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Toyo Tanso R&D Strategy

Held on October 8, 2019

Toyo Tanso Co., Ltd.

1. R&D Direction

Naotaka Kondo,
Representative Director,
Chairman & President, CEO

Low of Products and Technology Development for Toyo Tanso

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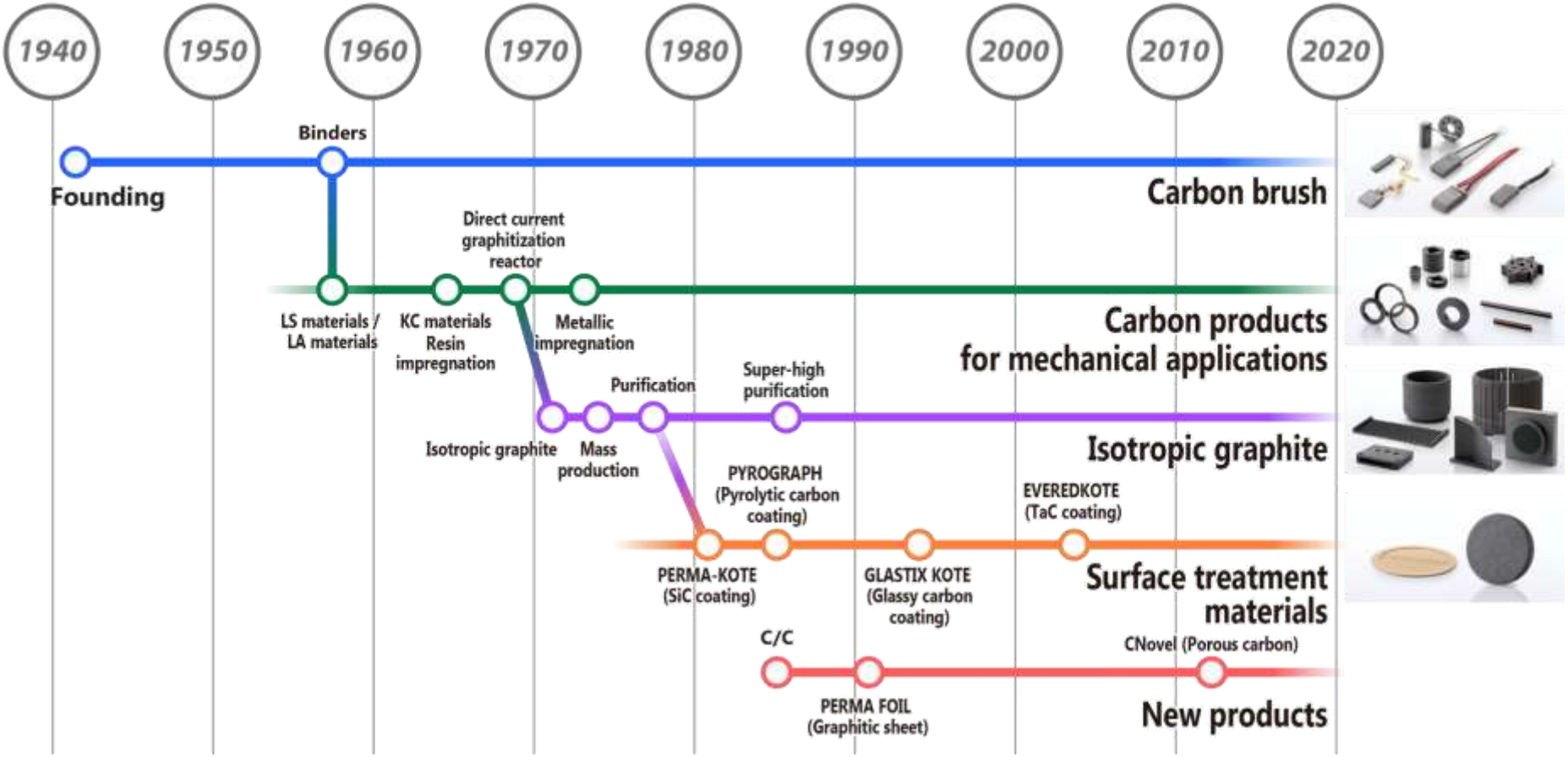
Technologies lineage:
Expansion and evolution of R&D themes and creation of technologies so we can keep up with changes in customer needs as industry develops and becomes more advanced



Toyo Tanso's strength is using technology and added value products to help customers overcome challenges.

Toyo Tanso R&D Strategy

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Ensuring that Toyo Tanso continues to be a company known for its technology

Means of R&D as a material manufacturer

What to make × **How to make**

- **Product development** (needs)
  Develop new products to meet customer needs timely
- **Technology development** (seeds)
  Build up a store of elemental technology using the most recent technology

Targets

Energy

Electronics

Environment

Mobility

2. Position of R&D

Tatsuro Hamada,
Director, Director of Corporate Planning Division,
in charge of Global R&D Division

April 1983	Joined Bridgestone Corporation
July 2010	Vice President and Officer, in charge of internal manufacturing management
May 2011	Vice President and Officer, in charge of tire research and material development
January 2017	Vice President and Officer, in charge of central research
September 2017	Joined Toyo Tanso Co., Ltd. Executive Officer, in charge of Technical Development Division
September 2018	Executive Officer, Director of Global R&D Division
February 2019	Executive Officer, Director of Corporate Planning Division
March 2019	Director, Executive Officer, Director of Corporate Planning Division, in charge of Global R&D Division

Basic Policy of the Medium-Term Management Plan

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Transitioning away from our current business structure

- Business structure dependent on special graphite products
- Earnings structure affected by circumstances in the electronics market
- Expansion centered on Asia

Vision over the medium to long term

Building pillars of growth and enhancing the earnings platform

We will **tap growth domains and place focus on high value-added products** in order to build new pillars of growth and enhance our earnings platform, thereby shifting to a business structure that does not solely rely on special graphite products

Establishing a consistent portfolio

We hold electronics volatility in check and build stable business foundations by **diversifying operations across end-market industries**

Making the leap to becoming a global company

Toyo Tanso will make the leap toward becoming a global enterprise extending beyond our current operations in Asia, which will involve **enhancing capabilities of our subsidiaries (production, sales, and management)** in order to more rapidly achieve overseas expansion primarily in Europe, the US, and emerging countries

Position of R&D in the Medium-Term Management Plan

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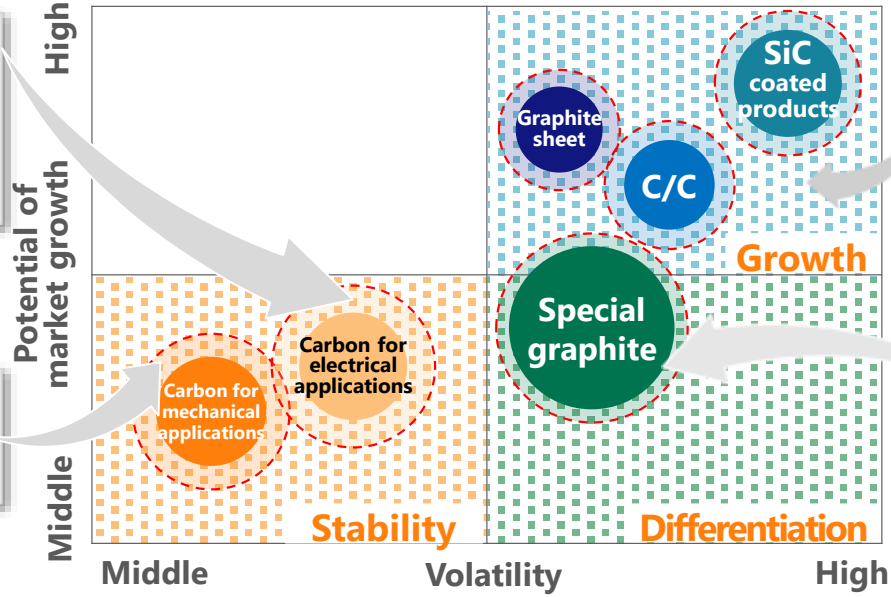
Promote R&D that builds customer value by developing targets based on our business portfolio

Enhance market entry efforts with respect to carbon brushes for automotive and industrial applications

Win over customers abroad by enhancing cost competitiveness



Win over customers abroad by enhancing development of applications involving compound materials

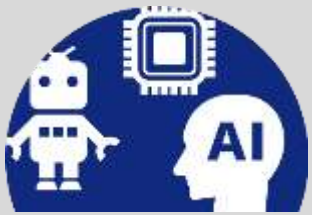
Expand market share in high value-added domains

Depicts current earnings performance

Depicts future earnings performance

Targets

Energy



Electronics

Environment

Mobility

R&D Aims for Even Further in the Future

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Key initiatives of the Medium-Term Management Plan

Enhancement and innovation of production technology	Reinforcement of overseas expansion efforts

Outlook of R&D

- **Achieve greater quality and lower costs than the competitors**
- **Offer appealing new products that can create customer value**
  ⇨ Make full use of leading-edge technologies like simulation, sensing, AI, and automation
- **Diversify development by setting up R&D centers globally**
- **Use & collaborate with academia overseas**

Learn customer needs in each region	Establish de facto standards globally	Use small starts to develop with speed

3. R&D Strategy

Dr. Takahiro Morishita,
Executive Officer, Director of Global R&D Division,

April 2006	Joined Toyo Tanso Co., Ltd. Fundamental R&D Group, Technology Development Division
April 2008	Leader of Advanced Technology Development Group, Technology Development Division
June 2014	Manager of Porous Carbon Business Unit
July 2015	General Manager of Performance Chemicals Division
March 2017	Executive Officer, Director of Technical Development Division, and General Manager of Performance Chemicals Division
September 2018	Executive Officer, Director of Global R&D Division

Toyo Tanso's Technical Development Strengths

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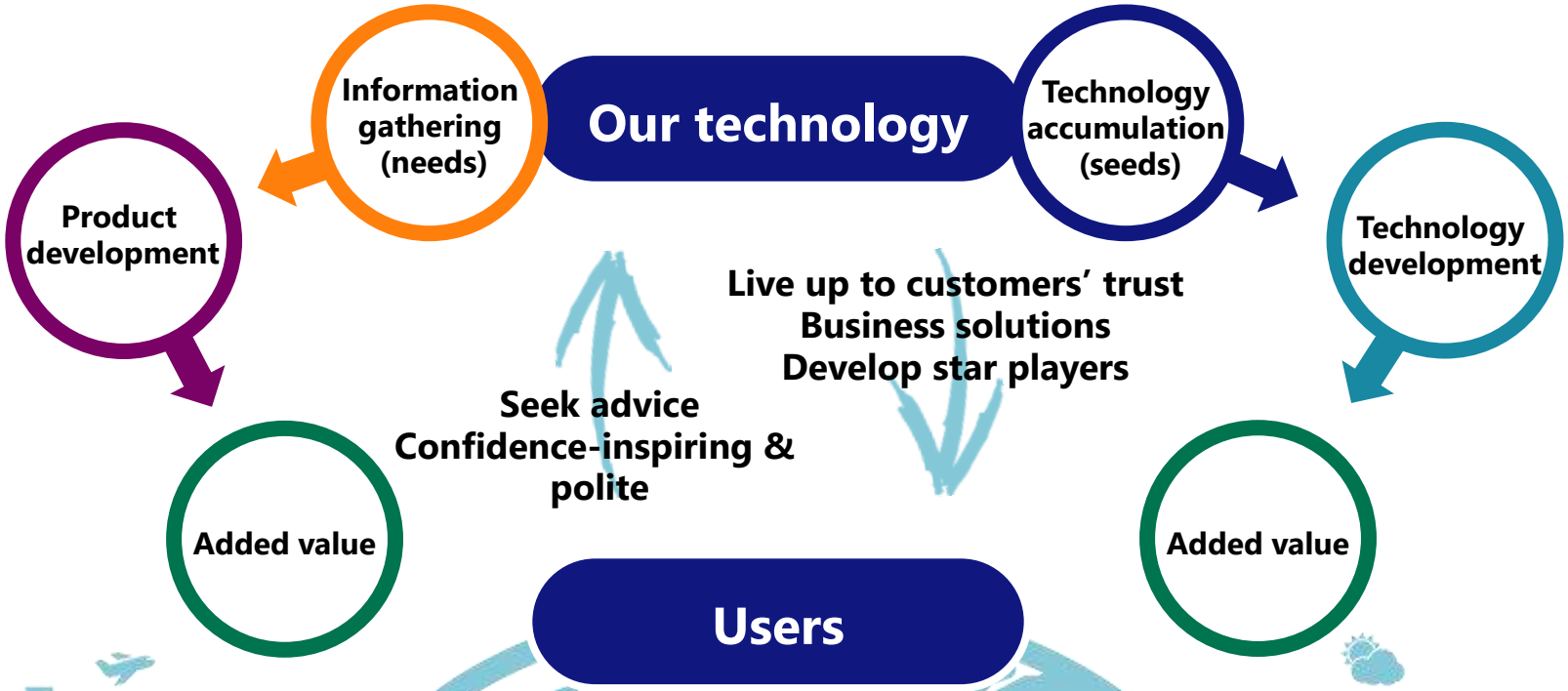
Build up a store of technology and develop human resources to answer technological challenges timely



Plentiful customer interfaces in each target domain

- Energy
- Electronics
- Environment
- Mobility

The Ideal R&D Approach for Executing Strategy

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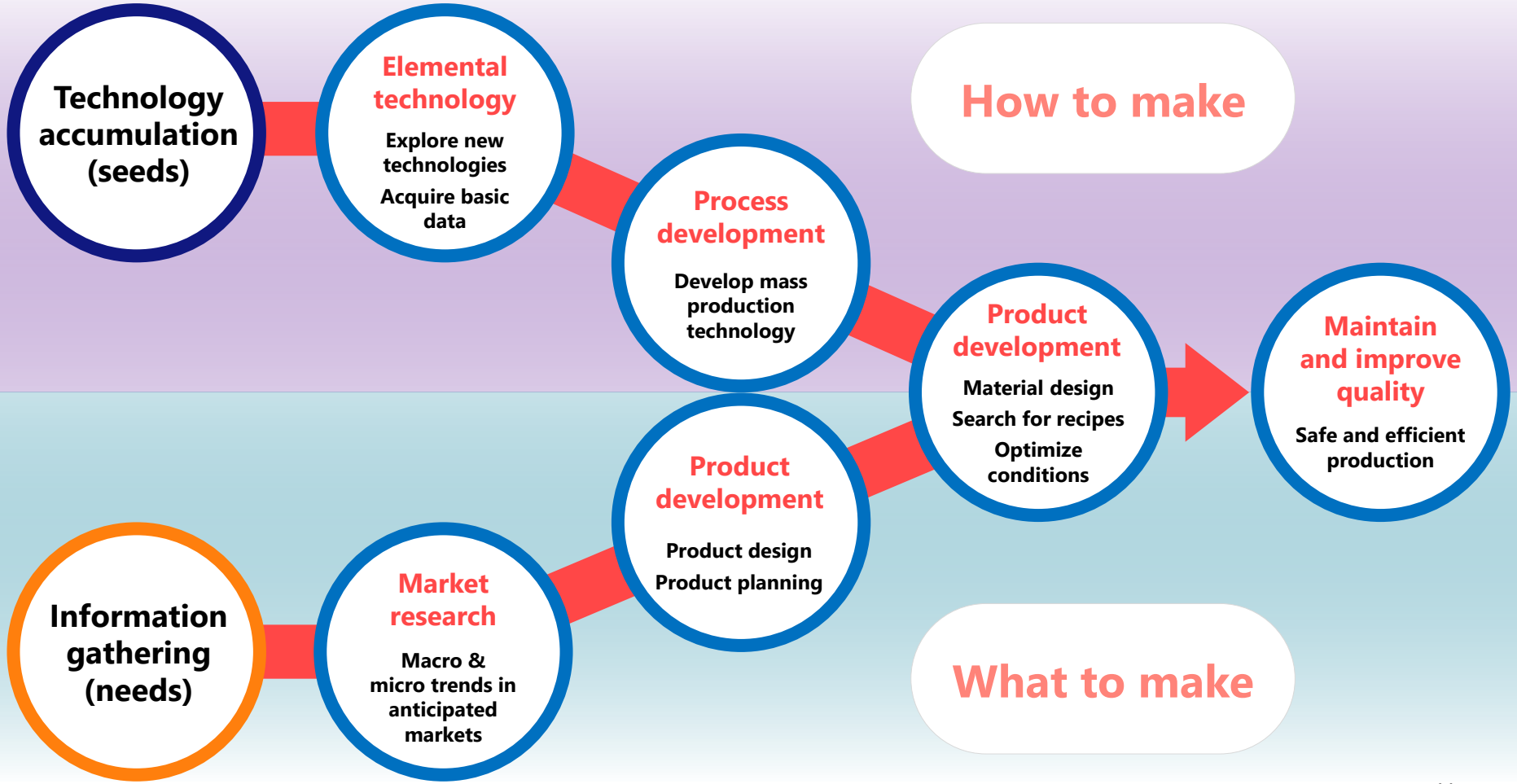
Make it possible to turn out products suited to the latest trends in a timely way, by matching needs and seeds in a balanced way



R&D Approach (1) Elemental Technology

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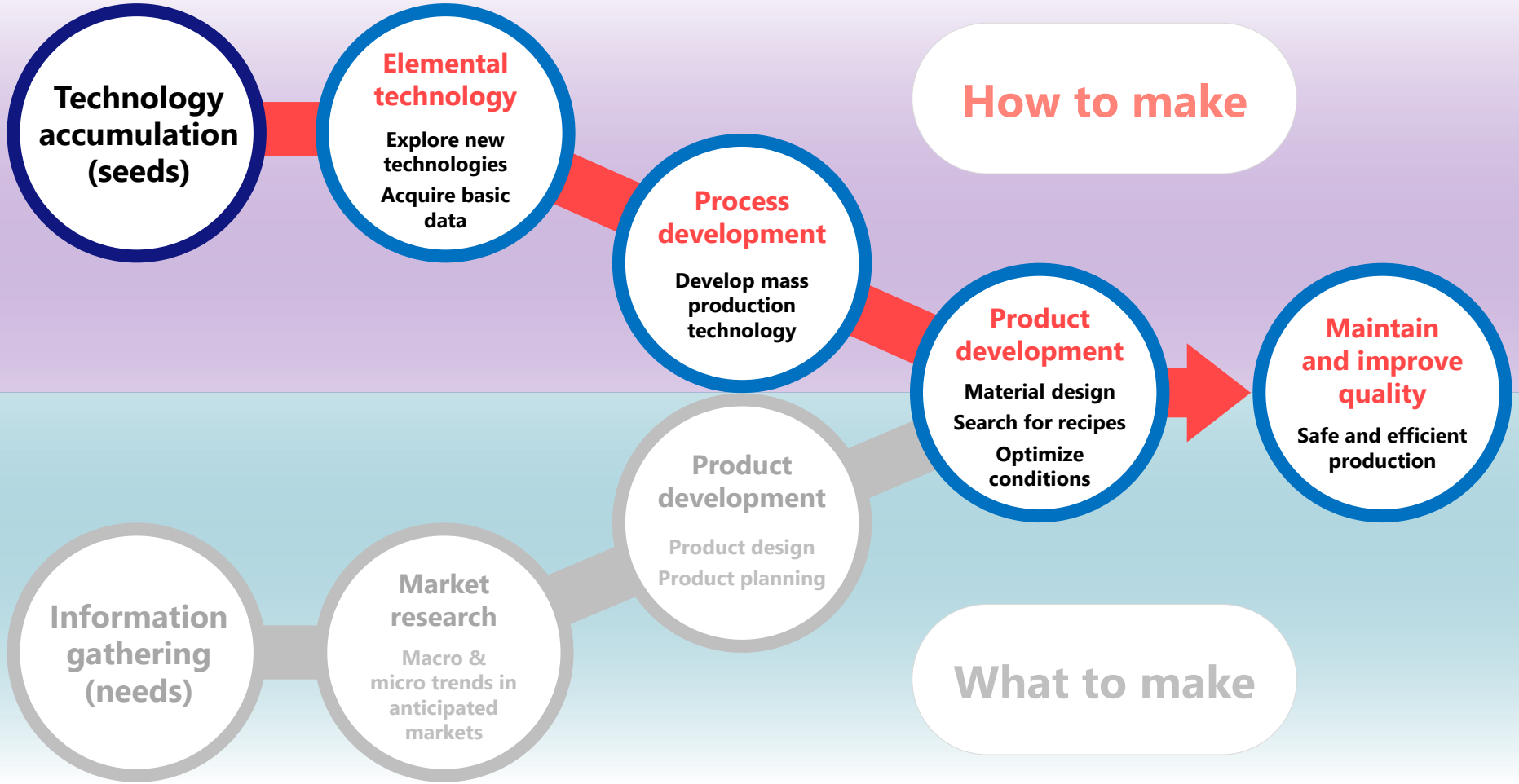
An approach from elemental technology by deep-plowing seeds



Key Development Processes in Basic Graphite Materials

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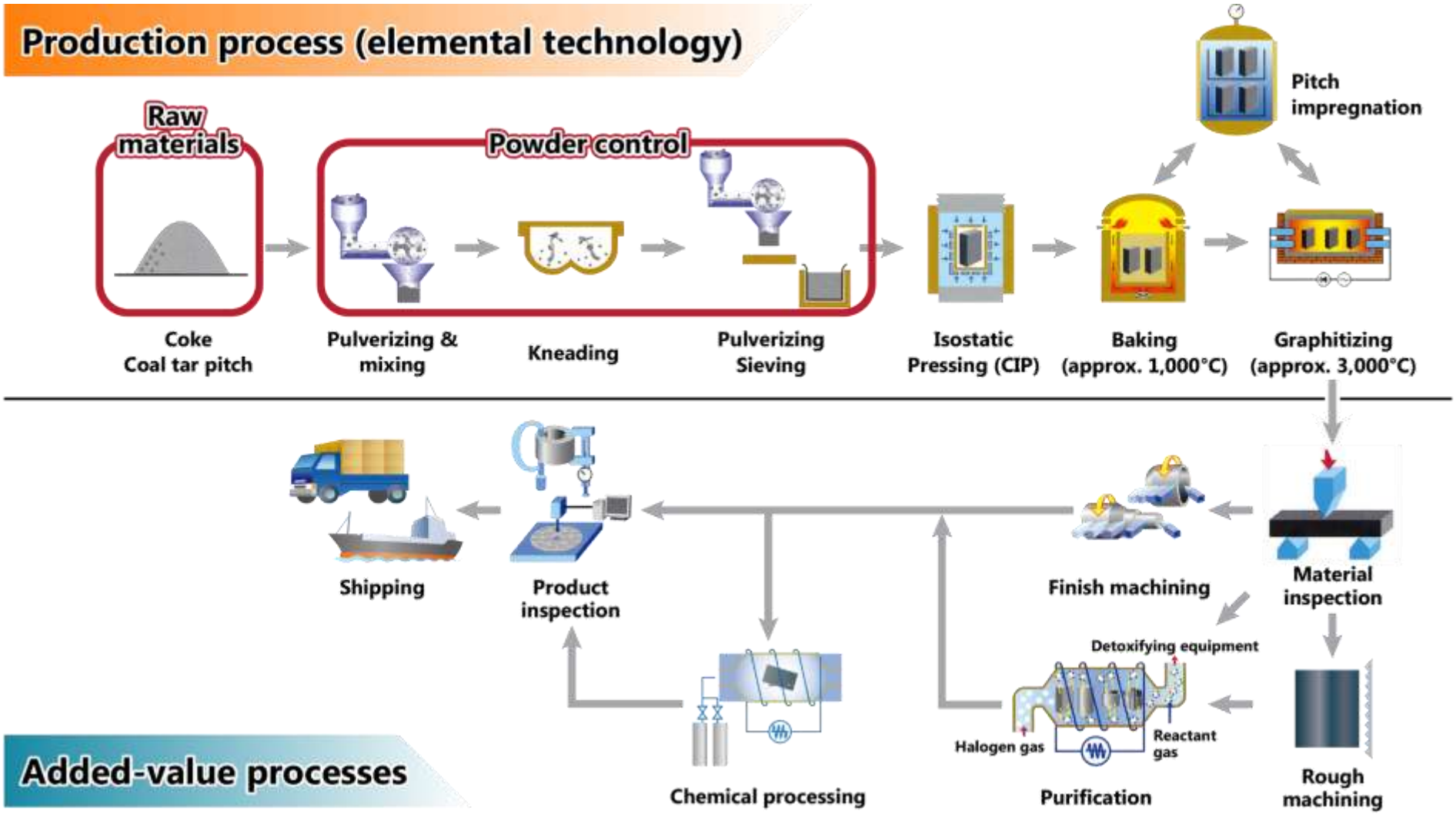
Incorporate new technologies that "exceed" existing ones



Creation and Development of Graphite Industry Materials — Raw Materials Research

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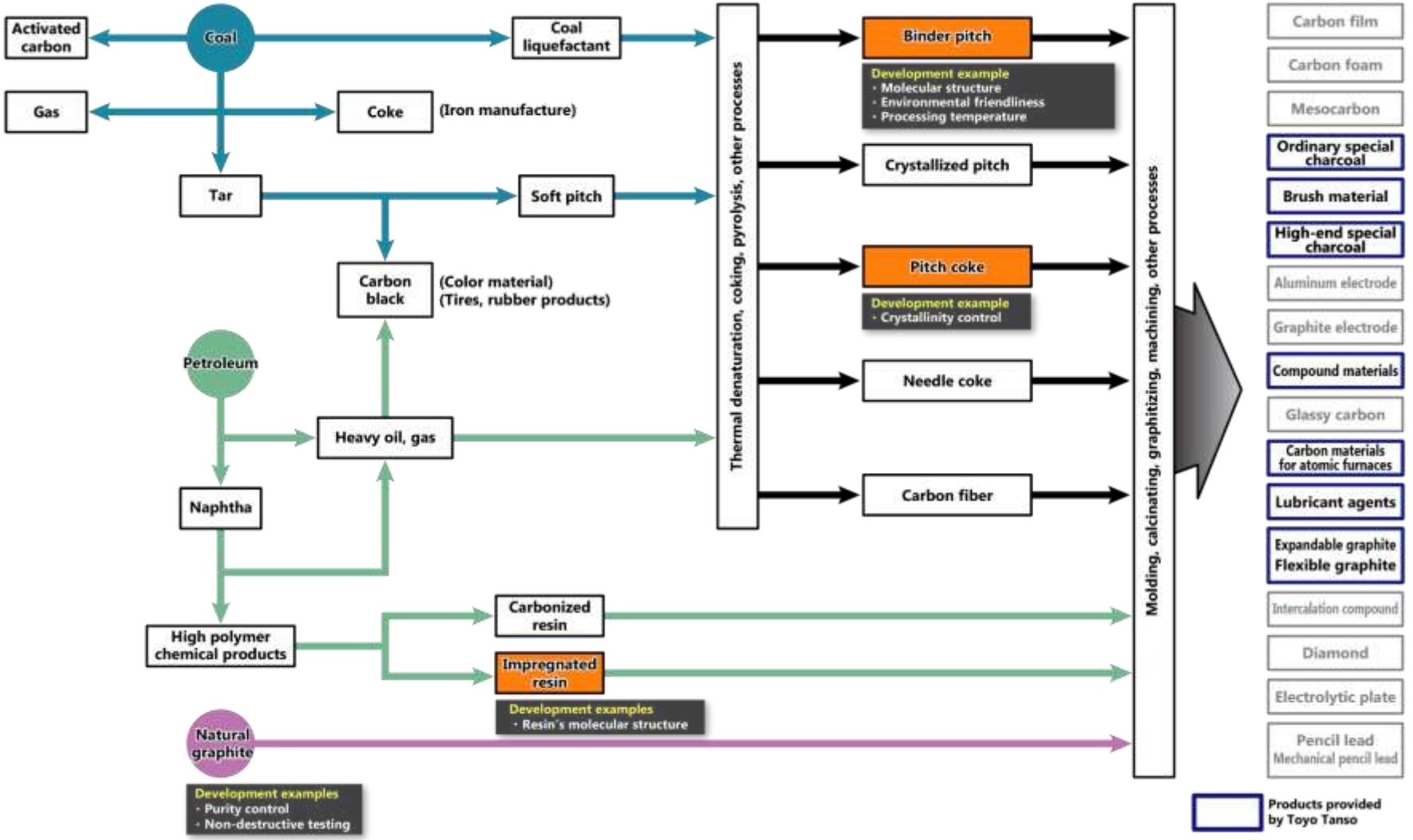
Conduct R&D reaching back to the raw materials stage by collaborating with raw materials manufacturers



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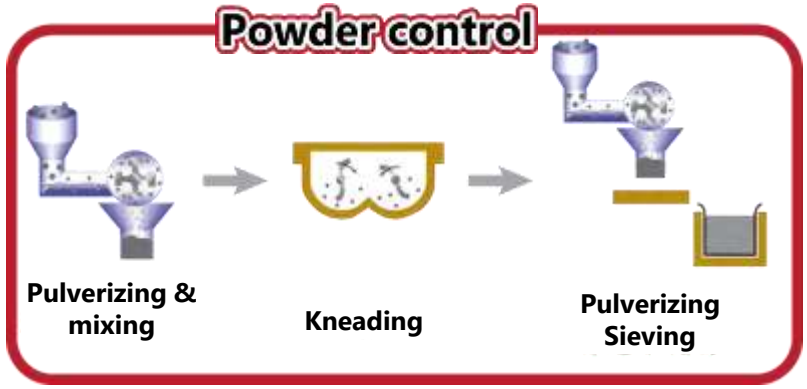
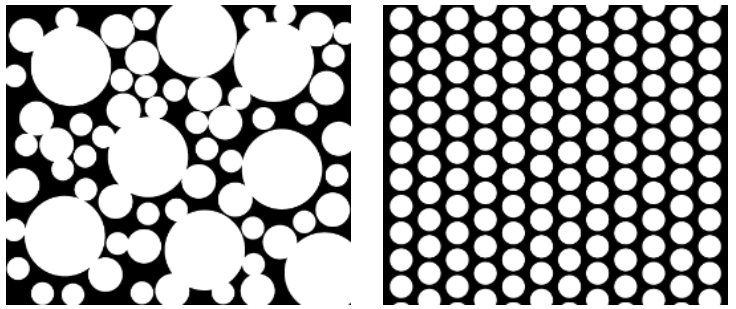
Optimize key processes using forecasting technology

Shorten development time and lower costs by forecasting before starting





Simulation analysis using powder injection models

Size and shape

How to mix materials & how materials mix

- Shorten production processes
- Increase yield

R&D Approach (2) Product Development

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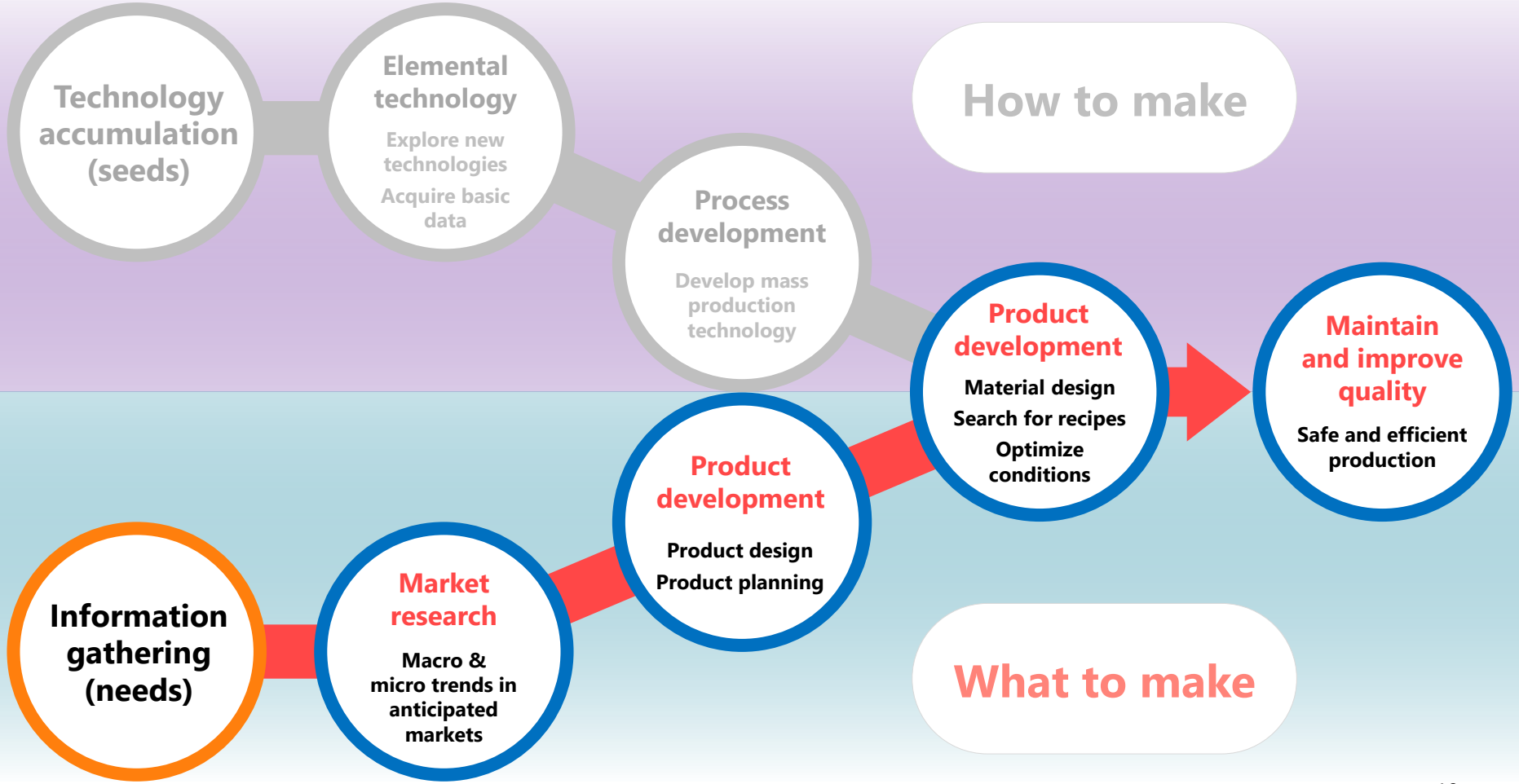
Develop products that anticipate latent needs



Product Development Standpoint — Expand Market Domains

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Targets

Energy

Electronics

Environment

Mobility

- Respond to structural changes in semiconductor and solar cell markets
- Further increase share with technical strengths and differentiation
- Promote substitution with other materials

1. Expand existing products

2. Strengthen overseas business expansion

- Expand to new regions
- Expand in China market
- Strengthen collaboration with overseas affiliates

3. Launch new products

- Actively expand compound materials business
- Expand launches of high-function grade products
- Launch and expand newly developed products (CNovel, TaC-coated material)

Product Development Standpoint — Technology for Social Issues

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Habitation, environment, industry

Efficient energy use
Environmentally friendly materials
Sensor technology

Carbon materials

Materials indispensable for supporting society's energy infrastructure

Electrical energy

- Power generation (solar / wind / nuclear power)
- Power storage (batteries / capacitors)
- Conversion (power semiconductors / sensors)

Transportation, information, electronic materials

Non-internal combustion engine components

Automated, safe, high-performance communication products

Thermal energy

- Heat dissipation (energy saving / sensors)
- Heat storage (air conditioning / power generation)
- Heat generation (heater / furnace materials)
- Unused heat utilization (cogeneration / power generation)

Chemical / optical / mechanical energy

- Transportation / storage (material handling / tanks)
- Movement (motors)
- Power generation / conversion (chemical catalysts)
- Combustion / abrasion (members)

Product Development Case Study — 5G Communications Market

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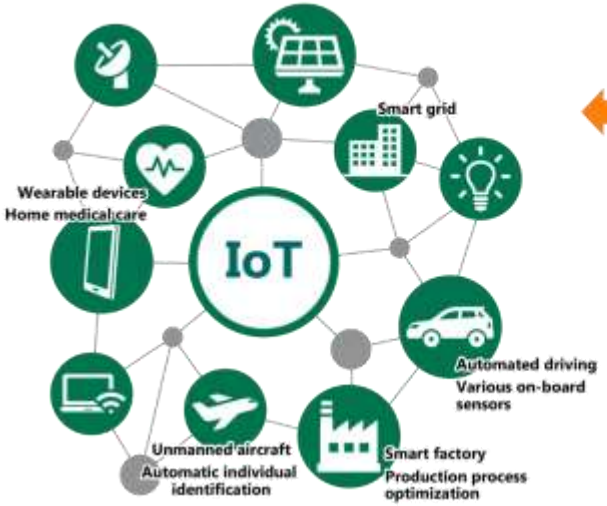
Corresponding Toyo Tanso targets:



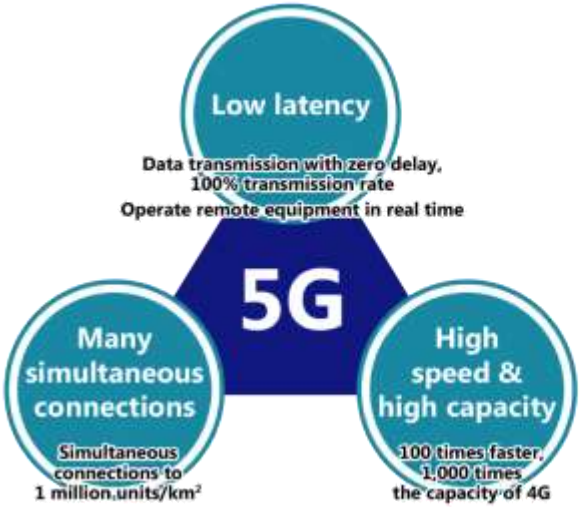
SiC
GaN-on-Si
GaN-on-SiC

Components for power semiconductor manufacturing

Development theme examples

- Begin developing for the size, purity, and mass producibility to support 8-inch (200 mm) size and up, which is predicted to be the mainstream in future
- Develop micromachining technology suitable for power semiconductor manufacturing processes (jig applications)

- Develop machining technology that pastes together graphitic sheets for heat dissipation applications, etc.



IC chip heat dissipation sheets

- Smaller base stations and increasing energy consumption have led to the problem of how to deal with a large amount of heat
- 5G signals travel in a straighter line than 4G, so a large number of base stations with short travel distances are necessary

➡ Demand expected to rise for inexpensive heat-dissipating materials that are resistant to high temperatures

Product Development Case Study
— Initiatives for a Clean-Energy Society

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Corresponding Toyo Tanso targets:

■ Emission control

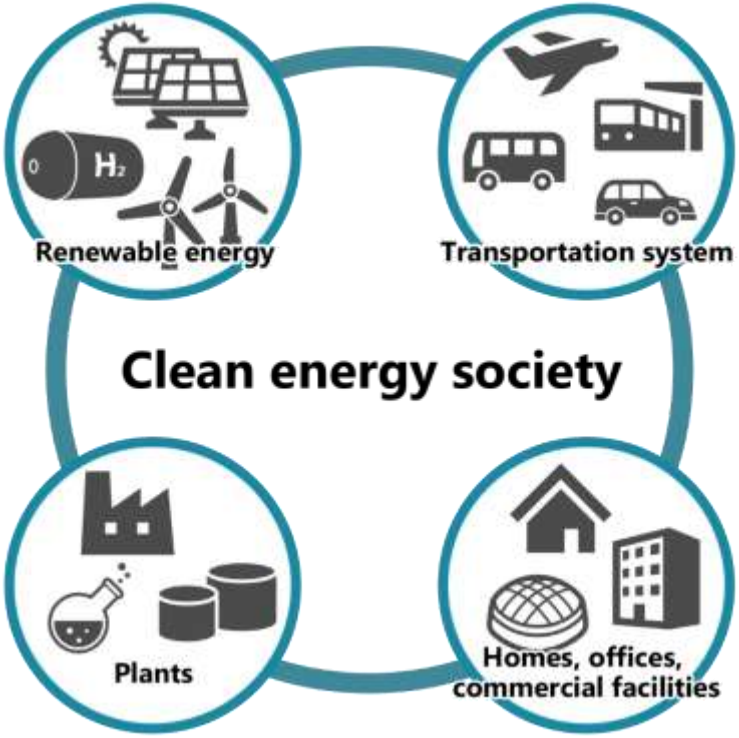
- Hotter exhaust gases
  - ➡ Development of highly heat-resistant graphitic sheets reaching **back to raw materials**

■ Chemical substance control

- Carbon products for mechanical applications (for Europe)
  - ➡ Materials development using eco-friendly raw materials

■ Hydrogen energy

- Development of catalyst supports for fuel cells
- Development of catalyst supports for ammonia synthesis
  - ➡ Graphitized CNovel™



Product Development Case Study
— Realization of Hydrogen-Based Society

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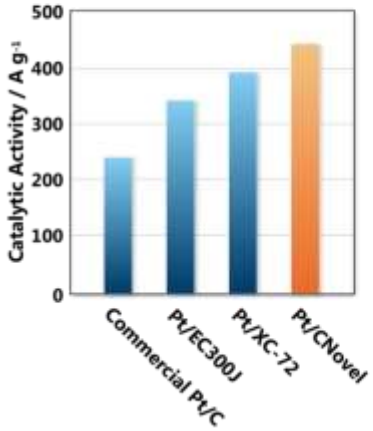
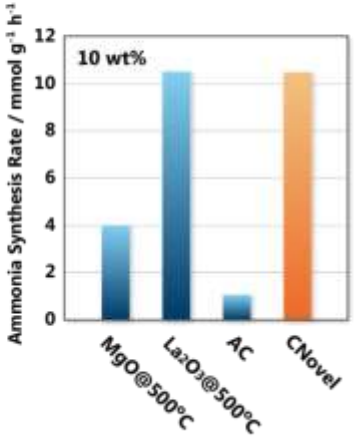
Corresponding Toyo Tanso targets:

Graphitized CNovel™

Catalyst supports for fuel cells ➡ High output, low platinum, long life

Catalyst supports for ammonia synthesis ➡ Lower energy costs, greater stability



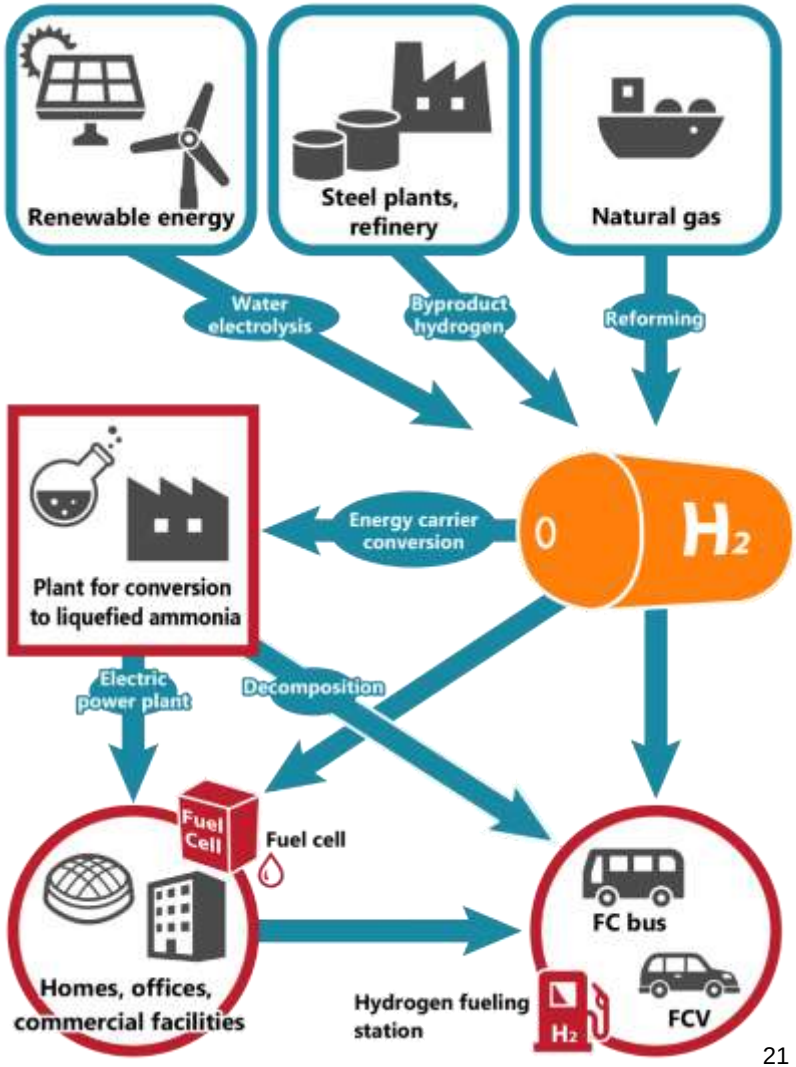


Heat- and cold-resistant carbon components
(plants, hydrogen fueling stations)

- Graphite sheet
- Carbon products for mechanical applications

Graphite sheet

Carbon products for mechanical applications



Research and Development System — Global System

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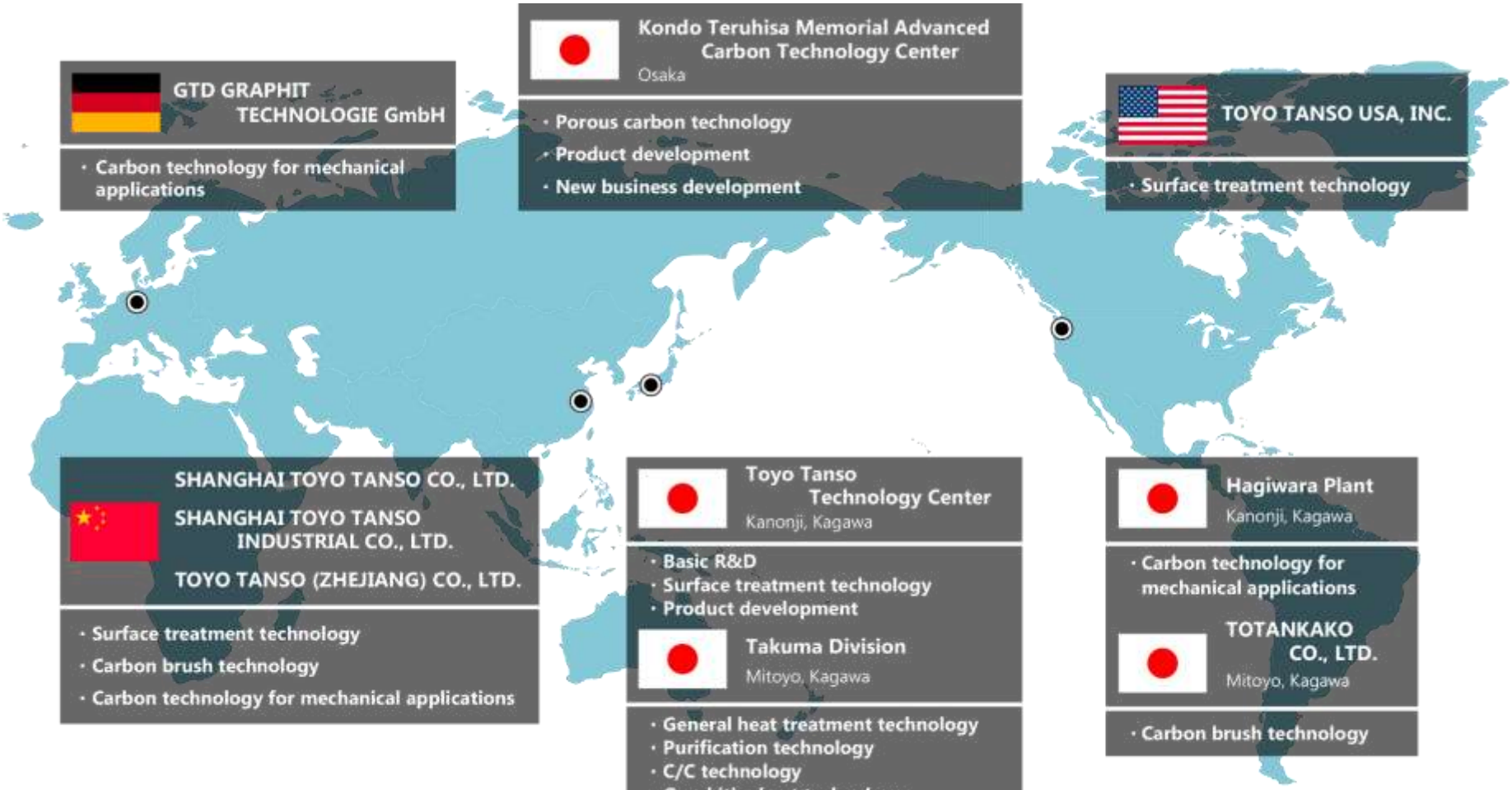
Build a global development system with development of the right material in the right spot in the right country



Research and Development System
— Management of Development Products

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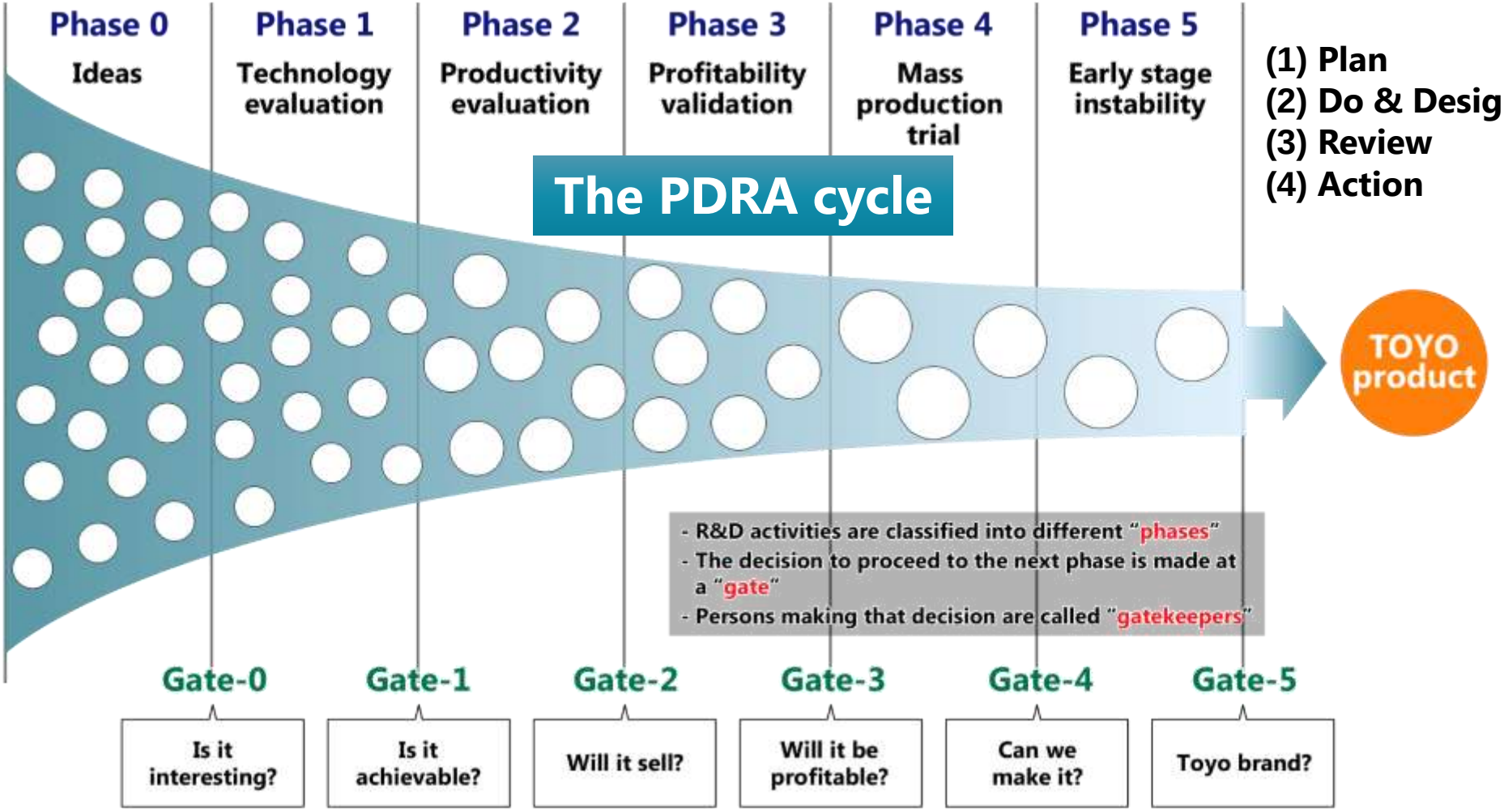
Expansion of development management system to all group companies; visualization and central management of system
– Transition from PD"C"A to PD"R"A–



Research and Development System
— Strengthening the Development System

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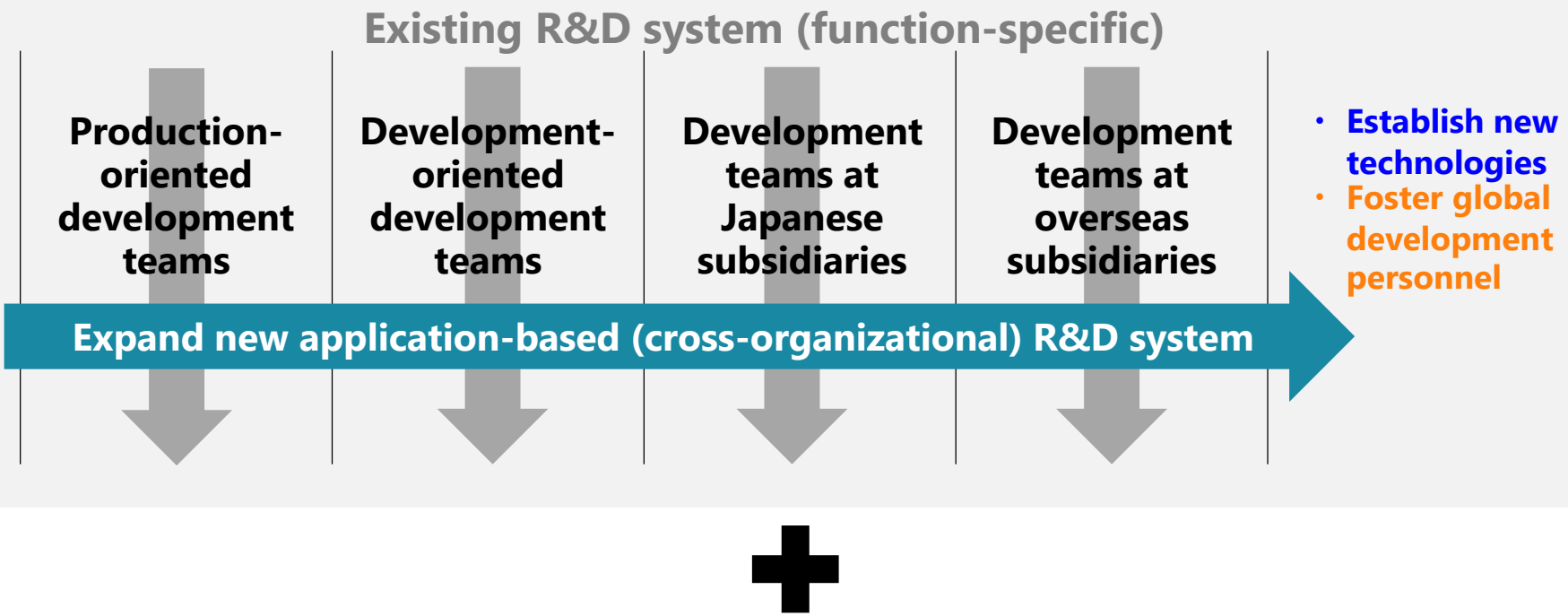
We are setting up a global, cross-application system on top of the existing function-specific organization and speeding up R&D accordingly.



Strengthen collaboration with research institutes and universities in and out of Japan

Practice both “pursuit of technology” and “creation of business value”

Example of External Collaboration — Exploring New Possibilities for Graphite Powders

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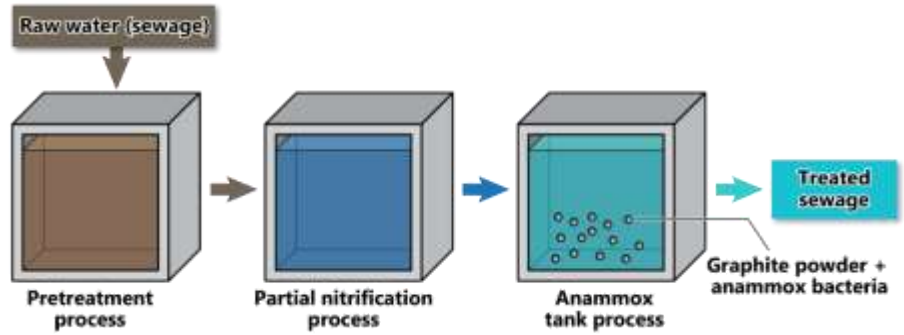
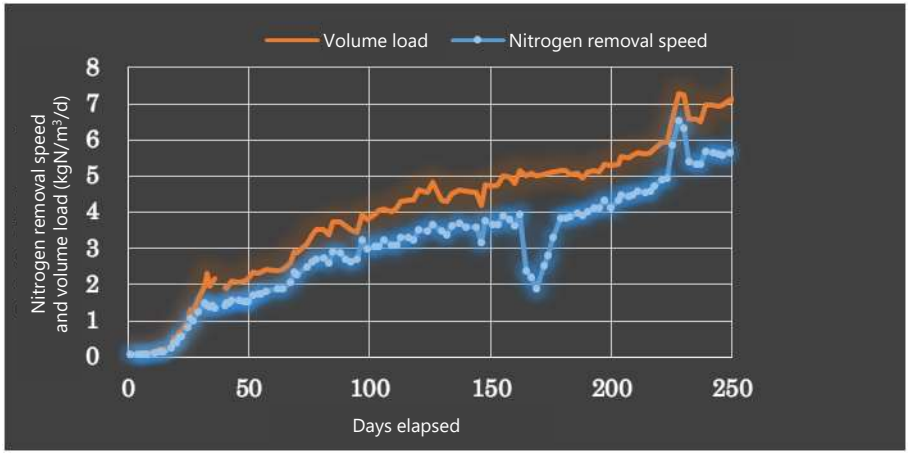
Corresponding Toyo Tanso targets: Environment

- **Open innovation collaboration with Toyo University (since 2017)**
- **Confirmed the suitability of graphite powders as a culture medium for anammox bacteria (bacteria thought to have potential for inexpensive wastewater treatment) and successfully cultivated such bacteria to the point where processing could be done three times faster than with conventional supports**
- **Testing is currently underway with water processing system manufacturers and end users with goal of implementation**

High-efficiency sewage treatment technology using graphite powders to lower environmental burden



Graphite powder derived from polishing during product machining is used as sewage treatment bacteria cultivation supports



Presentation at meeting of Japan Society of Water Treatment Biology (2019)

Provided by Prof. Sumino, Toyo University

Contribution to Sustainable Development Goals (SDGs)

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APPENDIX
Product Range Special Graphite Products

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	Products	Applications	Related markets	Percentage of sales (FY2018)
Special graphite products	**Electronics applications**  Crucibles  Heaters	・Parts for single-crystal silicon manufacturing furnaces (crucibles, heaters) ・Parts for compound semiconductor manufacturing equipment (crystal pulling devices, susceptors for MOCVD equipment)	Semiconductors Solar cells LED Next-generation semiconductors	**15.1%**
	General industries applications  Continuous casting dies EDM electrodes   Hot press molds (cut models)	・Metal casting furnace components (continuous casting dice) ・Die manufacturing equipment components (electrical discharge machining electrodes) ・Industrial furnace components (heaters, trays) ・Optical fiber manufacturing components (heaters, furnace core pipes)	Automotive Aircraft Semiconductors Home electronics Industrial machines Optical fibers	**22.1%**
	Other Ion engine parts   CT device parts  High-temperature gas reactor core materials	・Silicon semiconductor manufacturing equipment components (ion implanter electrodes, glass sealing jigs) ・High-temperature gas-cooled reactor structural components (furnace core materials) ・Nuclear fusion reactor structural components (furnace wall materials) ・CT scanning components (target materials)	Semiconductors Nuclear power Aerospace Medical care	**12.1%**

APPENDIX
Product Range　Carbon Products for General Industries

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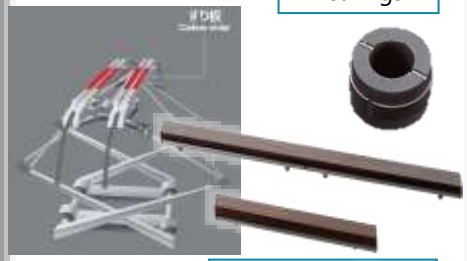
	Products	Applications	Related markets	Percentage of sales (FY2018)
Carbon products for general industries (mechanical applications)	Mechanical seal  Bearings  Pantograph sliders	・Parts for pumps and compressors (bearings, piston rings, mechanical seals) ・Pantograph parts (sliders)	Industrial machines Railways Ships Automotive Home electronics	8.9%
Carbon products for general industries (electrical applications)	 Small brushes  Industrial brushes	・Small motor components (vacuum cleaners, washing machines, electric tools) ・Large motor components (general industrial, power supply, electrical equipment)	Home electronics Power tools Railways Automotive Industrial machines Wind-power generation	12.1%

APPENDIX
Product Range Compound Materials and Other Products

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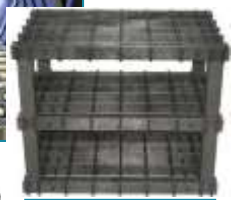
	Products	Applications	Related markets	Percentage of sales (FY2018)
Compound materials and other products [three major products]	**SiC-coated graphite products**  MOCVD susceptors	・Silicon, compound semiconductor thin film manufacturing equipment components (susceptors for MOCVD equipment) ・Parts for Si-Epi equipment (susceptors) ・Parts for SiC-Epi equipment (susceptors)	Semiconductors LED Next-generation semiconductors	**21.3%**
	C/C composite products  Bolts, nuts  Three-layered trays	・Parts for single-crystal silicon manufacturing equipment (crucibles, inner shields) ・Parts for polycrystal silicon manufacturing equipment (crucibles, trays) ・Parts for industrial furnaces (trays, baskets, bolts, nuts) ・Nuclear fusion reactor structural components (furnace wall materials) ・Small probe engine parts	Semiconductors Solar cells Automotive Aircraft Nuclear power Aerospace	
	Graphitic sheet products 	・Automotive parts (gaskets) ・Parts for synthetic quarts manufacturing (release agent) ・Parts for single-crystal silicon manufacturing (protective layer) ・Heatsink ・Packings for general industries	Automotive Semiconductors Industrial machines	

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IR Contact

E-mail：ir@toyotanso.co.jp