Toray's Advanced Materials

- Innovation by Chemistry -

Toray Industries, Inc.
Executive Vice President and Representative Director
Hiroaki Kobayashi

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Innovation by Chemistry

Ⅰ. Technology Innovation Supported by Materials Innovation

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Society in 21st Century & Industrial Circumstance

Society in 21St Century / Industrial Circumstance	Information Tele-communication	Healthcare	Environment	Energy	Safety & Security
Newly Created Industrial Fields	Ubiquitous Network High Speed Communication Next Generation Displays Etc.	Global Warming CO_2 Emission Pollution Oil Supply Etc.	Taylor-made Medicine Regenerative Medicine Nursing Care System Etc.	Solar Cell Wind Power Fuel Cell Etc.	Personal Identification Air/Water Purification Safer Construction Materials Etc.
Globalization	Global Competition, Rising Korean & Chinese Companies,Entering Chinese Market				
CSR	Corporate Governance, Compliance, Risk management, Safety/Disaster Prevention/Environment				
IP	IP Management, Employee Inventions, Technology Transfer, International Harmonization				

New Value Creation | Product Design Strength | Solution for Social Problems | Global Competitiveness

Nanotechnology provides solutions for 21st century

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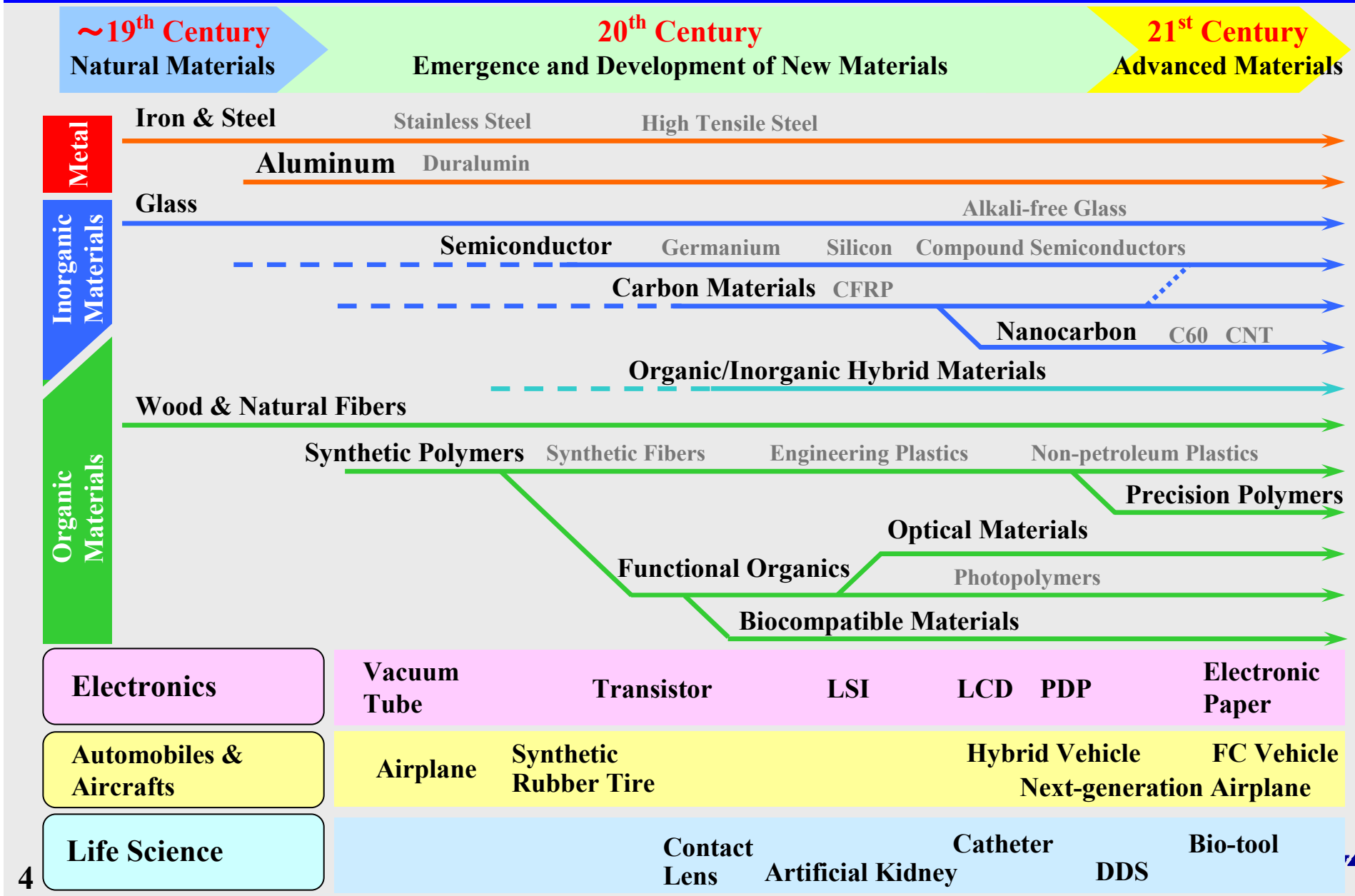
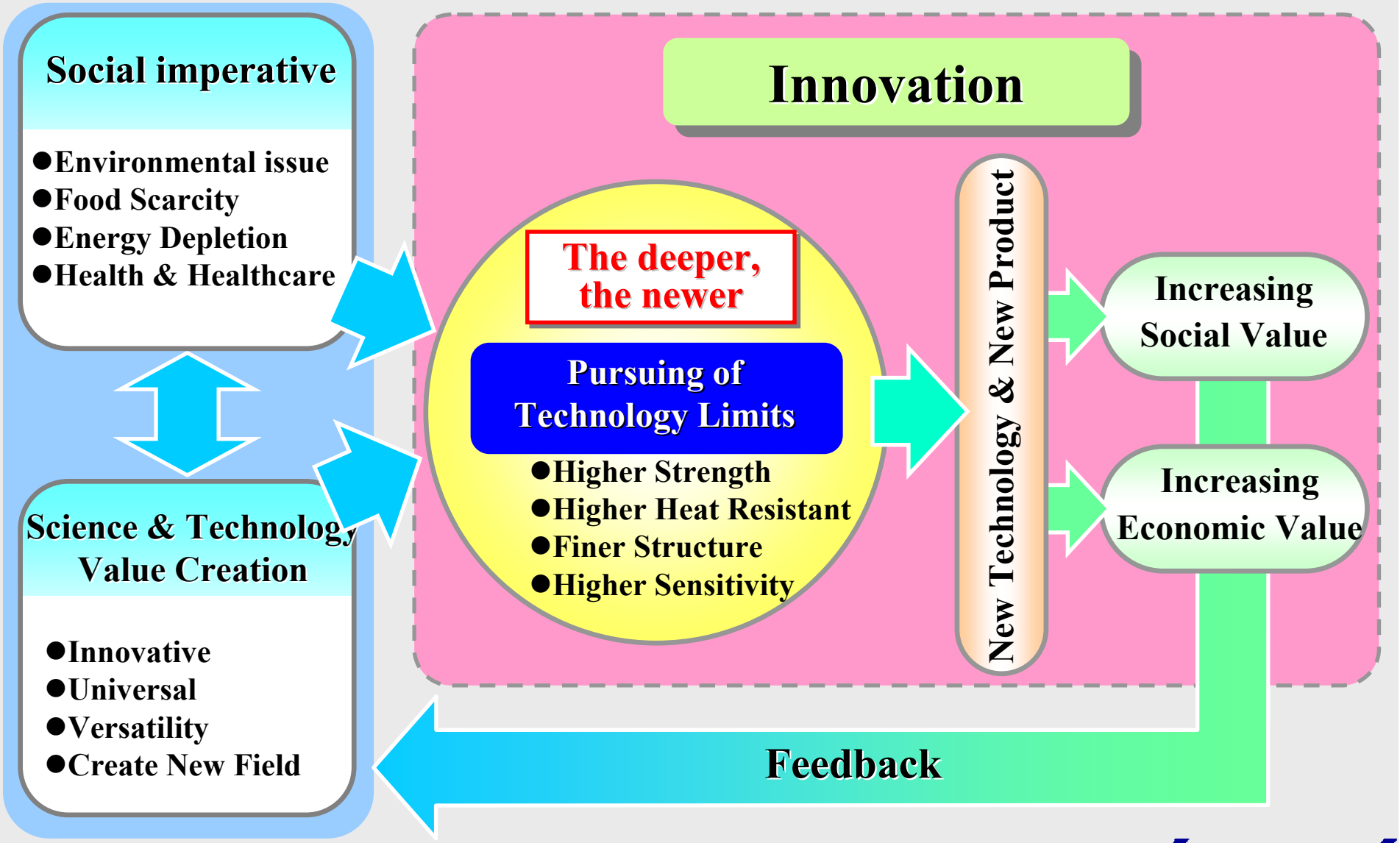
Advanced Materials Lead Advanced Industries



Innovation by Pursuing Limits



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Innovation by Chemistry

Ⅱ. Toray's R & D Activity

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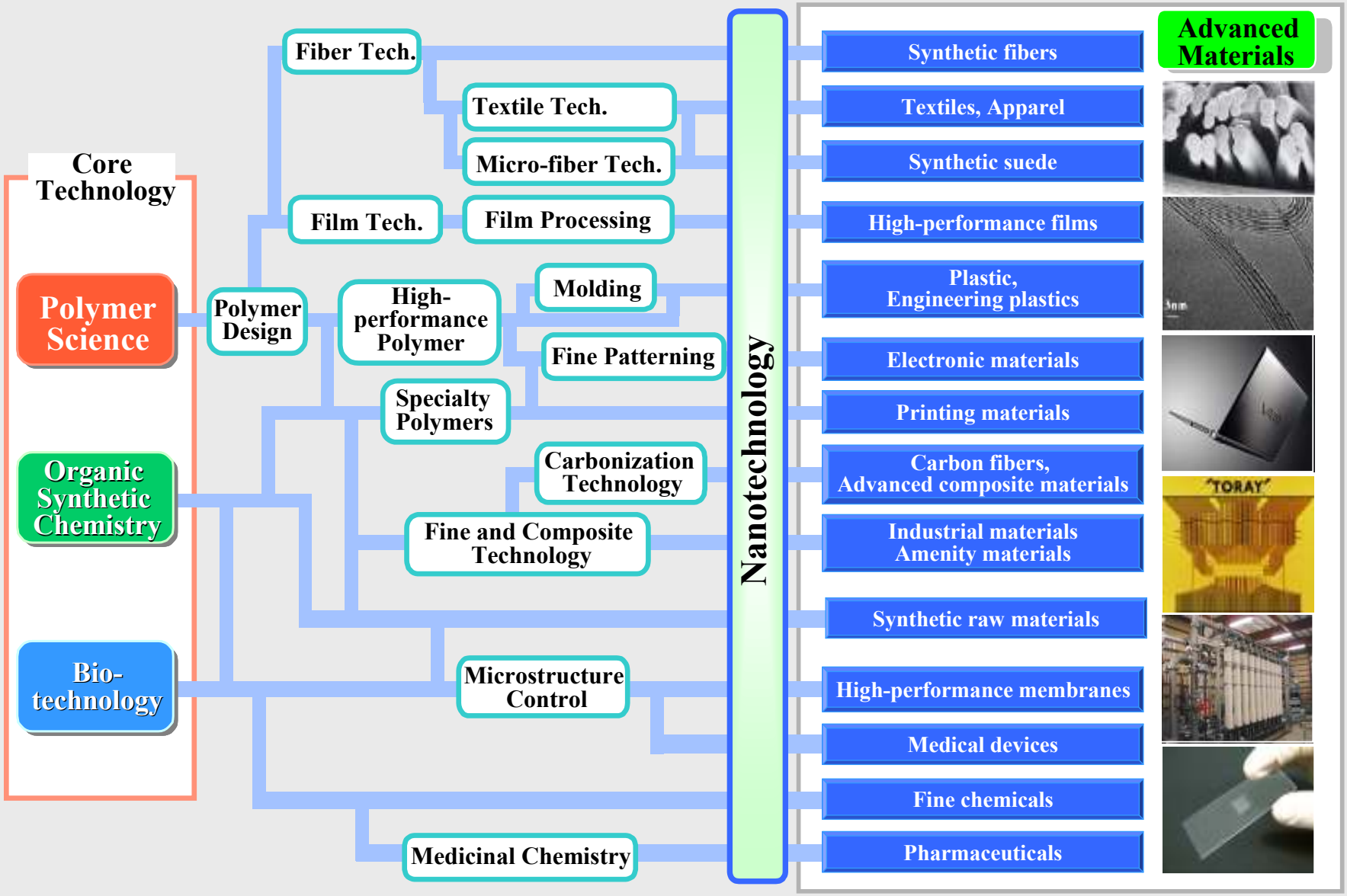
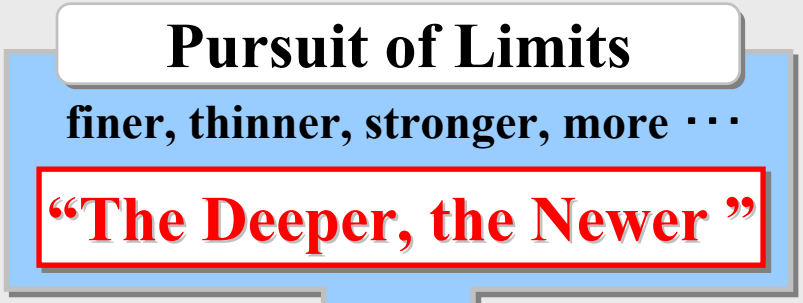
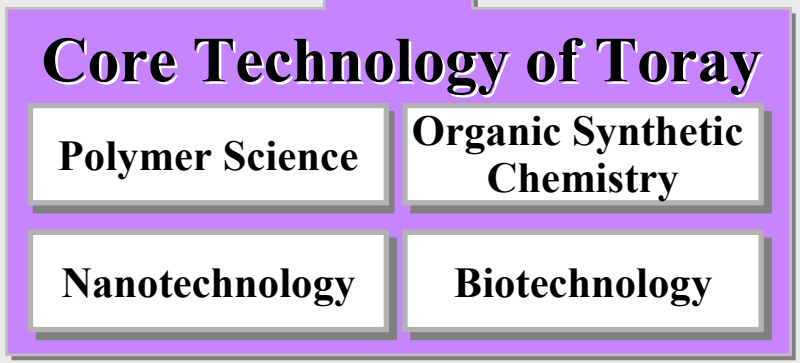
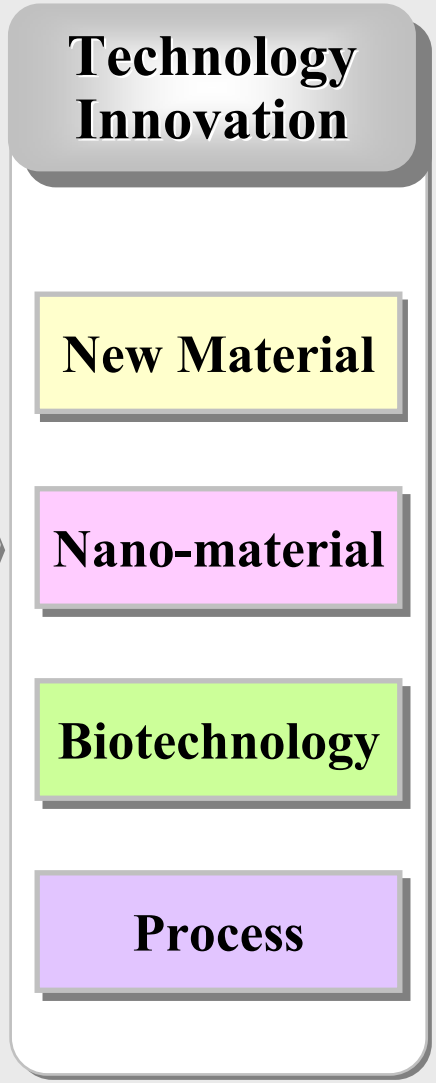
Toray's Technology Fields & Products



Toray's Challenge for Technology Innovation







- Example of Toray's Advanced Materials -

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Technology Innovation	Main Strategic Region			
	IT-related Materials	Automobile ・Aircraft	Life Science	Environment ・Water・Energy
New Materials	Optical Circuit Board Materials	Carbon Fiber Composite Materials	Innovative Synthetic pharmaceuticals	Organic Semiconductor
	New Optical Film	New transparent heat-resistance resin		Bio-mass Fibers
Nano Material	Nano–multilayer Films	Nano-composite	Nanofibers	PLA Polymers
	CNT	Nanoalloy	DDS	Membrane
Biotechnology			Bio-pharmaceuticals	Green Chemistry
			Bio-tools	
Nano Process	LCD Color Filters	Next Generation Molding	Human-friendly Material	Next Generation Recycling
	PDP-related Materials			MBR

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- Example of Toray's Advanced Materials -

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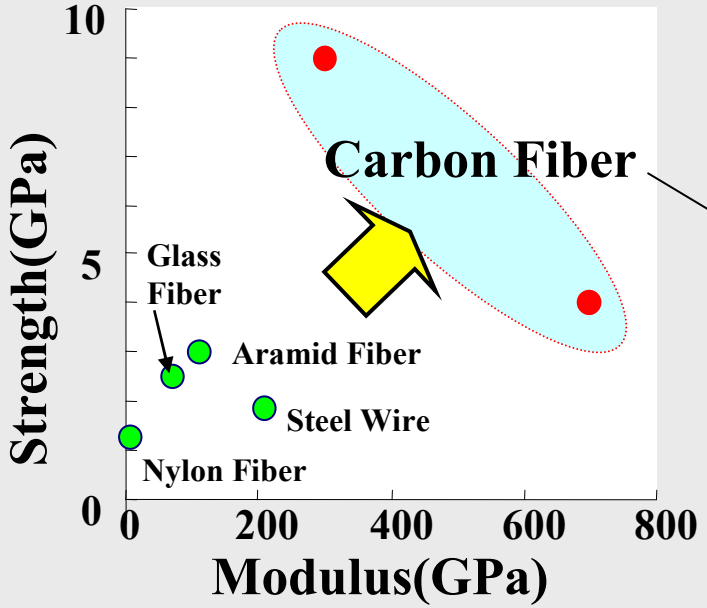
	PDP-related Materials			MBR

New Materials Innovation
Carbon Fiber
Composite Materials

Pursuit of Ultimate Strength and Modulus



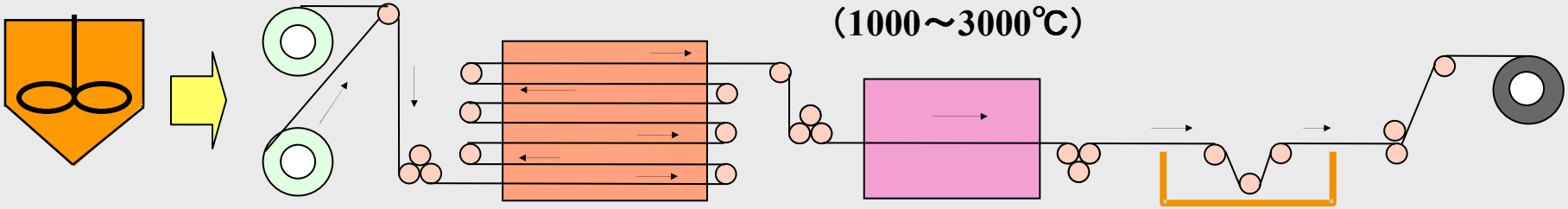
Merit of Carbon Fiber

- Lightweight
  Specific gravity=1.8
  :2/3 of Al
- Rust resistance
- Chemical resistance
- High conductivity
- Dimensional stability

etc

Industrial process and technology for pursuit of ultimate performance

PAN polymerization and spinning → Oxidization (200～300℃) → Carbonization (Graphitization) (1000～3000℃) → Sizing → Carbon Fiber



Polymer design Control of fiber structure	Control of defect Orientation by draw	Control of graphite crystalline（size, orientation）

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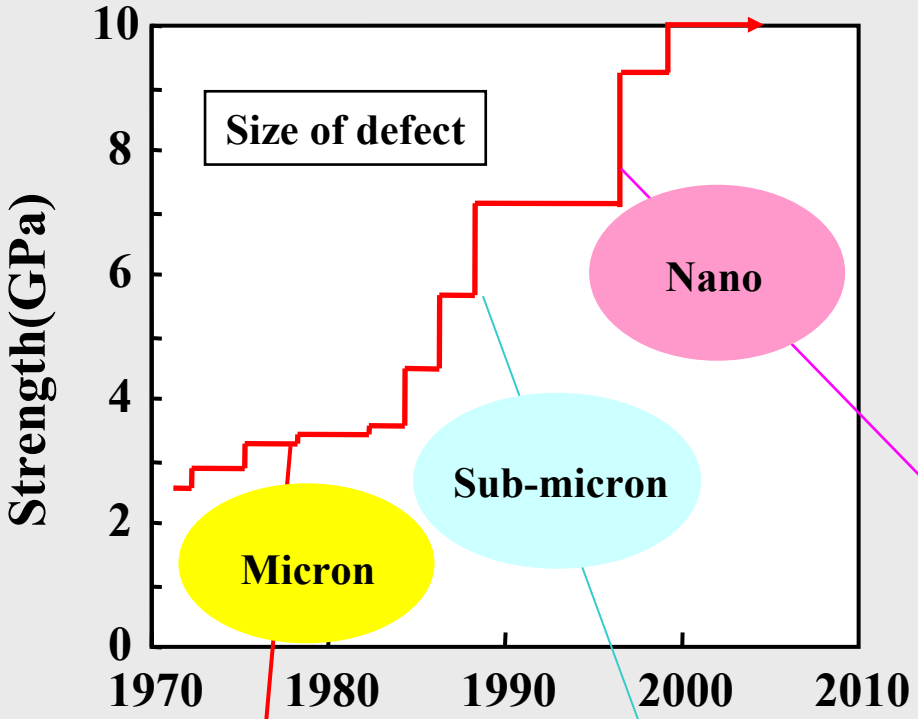
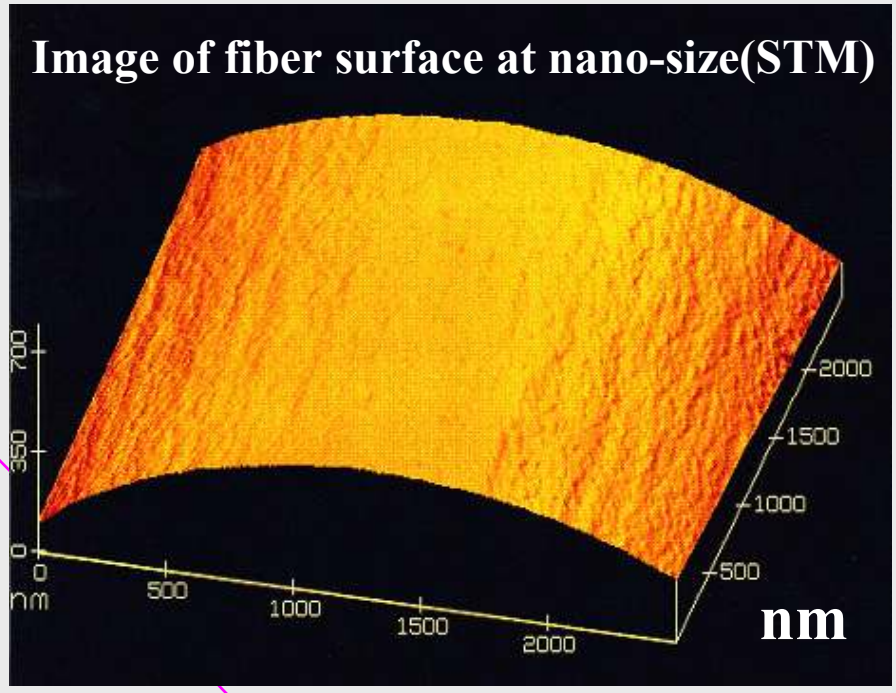
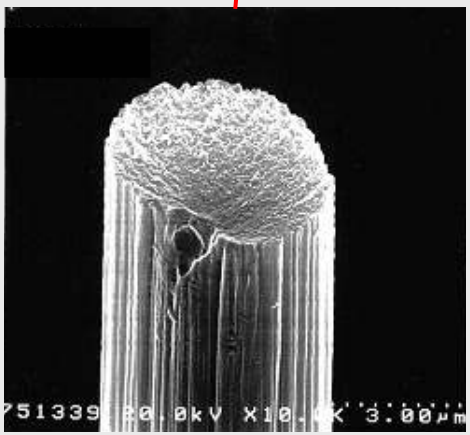
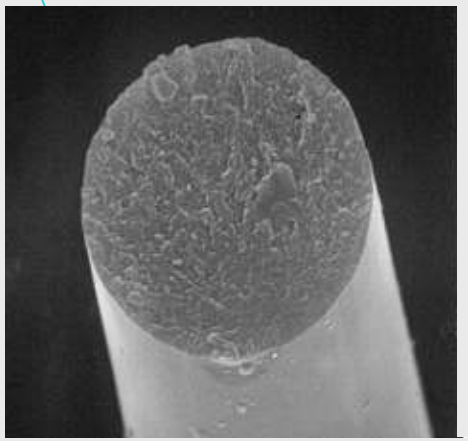
New Materials Innovation
Carbon Fiber
Composite Materials

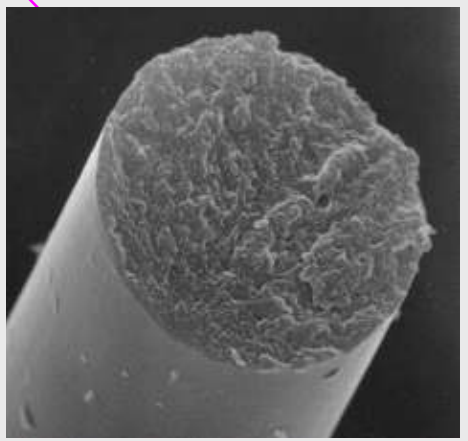
Pursuit of Ultimate Strength / Control of Surface Defect





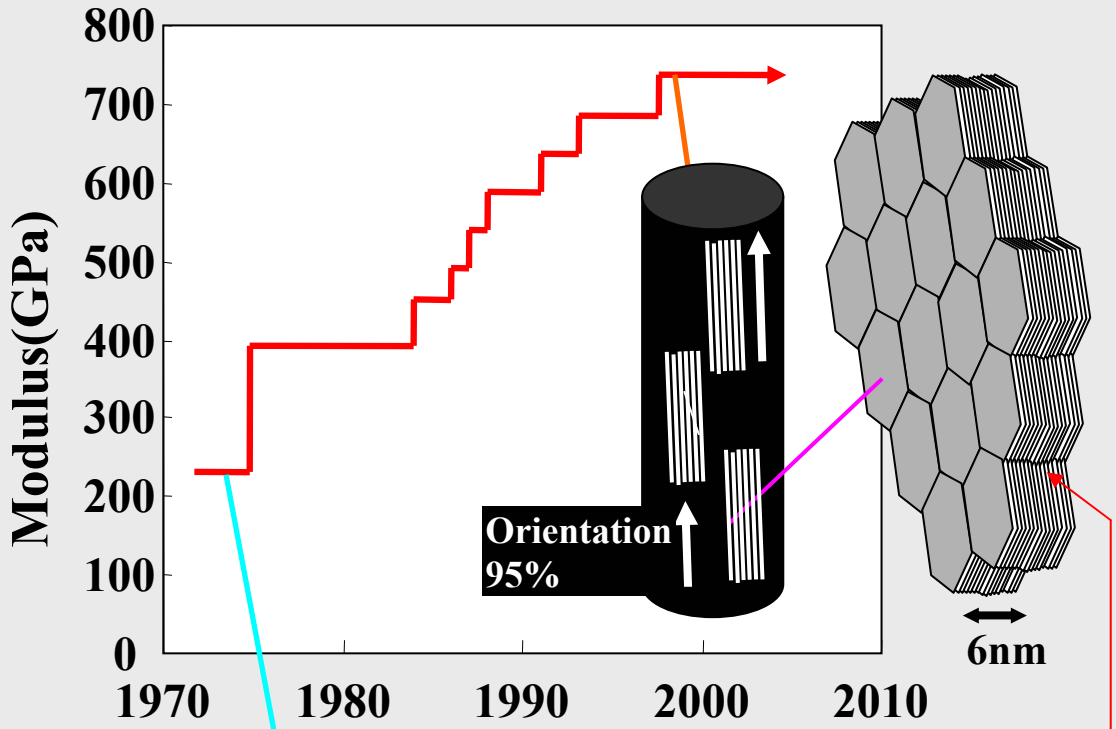




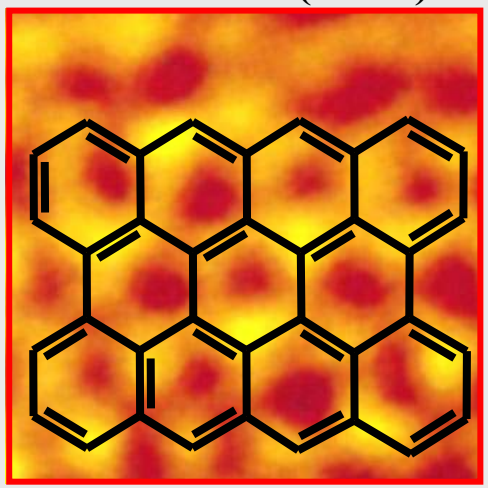


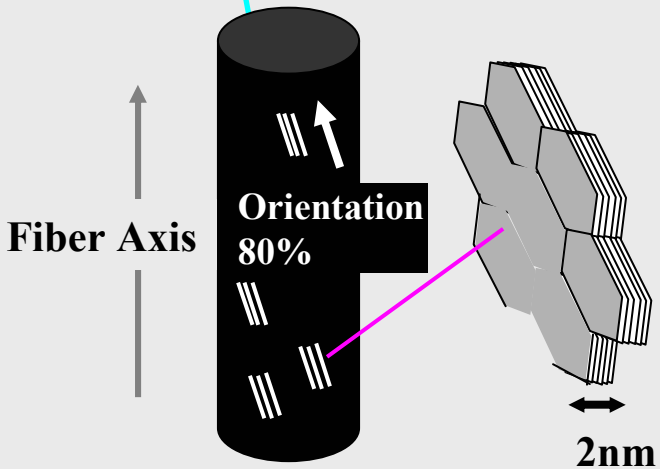
New Materials Innovation
Carbon Fiber
Composite Materials

Pursuit of Ultimate Strength /Control of Graphite Crystalline



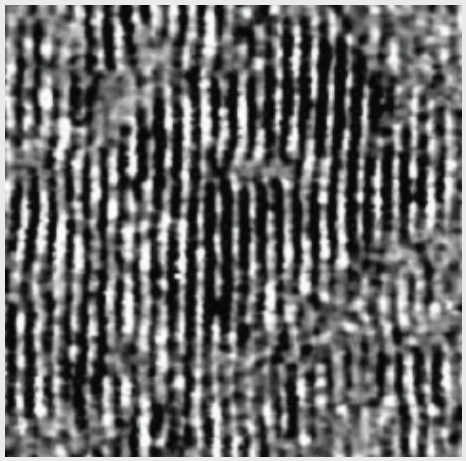
Surface(STM)





Graphite
Crystalline

Cross Section
(TEM)



New Materials Innovation
Carbon Fiber
Composite Materials

Pursuit of Ultimate Weight Reduction of Aircraft Structure

—CFRP : Carbon Fiber Reinforced Plastics —

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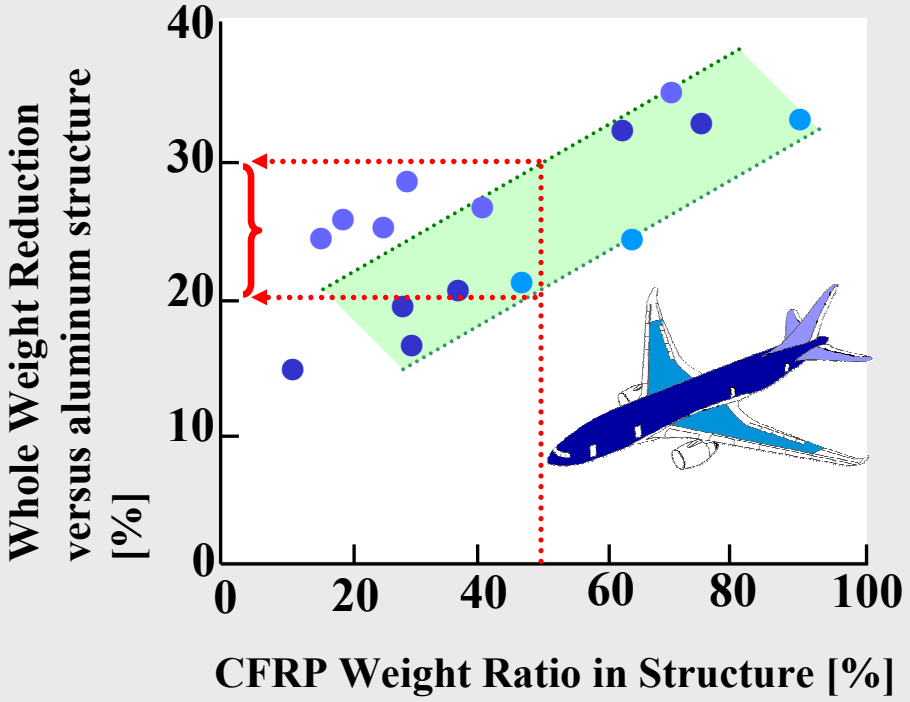
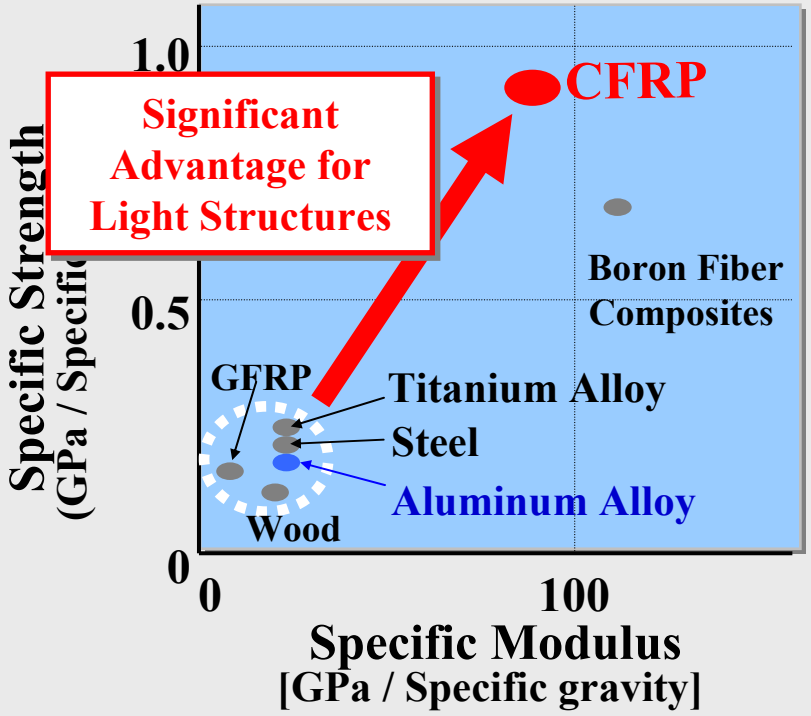
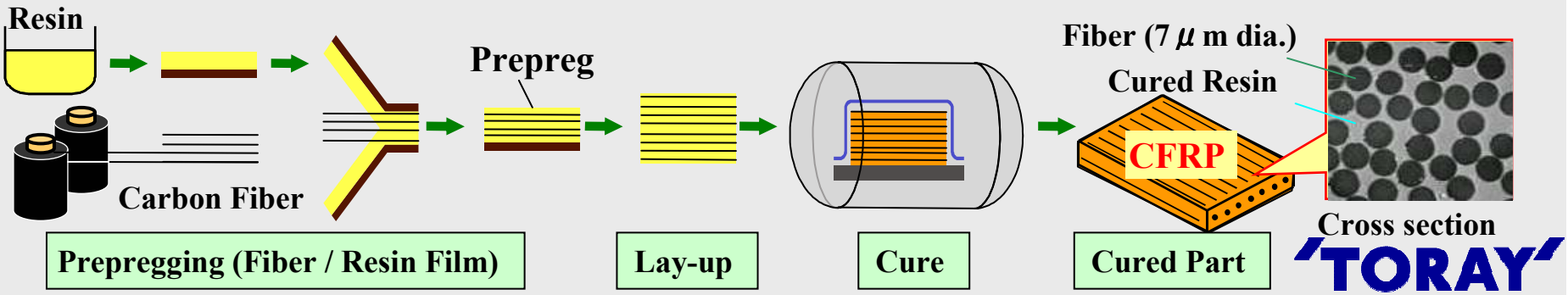
Replacement of 50% of structure with CFRP yields 20% reduction of whole structural weight versus aluminum alloy.







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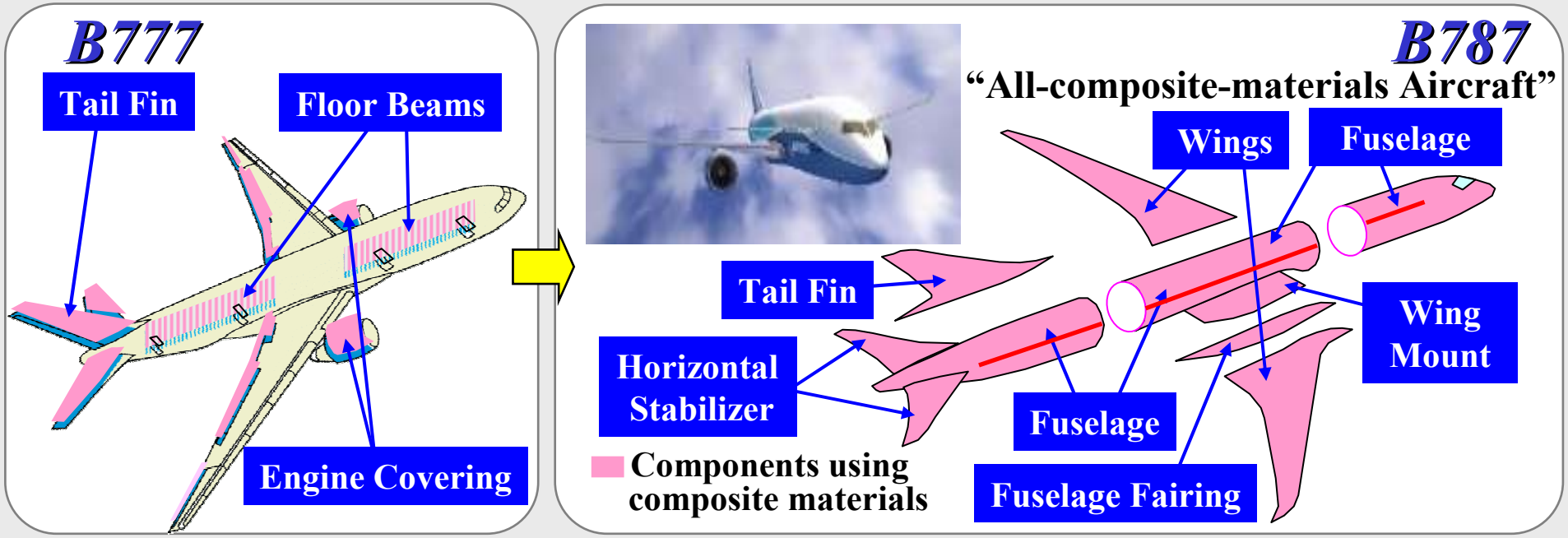
Expansion of Aircraft Application



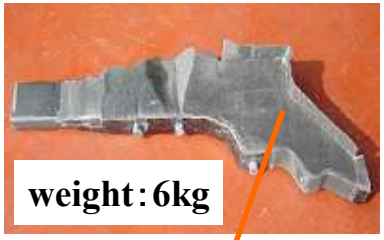
Introduction	1982	1995	2008
Mode	B767	B777	B787
Section using CFRP	Secondary structures	Primary structures (tail assembly etc.) Secondary structures	Primary structures (main wings, tail assembly,etc.) Secondary structures
Using CF type	T300H	T800H	T800S
CFRP utilization (wt%)	3	12	50
CFRP utilization/plane (ton)	1.5	9.6	35

Expansion of Automobile Applications

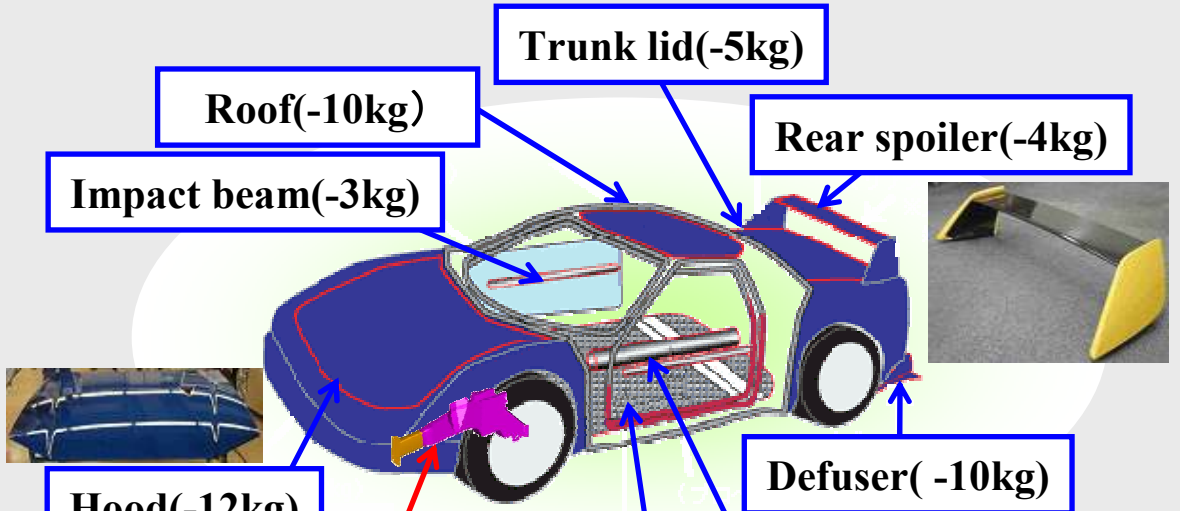
New Target : From exterior panels to main strictures

First full-scale test of CFRP passenger car

Front side member made of CFRP



Total weight : 2060kg
Test speed : 47km/h



Approx. 200 kg weight reduction

CFRP Application Sections and Weight Reduction

( )comparisons with conventional materials such as steel

★ Approx. 200 kg weight reduction and improved safety by use of CFRP

※"Innovation Global Warming Countermeasure Technology Program" (METI: 2003 to 2007)

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Process	LCD Color Filters	Next Generation Molding	Human-friendly Material	Next Generation Recycling
	PDP-related Materials			MBR

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Nano Material
Innovation
Nanofibers

Pursuit of Ultimate Thin Fibers

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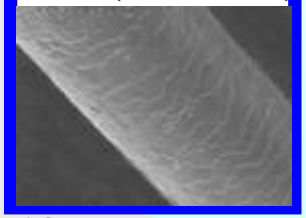
10,000nm(10μm)　1,000nm(1μm)　100nm　10nm

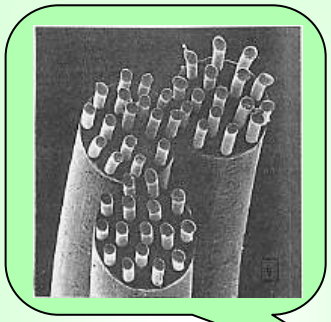
6μm

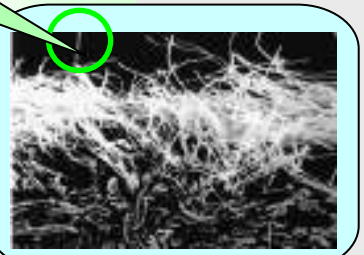
Conventional Fibers
(Polyester、Nylon et.al.)

Hair(～50μm)



Microfibers
(Polyester、Nylon et.al.)





Man-made
Suede

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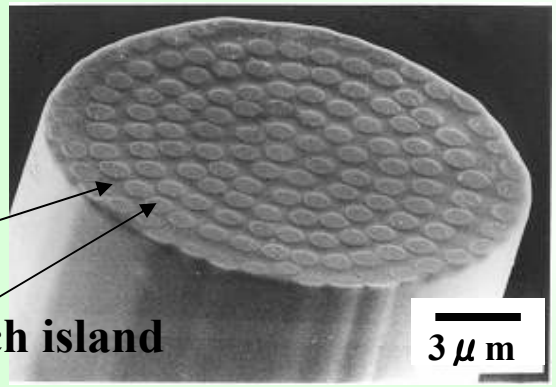
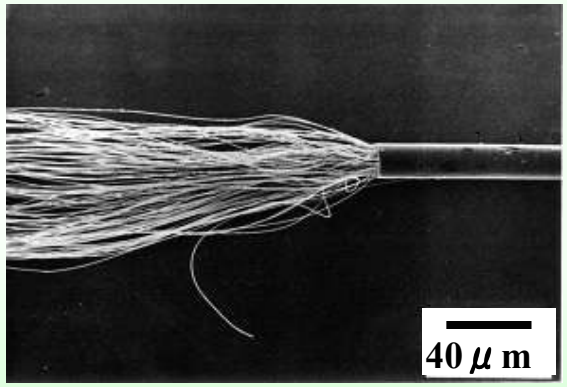
Innovation of Synthesis of Microfibers

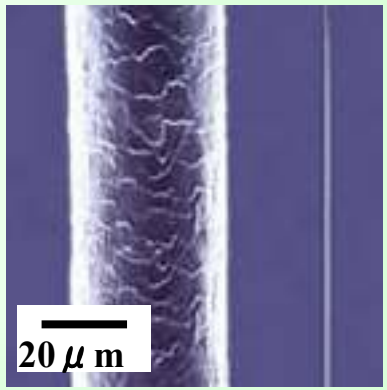
Polymer-mosaic fibers
(Islands in sea fibers)

→ Removing sea component →

Microfibers







hair Microfibers

Man-made Suede
(launched at 1970)

Applications

Garments

Car interiors

Furniture

Industrial Materials

Nano Material Innovation Nanofibers

Pursuit of Ultimate Thin Fibers

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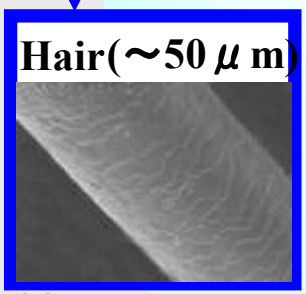
10,000nm(10 μ m) 1,000nm(1 μ m) 100nm 10nm

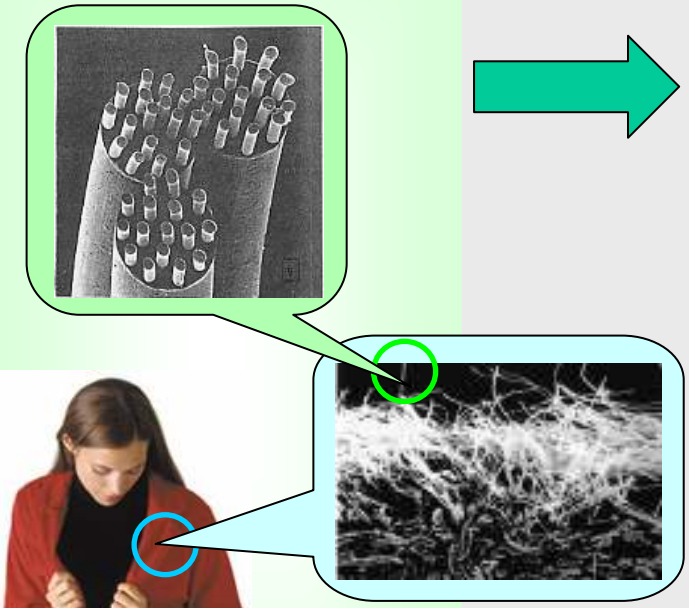
6 μ m

Conventional Fibers
(Polyester、Nylon et.al.)

Hair(～50 μ m)

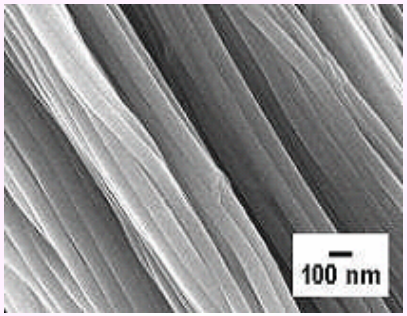


Microfibers
(Polyester、Nylon et.al.)

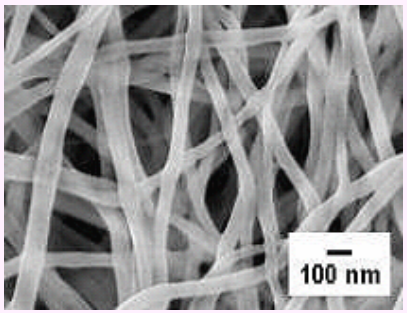


Man-made Suede

Nanofibers
(Nylon,Polyester et.al.)



Bundles（ Aggregation ）



Fiber Dispersion

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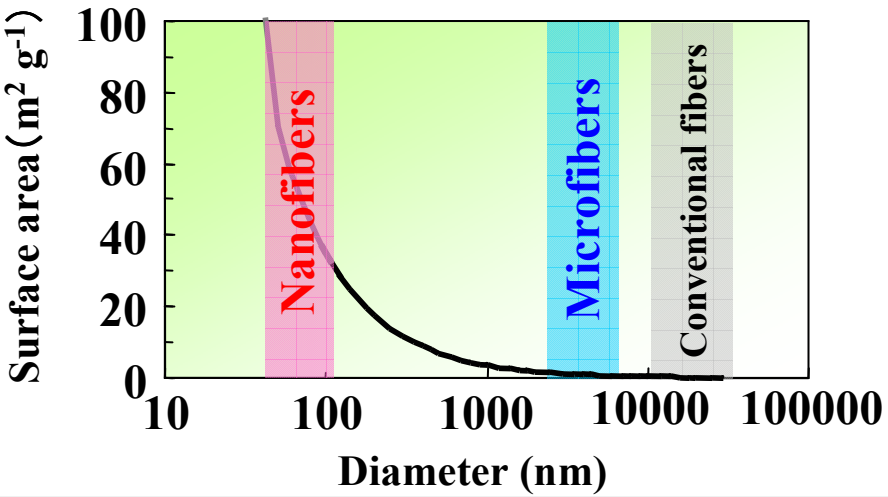
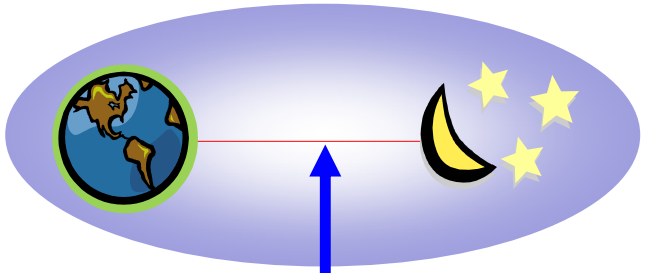
Nanofibers

Pursuit of Ultimate Thin Fibers

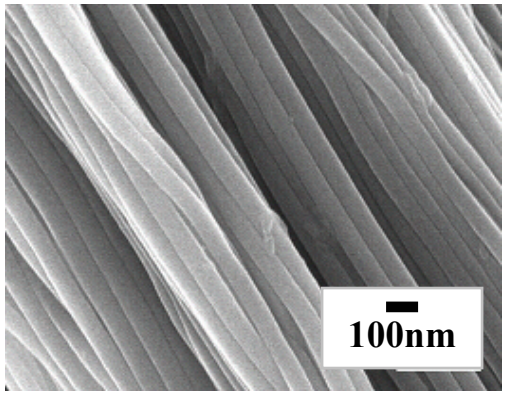




Amount of fibers to reach the moon

Microfibers : 450g

Nanofibers : 0.15g



Side view of N6 nanofibers

Features

- fineness
- adsorption
- absorption
- slow release

Applications

- textile
- abrasive cloth
- filter
- medical device
- cosmetics

- ◆ commodity polymers
  - Nylon
  - Polyester
  - Polyolefin et. al.
- ◆ using existing plants

Launched in 2006

Nano Material Innovation "NanoMATRIX"

Nano-Scale Technology for Processing Textile

(Policy) Pursue and develop "Seeing and finding nano-processing technology" "Wearing and understanding innovative function" in Toray's textile 'nano-scale technology for processing textile'.

"NanoMATRIX"

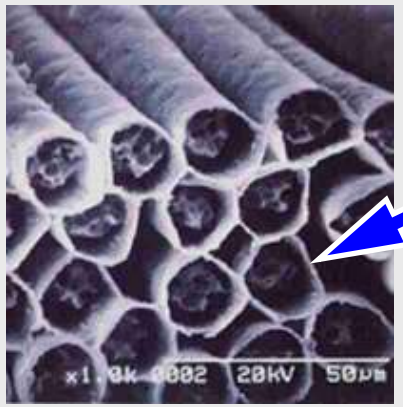
Continuous Coating on the single fiber surface by functional material

Expected advantages

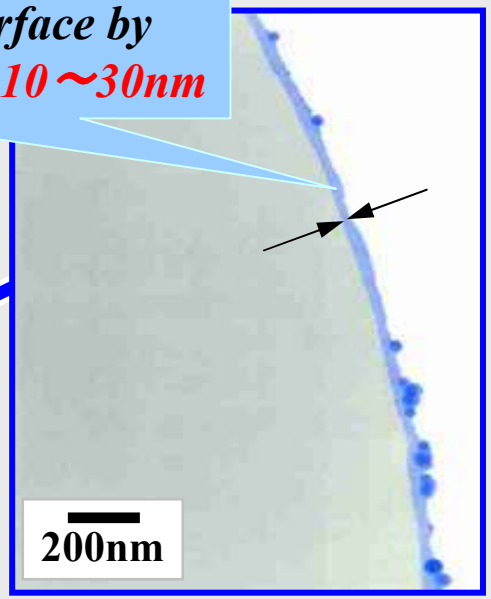
- ***Level up function***
- ***Improve durability of function***
- ***Keep soft handle***

Bring a new products to market

Coating on the single fiber surface by functional material. Thickness : 10～30nm



SEM Photograph of Coated functional material on the single fiber

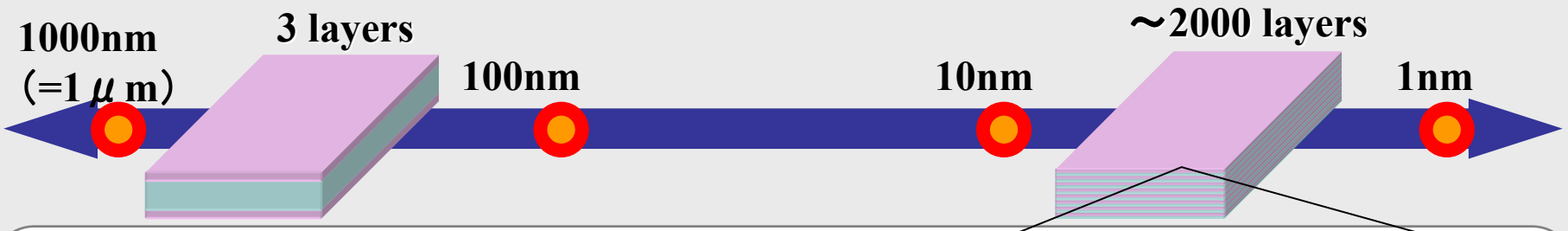


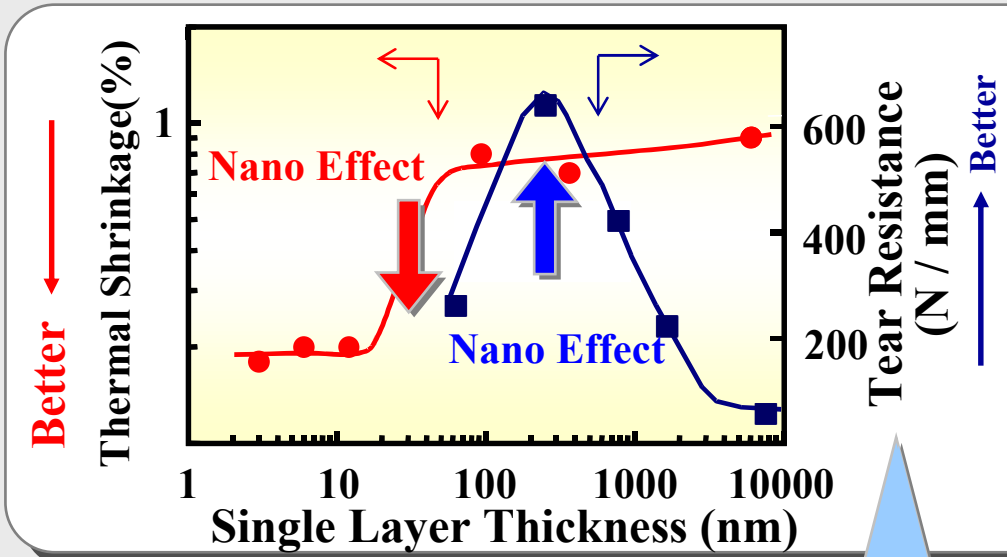
TEM photo of Coated single fiber cross-section

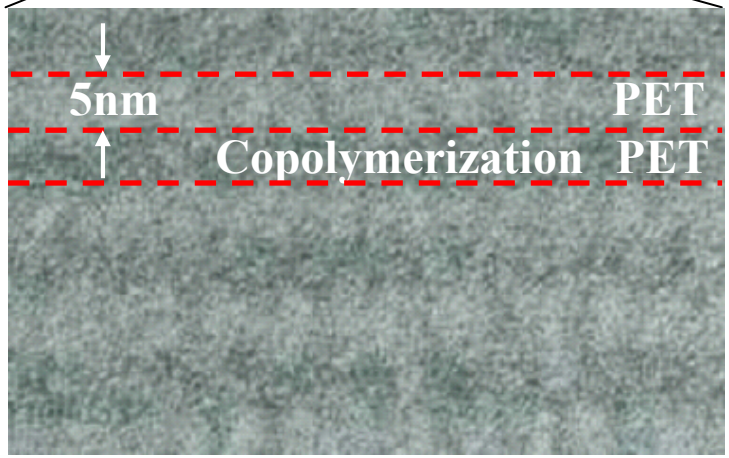
★"BEAULAVAGE"(2004)
;Easy to wash out of rouge and etc. even if they stick

★"ANTI POLLEN" NT (2005)
; Easy not to stick pollens and easy to shake off

Nano-multilayer Films

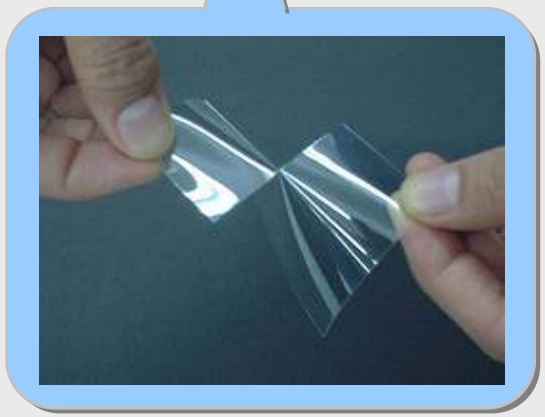






Expanding Applications

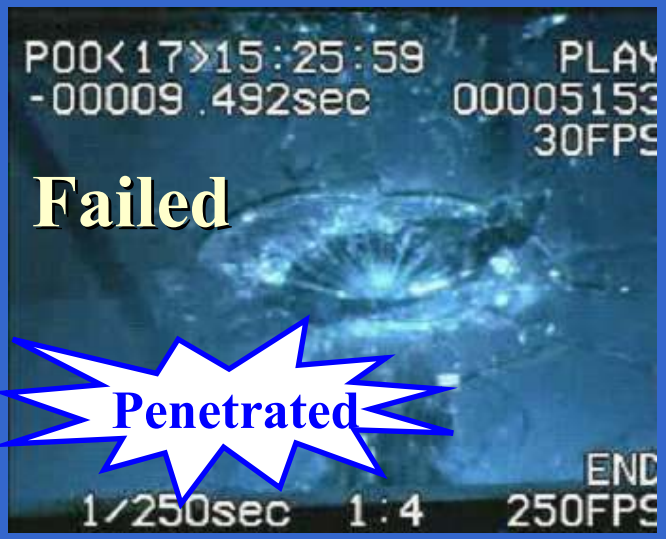
- Glass Protective Films (for safety & security)
- Electronic Materials
- Optical Functional Tapes



Nano-multilayer Films

Falling Ball Penetration Test

(Height 3m , Weight 2.2kg)



【PET Film】

【Newly Developed Film】

Expanding Applications

- ◆ Glass Protective Films (for safety & security)
- ◆ Electronic Materials
- ◆ Optical Functional Tapes

→ ★ Launched in 2004

Nano Material Innovation Membrane

Separation Membrane for Water Treatment
- Types and Surface Morphologies-

80 ANNIVERSARY

Size	1 nm	10 nm	100 nm	1000 nm

Target

Ions, Small molecules → ← Polymers → ← Colloids →

Monovalent ions

Organic matter

Multivalent ions

Trihalomethanes

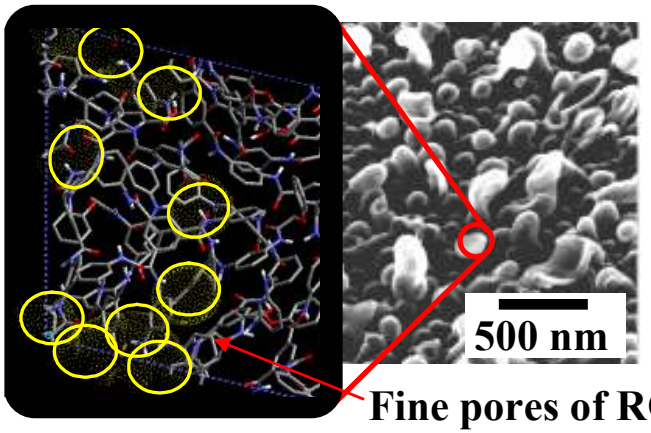
Viruses

Coliform

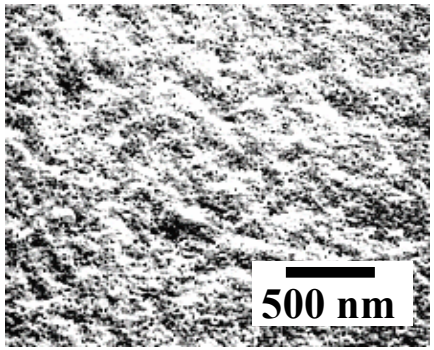
Bacteria

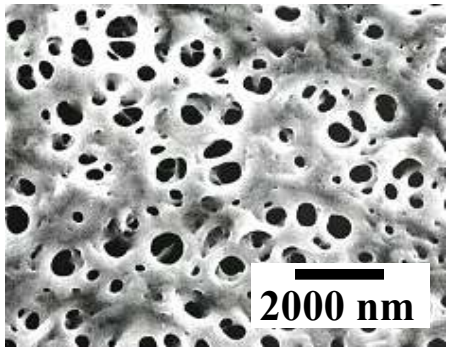
Membrane

RO (Reverse Osmosis)	NF (Nanofiltration)	UF (Ultrafiltration)	MF (Microfiltration)



Fine pores of RO Membrane (0.6~0.8nm)





Seawater Desalination
Drinking Water Production
(Removal of hardly decomposed substances)

Drinking Water production
(Removal of suspended solids & microorganisms)
Wastewater Reclamation & Reuse

Pursuit of limitation by deepening & fusion of membrane and microorganism technology

TORAY

Nano Material Innovation Membrane

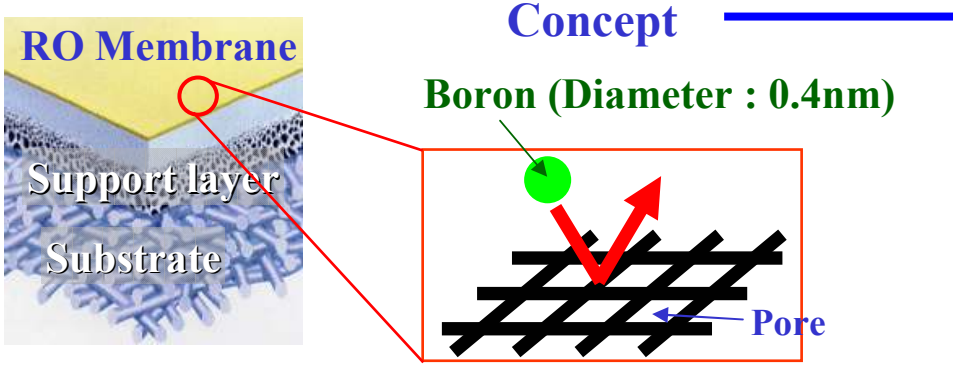
High Boron Rejection RO Membrane
(Separation Membrane for Seawater Desalination)

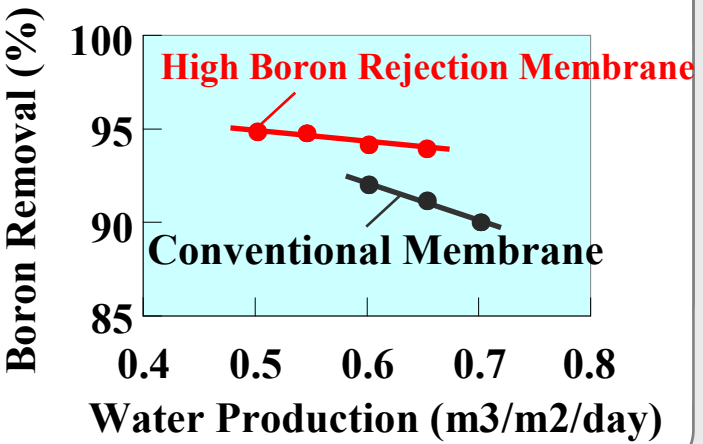
80 ANNIVERSARY

New technology points

Densification of membrane structure by using precise molecule design & nanofabrication technology

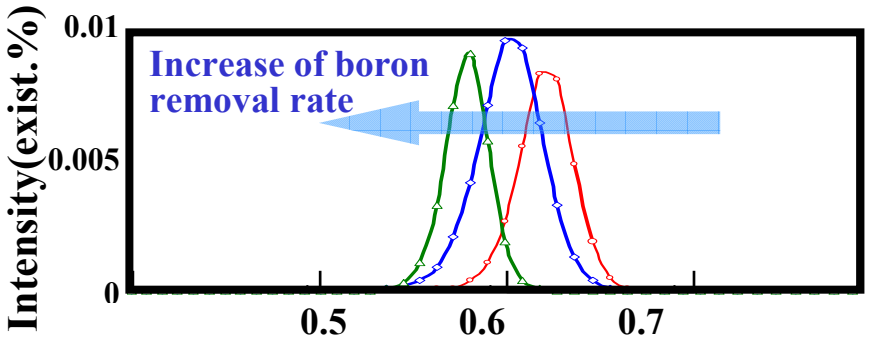
Concept → Performance of Membrane





[Positron Annihilation Spectroscopy]
/ Nanostructure analysis technology by TRC

Proof of correlation between pore size & boron removal (The world's first quantification)



Seawater RO desalination plant

TORAY

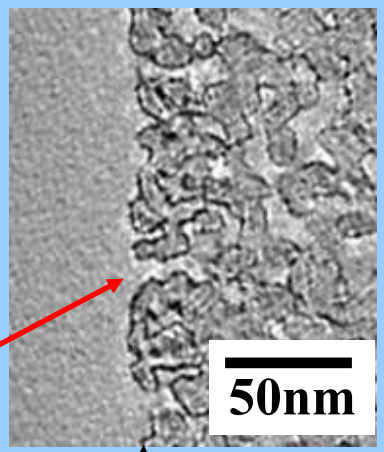
Nano Material Innovation Membrane

High Boron Rejection RO Membrane
(Separation Membrane for Seawater Desalination)

80 ANNIVERSARY

Nano-pore Hollow Fiber Membrane for Artificial Kidney

Artificial Kidney



Nano-pore

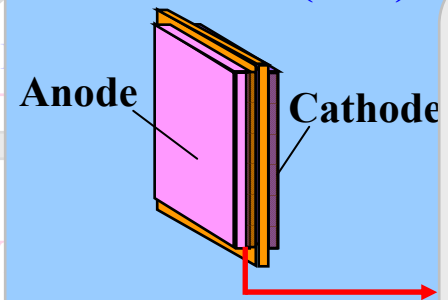
(Radius : ~5nm)

Membrane surface

Specific removal of uremic substance from blood（first β2-microglobulin removal in the world）

Polymer Electrolyte Membrane for Fuel Cells (Direct Methanol Type)

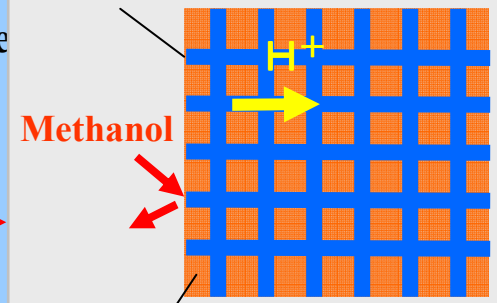
Fuel Cells (Cell)



Electrolyte Membrane

(Non-Fluorine)

Non-freezing water (Proton Conduction)



High ionic conductivity and low methanol cross over (1/10 of conventional membrane)（world top level）

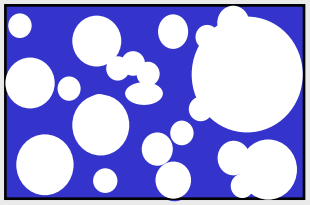
TORAY

Polymer Alloy／Nanoalloy

Polymer A + Polymer B

Polymer Design
Compatibilizer Design
+
Nano-dispersing Technology

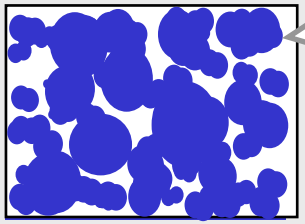
Conventional Alloy

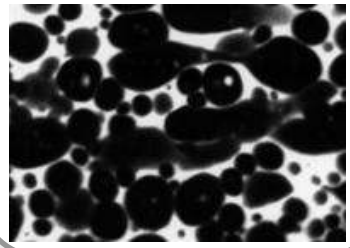


Transmission Electron Microscope photo (cross section of polymer)

- High impact PA
- High impact PBT
- High impact PPS

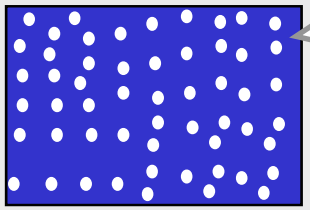
Phase-inversed Alloy

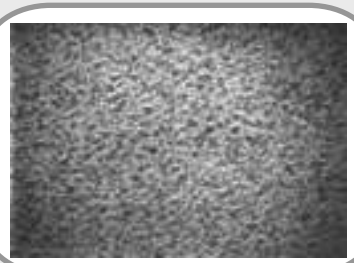




- Low water absorption PA

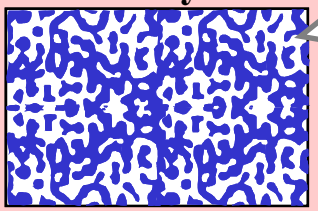
Nano-dispersed Alloy

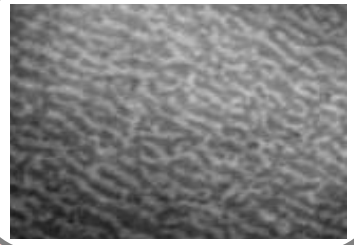




- High thermal resistant PLA
- High thermal resistant PET
- Flexible PLA

Nano-co-continuous Alloy





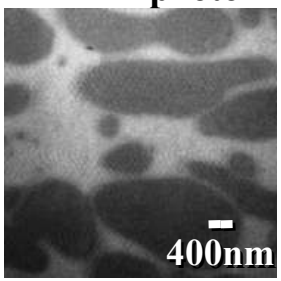
- High chemical resistant PET
- Innovative PBT／PC

Nano-co-continuous Alloy

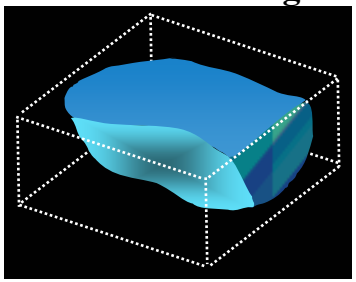
Toray succeeded in developing a world's first nano-alloy technology which makes it possible to combine only the best properties of two different polymers.

Conventional Alloy

TEM photo

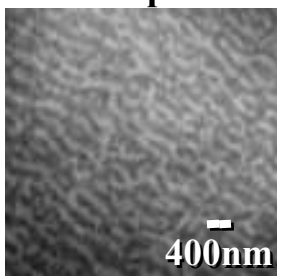


3D-model image

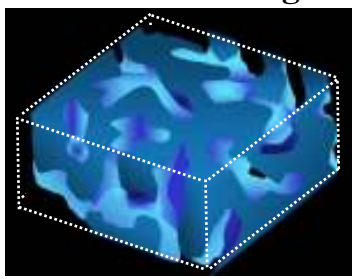


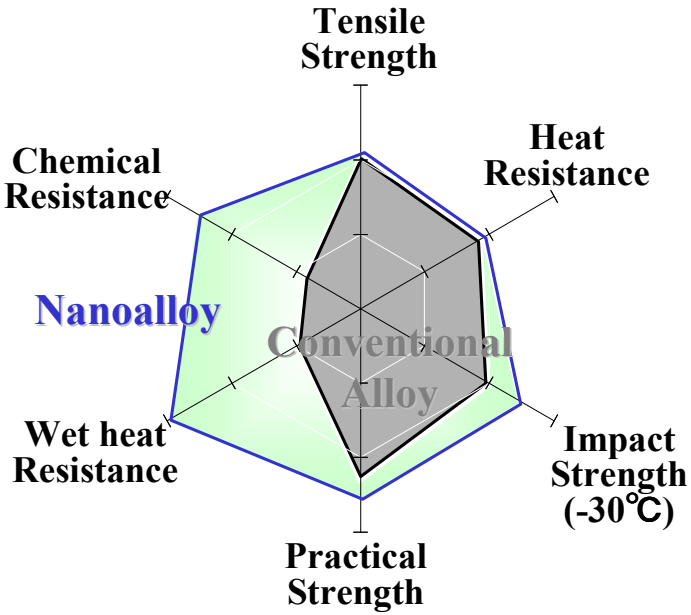
Nanoalloy (Development material)

TEM photo



3D-model image





Comparison of Properties between Conventional Alloy and Nanoalloy (PBT/PC system)

We plan to place the material on the market within one year, especially for automobile parts, electric and electronic parts, and transparent sheet and so on.

Nano Material Innovation
PLA Polymers

Development of Non-petrochemical Raw Materials

Fossil material

Refining / Synthesis

Raw material

Polymerization

Nylon
Polyester
Acrylics
Polyurethane
others

Fibers & Textiles
Films
Plastics
others

Biotechnology

Nanotechnology

Lactic acid

Polymerization

Polylactic acid

Examples of PLA plastics products

Plant-based raw materials

1,3-propanediol (+TPA)

Polymerization

3GT

Photosynthesis

Plant oil

Flexible heat resistant films

Toray's Business Domain

Water, Carbon Dioxide

★ Toray is developing non-petrochemical raw materials making full use of Toray's technologies.

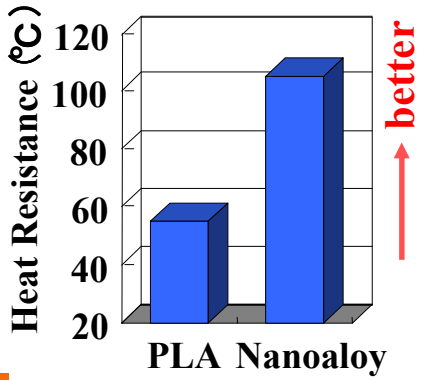
TORAY

Example of Application of PLA Polymer

High heat-resistance

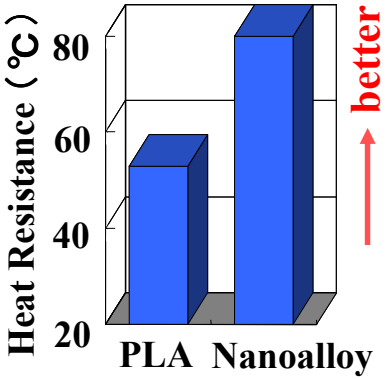
Improved heat-resistance with original nanoalloy technology

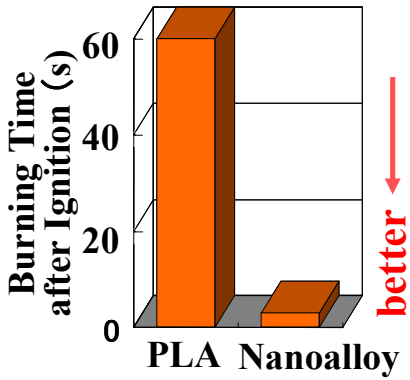
Conventional Alloy　Nanoalloy



Non-halogenated flame-retardant

Improved heat-resistance and realized high–level of flame-retardancy with nanoalloy technology and non-halogenated flame-retardant technology





★Enhancing performances of PLA for electronics use with Toray's original nanoalloy technologies.

★Toray has contributed to global environment thorough reduction of CO2 emission and fossil resources consumption.

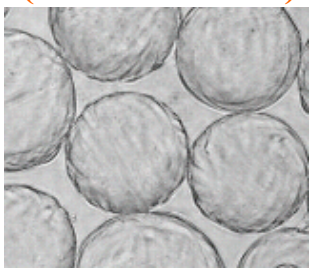
- Example of Toray's Advanced Materials -

	Main Strategic Region			
Technology Innovation	IT-related Materials	Automobile ・Aircraft	Life Science	Environment ・Water・Energy
New Materials	Optical Circuit Board Materials	Carbon Fiber Composite Materials	Innovative Synthetic pharmaceuticals	Organic Semiconductor
	New Optical Film	New transparent & heat-resistance resin		Bio-mass Fibers
Nano Material	Nano–multilayer Films	Nano-composite	Nanofibers	PLA Polymers
	CNT	Nanoalloy	DDS	Membrane
Bio			Bio-pharmaceuticals	Green Chemistry
			Bio-tools	
Process	LCD Color Filters	Next Generation Molding	Human-friendly Material	Next Generation Recycling
	PDP-related Materials			MBR

Interferon

Natural Human Interferon-β : Feron*

Establishment of large scale production technology (Beads culture)



Fibroblast cells on the beads

The world first interferon product

Launched in 1985 (Toray, Daiichi)

Indication: Hepatitis B & C
Melanoma/Brain tumors

Interferon Stereo Structure

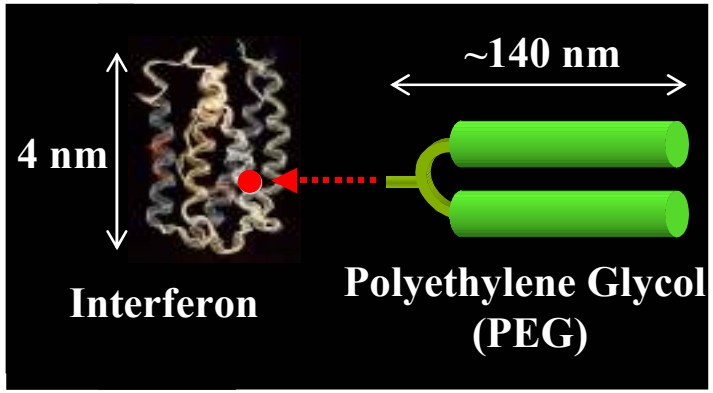
Structure elucidation of mouse interferon-β
(Tokyo Univ. & Toray)

New Drug Research

We discovered the optimum binding site of PEG on IFN (●)

Innovated the active PEGylated IFN-β (World's first)

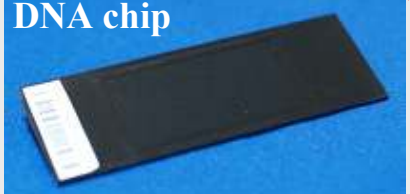
- Improved and durable therapeutic effects
- Many indications (Start clinical trial in 2008)



DNA Chip

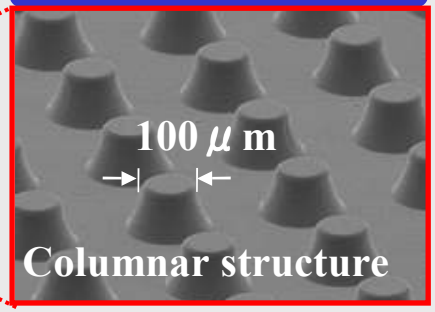
Appearance

High performance DNA chip



"3D-Gene"

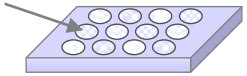
Magnified detection area



Feature of TORAY DNA chip

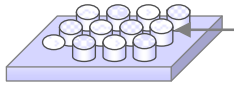
Flat substrate (conventional)

Probe DNA



Conventional glass chip

Columnar structure (newly developed)



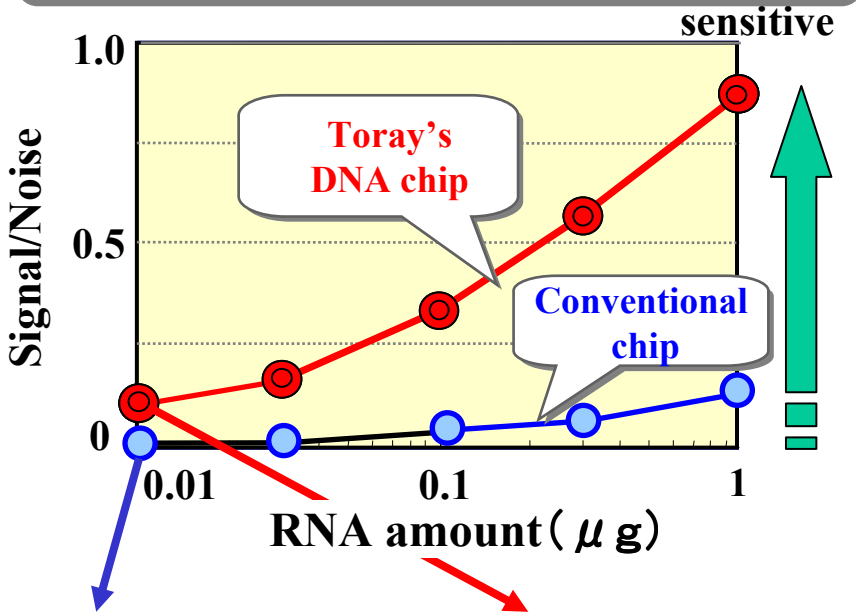
Next generation plastic chip

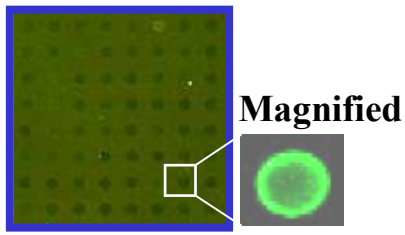
- Columnar structure
- Increased probe DNA
- Accelerated reaction

→ **High sensitivity**

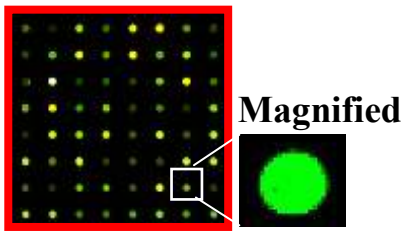
Performance of Toray's DNA chip

Sensitivity : 100-fold higher than conventional chip





Scanned image

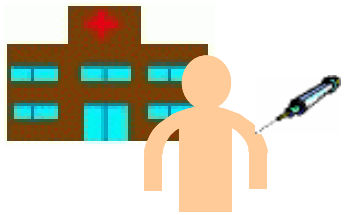


Scanned image

※This project is partially supported by NEDO.

Lab-on-a-Chip

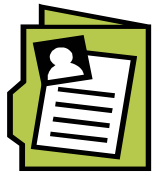
Rapid testing with Lab-on-a-Chip (within 15 mins)



Blood Sampling

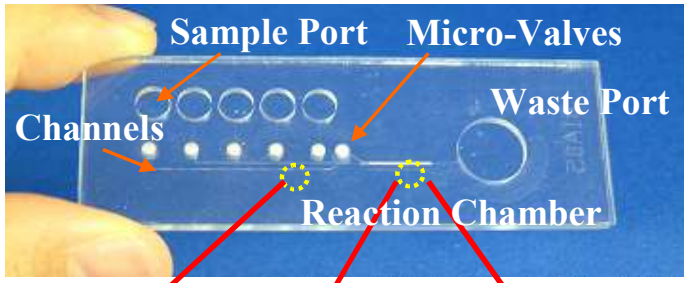
Drop on the chip

Measuring System



Complete !!

Structure of Lab-on-a-Chip



Micro-Channels　　Micro-Beads

4 Key-Technologies

1. Surface Modification

※Adsorption of proteins to the plastic surface were reduced to 30-fold less than non-modified surface

2. Micro Fabrication

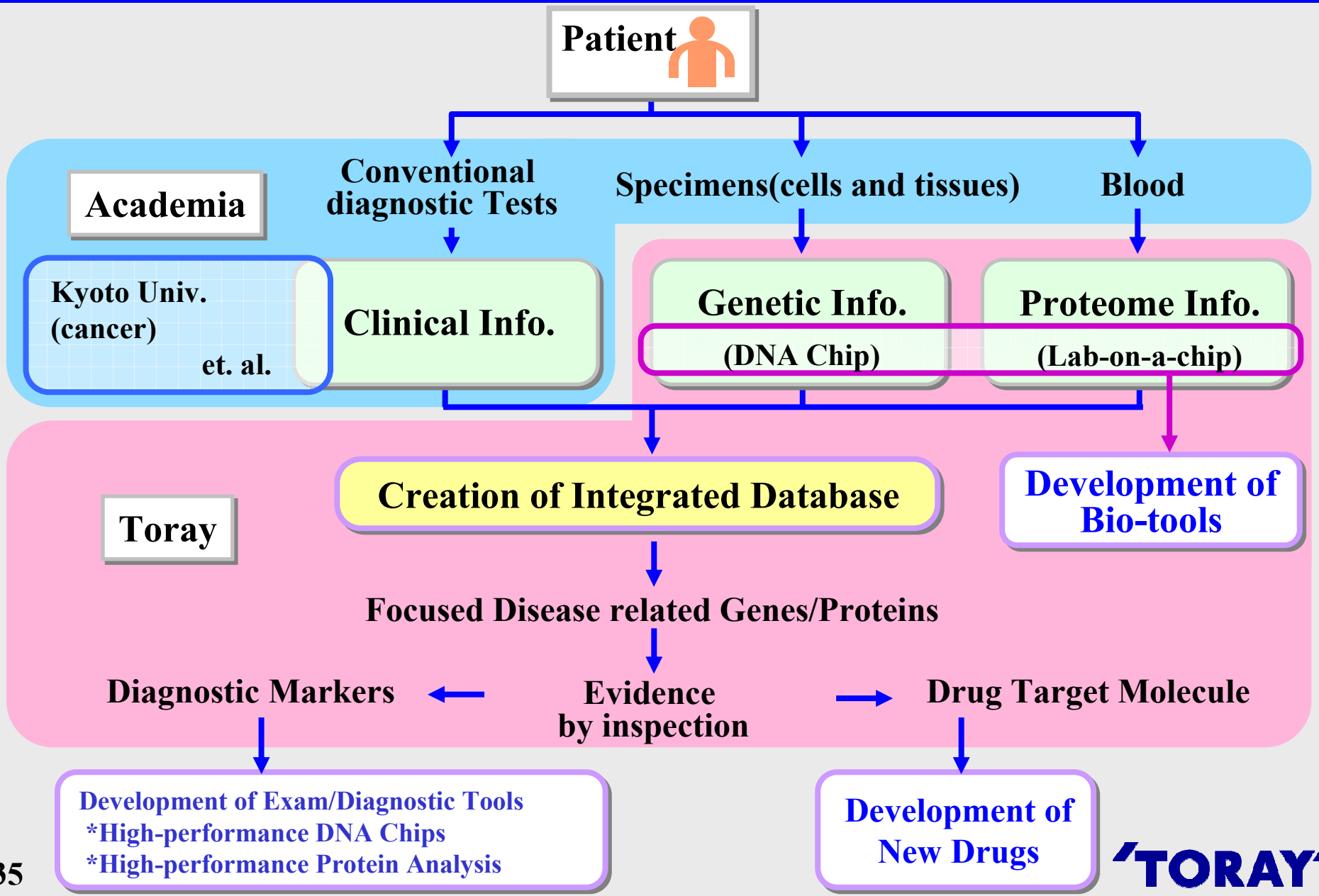
3. Biological Measurement

4. Micro Engineering

(Collaborators) Osaka Univ. Prof.Kawai, Nagoya Univ. Prof Baba

★ We have developed the diagnostic use Lab-on-a-Chip made of plastics. (Only-one in the world)

R&D Strategy of Bio-tools

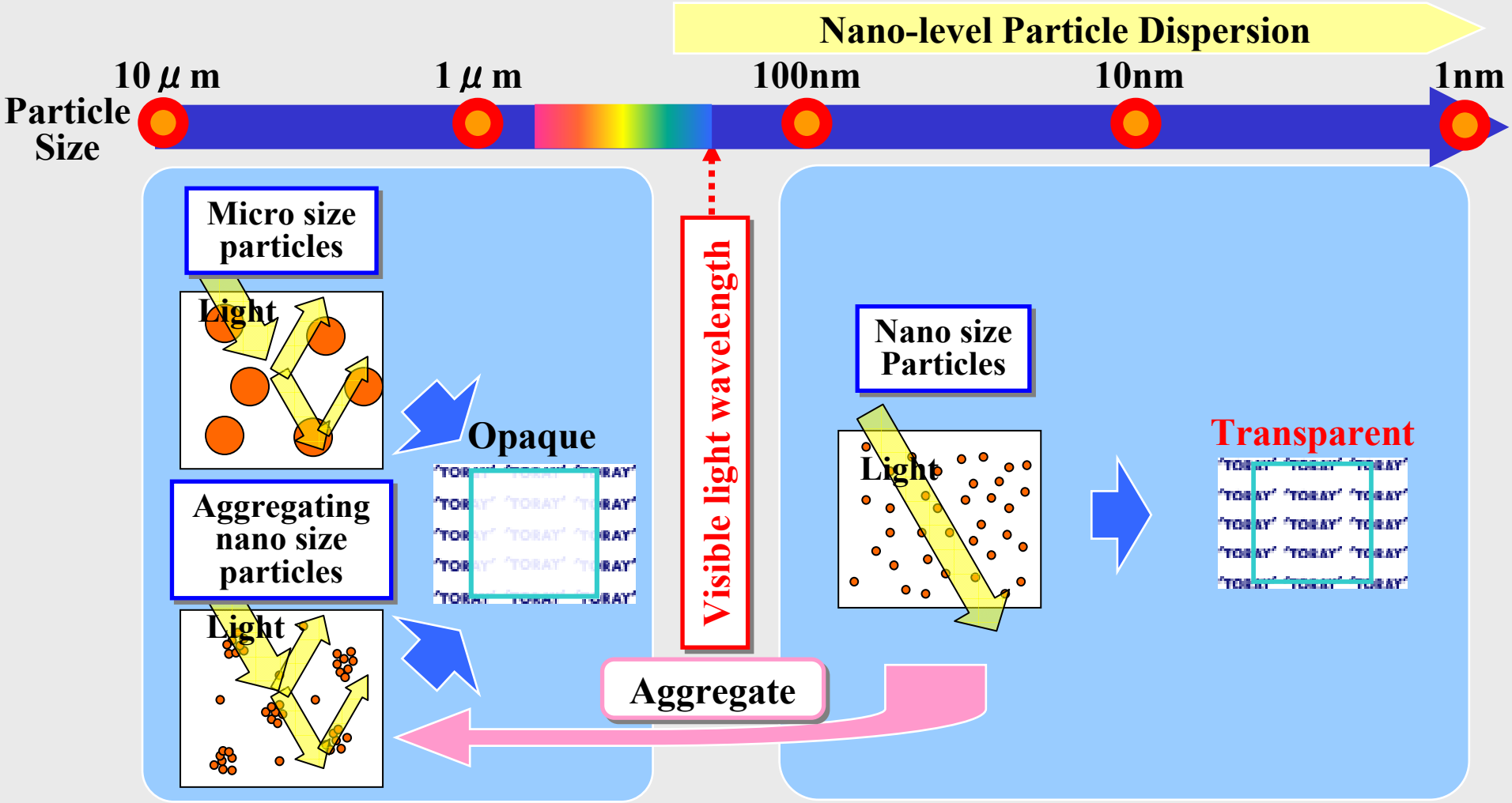


- Example of Toray's Advanced Materials -

Technology Innovation	Main Strategic Region			
	IT-related Materials	Automobile ・Aircraft	Life Science	Environment ・Water・Energy
New Materials	Optical Circuit Board Materials	Carbon Fiber Composite Materials	Innovative Synthetic pharmaceuticals	Organic Semiconductor
	New Optical Film	New transparent & heat-resistance resin		Bio-mass Fibers
Nano Material	Nano–multilayer Films	Nano-composite	Nanofibers	PLA Polymers
	CNT	Nanoalloy	DDS	Membrane
Bio			Bio-pharmaceuticals	Green Chemistry
			Bio-tools	
Nano Process	LCD Color Filters	Next Generation Molding	Human-friendly Material	Next Generation Recycling
	PDP-related Materials			MBR

TORAY

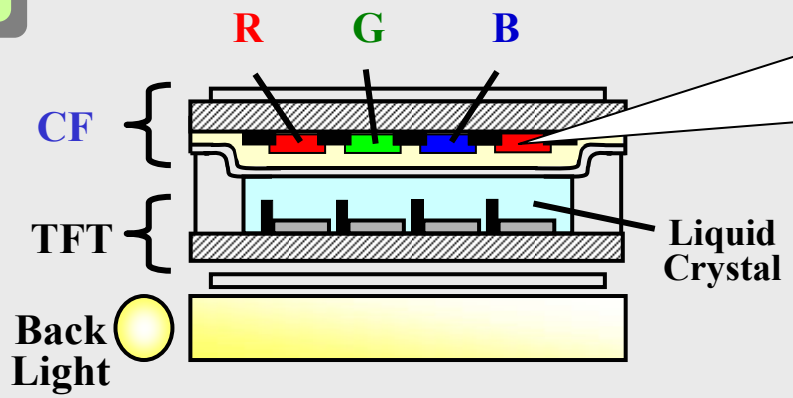
Pursuit of Particle Dispersion Technology



★Expected Effect of Deepening of Nano Dispersion Technology :
Control of refractive index, Improvement of Optical property,Fulfill New function

Pigment of LCD Color Filter (CF)

Structure of LCD



Clear, Bright Display

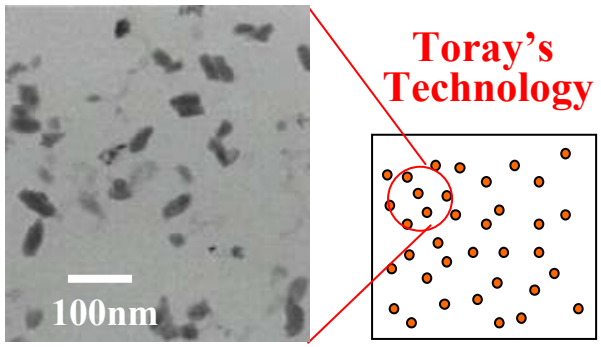
↓

Suppression of Light Scattering by CF (Measure: Contrast Ratio)

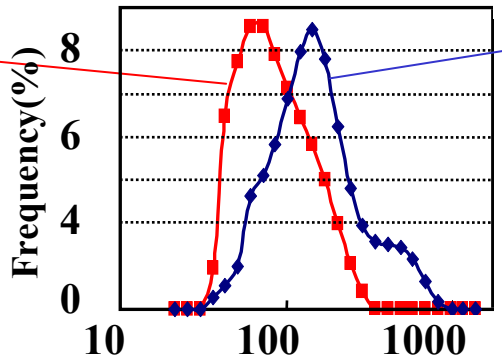
↓

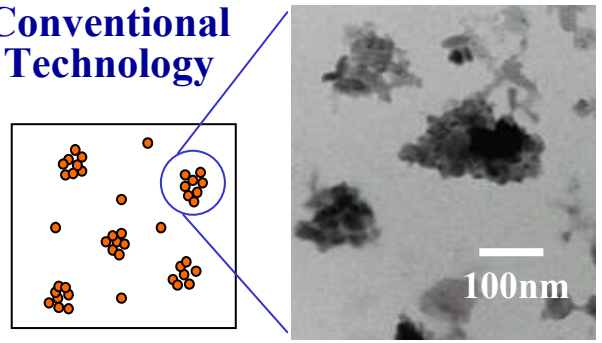
Key Point: Nano-dispersion of Pigment Particle

Stabilization of Nano-Dispersion for Nano-Pigment



Contrast Ratio: 1.8





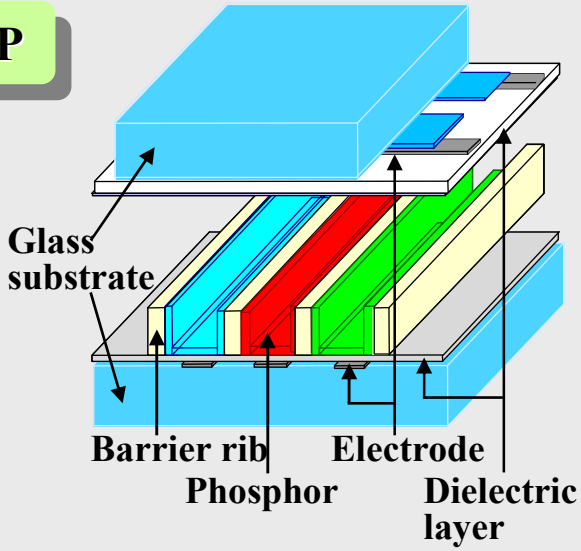
Contrast Ratio: 1.0

★ 1.8 times higher Contrast Ratio → Already Applied to Mass Production

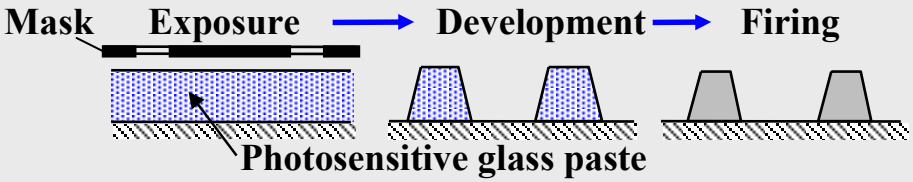
PDP Rear Panel Paste Materials

Structure of PDP

PDP-TV



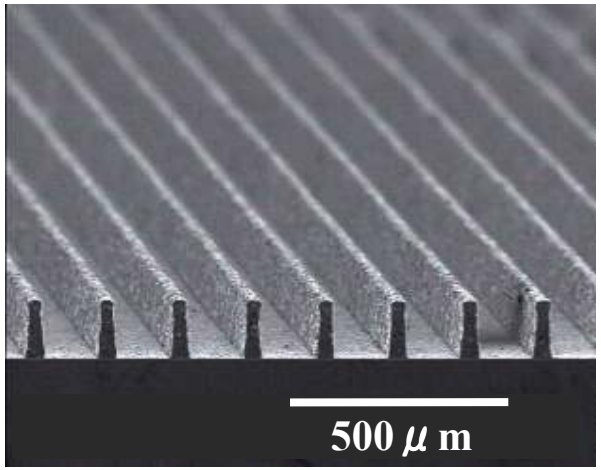
TORAY's technology for forming barrier rib by applying photosensitive glass paste



1. Short process & High productivity
2. Flexibility of pattern shape
3. High accuracy forming

Rear Panel Paste Materials

- Photosensitive barrier rib paste
- Photosensitive electrode (silver) paste
- Dielectric paste
- Phosphor paste（Red, Green, Blue）



Full high definition (barrier rib pitch)

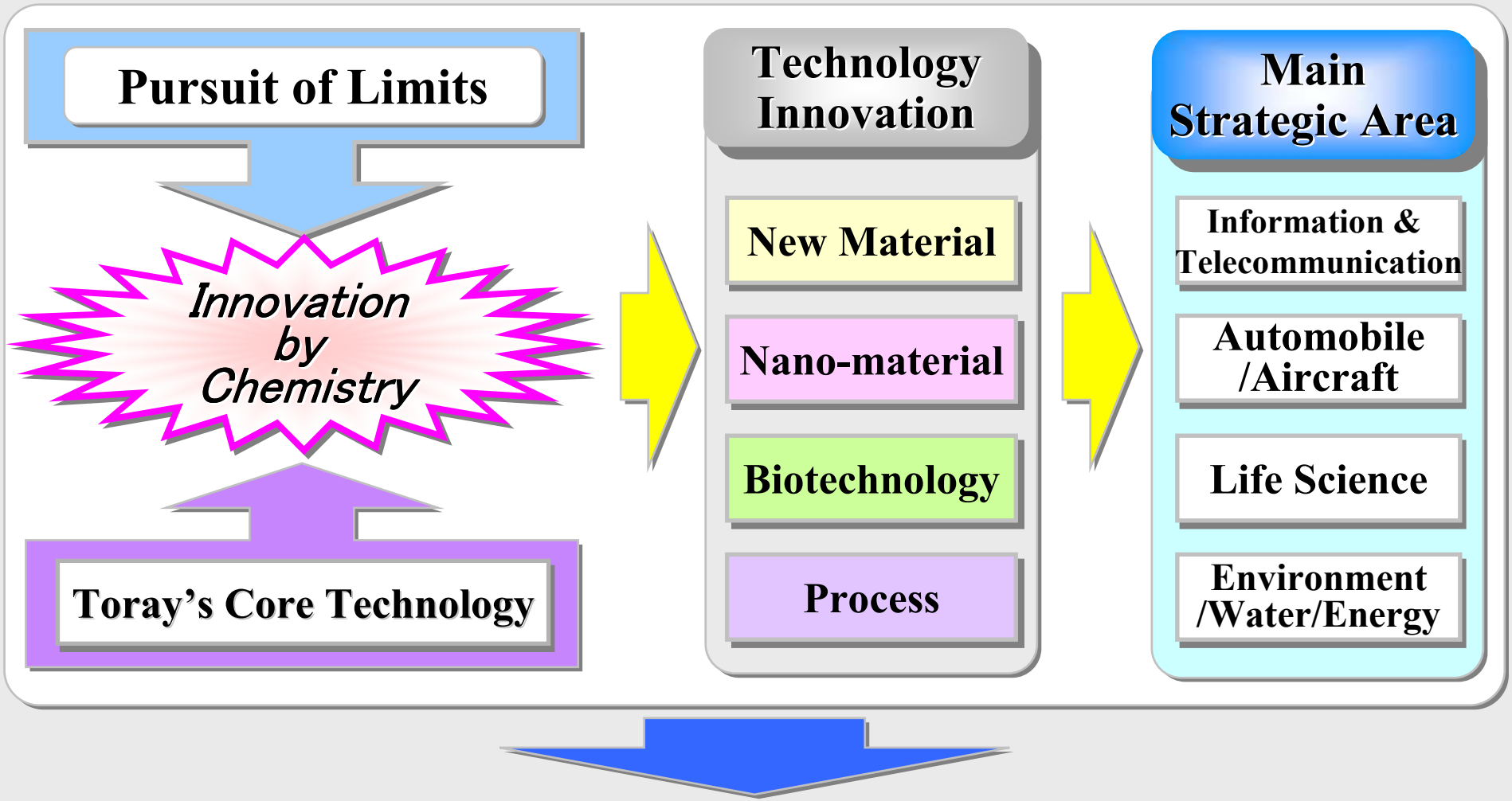
270 μ m (HD)

↓

<150 μ m(Full HD)

★Supply to the world largest factory of the MPDP (250,000 sets/month)

Toray's Challenge for Technology Innovation



Aiming at the Most Excellent Company for Advanced Materials by Challenging Technology Innovation

Advanced Materials for Pioneering 21st Century