George san, our CTO : His Work and Legacy at Mitsubishi Chemical, and our Vision for Sustainable Future

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2040 Visions of Process Systems Engineering
Symposium on the occasion of George Stephanopoulos’ 70th Birthday and Retirement from MIT

Mitsubishi Monitor

A BIMONTHLY REVIEW OF THE MITSUBISHI COMPANIES AND THEIR PEOPLE AROUND THE WORLD

MITSUBISHI CHEMICAL RECRUITS A CHIEF TECHNOLOGY OFFICER FROM ABROAD

Mitsubishi Chemical president Kanji Shono introduces his company's chief technology officer, Dr. George Stephanopoulos.

The newly named head of research and technological development at Japan's largest integrated chemicals manufacturer is from Greece, via Canada and the United States. Dr. George Stephanopoulos, a professor of chemical engineering at the Massachusetts Institute of Technology (MIT), recently began serving as chief technology officer at Mitsubishi Chemical. He has a two-year appointment and a mandate from the board of directors to reshape the company's research and technology development.

Stephanopoulos is famous worldwide for his work in process systems engineering. He has supervised work by a continuing procession of researchers dispatched to MIT from Mitsubishi Chemical and also has done consulting work for the company. The long list of leading corporations and organizations that have turned to Stephanopoulos for consulting also includes such names as Control Data, DuPont, Eastman Kodak, Exxon, Honeywell, and the U.S. National Aeronautics and Space Administration (NASA).

July 4, 2000

George-san's mission:

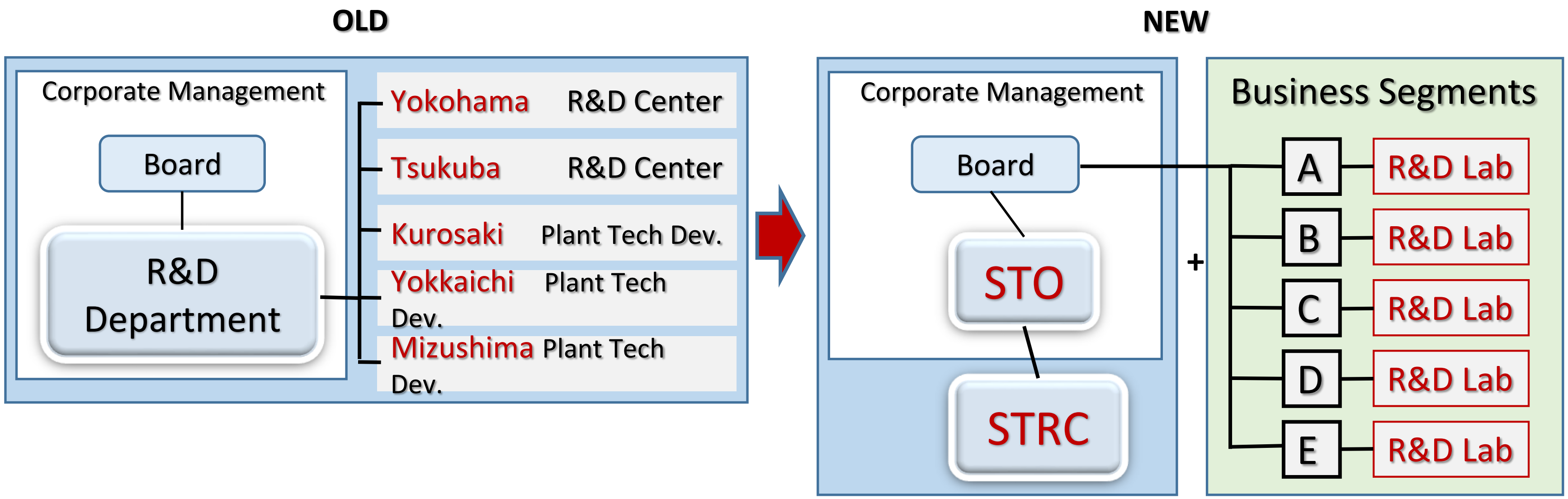
Improve the effectiveness of technology generation for new business development,
By reforming the management structure
and
culture
of the R&D organization

The Situation in Mitsubishi Chemical Corp. (MCC) in July 2000

- The profits were low and decreasing
  (Asian Financial Crisis of 1997)
- Investments by the business divisions in capital expenditures and R&D were declining
- Management of MCC wanted very badly to generate new revenues and profits from the development of new business activities
- The enthusiasm of researchers for commercializing the technology under development was low

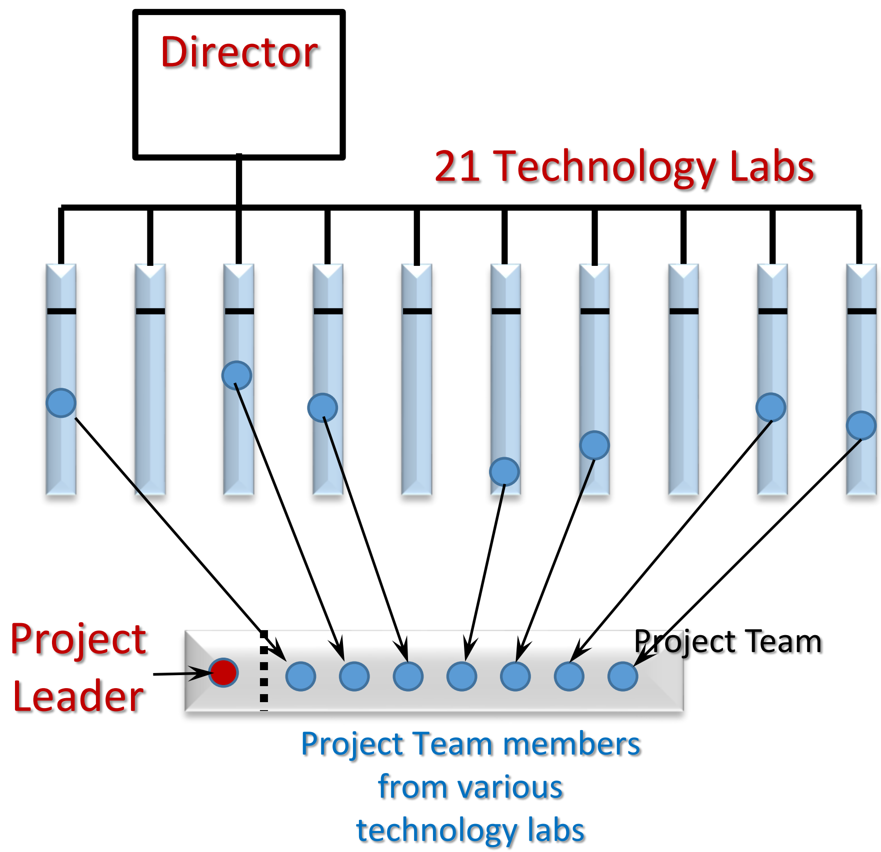
George san's favorite phrase

The Structural Transformation of the R&D Organization



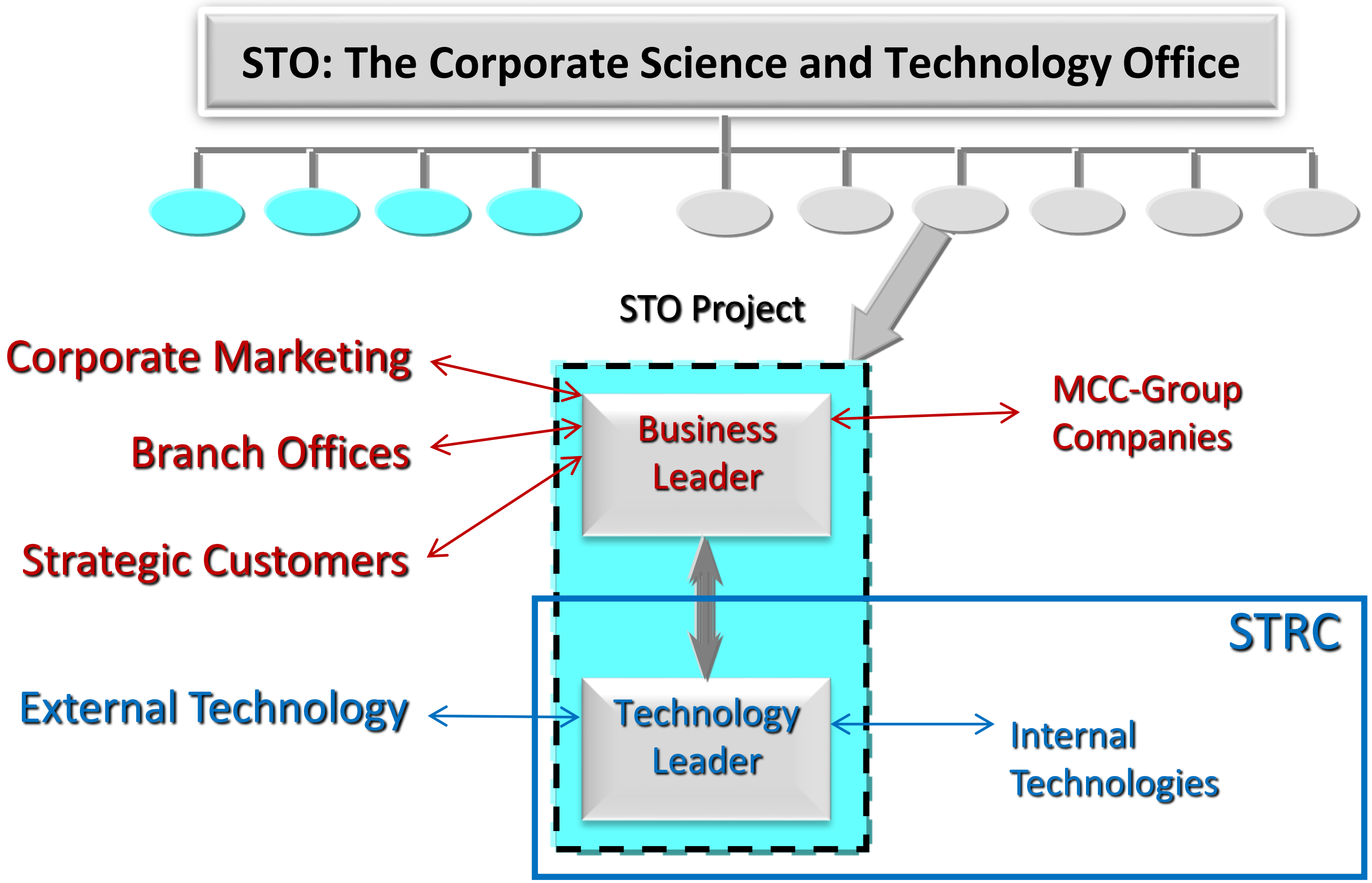
- R&D was divided into two parts: Corporate R&D and Business Segments R&D
- Corporate Science and Technology Office: **STO**
  - **Plans and Promotes New Business development through New Technologies**
  - Plans Group-Wide R&D Strategy
- Science and Technology Research Center (700 members): **STRC**
  - Group-wide coordination and execution of R&D
  - Creation and enhancement of Common Core Technologies
  - **New Products Incubation**

STRC and its Matrix Management

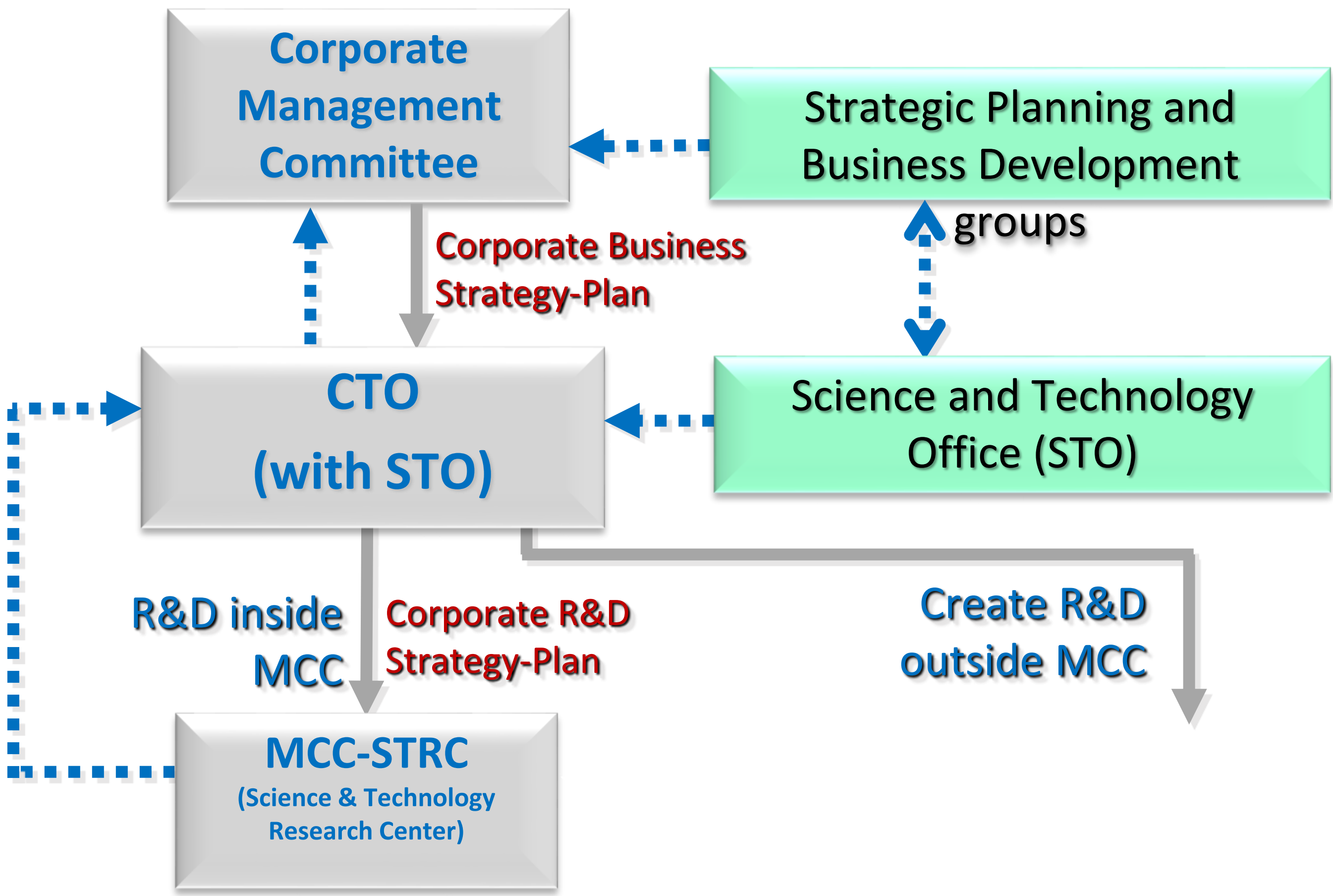


- STRC was organized into 21 Basic Technology Labs
- All members belong a Technology Lab
- The Manager of each Technology Lab is responsible for enriching the technology in the Lab
- The R&D projects are carried out by Project Teams
- Each Project draws members from the Technology Labs (specific skills)
- The Project Leader has exclusive rights on project management

Creating New Business Opportunities: Integration of Marketing-Business and Technology Development



Alignment of Corporate Business and R&D Strategies



STRC's early days R&D projects aimed at new businesses

Biotechnology

- Bio-polymer
  - PBS
  - New bio-polymer
  - Bio-Synthesis (Succinic acid)

- Bio-Synthesis (Drug substances)
- Cell-free protein synthesis

Organic Chemicals

- Designed Chemicals
  - Photoresist monomer
  - Personal care
  - New monomers with new functions

- OLED materials
- Organic transistor

Polymers

- Plastic devices
  - PDP filter
  - Aspheric miller
  - LCD materials
  - Glass substitutes

- SLPP (PP primer)
- Barrier coat
- Hair coat
- Anti-fogging coat
- Hologram memory
- Metallocene soft PP

- Transparent nano composites
- Low shrink UV cure

Inorganic materials

- New Carbon
  - CNT
  - 

- New adsorbent
- Phosphor for LED
- GaN single crystal
- Fuel cell materials

- Hybrid Phosphor
- Nano-particles

Academic Alliances with External Research Organizations

Mitsubishi Chemical Center for Advanced Materials
(UC-Santa Barbara; 2001 – present)
solid-state lighting, battery materials, solar cells, and organic transistors

Cornell University
(Post-Metallocene Catalysis and Polymers)

Comprehensive Industry Academia Alliance
International Innovation Center
Kyoto University
(2001-2008)
Flexible Display, Organic Solar Cell, Organic photoelectric Conversion Organic Memory Device, Nano Composites

With NTT, Hitachi, Rohm, Pioneer

Mitsubishi Chemical

Collaborative Research
National Institute of Advanced Industrial Science and Technology, Japan
(2002-2006)
Flexible Display, Fuel Cell materials
Genom-based drug discovery
Bio-informatics, Healthcare

George-san's Legacy at Mitsubishi Chemical

- Today the researchers at MCC are much more sensitive to the need to create technologies that can lead to successful business, i.e. "make money".
- The concept of "Innovation" that was introduced with STO is still the governing principle, and has expanded significantly.
- The Company and the researchers maintain the "extrovert" attitude, introduced 15 years ago, and have expanded it with many new collaborations.
- We started many projects under the leadership of George san
  - Some went well and some businesses were short-lived
  - Yet, we were able to develop several new technologies and succeeded in building new businesses.
- After George san left, we have expanded the technologies and businesses, and now they are those which represent MCC.

Examples of Technologies and Businesses from George-san's Legacy at Mitsubishi Chemical

"The New Adsorbent Project "

Zeolite Technology and Business

Many Products in the Environmental and Energy Markets

New AlPO Zeolites with tunable micro-porous structures

AQSOA: "AQua SOrb zeolitic Adsorbent"

– "Adsorption Heat Pumps" (many applications)
  - Regeneratable with low temperature waste heat
  - High adsorption capacity at low humidity

– SCR catalyst(Cu/AQSOA Z02) for NOx removal
  - High catalytic performance
  - High stability for water vapor repetitive adsorption-desorption

– Zeolite Membranes for
  - Industrial (ZEBREX): solvent recycle, Bio-ethanol, natural gas
  - Food Processes (Konker): wine making, fragrances

Examples of Technologies and Businesses from George-san's Legacy at Mitsubishi Chemical

"SLPP and Transparent Soft Polymer Project":
Metallocene catalyst Technology for olefin polymerization and High-value-added PP Business.

- MCC and JPP had developed a unique metallocene catalyst with dual function support activator and 7membered ring.
- A number of metallocene ligands were tried to control the structure of polymers

New Polypropylenes:

- **WINTEC**™, Transparency
- **WELNEX**™, Balanced Transparency and Flexibility
- m-High Melt Strength PP, Foams
- Solvent-Soluble PP, e.g. Bumper Coating

Pivotal products in petrochemical growth strategy

- Copolymer of Polar Monomers and α-Olefins

Examples of Technologies and Businesses from George-san's Legacy at Mitsubishi Chemical

"GS-Pla Project"

Green Sustainable Plastic

Bio-based Polymers Technology and Business

Goal: MCC will replace 20% of raw materials from exhaustive resources to sustainable/renewable resources by 2025

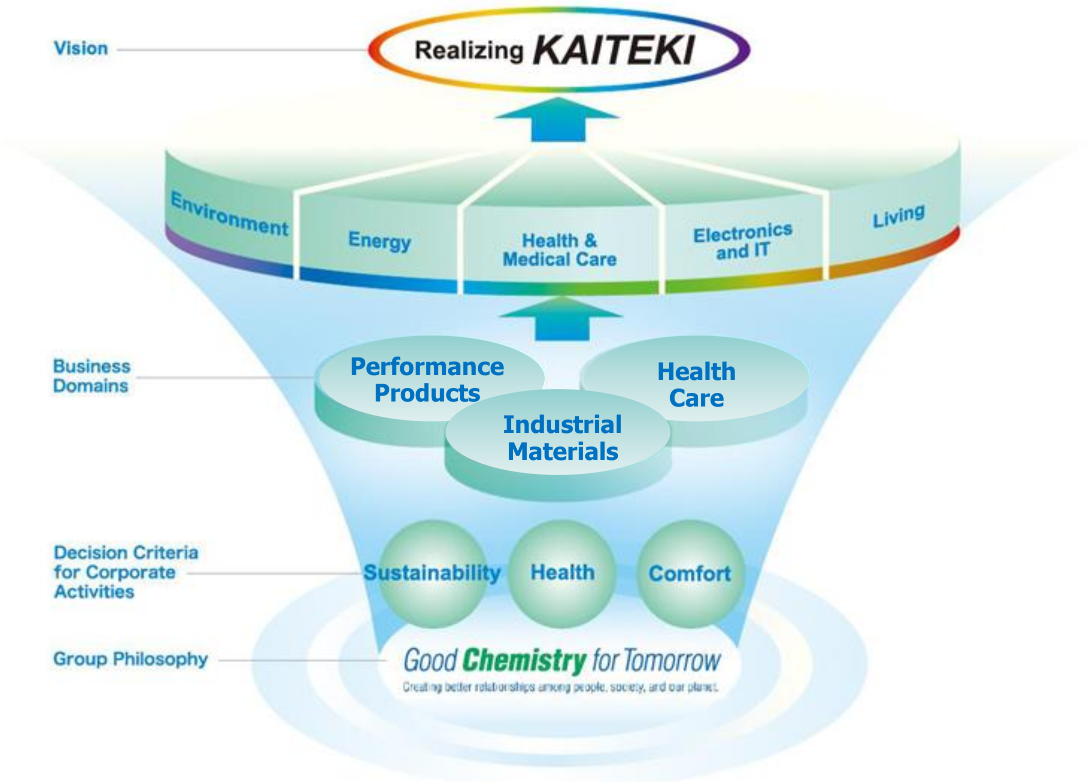
- Biodegradable polyester of Succinic acid and 1,4-Butanediol
- Succinic acid from Biomass
- New Bio-Based Polymer : Products:
  - BiOPBS™ (GS-Pla)
  - DURABIO™ : Low birefringence, Transparent, Surface hardness, Coloring property
  - BENEBiOL™ : Hydrolysis resistance, Flexibility at low temperature, high mechanical properties, Abrasion resistance, High hardness, Chemical resistance

Our Vision for the Sustainable Future

Mitsubishi Chemical Holding Co. is THE KAITEKI COMPANY

KAITEKI means:

"a Sustainable Condition which is Comfortable for People, Society and the Earth, Transcending Time and Generations."



Implementing KAITEKI

We do not conduct corporate activities
that violate the following guidelines

Sustainability	Continuously reduce environmental burden such as, CO_2 emissions, and promote energy saving and conversion to renewable resources / new energy sources.
Health	Contribute to early care and health maintenance, before an illness strikes (Me-Byo), healthy aging, disease treatment.
Comfort	Contribute to creating a more pleasant society and comfortable living through advances in food, clothing and shelter.

The KAITEKI Institute

Created by Mitsubishi Chemical Holding Co.
To Support the Implementation of the Kaiteki Concept

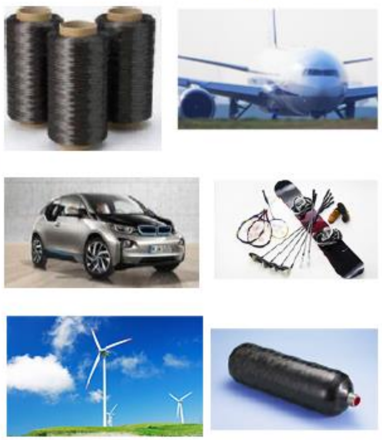
- Anticipate the Human Future Needs: Collect and analyze information on future market needs and trends. Formulate concepts and road maps for businesses that will address people's needs. Propose them to the MCHC Group.
- Anticipate the Need of Future Technologies: Investigate the key technologies, required for the implementation of future products, by partnering with researchers around the world. Assess the potential of these technologies.
- Spread the Message: Communicate the message of KAITEKI to the world, and introduce new culture to the MCHC Group.

Chemical Companies: Solution Providers to the Global Agenda (for the Sustainable Development of Humankind)

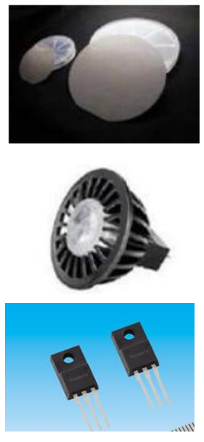
Global Agenda (megatrends)	The Solution Chemical Companies can Provide
• **Energy Demand:** x 1.3 by 2030	• Parts for Solar, Wind turbine power • Lightweight parts for cars or aircrafts • H_2 society, Artificial photosynthesis
• **Water:** x 1.5 by 2050	• Water purification system with high performance membrane • Water saving agriculture
• **Food:** x 1.6 by 2050	• Fertilizer, agrochemical and plant factories; minimal environmental impact • High yield varieties, heat resistant varieties
• **Aging:** (over 65) x 2.3 by 2060	• Pharmaceuticals, Vaccines • Preventive health care solutions
• **Urbanization:** x 1.2 by 2050	• Zero energy building with energy saving and creating energy members • Various members constituting the smart city

Future Businesses and Technologies that Meet KAITEKI Guidelines

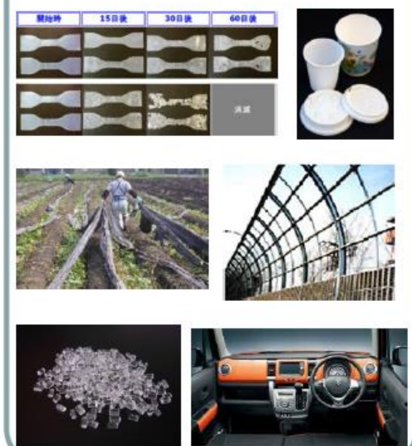
Carobon fiber composites



GaN,Lighting,Power device



Bio-based Polymers

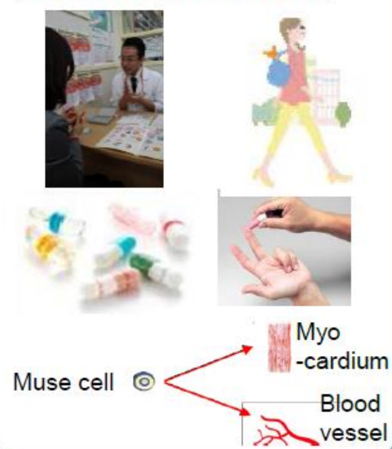


Agri-business

Li ion battery parts

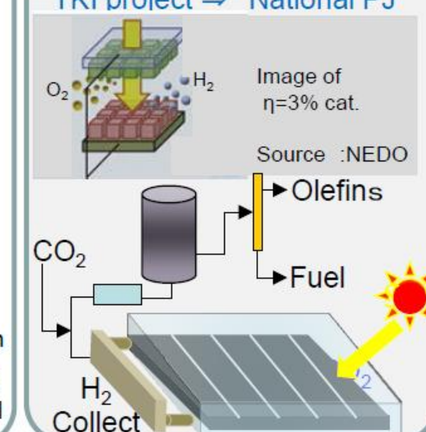
Organic EL, Solar Cell

Healthcare and ICT



Artificial Photosynthesis

TKI project ⇒ National PJ



Thank you George san

Thank you all
for your attention