresponding author: jjli@iphy.ac.cn Analysis and Characterization Center (MACC), Cryogenic Service (CS), and Mechanical Engineering Facility (MEF)–associated with the following respective service fields: micro-/nanofabrication for novel structures and devices; R&D of signal detection technology and advanced integrated experimental facilities; materials analytical testing and characterization through Raman spectroscopy, X-ray diffraction, and inductively coupled plasma–atomic emission spectrometry/mass spectrometry; production and supply of liquid nitrogen and liquid helium; and equipment-unit precision machining.

As a typical DTS department, the LMF is introduced here. The LMF opened in 2002 and occupied over 1,000 m² in the cleanroom area, as a new IOP-based multidisciplinary research center to facilitate cuttingedge research in nanoscience and nanotechnology. LMF's primary focus is the fabrication and characterization of artificial micro-/nanostructures from



FIGURE 1. (A) Division of Technical Support (DTS) Departments. (B) Schematic frame of Micro-/Nanofabrication Platform. (C) The cleanroom and primary nanofabrication techniques in LMF: electron-beam lithography, focused ion beam direct writing, and thin-film deposition.



FIGURE 2. Nanofabrication for functional devices. (A) and (B) 3D folding micro-/nanostructures of metamaterials. (C) In situ measurement for electronic transport in a single carbon nanotube. (D) Nanocrack-defined metal nanogap arrays for sensoring systems.

low to three dimensions (3D), with devices and technology for integration. It provides technical services and advice to IOP and international researchers. User training is given, and summer schools are hosted regularly, providing a bridge toward research careers for young researchers with strong capabilities in the underlying disciplines of engineering, physical sciences, and biomedicine. LMF's goal is the provision of world-class technical support while satisfying major requirements in the fields of information processing, microelectronics, clean energy, environment, and bioscience.

LMF was founded considering several academic and scientific requirements, including development of novel nanofabrication technology to provide strong support for construction of new artificial nanostructures and nanodevices, thereby facilitating exploration of underlying quantum phenomena and novel physical effects. It ranks among the leading micro-/nanofabrication facilities worldwide. Additionally, a wide range of facilities, operations, and management functions are carried out at LMF to maintain critical infrastructure functionality, and to fully support the research needs of the IOP and other organizations in China.

LMF provides access to a full range of cutting-edge instruments for fabrication and characterization on the nanoscale, offering services in the Zhongguancun area and internationally. These instruments include ultraviolet (UV) lithography and electron-beam lithography (EBL) equipment, focused ion beam (FIB) and laser direct writing systems, and dry etching and thin-film deposition equipment. Cleanrooms and equipment within LMF are accessible to external academic or industrial users. Processing is available for structures ranging from a few nanometers to a few hundred micrometers, and in formats from quantum dots to 3D, based on various materials [including silicon (Si), III-V semiconductors, carbon-based materials, dielectrics, metals, metal oxides, polymers, and biological materials]. We also explore and provide technology for the construction of various devices, such as field effect transistors; for quantum computing, superconducting, and magnetic information storage; for nano-optical, single-photon, single-electron, plasmonic, and other new energy devices; and for biodevices, sensors, and detectors. To date, LMF has reported important technical achievements in fabrication, characterization, and device development, especially regarding the formation of sub-5-nm metal gap arrays, folding of 2D film into 3D nanostructures, in situ measurement of local properties, and 3D metamaterials. LMF has also achieved important research outcomes, including multichannel ballistic transport in multiwall carbon nanotubes (1), an all-metallic logic gate based on current-driven domain wall motion (2), optical control by 3D folding metamaterials and applications (3, 4), and sub-5-nm metal nanogap arrays for sensoring and memory (5-8), greatly advancing the development and status of LMF.

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