

Advanced Materials China Quick-scan

Consulate General of the
Kingdom of the Netherlands in Guangzhou

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Introduction

Background

The Consulate General of the Kingdom of the Netherlands in Guangzhou organises a conference focussed on advanced materials on December 10, 2015. This document is primarily prepared for the Dutch audience of this conference to get a basic insight of advanced material technology in China and in particular in the Guangdong area. Chinese readers are likely already familiar with their domestic industry's capabilities. But because of that they are even more encouraged to read the quick-scan and share their feedback and opinion.

While most readers of this document are expected to have a link with the chemical industry, many will have diverse backgrounds and different interests. To get an idea of the diversity of advanced materials research the list of topics (symposia) of the China Materials Conference 2015 has been included as Appendix I to this report. There were 26 domestic symposia and four international ones, each with a different topic. This demonstrates the breadth of topics that can be addressed in this quick-scan. Needless to say a selection had to be made in order to keep this research. The company examples, industry statistics and government policies described in the document do however give a good feeling of the situation in China and the importance of advanced materials.

Goal

The goal of this document is twofold.

1. A primer on advanced materials in China.
2. A catalyst for starting discussions on China's advanced materials plans.

This quick-scan does not focus on market share or production capacity. Instead the document focusses on giving information about government policies related to advanced materials as well as examples and statistics. Whether a foreign company is intending on finding an R&D partner or wants to enter the Chinese market, it is necessary to assess the local technology level. This document is a first step in such a (continued) process.

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Policy

The Chinese central government has various policy mechanisms to control and guide R&D. Many organisations, at different levels have to interpret these national plans and regulations to their own regional situation. One of these national plans are the Five Year Plans (FYP)¹. These plans give input to existing programs like the 863 Program, the 973 Program and the Key Technologies R&D Program. For instance the previous 11th FYP initiated a project called “Ultrahigh molecular weight polyethylene fiber key technology” as part of the 863 Program.

Five Year Plans can also initiate complete new programs. The National Science & Technology Megaprojects, jointly operated by the Ministry of Science and Technology (MOST) and the National Development and Reform Commission (NDRC) are a good example of such a new program. (This program is also noteworthy because it is one of few programs not addressing new materials as a specific topic.)

While policy documents do not always seem important for daily decision-making, understanding Chinese R&D policy is equally important as having a separate patent strategy for China. For this quick-scan an advanced materials oriented summary of the current (12th) Five Year Plan policies in Guangdong and Shenzhen are given.

While it is to be expected that these plans will be updated next year in line with the upcoming national 13th Five Year Plan, it is still very informative to have a look at the existing plans. Many programs based on the 13th Five Year Plan are still being updated and implemented, plus China has the good habit of building on top of results of past/current plans.

Guangdong

As part of the “Twelfth Five Year Plan” (2011-2015) the Guangdong Province setup plans for its strategic emerging industries². In it they described Guangdong’s key (emerging) industries:

- High-end electronic information industry
- New energy automotive industry
- LED industry
- Biotechnology industry
- High-end equipment manufacturing industry

¹ Another relevant plan for national R&D policy is: “The National Medium- and Long-Term Plan for the Development of Science and Technology (2006-2020)”

² Guangdong Provincial People’s Government Office

- Energy saving and environmental protection industry
- New energy industry
- New materials industry

There definitely is some overlap between these industries. Many of the key emerging industries are relying on advances in material research. But the Guangdong government chooses to also list 'new materials industry' separately. The new materials industry is also further specified into six focus areas.

1. Advanced metallic materials. Focus on the development amorphous and nano-crystalline alloys, high-performance ferrite magnetic materials, efficient cooling material, oil and natural gas pipe and other high-performance special steels. Developing high-purity metal organic source (MO source) material, nuclear grade zirconium sponge material, and high-performance aluminum, magnesium alloy, and other high-end non-ferrous alloys and metal matrix composites.
2. New inorganic non-metallic materials. Focus on the development of flat panel displays, solar cell glass substrates and polarizers, filter materials, as well as energy saving and environmental protection ceramics, and other high-performance ceramic materials. Develop ceramics for passive electronic components and other electronic components.
3. High-performance polymer materials and composites. Focus on the development of new separators, electrolytes and other new energy materials, high-performance synthetic resins, (thermal) conductive plastic, high-grade synthetic fibers, and plastics alloys. Actively develop OLED material, non-silicon-based semiconductor photovoltaic materials, optical silicone, ABS, PMMA, and other synthetic materials.
4. Specialty chemical materials. Focus on the development of reagents in general, specifically photoresist supporting reagents and other chemicals for electronics. Actively develop electronic ink materials, high-performance green paint, efficient, versatile, food-safe adhesives and inks, and polymer process aids (PPA) .
5. New rare earth functional materials. Focus on developing high-performance rare earth luminescent phosphor materials, high performance rare earth magnetic materials, rare earth functional additives, rare earth functional materials. Actively develop high performance rare earth hydrogen storage, super capacitors and other new battery materials.
6. Forefront of new materials, primarily nano materials and meta-materials. Targeting key breakthroughs in nano materials and products, development of carbon nanotubes, graphene, nano-powder materials, nano-functional coatings, nano-catalysts nano-materials. Strengthening mechanism of meta-material, preparation, packaging and other key technology research and development, accelerate the construction of meta-materials test lines, and actively develop meta-materials used in communications, biomedical, new energy and other areas.

Shenzhen

Shenzhen is part of Guangdong, but as many other larger cities and economic zones it also has its own plans. Often these are more specific and are tailored to support local industries or even specific companies. In 2011 the "Shenzhen New Material Industry Development Plan (2011-2015)" was launched. Each year the local government allocates more than 1 billion RMB³ with the goal to 'enhance the capability of independent innovation, expand the industrial scale, and strive to build Shenzhen into an internationally renowned, leading new materials industry base.'

A few months ago the Shenzhen Development and Reform Commission released the specifications for the fourth instalment (phase) of this plan. The following key support areas are defined for this phase:

1. Semiconductor materials. Flat panel display materials, LED materials, microelectronics materials, optoelectronic materials and new generation of semiconductor materials.
2. New energy materials. Focusing on lithium-ion batteries key materials, super capacitors key materials, hydrogen high-energy storage materials, fuel cell materials, solar photovoltaic and solar thermal materials, and new building materials.
3. Biological materials. Controlled drug release materials, tissue engineering materials, bioactive materials, new materials for early diagnosis and treatment, biodegradable and absorbable biological material, and artificial blood.
4. New functional and multi-function materials. High-performance membrane materials, functional polymer materials, special glass, high-performance ceramics, high-end metals, new anti-corrosion coatings.
5. Other materials, such as meta-materials, nano materials, superconducting materials, new energy-saving materials, new engineering plastics, high-performance fiber and composite materials.

³ Source: Shenzhen Development and Reform Commission; exact amount varies based on included funding instruments

Statistics

Looking at statistics without any knowledge of an industry is ambitious at best and can easily result in erroneous conclusions. Many underlying industry specific processes and strategies are either overseen or underestimated. Having said that, statistics are often a good way to find interesting companies, institutes and trends to further investigate. Statistics are a means to an end, not an end itself.

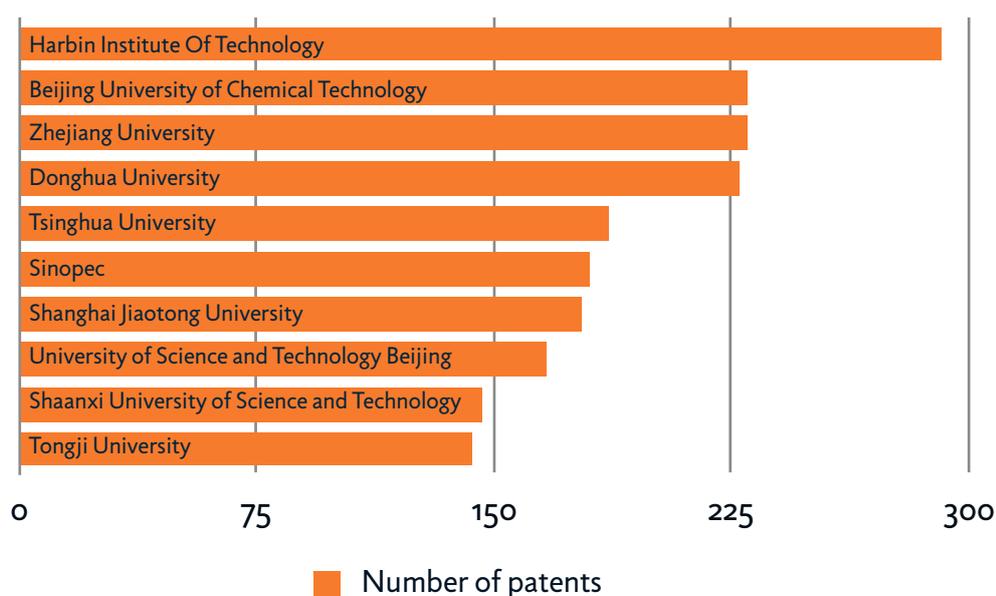
Patents

Many different patent filing strategies are often used, making easy comparison between regions and industries difficult. But by and large innovative (chemical) companies do file more patents nowadays in comparison with their less innovative counterparts in the same sector. Moreover, sectors where foreign companies are filing patents in with the Chinese State IP Office (SIPO) are deemed interesting by those companies. Looking at all advanced materials patents would not create any useful charts, as this would cluster companies together that are not related to each other. Therefore two more or less random topics have been selected: composites and battery materials.

Composites

As mentioned, caution is advised when drawing conclusions based on patent statistics. Looking at patents related to composite materials is no exception. Especially since there are many different composite technologies and applications, making overgeneralised statements an easy trap to fall into.

Granted 'composite' invention patents



Nevertheless, patents are a good way to start exploring a sector in China. The just presented bar chart represents the top-10 organisations who successfully got their composite materials patents⁴ granted in the period 2010 - 2015. Interestingly the only company in the list is Sinopec. One reason for the seemingly overrepresentation of universities is that they get their patent applications subsidised and therefore apply for many patents that are not always economically interesting. Another explanation is that several companies outsource their R&D to universities, and while these companies do file for jointly owned patents, the universities would have the numerical benefit of filing together with several companies. A third reason is that companies often file from various branches hereby lowering the total patents per legal entity.

The total amount of granted patents (28,144) that were checked for this composite material quick-scan, indicates a big and long tail to the distribution of patent applicants. Looking into that 'tail' in Guangdong quickly makes the company Shenzhen Keju New Materials⁵ stand out (see below). The company filed less composite-related patents in the past two years, but overall it is one of the most active companies in the region. Together with its parent company Keju New Materials it is also active in engineering plastics, polyimide fibers, and resin-based composite materials.

Composite patent filing companies in Guangdong:

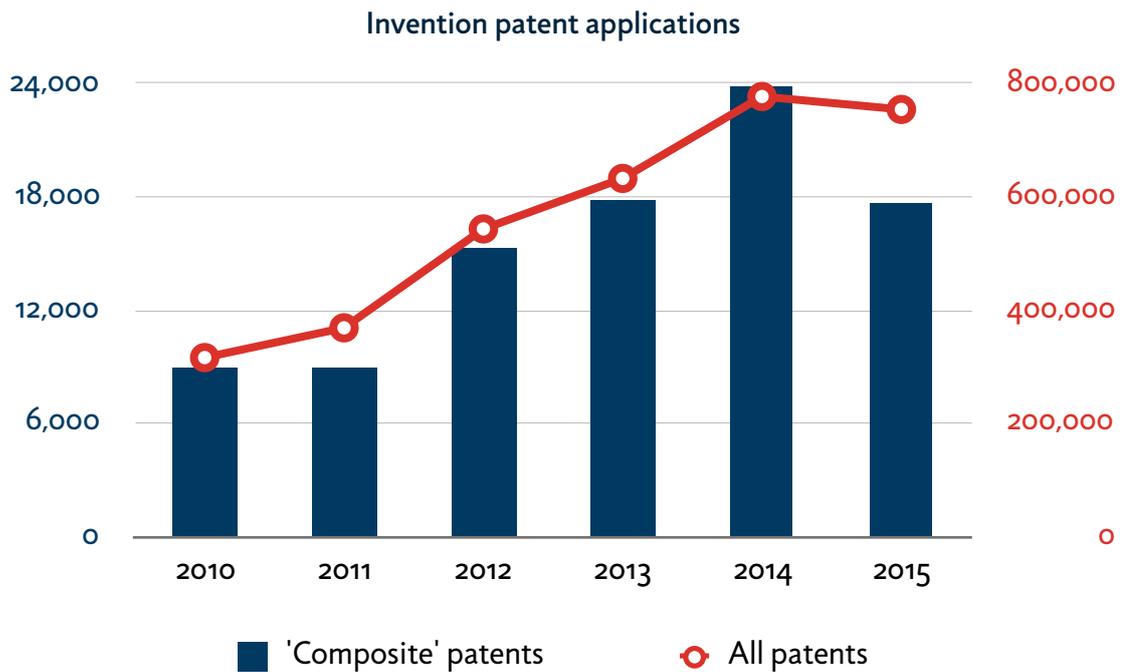
- Keju New Materials (Shenzhen Polymer Science New Materials)
- Shenzhen University
- Guangdong University Of Technology
- Guangzhou Chemistry, Chinese Academy of Sciences
- Shenzhen Guangqi Innovative Technology (Kuang Chi)
- Shengyi Technology
- Shenzhen Oceanpower New Material Technology
- Shenzhen Xingshengdi New Materials

It is often better to use granted patents instead of patent applications when exploring a sector or scout for interesting companies. However to get a notion whether or not a sector as a whole is still growing in China it is also useful to look at patent applications. Based on the graph on the next page it is fair to assume that the composite industry in terms of patent filing grows, but not faster than the average growth rate of all patent filings in China⁶.

⁴ A semantic search targeting patents ranging from nano-composites to fiber composites was performed.

⁵ Keju New Materials: 科聚新材料, <http://www.aie-world.com/>

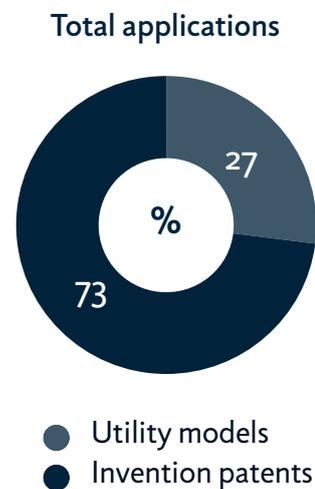
⁶ SIPO's 2014 statistics reports more filings than in their database, likely due to yet unreleased applications



Filings of composite patents have grown from an annual 10,000 patents in 2010 to almost 24,000 in 2014. As many filings have not been processed or published it is likely that the 2015 total filings for composite patents will show a continued growth.

Battery materials

New batteries require new materials or better ways of using existing ones. Given the economic potential of battery technology China is investing heavily in its research. This has resulted in about 28,000 patent applications⁷, all linked to battery materials. Most of these patents are invention patents that have to be verified by SIPO. A much smaller portion are utility models, which are granted immediately upon application and only give limited (but still useful) protection.



When looking for R&D excellence it is often better to focus on invention patents instead of utility models.

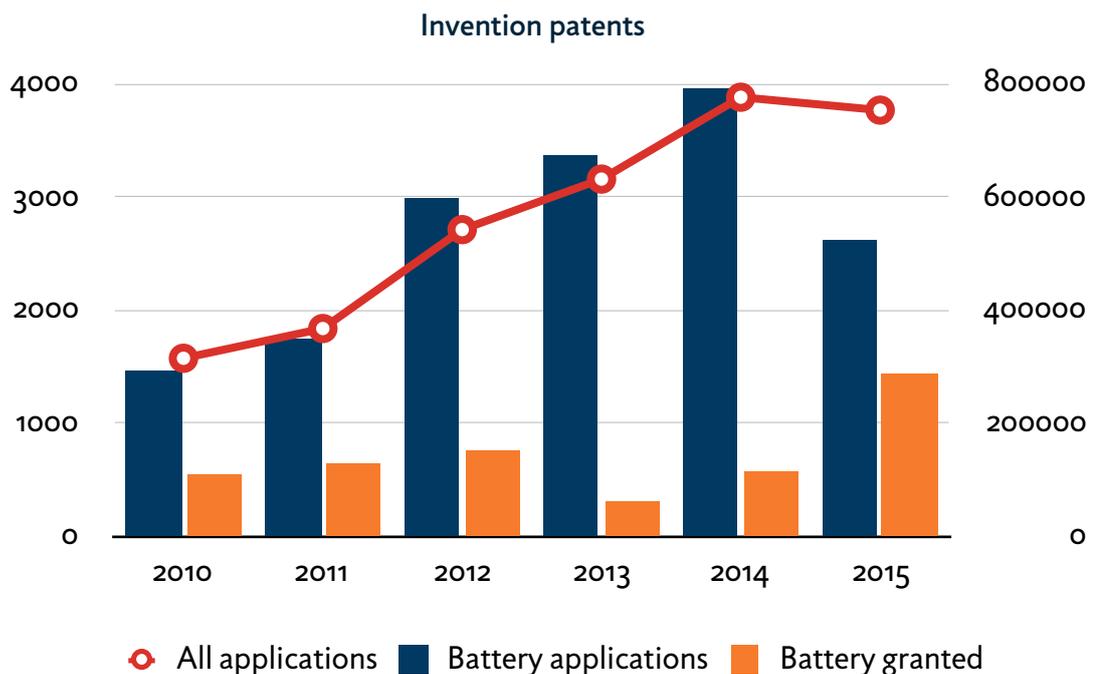
The top-10 patent applicants in this field are given below. It was to be expected that BYD would be in this list, and many Japanese companies also file heavily in China. The remaining top ranking patent filers are mainly Chinese universities not companies. As discussed before universities have a tendency to file a substantial amount of patents, this is also observed in other sectors.

⁷ A semantic search was performed targeting patents related to battery materials.

Ranking	Organisation	Total applications
1	LG Chemical	307
2	BYD	297
3	Samsung SDI	293
4	Sony	256
5	Tsinghua University	255
6	Toyota Motor	229
7	Central South University	221
8	Sanyo Electric	218
9	Zhejiang University	202
10	Sichuan Normal University	182

Battery materials, Chinese invention patent applications
Source: SIPO, Datenna

The 28,000 patent applications, or 20,000 invention patents, might seem like an impressive number. Looking at the invention patent chart below, a serious growth rate appears to be visible. But again take into account that the overall patent applications in China (the red line) have also more than doubled in the period 2011 - 2014 and it becomes clear that growth in battery technology is not exemplary in terms of amount of patents. Of course with such a high average growth of patent filings, it is hard to outrun it with any technology. What is somewhat strange is the decline of granted patent applications in 2013 - 2014, as this was not seen in the overall patent statistics. (Note: the decline in patent applications in 2015 is likely due to a regular lag in patent application information released by SIPO.)



In the general battery material patent top-10 quite some foreign companies were represented. However looking at a specific new material, such as Li-Sulfur, the lack of foreign companies in the top-10 indicates that Chinese companies are producing more patents in newer battery technology areas.

Ranking	Organisation	Total applications
1	Sichuan Normal University	63
2	Central South University	21
3	Dalian Institute of Chemical Physics	20
4	Tsinghua University	19
5	Shanghai Jinzhong Information Technology	15
6	Beijing Institute of Technology	13
7	Samsung SDI	13
8	Zhejiang University	13
9	Lanzhou University of Technology	11
10	Xiamen University	11

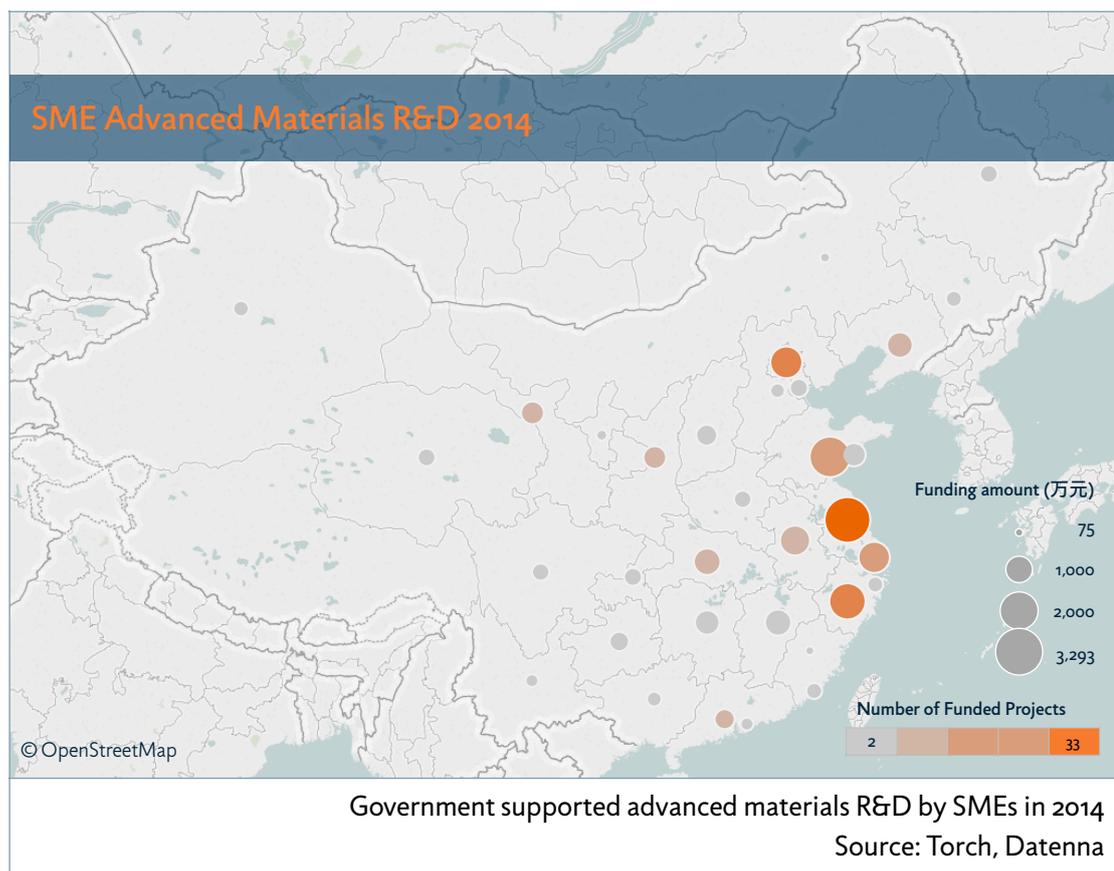
Li-Sulfur battery materials, Chinese invention patent applications
Source: SIPO, Datenna

It is likely, but not examined, that other new battery material technologies show similar signals. Recent examples in both domestic and international news reports indicate that China is indeed making progress with various different battery materials. Especially great emphasis is put on researching carbon nanotubes (CNT), graphene and graphdiyne.

SME R&D Funding

In the chapter 'Policy' various R&D programs were already discussed. These programs are mainly focused on universities, CAS institutes and larger companies. However under the Ministry of Science and Technology (MOST) there is also a program called China Torch Program operated by the Torch High Technology Industry Development Center. This program aims to promote innovation in small and medium-sized (SME) companies.

Looking at about 3,700 funded R&D projects in 2014, about 271 could be marked as related to advanced material research. These 271 projects were plotted on a map of China. The size of the circle indicates the total amount of funding in that region, the color indicates the number of projects. There is a strong correlation between the total amount of funding and the number of projects, though some region do tend to allocate more funding per project than others.



It is instantly clear that the "Go West" campaign has not worked yet for material research under SMEs. It is still the coastal areas that are highly represented in these projects. Whether it is the government focus or a lack of suitable funding applications, that is something not apparent from this map.

Companies

Even though SME companies do not seem to be involved with many government funded SME projects, there are many companies in the Guangdong conducting advanced material research. The following list gives the reader an initial overview of companies that the province of Guangdong has to offer. Needless to say this isn't even the tip of the iceberg.

Baoan

Website: <http://www.chinabaoan.com/>

Their high-tech industry group has several companies in its portfolio in various materials related industries. There is a strong focus on energy materials, but they are also active in ceramics and carbon fibers.



BYD

Website: <http://www.byd.com/>

Most of its material research is focused on rechargeable batteries. Their usage of (advanced) materials stretches out into many sectors, such as cell phones, solar power, and LED.



Capchem

Website: <http://www.capchem.com/>

The company is specialized in R&D and manufacturing of advanced electronic chemical products; dealing with lithium-ion batteries, supercapacitors, photoelectric polymer materials, semiconductor chemicals, chemical reagent, etc.



EON

Website: <http://www.e-ande.com/>

Their research is focused on light alloy materials (such as magnesium and aluminum alloys). The company is also active in lightweight alloy precision die-casting, and mold design.



JPMF

Website: <http://www.jpmp.com.cn/>

JPMF is one of the largest manufacturers of ferrite magnets in China. research on high grade hard and soft ferrite materials is done together academic institutions such as Huazhong University of Science and Technology and Wuyi University.



Kuang-Chi

Website: <http://www.kuang-chi.com/>

Kuang-Chi was already mentioned in the composite patent ranking, but should also be listed here. The company is highly specialised in metamaterials that can be used for RF electromagnetic waves, microwaves and millimeter waves, infrared electromagnetic waves, and optical waves.



Kingfa

Website: <http://www.kingfa.com.cn/>

Another company that cannot be omitted from this list is Kingfa. The company has a broad scope of products related to engineering plastics, modified plastics, fine chemical materials, biodegradable plastics, carbon fibers and carbon fiber composites.



Woer

Website: <http://www.woer.com/>

Conducted R&D and provided materials for China's High-Temperature Superconducting Power Cable project. Strong focus on (also lower tech) thermal products.



Appendix I - Chinese Materials Conference 2015

List of topics (symposia) that were on the agenda of the Chinese Materials Conference 2015.

Source : <http://www.c-mrs.org.cn/cmcc2015/en/page.asp?hid=&pageid=71.html>

International Topics

- AA. Multifunctional composites and Meta-composites
- BB. Amorphous and high entropy alloys
- CC. Serration and Noise Behavior in Advanced Materials
- DD. Magnesium Alloys

Domestic Topics

- A. Photocatalytic Energy Materials
- B. Functional Materials for Environment
- C. Energy Conversion and Storage Materials
- D. Thermoelectric Materials and Devices
- E. Advanced Materials of Oil and Gas Fields
- F. Low Dimensional Materials and Devices in Extreme Conditions
- G. Microelectronics and Optoelectronics Materials
- H. Ferroelectric and Oxide Electronic Information Materials
- I. Multiferroic Materials
- J. Superhard Materials
- K. Preparation and Application of Superconducting Material
- L. Bulk Nano Ultra-fine Crystal Materials
- M. Biomedical Materials
- N. Advanced Ceramic Materials
- O. Polymer Materials
- P. Functional Elastomer Materials
- Q. Shape Memory and Self-healing Polymeric Materials
- R. Advanced Metal Matrix Composites
- S. High Temperature Structural Materials and Coating
- T. High Performance Titanium Alloy
- U. Powder Metallurgy
- V. Piping and pressure vessel materials
- W. Advanced Preparation and Processing of Materials
- X. Application of Advanced Characterization Methods in Materials Science
- Y. Materials Evaluation and Service Security
- Z. Materials Simulation, Calculation and Design
- FA. Materials Education Forum
- FB. New Materials Enterprises and Experts Forum
- FC. Forum for Materials Science and Technology Journals
- EM. 2015 New Equipment Exhibition for Materials Laboratories

Appendix II - List of Acronyms Used in the Report

863 Program	National High-tech R&D Program
973 Program	National Basic Research Program
FYP	Five Year Plan
MOST	Ministry of Science & Technology
NDRC	National Development and Reform Commission
R&D	Research & Development
RMB	Renminbi
SIPO	State Intellectual Property Office