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CHINA— Tradition and transformation

China pursues technological advances that can disrupt global markets—and its own economy

By Alex Talavera and Randy B. Hecht

As both government and global expectations make innovation a precedence over the traditional value of stability, private industry and entrepreneurs are increasingly taking the lead to meet science and technology objectives.

Its people represent more than a sixth of the world's population, but in key science and technology areas and even in factories that employ unskilled workers, it faces a labor shortage. Its current economic strength relies in part on factors and strategies that it will need to remake—if not scuttle entirely—to achieve its future performance targets. And while the government's policies still play to the interests of state-owned enterprises, private industry and entrepreneurs are increasingly taking the lead in meeting the objectives outlined in successive five-year plans.

As innovation moves to take precedence over the more traditional value of stability, China's science and technology community finds itself living in interesting times.

Pursuing energy imperatives

Within the materials science sector, research and development responds to a mix of demands to promote growth and adhere to government policy. To achieve a more technology-driven economy, China's policymakers identified seven strategic emerging industries. The list includes energy efficient and environmental technologies; next-generation information tech-

Capsule summary

NEW VALUES

To achieve a more technology-driven economy, China's policymakers identified seven strategic emerging industries that place innovation over stability. This expectation shapes both industry and academic research pursuits.

nology; biotechnology; high-end equipment manufacturing; new energy; new materials; and new-energy vehicles.

"Therefore, energy materials, environmental material, advanced structural materials, and functional materials are of the first priority in China's next development in materials science engineering," says professor Fei Chen of Wuhan University of Technology in an interview.

For Chen and his colleagues, those needs translate to an expectation that their work will promote innovation that conforms to government policy and national priorities. "Our research focus is on new energy, such as composite solid electrolyte and all-solid-state lithium-ion batteries; grid-scale energy storage systems, such as liquid metal batteries; and additive manufacturing," he says.

China's government established ambitious performance standards in these areas. For example, "By the year 2030, 40 percent of automobiles in China will be new energy automobiles," Chen says. And that, in tandem with the government roadmap for energy saving, foreshadows rapid growth in the lithium-ion battery market in the coming decades.

Chen is concerned with resolving the safety concerns and energy density constraints that prevent current battery technology from meeting these demands. He is collaborating with local industry to create next-generation safe, high-energy, high-density solid-state battery applications for new energy vehicles.

"One of our areas of research in new energy focuses on composite solid electrolyte and all-solid-state lithium-ion batteries. Currently, the research group is implementing pilot production of solid electrolytes in all-solid-state batteries, collaborating with Smoothway Inc. in Shuhai City, Guangdong Province," he says. "That is my work, and I think it is in agreement with China's development policy."

BALANCING EXPECTATIONS

Global markets with competing or conflicting priorities regarding energy savings and environmental concerns challenge China's competitive edge. Cross-border teamwork may encourage innovation, but it also stimulates a more capitalist mindset.

Economy and environment

Changes in global expectations and standards are also having an impact on industrial fortunes in China. The abrasives sector is a case in point.

Rex Hadley, sales director for the Americas at Abrasives.com, notes that as North American and European countries impose limits on production and enact new environmental regulations, those controls "make it either not possible or simply very expensive to extract, process, and produce these abrasives."

"Companies end up not doing it or have to sell at a high price. Whereas in China, let's say some of these restrictions are a bit more lax," he adds.

However, Hadley sees China's abrasives producers' market advantage diminishing. "The Chinese government has been increasing their regulations on environmental impact," he says. "Prices have been going up directly as a result of that."

THE GREATEST ASSET

As China seeks equilibrium between stability and startup potential, size may be its greatest asset. China can afford to pursue technology advances without abandoning customers who still require less-developed solutions.

The company's CEO, Dever Yang, envisioned the website as a kind of Alibaba that serves the abrasives industry exclusively. A trader whose focus has always been export markets, he parlayed his relationships with producers in China to create the site, which charges suppliers a membership fee.

"A lot of producers in China don't have access to the foreign markets and customers," Hadley says. And because margins are fairly low and the industry relies on volume business, they see advantages to having a presence on a sector-specific site. Amid growing global consciousness of environmental concerns, this approach may be part of a strategy for maintaining China's competitive edge and price-to-quality ratio in abrasives.

Old school vs. new markets

Other industries are also navigating a balancing act between markets with competing or conflicting priorities



Fei Chen and his students at Wuhan University of Technology study new energy technologies to promote innovation that agrees with government policy and national priorities.



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A view of Chongqing Central Business District from across Jialing River. Chongqing is the fastest-growing city in the world, in part because the Chongqing government was among the first local governments to encourage entrepreneurship.

regarding energy savings and environmental concerns.

Weifang Renhe Special Ceramics Co., Ltd. makes silicon carbide products for customers in Asia, Africa, the Middle East, Europe, and North America. Xu Han, manager of the foreign trade department, estimates that “95 percent of the kilns in the world are using reaction bonded silicon carbide. There are

some higher-temperature ones for special ceramics, using nitro bonded. Some are with crystallized SiC, some are sintered SiC. Some countries, such as India or Pakistan, are still using the regular SiC or the older material, which is much cheaper. But those countries really don’t care about energy saving.”

The company must maintain its work with those materials because it com-

mands an estimated 70% of the existing market in India. As in China, that market is set for substantial expansion. “New factories are building nonstop, and the technologies in China and India are behind,” Han says. “So, more technologies need to be developed and new materials need to be developed in order to save energy, save labor, cut costs. We’re trying to catch up with the factories in the U.S., Germany, Italy, Poland, to see what they’re doing so we can bring it back to China or bring it to India.”

Weifang Renhe Special Ceramics has seen demand increase “significantly” in the past five to 10 years, but “even where you have strong demand, you don’t depend on that to continue indefinitely,” Han notes. “For silicon carbide, after five years the price will drop, because more factories for silicon carbide are coming right now in China. One material or technology can be used for maybe 10 years, but after 10 years, if you don’t come up with a new thing, other people may find something else to replace you.”

Among the recent developments in China are form ceramic wall panels—light, environmentally-friendly alternatives to traditional building materials like bricks. “It’s old technology, but it’s been super

The Chinese Academy of Sciences

A global outlook on innovation, cooperation, and commercialization

Mao Zedong declared the creation of the People’s Republic of China on October 1, 1949. The Chinese Academy of Sciences was founded one month later—an early indicator of the priority the government placed on “driving national technological innovation.” Its research focus encompasses “most areas of basic science and technology as well as strategic advanced technology and areas related to the public welfare and the development of emerging industries.”

To get a sense of the Academy’s size and scope, consider that its *Guide to CAS*, published in 2014 and accessible online in PDF format, runs 138 pages. Included within its gargantuan structure are 104 research institutes, 12 branch academies, and 11 supporting organizations. In total, there are more than 1,000 CAS labs, engineering centers, and other sites throughout the country. The main CAS website provides links to each of the research bodies. Its staff of 67,900 includes approximately 56,000 research professionals, of whom some 22,800 are research professors. To develop future generations of scientists, it maintains an affiliation with the University of Science and Technology of China, University of the Chinese Academy of Sciences, and Shanghai Tech University. Graduates of these programs include to date more than 86,000 masters and 65,000 Ph.D. recipients.

CAS charted its future in 2011 with the launch of CAS Innovation 2020, which “aims to further promote innovation . . . to turn scientific discoveries into technologies that power economic growth and sustainable development” and to “improve the quality of research by supporting risky and long-term projects

and encouraging scientists to study the frontiers of knowledge.” While the Academy’s evaluation system once prioritized number and quality of scientific papers, it now assesses research “based on its innovativeness and potential to benefit society.”

To that end, CAS has established science parks in Beijing, Shanghai, and Guangzhou “to turn basic research into marketable technologies, especially in the areas of information technology, space science, renewable energy, and health.” It notes that “in 2014 alone, over 700 CAS spin-off companies” grossed RMB 350 billion (equivalent to \$56 billion).

“Innovation 2020 has already launched projects on nuclear fusion and nuclear-waste management, materials science, information technology, public health and the environment,” the Academy notes. “Furthermore, it has commenced research to calculate the flux of carbon between land, oceans and the atmosphere. In its drive to develop clean nuclear energy, CAS has also started a project to develop a thorium-fueled molten-salt nuclear reactor, which aims to offer an alternative, environmentally safe source of energy.”

The organization notes that its strategy has long emphasized the pursuit of innovation that draws on research, education, interdisciplinary and cross-sector cooperation. International collaboration is a cornerstone of this strategy, and its cross-border ventures span Europe, Asia, Africa, and the Americas. U.S. partners include the National Academy of Sciences, National Science Foundation, U.S. Department of Energy, National Institutes of Health, National Institute of Standards and Technology, and American Association for the Advancement of Science. A full list of its international cooperation partners may be found on the CAS website, www.cas.cn. ■

popular in China for the past one or two years, because the Chinese government is paying factories a lot of money to develop this technology,” Han says.

Those factories’ kilns use silicon carbide, and the company is working with two of the three biggest factories in the sector. “Everything is new,” he says. “The kiln is new. The technology is new. The shape of the silicon carbide product we also had to develop, we had to do R&D with the customer. We had to work together to find out the size of the material, the lens, the thickness, the shape—everything is brand new. So, there’s lot of new technology and lots of new developments.”

Weifang Renhe Special Ceramics participates in Ceramics Expo and exhibitions in Germany and Italy each year to stay abreast of emerging trends and technologies. Among its current interests is sintered silicon carbide. “For our company, this is definitely a new technology that we need to experience more with

other companies, lab services, to develop the thickness, the shape, for our customer,” Han says. “Another technology we want to develop for our company is nitro bonded silicon carbide. That’s the next technology we need to go into.”

The labor conundrum

Ambitions at this scale require an extensive workforce of skilled and unskilled labor, and China faces unusual challenges in that regard.

Because it is sometimes playing technological catch-up, the country has relied on visiting scholars and “strategic scientists” to work at its universities and institutes to train the next generation of STEM professionals. Based on his experiences at his university, Chen regards having foreign researchers teach students a positive move. He believes scientific research “should have no border” and that regardless of political tensions between countries, “in scientific research, we need to do more collabora-

tive work” on behalf of “a community of shared future for mankind, not only the community of China.”

His team has collaborated on additive manufacturing projects with professor Enrique J. Lavernia of the University of California, Irvine, who is a member of the U.S. National Academy of Engineering. Another collaboration partner is professor Takashi Goto of Tohoku University in Japan, who has worked with Chen’s team on projects related to advanced thin films and coating technology using chemical vapor deposition (CVD) or physical vapor deposition (PVD) methods.

This cross-border teamwork may encourage not only innovation but also a more capitalist mindset. Chen is conscious of his work’s being “in agreement with China’s development policy,” and Han sees opportunity in kilns used in government-subsidized factories. But a new generation of students is finding motivation in the pursuit of personal



Locations of Chinese Academy of Sciences Institutes throughout China.

wealth. The push to pursue entrepreneurialism is a decided shift from old university standards that regarded their volumes of published paper output as the greatest measure of performance.

Today, “most of our students have greater interest in research that is viable commercially,” Chen says. But he does not see the current science and engineering curriculum, education, and training fulfilling the development needs that will evolve in the coming decades, either domestically or globally. He advocates educational reform to resolve that challenge.

Individualism is also rising among students who want to “do something

they are interested in,” Chen says. “They would like to maybe start up their own business after they graduate. The number is still very small, but it grows. And the Chinese government encourages them to do more startup companies and try to use their knowledge to open their own business. I think the number will increase gradually.” But if those startups flourish and more graduates are drawn to commercial ventures, the country will remain reliant on foreign STEM professors to train succeeding generations of students.

Meanwhile, factories face their own challenges in attracting and retaining employees. Han estimates that his company’s workforce averages about 45 years

in age. Younger people, including new graduates, want to live and work in cities, and factories for the most part are located just outside those urban areas. And that is driving salaries upward for “basic labor” as well as engineers and other skilled professionals—a class of employees who are paid “a lot more to keep them in the factory so they don’t go to other companies with our technology.”

Strength in numbers

And so it goes in China as the country seeks its equilibrium between stability and startup potential. In that, size may be its greatest asset. Unlike smaller countries that are forced to jettison fac-



MARKET SNAPSHOT Globalization giant

The world trade dominator pins its growth ambitions on increased innovation and domestic consumption.

The fourth-largest country by area in the world—just after the United States and before Brazil—China is a land of complex cultures and climates. It shares its border with 15 countries, and its territory stretches from the tropical south (at the crossing into Laos) to the subarctic north (where it juts into Siberia).

Within that sprawling land mass live 1.43 billion people, which is more than a sixth of the planet’s total. But population density runs at extremes from west to east. The World Factbook notes that an “overwhelming majority . . . is found in the eastern half of the country.” Six Chinese cities are home to more than 10 million people: the populations of Shenzhen, Tianjin, Guangdong, Chongqing, Beijing, and Shanghai number 11.9, 13.2, 12.7, 14.8, 19.6, and 25.6 million, respectively.

While the total working-age (15–64) population is estimated at over 1 billion, the labor force stands at a mere 806.7 million. Services employ 43.5%, with the remainder divided almost evenly between industry (28.8%) and agriculture (27.7%).

Services generate 51.6% of GDP, followed by

industry (40.5%) and agriculture (7.9%). The industrial production growth rate was an estimated 6.1% in 2017, and China ranks as the world leader in gross value of industrial output. And GDP is a monster by any measure. In 2017, China’s purchasing power parity GDP was an estimated \$23.21 trillion—that is \$16,700 per capita—up from \$21.72 trillion in 2016. What is more, Gross National Saving was 45.8% of GDP in 2017.

Leading industries include mining and ore processing; iron, steel, aluminum, and other metals; coal; machine building; armaments; textiles and apparel; petroleum; cement; chemicals; fertilizer; consumer products (including footwear, toys, and electronics); food processing; transportation equipment, including automobiles, railcars and locomotives, ships, and aircraft; telecommunications equipment; commercial space launch vehicles; and satellites.

China is also the planet’s number one force in foreign trade and operates at a trade surplus. In 2017 its exports, calculated on an exchange rate basis, totaled \$2.2 trillion against \$1.7 trillion in imports. The top export targets are the U.S., Hong Kong, Japan, and South Korea, while primary import sources are South Korea, Japan, the U.S., Germany, and Australia. Imports from China to the U.S. are more than double U.S. exports to China.

Leading exports include electrical and other machinery, including computers and telecommunications equipment, apparel, furniture, and textiles. On the import side, the list comprises electrical and other machinery (including integrated circuits and other computer components), oil and mineral fuels, optical and medical equipment, metal ores, motor vehicles, and soybeans.

The government issued its latest Five-Year Plan in 2016, when it prioritized increased innovation and domestic consumption “to make the economy less dependent on government investment, exports, and heavy industry,” The World Factbook notes. “However, China has made more progress on subsidizing innovation than rebalancing the econ-

omy. Beijing has committed to giving the market a more decisive role in allocating resources, but the Chinese Government’s policies continue to favor state-owned enterprises and emphasize stability.”

The Export.gov China Country Commercial Guide provides further market details and resources. It also published introductions to the market opportunities available in rapidly growing “second-tier cities” in China, including Chongqing—the world’s fastest-growing city—as well as Dalian, Hangzhou, Harbin, Kunming, Nanjing, Ningbo, Qingdao, Shenzhen, Tianjin, Xiamen, Xi’an, and Zhuhai.

The Asian Development Bank maintains a database of projects in China that you can search for bidding opportunities and offers a procurement resource to assist in pursuing business.

Additional information, support, and resources are available through the United States of America—China Chamber of Commerce (which has domestic offices in Chicago, Los Angeles, and New York), China General Chamber of Commerce—USA, the US—China Business Council, and the U.S. Chamber of Commerce China Center. ■

A natural resource repository

As you would expect, a land mass as big as China’s yields extensive natural resources. They include coal, iron ore, helium, petroleum, natural gas, arsenic, bismuth, cobalt, cadmium, ferrosilicon, gallium, germanium, hafnium, indium, lithium, mercury, tantalum, tellurium, tin, titanium, tungsten, antimony, manganese, magnesium, molybdenum, selenium, strontium, vanadium, magnetite, aluminum, lead, zinc, rare earth elements, and uranium. China also boasts the world’s greatest hydropower potential, a prospective environmental and economic advantage for what The World Factbook calls “the world’s largest single emitter of carbon dioxide from the burning of fossil fuels.” ■

ing industries or technologies as they are replaced with newer advances, China can afford to pursue technology advances without abandoning customers who still require less-developed solutions.

Those solutions may not represent the country's future, but they still generate a respectable contribution to its export volume and GDP. And they do not stand in the way of innovation—witness the hundreds of entrepreneurial ventures that have emerged from research at the Chinese Academy of Sciences (see sidebar). Since last year, that organization and its affiliated institutes have announced such breakthroughs as:

- Fabrication of fine-grained pure Y_2O_3 transparent ceramic with improved mechanical and thermal performance, by a research team led by professor Zhang Long of the Key Laboratory of Materials for High Power Lasers at Shanghai Institute of Optics and Fine Mechanics. Long also led a research team that suc-

cessfully fabricated a high transmittance yttrium aluminum garnet (YAG) planar waveguide (PWG) composite structure without pores on the bonding interface by two-step sintering process.

- A new composite material that is highly effective in cleaning water contaminated by organics, developed by a team led by Huang Fuqiang, chief researcher at the Shanghai Institute.

- A new ceramic aerogel that can be used in thermal insulation developed by a team of researchers from China and the U.S., that has strong mechanical and thermal stability, and scores well in transformation and toughness.

- Fabrication of a $Cu_2Se/Yb_{0.3}Co_4Sb_{12}$ thermoelectric module with eight *n*-type Ni/Ti/ $Yb_{0.3}Co_4Sb_{12}$ legs and eight *p*-type Ni/Mo/ Cu_2Se legs that achieved a high energy conversion efficiency of 9.1% and excellent service stability. Scientists from the Shanghai Institute of Ceramics and Northwestern

University based the advance on high-performance liquid-like materials.

- Completion of the world's first ceramic manufacturing experiment under microgravity by scientists at the Technology and Engineering Center for Space Utilization. The team used digital light processing technology, an additive manufacturing technique that is already in widespread use but was not thought to work in microgravity. The experiment was conducted aboard a European parabolic flight aircraft in Switzerland, and the team also tested a metal casting technique using 3D printed ceramic molds.

China continues to court exchanges with scientists and researchers from other countries as well as partners in commercial ventures and foreign trade. Its sheer size promises opportunity in a market that is still a long way from realizing its full expansion potential. ■

Directory of Chinese companies, institutes, universities, and publications

Chinese Academy of Sciences

Address: 52 Sanlihe Rd., Xicheng District, Beijing 100864
Phone: 86 10 6859-7521 (day) 86-10-6859-7289 (night)
Fax: 86 10 6851-1095 (day) 86-10-6851-2458 (night)
Email: cas_en@cas.cn
Website: <http://english.cas.cn>

See sidebar on page 30 for a full profile of the organization. Also note that the "day" and "night" notations for phone and fax numbers are as indicated on the website. For calls made during U.S. business hours, use the "night" numbers.

Institutes under the Chinese Academy of Sciences umbrella include

- Academy of Opto-Electronics,
- Institute of Metal Research,
- Advanced Ceramics and Composites Division,
- National Center for Science and Technology,
- Ningbo Institute of Industrial Technology,
- Shanghai Institute of Ceramics, and
- Suzhou Institute of Nano-Tech and Nano-Bionics.

CORPORATIONS

2D Carbon Graphene Material Co., Ltd.

Address: No. 6 Xiangyun Road, Wujin Economical Development Zone, Changzhou, Jiangsu
Phone: 86 0519 8168-7925
Email: cz2d@2dcarbon.com.cn
Website: <http://www.cz2dcarbon.com/en/index.asp>

Arknano

Shanghai Feibo Chemical Technology Co., Ltd.
Address: 4-3F-82#, No. 9 Longcheng Road Damian Longquanyi district Chengdu
Phone: 86 21 5895-5608
Email: blinkzeng@gmail.com
Website: <http://www.arknano.com>

Astral Material Industrial Co., Ltd.

Address: Rm. 2303 Block 1 JunNing Bldg., No.213 FuNing Road, ChanCheng Dist. FoShan, Guangdong
Phone: 86 757 8303-0798
Fax : 86 757 8270-1478
Email: info@amic.biz
Website: <http://www.amic.biz>

The company is focused on thermal and structural ceramics and metal-nonmetal composites manufactured using a high temperature sintering technique. It serves customers throughout the world within a variety of industries, including building materials (tile, mosaic, sanitaryware, tableware ceramic), advanced ceramics, glass, semiconductors, petroleum oil, energy, chemical, mining, metallurgy foundry, and thermal engineering.

Beijing Goodwill Metal

Address: RM6B15, Huajie Mansion, Haidian, Beijing
Phone: 86 10 8212-0929
Fax: 86 10 8212-3929
Email: sales@goodwillmetal.co/service@goodwillmetal.co
Website: <http://www.goodwillmetal.co>

Chengdu Alpha Nano Technology

Address: 503, Science and Technology Innovation Center, Sichuan University, Chengdu, Sichuan 610064
Phone: 86 28 6648-6191
Email: lhr1118@gmail.com
Website: http://www.nanotubes.cn/default_nanopowder.htm

Chengdu Organic Chemicals Co. Ltd.

Address: No.16, South section 2, the first Circle road, Chengdu 610041
Phone: 86 28 8523-6765
Email: carbon@cioc.ac.cn
Website: <http://www.timesnano.com/en>

Chengdu Organic Chemicals Co. Ltd. is a holding company of the Chinese Academy of Sciences and, according to its website, "the base of Chinese high technology research development and industrialization officially assigned by the Chinese government." Its focus is on the areas of catalytic technology and green process, chiral technology and engineering, polymer functional materials, and new energy materials. In addition to sales throughout most of China, the company exports to the United States, Germany, Denmark, Italy, India, and other foreign markets. It is also the parent company of Time Nano.

EPRUI Biotech Co. Ltd.

Address: A9101, No. 8 Shen Bei Road, Ming Hang District, Shanghai
Phone: 86 21 6419-2663
WeChat/Whatsapp: 86 138 1719-9526
E-mail: sales@epruibiotech.com/nano-biz@hotmail.com
Website: <https://www.epruibiotech.com>
A monodisperse microspheres supplier, the company's

Directory of Chinese companies, institutes, universities, and publications

product lines include polymer polystyrene, PS/DVB, PMMA, SiO₂, fluorescent polystyrene, dyed, and conductive microspheres as well as monodisperse magnetic beads. These microspheres are characterized by precise particle size, narrow particle size distribution, perfect spherical morphology, and optimized pore size.

FCC Inc.

Full company name: Hangzhou Sino-Holding Chemicals Co. Ltd.

Address: 387 Gundun Road, Hangzhou, Zhejiang 310012
Phone: 86 571 8805-1375

Global manager: Frank Lim/Mobile: 86 0 188 6871-0978

FCC specializes in such additives as organoclay, rheology modifiers, nanoclay, nano calcium carbonate, carbon nanofibers, ceramic honeycomb catalysts, and ceramic substrates.

Henan Abrasivestocks Technology, Ltd.

Address: L 536R XinYuan International Plaza, Jianshe Road Zhengzhou 450006

Phone: 86 400 006-0902

Email: info@abrasivestocks.com

Website: https://abrasivestocks.com

Hongwu International Group Ltd.

Address: 307, ChuangKeGu, No.43 Tangdong East Road, Tianhe District, Guangzhou Guangdong 510660

Phone: 86 20 8722-6359

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Website: https://www.hwnanomaterial.com

The company serves an international customer base with research, development, manufacturing, and processing of nanoparticles, nanopowders, and micron powders. Its primary focus is on silver nanoparticles, copper nanoparticles, silicon carbide whiskers/powders, carbon nanotubes, graphene, aluminum oxide nanoparticles, silicon nitride powders, silver nanowires, and other nano materials, all available either in small quantities for researchers or in bulk orders for commercial purposes.

KNANO

Address: 16# BLDS, No. 2881 DongFu Road, HaiCang District, Xiamen 361027

Email: cqfang@knano.com.cn

Website: http://www.knano.com.cn/En/index.aspx

Shanghai Huzheng Nanotechnology Co., Ltd.

Address: No. 158, Xinjunhuan Rd., Minhang District, Shanghai

Phone: 86 4006-8181-89

Email: zay@hznano.com

Website: http://en.hznano.com

The Sixth Element Materials Technology

Address: Plant 8, 9 West Tai Lake Avenue, Wujin Economic Development Zone, Changzhou, Jiangsu 213000

Phone: 86 519 8123-0981

Fax: 86 519 8123-0998

E-mail: rp.huang@thesixthelement.com.cn

E-mail: sales@thesixthelement.com.cn

Website: http://www.c6th.com

Sun Nanotek Co. Ltd.

Address: No. 339, East Beijing Road, Nanchang City, Jiangxi Province

Phone: 86 139 7913-8023

Email: Xiaoshu Zeng, zengxiaoshu@21cn.com

Website: http://www.sunnano.com/index.html

Suzhou Green Nanotechnology Co., Ltd.

Address: Room 103, NW-07 building, Nanking City, 99, Jinji Hu Avenue, Suzhou Industrial Park

Phone: 86 0512 8686-7803

Website: http://www.szgraphene.com, http://www.graphene.cn

Tangshan Jidong Cement Co., Ltd.

Online contact form: http://en.jdsn.com.cn/contactus/contactusonline.aspx

Website: http://en.jdsn.com.cn/Default.aspx

XFNano

Address: No. 9 Buyue Road, Pukou District, Nanjing City 210000, Jiangsu Province

Phone: 86 25 6965-7070

Email: sales@xfnano.com

Website: https://en.xfnano.com

Xiamen Innovacera Advanced Materials Co Ltd.

Address: A506-507, No.7 Yu'n'an 4th Road, Huli District, Xiamen Area of China (Fujian) Pilot Free Trade Zone 361006

Phone: 86 592 558-9730

Fax: 86 592 558-9733

Innovacera conducts R&D in and manufactures and sells products made of alumina, zirconia, boron nitride, silicon nitride, machinable glass, and other advanced ceramic materials. The company specializes in high tolerance ceramic machining, grinding, and polishing of unfired and fired ceramics. Among its services are isostatic pressing, dry pressing, injection molding, pre- and post-fire ceramic machining, precision grinding and machining, CNC ceramic machining and grinding, lapping and polishing, and ceramic metallization. Its target industries include aerospace, automotive, and defense.

INSTITUTES

Aerospace Research Institute of Materials & Processing Technology (ARIMT)

Address: No. 1 Hongmen Road, Nanda, Fengtai District, Beijing

Phone: 86 010 6875-5654

Fax: 86 010 6838-3237

Website: http://www.arimt.com (in Chinese only)

Central Iron and Steel Research Institute (CISRI)

Address: 76 Xueyuan South Road, Haidian District, Beijing, 100081

Phone: 86 010 6218-6017

Website: http://www.cisri-rc.com (in Chinese only)

LinkedIn company page: https://www.linkedin.com/company/cisri-international-co-ltd-/about

CISRI's LinkedIn presence offers an English-language overview of the organization as well as links to more than five dozen employee profiles on LinkedIn. According to the overview, the state-owned enterprise was founded in 1952 and is "an important R&D base and a leading provider of advanced materials and products" that "owns a broad spectrum of technical know-how and advanced products" in such industrial fields as functional materials, powder metallurgy materials, refractory metals, high temperature alloys, and structural materials. Its primary products are

- Amorphous and nanocrystalline ribbons and cores,
- Refractory metals and alloys,
- Metal powder and metal injection molded parts,
- High temperature alloys and products,
- Structural materials,

- Rare earth permanent magnets,
- Welding consumables,
- High speed steel products, and
- Metallurgical engineering technology and equipment.

Harbin Institute of Technology

Address: 92 West Dazhi Street, Nan Gang District, Harbin

Phone: 86 451 8641-2114

Email: caiz@hit.edu.cn

Website: http://en.hit.edu.cn

Note: the email provided above is the designated address for U.S. enterprises interested in international collaboration.

Sinosteel Luoyang Institute of Refractories Research

Address: Luoyang City, Xiyuan Road 43 471039

Phone: 86 379 6420-5114

Fax: 86 379 6420-5800

Email: lirrc@lirrc.com

Website: www.lirrc.com

Luoyang Institute of Refractories Research is the enterprise behind "production lines for series high-purity oxide products, high quality silicon carbide materials, functional refractories for metallurgy, unshaped refractories, series refractory ceramic fibers and products and refractories for alkali-free glass tank," the website notes, along with "series high-tech products for metallurgical, petrochemical, building materials, ceramics, mechanical and other industries." It maintains relationships with more than 40 companies abroad and distributes more than 40% of its output internationally. The company is also the publisher of China's Refractories, a magazine published in Chinese and English.

UNIVERSITIES

Donghua University

Address: 1882 Yan'an Road West, Shanghai 200051

Phone: 86 21 6237-8595, 6237-9336, 6237-3452

Fax: 86 21 6270-8702

Email: ices@dhu.edu.cn

Website: http://english.dhu.edu.cn/main.htm

Fuzhou University

Address: No. 2, Wulongjiang North Avenue, Fuzhou University City, Fuzhou City 350108

Fax: 86 0591 2286-6099

Website: https://www.fzu.edu.cn

Note that although the website includes a link to English-language content (http://en.fzu.edu.cn/) the page was not functioning as we went to press.

Huazhong University of Science & Technology

Address: Luoyu Road 1037, Wuhan, China

Phone: 86 27 8748-5855 (International Cooperation)

Email: eww@hust.edu.cn (International Cooperation)

Website: http://english.hust.edu.cn

HUST houses the Wuhan National Laboratory for Optoelectronics and the Wuhan National High Magnetic Field Center as well as six national engineering research centers and a national engineering lab. HUST's international joint ventures include the China-EU Institute for Clean and Renewable Energy, and it maintains partnerships with more than 100 universities and research institutes worldwide.

Directory of Chinese companies, institutes, universities, and publications

Hunan University

Address: Lushan Road (S), Yuelu District, Changsha, Hunan Province 410082

Email: xiaoban@hnu.cn

Website: <http://www-en.hnu.edu.cn/index.htm>

The University has established international cooperation partnerships with dozens of universities in the U.S. and other countries as well as corporations, including DuPont.

Jiangsu Normal University

Address: No.101, Shanghai Road, Tongshan New District, Xuzhou, Jiangsu

Phone: 86 516 8350-0143 (General Office);

86 516 8350-0045 (Cooperation & Communication Office);

86 516 8350-0045 (Foreign Affairs Management Office)

E-mail: office@jsnu.edu.cn

Website: <http://en.jsnu.edu.cn/main.htm>

Northeastern University

Address: No. 3-11, Wenhua Road, Heping District, Shenyang

Email: 85590@mail.neu.edu.cn

Website: <https://english.neu.edu.cn>

Founded in 1923, the university was the site of China's first science park and is home to a mix of academic and entrepreneurial activity. The website notes that "it has established a series of high-tech enterprises, such as the Neusoft Corporation and the Neunn Technology Inc., and formed its unique characteristics in the areas of technological innovation, technological transfer and industry-university cooperation." Schools within its College of Resources and Civil Engineering are devoted to metallurgy, material science and engineering, and mechanical engineering and automation.

Shanghai Jiao Tong University

International Science & Technology Project Office

Address: 800 Dongchuan Road, Minhang District, Shanghai 200240

Phone: 86 21 3420-7982

Contact Page: <http://en.sjtu.edu.cn/about-sjtu/contact-us>

Website: <http://en.sjtu.edu.cn>

South China University of Technology

International Cooperation & Relations

Address: International Office, Room 346, Building No.37, Wushan Campus, 381 Wushan Road, Tianhe District, Guangzhou 510641

Phone: 86 20 8711-0948

Email: international@scut.edu.cn

Contact page: <https://www.scut.edu.cn/en/wontact/list.htm>

Website: <https://www.scut.edu.cn/en>

The university operates national engineering research centers with a focus on such areas as near-net-shape forming for metallic materials and novel equipment for polymer processing as well as key laboratories for polymer processing engineering and for special functional materials.

Tianjin University

Weijin Road Campus: No. 92 Weijin Road, Nankai District, Tianjin 300072

Peiyang Park Campus: No.135 Yaguan Road, Haihe Education Park, Tianjin 300350

Website: <http://www.tju.edu.cn/english>

The university's School of Materials Science and Engineering prioritizes international communication and cooperation and maintains relationships with universities and research

institutes in Europe, the Americas, Asia, and Australia. "We have established a joint research center respectively with National Institute for Materials Science (NIMS) and the University of Virginia Tech," the website notes, and "also organized international conference on materials, promote the development of international first-class materials discipline."

Tongji University

Address:1239 Siping Road, Shanghai

Email: newscenter@tongji.edu.cn

Phone: 86 21 6598-2200

Website: <https://en.tongji.edu.cn/index.htm>

Tsinghua University

30 Shuangqing Rd, Haidian Qu, Beijing Shi

Phone: 86 10 6279-3001

School of Materials Science and Engineering Phone:

86 010 6279-2520 (Chinese)

86 010 6277-1723 (English)

Website: <https://www.tsinghua.edu.cn/publish/thu2018en/index.html>

School of Materials Science and Engineering webpage: <http://www.mse.tsinghua.edu.cn/en>

In 2012, the university combined its Department of Materials Science and Engineering with the Department of Mechanical Engineering's Materials Processing Division to form the School of Materials Science and Engineering. The School's research facilities include "the State Key Laboratory of New Ceramics and Fine Processing, the Education Ministry Key Laboratory for Advanced Materials, the Education Ministry Key Laboratory for Advanced Materials Processing Technology, the Beijing National Center for Electron Microscopy, and the Center for Testing & Analyzing of Materials of the SMSE," the website notes. It also "encompasses several research centers and national production-study-research bases, including the Research Center for Bainitic Steels, the Research Center of Magnesium and Aluminum Alloys Processing Technology, the Beijing High-tech Ceramic Materials and Processing National Scientific and Technological Corporation Base, and the International Research Center of Functional Materials, appointed by Ministry of Science and Technology."

University of Jinan

Address: No. 336, West Road of Nan Xinzhuang, Jinan 250022, Shangdong

Website: <http://www.ujn.edu.cn/en>

School of Material Science and Engineering webpage: <http://www.ujn.edu.cn/en/info/1010/1024.htm>

The university's School of Material Science and Engineering is home to seven research institutes for new materials, functional materials, sensors, and wall materials. "The school implements scientific researches actively," the website notes, and conducts research in such fields as "advanced materials, electronic materials, metals and metal-matrix composites, ceramic-matrix composites, powder preparation and characterization techniques, with distinct characteristics." It offers doctoral programs in "building material, nano-material, energy material and technology, electronic and information material, metallic material, material processing and forming technology, principle of material compositing and material designing." In addition to its academic focus, the school works with companies on projects in the areas of processing designs and technological innovation and "has made great contributions to technical progress of material industries" in China.

Wuhan University of Science and Technology

Address: 122 Luoshi Road, Wuhan, Hubei 430070

Telephone: 86 27 8785-8005

Email: waishi@whut.edu.cn

Website: <http://english.whut.edu.cn>

In addition to a School of Materials Science and Engineering, the university is home to state or province key laboratories of advanced technology for materials synthesis and processing, optical fiber sensing technology, silicate materials for architectures, fuel cells, and mineral resources processing and environment. See the website for directories of current projects supported by the Ministry of Science and Technology, National Natural Science foundation, and Ministry of Education or other ministries. Each page provides a description of current projects and the name and email address of the person in charge.

Zhejiang University

Address: 866 Yuhangtang Rd, Hangzhou 310058

Contact Directory: <http://www.zju.edu.cn/english/20091/list.htm>

Website: <http://www.zju.edu.cn/english>

The contact directory page includes email and phone details for the Overseas Liaison Office in San Francisco, the Faculty of Engineering's School of Materials Science and Engineering, and more.

PUBLICATIONS

Donghua University

China's Refractories

Address: No. 43 Xiyuan Road, Luoyang 471039

Phone: 86 379 6420-5958

Fax: 86 379 6420-5968

Email: chajil@lirrc.com (Prof. Chai Junlan, editor-in-chief)

Website: <http://www.china-refract.org/cr/default.htm>

The only English-language journal of China's refractories industry, this quarterly magazine is sponsored by the Sino-steel Luoyang Institute of Refractories Research Co. Ltd. (LIRR). Its subscribers represent more than 20 countries in Asia, Europe, and the Americas.

Chinese Ceramic Society

Address: No.11 Sanlihe Road, Beijing 100831

Email: Zggsyxh@sina.com

Website: <http://www.ceramsoc.com> (Chinese only)

Journal of the Chinese Ceramic Society

Email: jccsoc@vip.163.com

Website: <http://www.jccsoc.com> ■