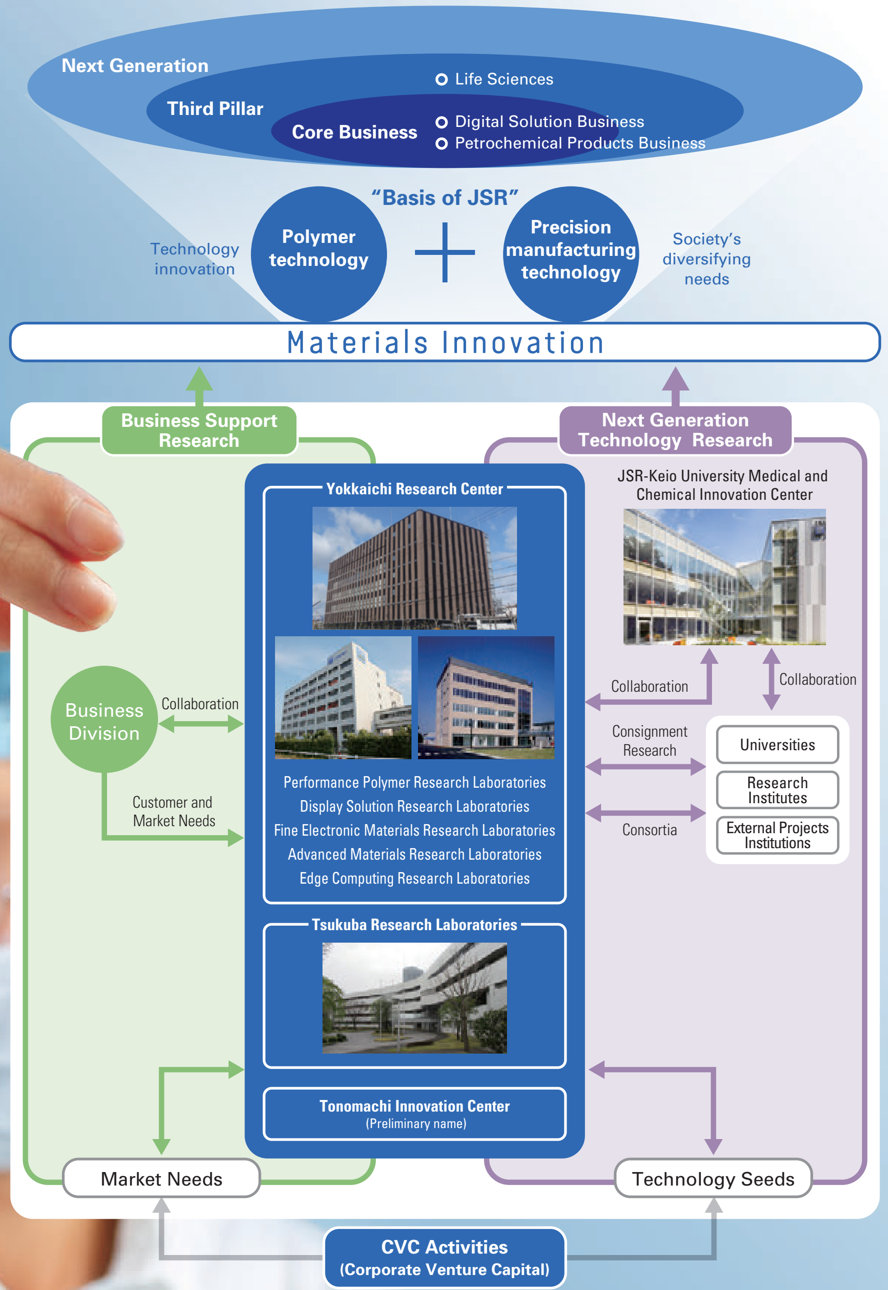
EVOLVING TECHNICAL CAPABILITIES



With deep expertise in its core polymer and precision manufacturing technologies, the JSR Group has widened the scope of its technological domains by integrating technologies from disparate fields such as photochemistry, inorganic chemistry, precision processing, and bio-technologies. In this way, the Group has advanced R&D activities, and its accumulated efforts have enabled it to develop unique strengths relative to chemical companies worldwide, which is our driving force to expand superior materials and technologies globally.

The JSR Group's main R&D centers are located in Yokkaichi City in Mie Prefecture and Tsukuba City in Ibaraki Prefecture. There we carry out R&D activities aimed at tracking swiftly evolving societal needs such as the changes emanating from the digital revolution.

Our R&D mission can be broadly divided in two categories: "business support research" for business domains we are developing, and "next-generation technology research," such as novel and applied research for peripheral fields. In promoting research, we emphasize close linkages in the Group's value chain, ranging from market development to process development and manufacturing technology development, and extending to manufacturing, sales, and distribution. We also promote integration within the system, with researchers themselves making direct contact with customers to uncover their needs. Moreover, we are enhancing technical services in various countries and building a system capable of providing global and timely support for customers' business activities.

For next-generation technology and seed research, it is necessary for R&D to anticipate latent market needs. Particularly in the case of new R&D fields, we promote open innovation such as joint research with universities and research institutions in Japan and overseas. We have established the JSR-Keio University Medical and Chemical Innovation Center (JKiC), a joint research facility on Keio University's Shinanomachi campus, which opened in October 2017. We will create innovation through investigating the wholly-novel concept of fusing medicine and chemistry, which will lead to practical technologies that contribute to global society with people living long and healthy lives.

We are now planning to open a new innovation center in the field of life sciences and materials informatics in the Tonomachi area of Kawasaki city, Kanagawa prefecture to acceralate R&D activities through collaboration with universities and start-ups.

1. Advanced Simulation Technology, Machine and Deep Learning

① IBM Q

IBM Q is the name of the quantum computer provided by IBM. The IBM Q Network is the world's largest network consisting of various private companies, universities, and public research institutions with the aim of utilizing quantum computers in different forms. JSR participates in the IBM Q Network as a member company of the IBM Q Network Hub at Keio University and also participates as an IBM Q Network Partner.

The fastest practical application of quantum computers is expected to be simulations using high-precision quantum chemical calculations. When this technology is perfected it is expected to drastically reduce experimental trial and error testing, having an immeasurable impact on material development. JSR is working on the development and acquisition of quantum chemical calculation technology focused on actual materials

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through the IBM Q Hub, etc., and is also looking at applications for the tests. It is expected to take several years, possibly more than ten, to put an actual quantum computer into practical use. However, development of algorithms and the identification of major use cases are expected to be completed by then with these being published in papers and patented at the current time.

IBM Q Network Hub at Keio University

② MI and Enthought

JSR is pushing forward with cross-organizational efforts in order to promote a digital transformation in R&D based on material informatics (MI).

In addition to various computer experiments and simulations, including first-principle calculation aimed at developing materials through cyber-space experiments as opposed to chemical experiments in the real world, we are working to establish underlying technologies such as advanced analytics, including machine learning. These technologies have been brought about by dramatic improvements in computer capabilities, but in the latter half of the 2020s, as more disruptive technologies, quantum computers and brain-type chips become ever more powerful, we believe that completely different methods for developing materials will be achieved.

In collaboration with Enthought, Inc., JSR has been working on the development of a data management system and various simulation technologies with an eye towards applications for actual product development. In the data management system, as a platform for data utilization such as machine learning, JSR has built a database of various materials and an automatic management tool for experimental results. By involving engineers with full knowledge of the current development process, in addition to placing importance on how easy the system will be to use in the workplace, we are expecting there to be a number of benefits including a big change in the current development process.

Through these efforts we will promote the development of data science with a business perspective, and not only improve efficiency, but also create real value for business. Furthermore, we will aim to create new businesses in the future.

2. Factory IoT

① Drones

Using drones to inspect facilities and for routine patrols dramatically improves our ability to collect information. Drones are able to improve security and reduce workloads by managing information history and automatically assessing equipment corrosion through image analysis.

The Kashima Plant began using drones for equipment inspection in its non-hazardous material area in 2017, and based on the March 2019 guidelines regarding the safe operation of drones at plants issued by the Ministry of Economy, Trade and Industry, the Ministry of Internal Affairs and Communications, and the Ministry of Health, Labor and Welfare, we carried out drone flights to inspect hazardous facilities from above the ground during regular repairs in June. Inspecting high places is labor-intensive with setting up scaffolding, expensive, and highly dangerous work. By continuing to carry out drone inspections, as well as increasing safety by eliminating the dangers associated with inspecting high places, we are promoting smarter work practices and improving visual inspections with more "eyes" to check our facilities.

Inspections using drones

② Smart Industrial Complex

The skills and know-how of experienced technicians with their tacit knowledge will, by using digital technology, be converted into explicit knowledge and utilized as such. More specifically, a platform will be built leveraging smart sensors and wireless technology to automatically collect and analyze unstructured data, such as motion images and sound recordings, from plant operation management and maintenance tasks performed by experienced technicians in the chemical products production process. This data will then be combined with data from machine equipment such as distributed control systems (DCS). In the future we will develop a solution that can present operators with more informed decisions using a machine learning algorithm in real-time, and we will continue to demonstrate and implement the functions and foundations required for next-generation smart industrial complexes.

Chiba Plant

③ Virtual Reality

Since the latter half of the 1990s, automation of plant equipment has progressed, reducing field work and greatly improving safety. The younger generation of workers who haven't had the opportunity to get to know the difficulties or troubles of operating the plant experience simulations of work training, occupational accidents, and equipment accidents using virtual reality headsets. Unlike paper-based manuals, through these kinds of simulations, workers are able to get an idea of the dangers that can happen in the field ensuring they don't make the same mistakes in real life.

Work training in virtual reality

3. Open Innovation

① JKiC

The Company and Keio University have established a joint research building, JSR-Keio University Medical and Chemical Innovation Center (JKiC), positioned as a base for collaboration among industry, academia, and medicine.

This kind of collaboration between a university medical school and a chemical materials manufacturer is the first of its kind in the world.

Through close collaboration with researchers from Keio University's medical department and

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hospital, who are developing basic through to clinical medicine and medical care, and JSR chemical materials researchers, who are developing advanced materials and products positioned as a strategic business in the field of the life sciences, we will realize a wide range of needs and advanced ideas in the medical field, conduct research and create businesses that lead to the establishment and spread of new diagnosis and treatment techniques, and medical support technologies that support a society of health and longevity.

At JKiC, where medical viewpoints and knowledge of material development come together, we plan to provide various solutions in the fields of health and longevity research based on new types of diagnosis and treatment techniques, medical support technologies that use digital health and 3D printing, and genome analysis.

While ensuring there is adequate space for promoting collaboration among industry, academia, and medicine, we will establish a department matches medical needs with the seeds of technology, working on new innovations in Japan where the advances of age far exceed those of any other country in the world. By delving into a completely new concept of fusion between medicine and chemistry, we will create innovations and establishing practical technologies that contribute to a world of health and longevity.

JKiC

② Center of Materials Innovation

The research and development base in the Yokkaichi Plant is made up of 5 laboratories; the Performance Polymer Research Laboratories concerned with the Petrochemical Products Business, the Display Solution Research Laboratories, the Fine Electronic Materials Research Laboratories, and the Edge Computing Research Laboratories concerned with the Digital Solutions Business, and the Advanced Materials Research Laboratories which develops new materials not connected with any existing business with the help of free-thinking researchers. The main purpose of our new research building will be to focus on research to create new businesses. To this end, we will establish a flexible research system, in close collaboration with the five research laboratories, to enable quick response to users' situations by setting research areas that anticipate market needs. Furthermore, in order to enhance our ability to create innovation, which is the source of our sustainable competitiveness, we utilize this new building to create an environment where adventitious communication and collaboration between different fields from each laboratory can flourish and research activities in collaboration with external parties as a base for open innovation can be promoted.

Center of Materials Innovation

4. Mass Production Expertise

① SSBR Global Manufacturing

New materials developed by researchers will be scaled up from the laboratory to plant production facilities, and advanced to the commercial production stage. To do this, we must not only realize function and performance but also develop safe and simple processes with low manufacturing costs. Materials with superb performance born in the laboratory cannot enter in the market unless they can be produced stably and economically. There are many things that work perfectly well in the laboratory but not at the scale of commercial production. By combining the materials produced through research and development with the best production processes and the best equipment design, we will surely acquire more business opportunities.

② Precision Manufacturing Technology for Semiconductor Materials and Display Materials

When manufacturing semiconductor materials, such as photoresist, and display materials, such as alignment films, a clean environment is required to prevent contamination of foreign substances. In particular, strict particle control is necessary for semiconductor materials as required pattern size is getting tighter.

Semiconductor materials and display materials are manufactured in a special room known as a cleanroom*[1] where air particles are removed and controlled at very low level. After raw material mixing, filtration*[2] takes place by a fine filter to remove any tiny, invisible foreign substances.

One of the major differences to the production of synthetic rubber is that manufacturing takes place using super pure raw materials in a super clean environment. Products are automatically filled into shaded bottles at very clean environment. Because semiconductor materials and display materials react when exposed to light, shaded bottles are required. Those bottles are thoroughly washed with ultrapure water*[3] (super DI water), which is free from fine particles and ions.

Considerations must also be given to environment control such as temperature and humidity for storing and transporting products. Temperature control is vital for materials used in semiconductors and LCD TVs to maintain quality. Each product is stored within a specified temperature range and vehicles capable of constant temperatures are used for transportation. One of the strengths of JSR is its ability to consistently mass-produce while carrying out strict quality control.

*1 Cleanroom
Designed to maintain extremely low levels of airborne particles. In normal air approximately 1 million minute dust particles, that are about 1 / 100th thickness of a hair, are present in 1 cubic foot*, but at the cutting-edge semiconductor manufacturing site, the number is confined to 10 or less.
* approx. 30 x 30 x 30 cm

*2 Filtration
The separation of tiny, invisible foreign matter from liquid products.

*3 Ultrapure water
Water with the highest levels of purity obtained by removing impurities such as ions, organic substances and gases from the water.

Cleanroom for photoresist manufacturing