



# Intellectual Capital

Idemitsu group will continue to create innovations that contribute to solving social problems such as climate change through the development of leading-edge technologies in various fields that has been

cultivated over the years through the development of petroleum products.

## Our Research and Development System

Our R&D system is comprised of "Advanced Technology Research Laboratories", which supervises corporate R&D, and research laboratories in each department. Each of them carries out specialized development. In addition, we established "Research and Develop-

ment Committee" as the company-wide organization to not only examine the direction of company-wide research and development, strategies, and issues, but also to deepen cooperation among laboratories and to strengthen technological capabilities.

Segment and name of laboratory		Outline of Initiatives	
Corporate R&D	Environment & Energy Research Laboratory	■ Research on climate change measures (Biofuels and Biochemicals), development of biological materials and high performance materials	
	Frontier Materials Development Laboratory	■ Development of advanced functional materials	
	Advanced Battery Materials Research Laboratory	■ Development of advanced battery materials related with all-solid-state lithium ion battery and lithium recovery technology	
	Atsugi Research Center	■ Research on climate change measures (Artificial photosynthesis and biomass conversion technology) ■ Development of high-performance inorganic thin film semiconductors and devices	
	Analytical Technology Center	■ Providing advanced analysis and solutions to a wide range of fields throughout the group	
Petroleum segment	Technology & Engineering Center	■ Technology development in the area of engineering design, construction, operation, quality control & assurance, and asset integrity & reliability ■ Technology-driven contribution to existing and new businesses	
Functional materials segment	Lubricants Research Laboratory	■ Research and development of lubricants and tribology (lubrication technology)	
	Lubricants	Idemitsu Lubricants America Corporation R&D Center Idemitsu Lube (China) Co., Ltd. Research & Development Center Idemitsu Lube Asia Pacific Pte. Ltd. R&D Center	■ Local-based research and development of lubricants ■ Global development of lubricants products and technologies with the Lubricants Research Laboratory (Japan) as the mother research center ■ Rapid product development and provision of technical services to meet local needs in overseas
		Nippon Grease Co., Ltd. Technical Research Laboratory	■ Research and development of grease, rust prevention oil, cutting oil, etc.
		Advanced materials & Performance chemicals	Performance Materials Laboratories
	Idemitsu Unitech Co., Ltd. R&D Center for Plastic Products		■ Research and development for resin processing product
	Lion Idemitsu Composites Co., Ltd. Composite Materials Research Laboratory		■ Design, development and analysis of customer grades of composite materials that meet customer needs
	Electronic materials	Electronic Materials Development Center	■ Research and development of OLED materials
		Idemitsu OLED Materials Europe AG	
		Advanced Electronic Materials Development Group	■ Research and development of special polycarbonate resins and functional coating agents
	Asphalt	Inorganic Materials Development Group	■ Research and development of oxide semiconductor materials
		Bitumen R&D Section	■ Basic research on asphalt and its applications ■ Development of high performance asphalt
	Agri-Bio	Agri-Bio Technology Section	■ Development of active ingredients for pesticides and feed additives derived from microorganisms and natural products
		SDS Biotech K.K. Tsukuba Research & Technology Center	■ Development of safe and useful products for the protection of livestock and plants and prevention of diseases
Lithium-ion battery material	Battery Material Development Center	■ Development of sulfide-based solid electrolytes for practical application of all-solid-state lithium ion batteries	
Power and renewable energy segment	Office of Next Generation Product Development		
	Solar Frontier K.K. Atsugi Research Center	■ Research and development of CIS solar cells	
Resources segment	Coal & Environment Research Laboratory	■ Only private research institute specializing in coal ■ Provision of technology services that anticipate needs and development of clean coal technologies to meet the needs of a low-carbon society	

## Utilization of Intellectual Property

We have established the Intellectual Property Department to supervise intellectual property. The Intellectual Property Department supports our business development and activities to increase the brand value of its products by collaborating with its business department and R&D departments to apply for, secure, maintain and utilize intellectual property rights, such as patents and trademarks.

### Promotion of Intellectual Property Activity Plans

We use the PDCA cycle to formulate IP Activity Plans based on the "Intellectual Property Strategy Council" headed by the general managers of each department. The departments, research laboratories, and the Intellectual Property Department work together to promote to solve priority issues. We have also introduced the "Unit Structure" which efficiently solves problems in a wide range of business fields, from petroleum to functional materials, in accordance with the characteristics and strategies of each business. By doing so, each unit can smoothly carry out intellectual property activities such as search and analysis of patent information, patent prosecution, negotiations, planning, and administration.

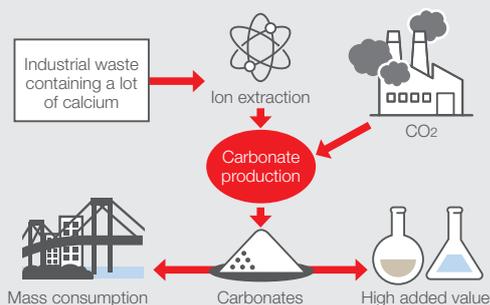
In the petroleum field, we have entered into a cross-licensing agreement and are working to strengthen our competitiveness by reducing costs by making available patents from both parties. In the lubricants field, we have a large share of the global market for refrigerating machine oil, which is one of our strengths, and we have established global patent portfolios.

Because market growth is expected in OLED business, the core field of the electronic materials business, we have entered into alliance agreements with companies in Japan and overseas that hold useful patents related to OLED materials, enabling the mutual use of patents in specific fields. Through these and other measures, we are working to create and expand businesses while expanding the areas in which development is possible.

### TOPICS 1

#### Carbonate production

Our company, with the participation of Ube Industries, Ltd., JGC Corporation, and several universities, established the "CCSU (Carbon dioxide Capture and Storage with Utilization) Study Group" as an industry-university collaboration to develop new technologies that convert CO<sub>2</sub> emitted from thermal power plants and factories into resources by utilizing industrial waste containing a large amount of calcium. As the Japanese government promotes the development of technologies for CO<sub>2</sub> recovery and other measures to combat global warming, we are working on the development of new technologies that utilize industrial waste containing high levels of calcium and other substances to react with CO<sub>2</sub> for production of carbonate and added-value materials.

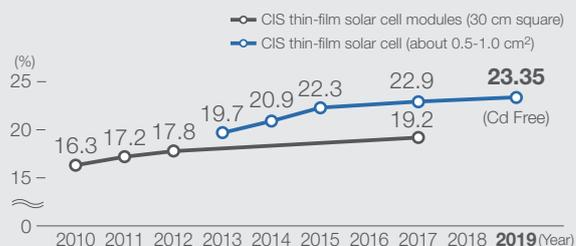


### TOPICS 2

#### Development of CIS solar cell technology

At the Atsugi Research Center of Solar Frontier K.K., we are engaged in leading-edge research and development related to CIS solar cells, aiming to improve energy conversion efficiency at both the research and commercial production levels, as well as developing new applications and developing advanced next-generation products with market development potential. In January 2019, a joint research project with the NEDO (New Energy and Industrial Technology Development Organization) led to the achievement of a world record energy conversion efficiency of 23.35% for the cadmium-free CIS solar cell (Cd-Free CIS solar cell)'s cell (about 1 cm<sup>2</sup>). This record is approximately 0.4 percentage points higher than the highest conversion efficiency of 22.9% (Achieved by our company in November 2017) for cadmium-containing CIS solar cells, and represents the highest conversion efficiency in the world for all CIS solar cells. By applying basic technologies, we are working to lower costs by increasing the output of panels and to deliver environmentally friendly and economical products to customers.

#### History of Solar Frontier's Renewal of the World's Highest Conversion Efficiency



### TOPICS 3

#### Artificial photosynthesis

We have succeeded in the direct synthesis of methane and other hydrocarbons from water and CO<sub>2</sub> using a gas diffusion electrode loaded with our original catalysts.

We will continue developing the gas diffusion electrode to advance research on artificial photosynthesis. By 2030, we will establish technology to produce valuable materials such as hydrocarbons and alcohols from water and CO<sub>2</sub> using renewable energy sources with high efficiency. Through the reuse of CO<sub>2</sub>, we will contribute to realizing a sustainable society.

