

Research and Development

Showa Denko and its Group companies are promoting R&D in line with the medium-term consolidated business plan “PEGASUS,” allocating resources preferentially to the two business domains of “Energy/Environment” and “Electronics.” We are pursuing our strategy of promoting the interconnection of inorganic, aluminum, and organic chemical technologies, while attaching great importance to marketing activities both at home and abroad. We are also focusing on early manifestation of fruits of businesses that will lead the growth of our Group in the future, including businesses of advanced battery materials, high-performance optical films, SiC epitaxial wafers, and plant factory systems.

Moreover, in order to strengthen our technologies and expand our businesses in line with “PEGASUS Phase II,” which we launched in 2014 as the latter half of “PEGASUS,” we are now strategically allocating our R&D resources preferentially to “Base (Growth)” and “Growth” businesses such as hard disk media, functional chemicals, and high-purity aluminum foil. In the same context, we are also allocating our R&D resources preferentially to businesses in the category of “New Growth,” which we expect to become our key businesses in the next generation.

To be specific, in order to strengthen our existing key businesses, we are working on acceleration of development of hard disk media with more storage capacity, expansion of uses of composite materials made from functional chemicals, and performance improvement of high-purity aluminum foil for domestic customers.

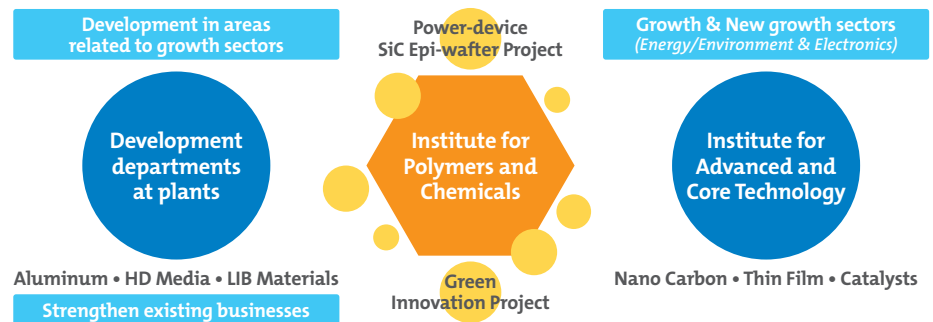
As for the “New Growth” businesses, we are preferentially allocating our R&D resources to anode materials for lithium ion batteries, for which the demand continues to grow as applications for smartphones and tablet PCs, and for SiC epitaxial wafers, which are used in power devices with more energy efficiency and the demand for such devices is expected to grow in the medium- and long-term perspective.

On the other hand, we terminated development of VGCF™-X and organic electroluminescence lighting devices, and reallocated R&D resources to more promising themes.

R&D Organization

We continue to have R&D organization that assembles technical experts for specific areas at the Business Development Center. The Center consists of two laboratories (Institute for Polymers and Chemicals, and Institute for Advanced and Core Technology), two technical assistance centers serving all business segments (Analysis & Physical Properties Center, and Safety Evaluation Center), and two projects for commercialization (Power-Device SiC Epitaxial Wafer Project, and Green Innovation Project). Institute for Polymers and Chemicals, in cooperation with divisions and plants, performs R&D to add value to existing businesses and products, R&D to cultivate promising peripheral areas of existing businesses and products, and strengthens businesses through provision of advanced technical support for products. Institute for Advanced and Core Technology promotes creation of next-generation business themes focusing on promising core materials and core technologies that enable us to take advantage of our long-term strong points, selected from our wide-ranging proprietary materials and technologies.

Showa Denko and its Group companies invested ¥20,362 million (US\$169 million) in R&D in 2014. A breakdown by segment of R&D efforts and investments during the year is as follows:



Research and Development (cont.)



Petrochemicals

To cope with expected tighter butadiene supply-demand balance in the future, we are vigorously developing processes to produce target butadiene products with improved efficiency, utilizing our proprietary catalyst technologies and business base.

As for acetyl and allyl alcohol products, we are improving performance of existing catalysts and developing new catalysts in order to boost the competitiveness of our products.

We are promoting intensive marketing of our proprietary heat-resistant transparent film *SHORAYAL™* (based on our spectacle lens technology) focusing on the market of materials for displays of mobile devices. Being appreciated for its good optical properties comparable to glass and a smooth feel, *SHORAYAL™* is successfully applied to an increasing number of devices both at home and abroad.

The Petrochemicals segment invested ¥989 million in R&D in 2014.



SHORAYAL™ pilot plant



Chemicals

Regarding “*Shodex™* column,” which is our proprietary high performance liquid chromatography column, we are developing columns applicable to leading-edge technologies, focusing on the markets in advanced countries, and, at the same time, actively cultivating the markets in emerging nations. As for the development of high-performance gel, we are strengthening our R&D system by taking advantage of technical synergy we have obtained through cooperation with a gel developing and manufacturing company in Austria, and conducting sales campaigns for our products in the business field of bio-pharmaceutical manufacturing.

As for base materials for cosmetics, in addition to high-performance vitamin C derivative *Apprecier™*, we are making preparations for launching various new compounds, including methyl hesperidin and carnitine derivative “*Hi-Carnitine.*” In the area of LIB-related materials, we started volume production of “*Polyso™* LB Series” water-based anode binder.

The Chemicals segment’s R&D investment amounted to ¥2,307 million in 2014.



Shodex™ column



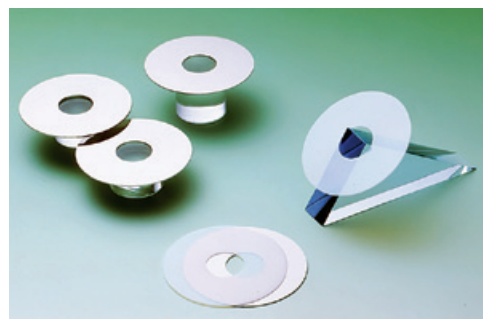
Electronics

Aiming to realize volume production of next-generation HD media with higher performance, we are developing shingled magnetic recording (SMR) and heat assisted magnetic recording (HAMR) technologies that will further increase recording density. Meanwhile, we started volume production of 3.5-inch HD media with the world best recording capacity of 1.1–1.3 terabyte per platter, using perpendicular magnetic recording (PMR) technology, which we commercialized for the first time in the world.

Regarding four-element (aluminum, indium, gallium, and phosphide) light emitting diodes, with our proprietary technology we have developed LED chips that emit red light with a wavelength of 660nm, the optimum light for accelerating the growth of plants. These LED chips are used as light sources in many plant factories and model facilities for plant cultivation.

In the area of rare earth magnetic alloys, we are working on further development of technology to produce neodymium-based magnetic alloy that does not contain dysprosium (Dy) but gives the same performance as conventional products in which Dy is added to increase heat resistance.

The Electronics segment invested ¥4,968 million in R&D in 2014.



HD media



Inorganics

We are developing filler materials with high heat dissipation and electrical insulation properties to be used in electronic and power devices.

We have developed *LUMI-RESH™* photocatalyst, which performs high antibacterial and antiviral functions even under visible low-energy light emitted by indoor lighting apparatus. We are opening up new avenues of use for *LUMI-RESH™*, including use in houses, public facilities, and plant factories. In July 2014, *LUMI-RESH™* started to be applied to an indoor-use membrane building material and high-performance curtains to add antibacterial and antiviral functions to these products, in its debut on the market.

The Inorganics segment spent ¥294 million on R&D in 2014.



Curtains containing LUMI-RESH™



Aluminum

Regarding our proprietary *SHOTIC™* aluminum products, we are developing processed aluminum products with gas pressure hot top continuous casting process and gas pressure completely horizontal continuous casting process as core technologies, which we have developed proprietarily, as well as with our forging technology. We are developing continuously cast aluminum rods and forged aluminum products with higher performance for car applications, in order to respond to growing demand for cars in the Asian market.

As for base technologies, we are improving our die technology for extrusion, forging, drawing, and press working; our process technologies for purification, fabrication, and bonding; as well as our simulation technology for structural and hot fluid studies.

The Aluminum segment's R&D investment amounted to ¥1,657 million in 2014.



SHOTIC™: aluminum forged products



Others

In the area of advanced battery materials, we are continuing to develop materials and components that will ensure sufficient capacity, output, life, and low electrical resistance in LIBs for various applications including electric vehicles and mobile devices, such as smartphones. We are providing such solutions as *SCMG™* graphite anode material, high-capacity Si-graphite composite anode material, *VGCF™* carbon nanofiber, and *SDX™* carbon-coated aluminum foil.

As for SiC epitaxial wafers, which attract people's attention as materials for next-generation power devices, we continue working on quality improvement including reduction of crystal defects, as well as production capacity expansion through addition of facilities and improvement of production technologies. More specifically, in 2014, we expanded our production capacity of SiC epitaxial wafers with a diameter of six inches, of which we had started commercial shipments in 2013.

Regarding components for plant growth facilities, we are working to develop the market by offering our Group's products including lighting equipment containing our proprietary ultra-bright LED chips, in combination with licensing of a high-speed plant cultivation technology, the *SHIGYO™* method, which we developed jointly with Yamaguchi University. Our plant factory systems continued to be adopted by many LED-based plant growth facilities in 2014.



SiC epitaxial wafers

Research and Development (cont.)

With regard to printed electronics, we developed printable silver nanowire ink jointly with Osaka University. The product enables free formation of patterns through printing. We are developing its applications, including transparent conductive film.

Furthermore, we are developing fuel cell catalysts that will display high levels of activation with a lower platinum content, when compared with conventional catalysts.

In the field of carbon materials, we are working on technical development to improve our productivity of fullerene, aiming to expand our fullerene business. We are promoting production and sales of nano-carbon products including fullerene via Frontier Carbon Corporation, which we jointly operate with Mitsubishi Corporation. Fullerene is a molecule composed entirely of carbon, and is one nanometer in diameter. It is expected to become a promising resource in the field of electronics to be used, for example, as an anode material for organic thin-film solar cells.

R&D expenditures in 2014 in the Others segment, including common activities, totaled ¥10,146 million.



Cultivation of vegetables using an LED light source



Fullerene products

Intellectual Property

Acquisition of intellectual property rights and establishment of patent networks

As the majority of Showa Denko K.K. (SDK)'s businesses are operated globally, we aggressively apply for patents in foreign countries with the aim of supporting those businesses from the intellectual property side.

The chart shown below is a composition of data shown in "Japan Patent Office Annual Report 2014" and SDK's own data on the number of applications for patents. It illustrates that SDK's global application ratios has been about 10% higher than those of all applicants in Japan.

We also make every effort to secure our superiority based on intellectual property rights, especially in the principal businesses and newly developed important products by establishing patent networks.

Risk management

SDK's "Our Code of Conduct and Its Practical Guide" stipulates that we should respect other parties' intellectual property rights. Therefore, in 1996, we built a patent monitoring framework to constantly grasp trends in the intellectual property rights of other parties. In 2005, we started computerizing of this framework. In 2011, we introduced "Sharesearch," a company-wide patent search system developed by Hitachi, and established a framework that enables us to monitor foreign patents as well.

