Toray’s Strategy for Carbon Fiber Composite Materials

April 11, 2008
Toray Industries, Inc.
Senior Vice President
Masayoshi Kamiura
Long-term Corporate Vision and Positioning of Carbon Fiber Composite Materials Business

Project Innovation TORAY 2010 (IT-2010)
Road map to IT-2010 and Targets in IT-2010

After achieved NT reforms, Toray Group launched Project “Innovation TORAY 2010 (IT-2010)” in October 2006 in order to challenge for further growth through Innovation.

2002 April - 2004 April - 2006 October - Around 2010

**Goals in and around 2010**
- Net sales ¥1,800 billion
- Operating income ¥150 billion
- Operating income to net sales ratio 8.3%
- ROA: 8%
- ROE: 11%

**AP-New TORAY 21**
- NT21
  - 「Corporate Structure Reinforcement defensive management postures」
  - Breakaway from Crisis -

**AP-Innovation TORAY 21**
- NT-Ⅱ
  - 「Offensive management postures」
  - Establish foundation for further growth -

**IT-2010**
- 「Management based on Innovation」
  - Challenges for further growth -

- Toward a Global Top Company of Advanced Materials

- Achievement of ¥100 billion in Operating Income

Long-term Vision
Mid-term Business Strategies
Basic Strategies (by Business Category)

**Fibers & Textiles, Plastics / Chemicals**
- ① Developing global operations
- ② Promoting "New Value Creator"
- ③ Developing downstream and processing business
- ④ Expanding advanced materials (automobiles, environment/energy, etc.)

**Foundation Businesses**
- ① Focusing on growing markets (IT, automobiles, aircrafts)
- ② Prioritizing allocation of managerial resources

**Strategically Expanding Businesses**
- ① Focusing on growing markets (IT, automobiles, aircrafts)
- ② Prioritizing allocation of managerial resources

**IT-related Products, Carbon Fiber Composite Materials**
- Positive expansion as profit driving businesses

**Life Science, Environment (water treatment)**
- Nurturing the next profit base beyond 2010
- ① Intensive allocation of managerial resources
- ② M&A and strategic alliances with external parties

Establish stable profit base
Promote advancement of foundation businesses

Sustainable Growth

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Positioning of Carbon Fiber Composite Materials Business in IT-2010

Consolidated Net Sales

- FY2006: 1,546.5 (B Yen)
- Around FY2010: 1,800.0 (B Yen)

Consolidated Operating Income

- FY2006: 68.6 (B Yen)
- Around FY2010: 160.0 (B Yen)

Comparing FY2006 and Around FY2010:
- Carbon Fiber Composite Materials: 4% → 9%
- Others: 18% → 21%
Strategy for
Carbon Fiber Composite Materials

(1) Business environment and market structure
Business environment of Carbon Fibers

Global Warming
- Strict exhaust gas regulations
- High consciousness of energy saving

Clean Energy
- Wind Power
- Natural Gas

Energy Saving
- Weight saving (Aircraft, Automobile)

Diversification of energy
- Atomic Power Generation (Uranium concentration)
- Deep water oil mine

Needs for High-performance Materials
- Corrosion-resistance
- High Modulus
- Radiolucency
- Electromagnetic Shielding, etc.

Requirements
- Medical Equipment
- PC Casing

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### Carbon Fiber Market transition

#### Main Application Remarks
- **Limited Field**
  - Fishing rods
  - Aircraft secondary structure
- **Increase in application**
  - Tennis rackets
  - Golf Shafts
  - Aircraft primary structure
- **Increase in Industrial Use**
  - Pressure vessel
  - Machine parts
  - Engineering, Marine
- **Full-scale increase in Aircraft and Automobile**
  - Large aircraft program
  - Wind blade
  - Automobile, Oil mine

#### Additional Remarks
- High Quality
  - Increase of product type
  - Progress in molding technology
- Cost reduction
  - Large scale structure
- Variety in molding method
  - Recycle of Carbon Fibers

#### Development of Golf Shaft and Fishing Rods

- **Introduction (1971—1983)**
  - Development of Golf Shaft and Fishing Rods
  - Selected as a material for Satellite

- **Growth (1984—1993)**
  - Tennis racket and Carbon Golf Shaft Boom
  - Selected for primary structure of Airbus A320
  - Selected for primary structure of Boeing 777 c

- **Expansion (1994—2003)**
  - Full-scale expansion in industrial application
  - Expansion of communication satellite
  - Recession of aircraft industry

- **Full-scale Expansion (2004—2011)**
  - Selected for primary structure of Airbus A380
  - Launch of Boeing 787 project
  - Full-scale expansion in automobile application

- **Rapid Expansion (2012—)**
  - Industrial Use
  - Aerospace
  - Sports

#### Thousand Tons / Year

- **1970**
  - Selected for second structure of Boeing 737
  - Fishing rods

- **1975**
  - Aircraft secondary structure

- **1980**
  - Tennis racket and Carbon Golf Shaft Boom

- **1985**
  - Selected for primary structure of Airbus A320
  - Selected for primary structure of Boeing 777 c

- **1990**
  - Full-scale expansion in industrial application

- **1995**
  - Expansion of communication satellite

- **2000**
  - Recession of aircraft industry

- **2005**
  - Selected for primary structure of Airbus A380

- **2010**
  - Launch of Boeing 787 project
  - Full-scale expansion in automobile application

- **2015**

- **2020**

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Forecast of Carbon Fiber demand

Unit: ton


Industrial Use
Aerospace
Sports

Previous Forecast
IR seminar in June, 2005

Updated Forecast

Growth rate ('04 - '10 average)

Market 10%→15%

Industrial Use
10%→15%

Aerospace
15%→24%

Sports
3%→8%

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Market classification of PAN-based Carbon Fibers

Classification by Mechanical characteristic 1

- Standard Modulus
- Intermediate modulus
- High Modulus

Classification by Mechanical characteristic 2

- Aircraft Primary Structure and Space
- Aircraft Secondary Structure
- High-performance Industrial Use and Special Sports
- Space
- Industrial Use Sports

Tensile modulus (Gpa)

Tensile strength (Gpa)
Market classification of PAN-based Carbon Fibers 2

Carbon Fiber TORAYCA® series

- High-strength Carbon Fiber
- High Modulus Carbon Fiber

- Tensile modulus (Gpa)
- Tensile strength (Gpa)
- Only TORAY

Competitors’ Products
Market structure of PAN-based Carbon Fibers 1

Market structure by grade

High-end
- High-strength/High-Modulus fiber
- Thin fiber
- High-grade Prepreg / fabric

Middle-range
- Intermediate Modulus fiber
- Intermediate strength fiber
- Prepreg / Fabric

Low-end
- Large-tow fiber
- Standard Prepreg

Market structure by application

Aerospace
Primary structure
Secondary structure

Sports

Industrial Use

Market size: 35,000 tons

*As of 2007, Toray’s estimation
Market structure of PAN-based Carbon Fibers 2

*As of 2007, Toray’s estimation

**Based on CF quantity**
- Low-end
- Middle range
- High-end

**Based on Sales amount**
- Low-end
- Middle range
- High-end

Toray’s occupation
- 34% Based on CF quantity
- 40% Based on Sales amount
Examples of application -Aerospace-

**Boeing 777**
Primary/Secondary structure
CFRP usage: Approx. 10t

**Boeing 787**
Primary/Secondary structure
CFRP usage: Approx. 35t

**Satellite**

**Airbus A320**
Primary/Secondary structure
CFRP usage: Approx. 2t

**Airbus A380**
Primary/Secondary structure
CFRP usage: Approx. 35t

**Rocket**
Examples of application  -3 major sports-

Fishing rod

Golf Shaft

Tennis racket
Examples of application -New sports-

Hockey stick

Softball bat

Bicycle
Examples of application -Industrial use-

- Energy-related
  - Wind power blade
  - Uranium centrifuge
  - Fuel cell

- Oil-related
  - Oil-related
Examples of application -Industrial use-

Automobile-related

Hood

Spoiler

Propeller shaft

Radiator core support

F1 machine parts

Body panel
Examples of application -Industrial use-

**Civil engineering, Repair and Reinforcement**

- Bridge pier reinforcement
- Deck reinforcement
- Bridge railing
- Pillar reinforcement
Examples of application -Industrial use-

- Ships and Boats -

Boat

Sailboat
Examples of application -Industrial use-

- Pressure vessel

SCBA (self-contained-compressed air breathing apparatus)

CHG (Hydrogen) tank

CNG (Compressed Natural Gas) tank
Examples of application  -Industrial use-

- Machine parts, Medical equipment and IT-related products

- Doctor blade
- Roller / Pipe
- PC casing (Compound)
- Robot hand for LC panel
- X-ray top panel
Examples of application  -Industrial use-

New applications

- Electric cable core
- Body panel for train
- Robot parts
- Tube trailer tank (length 12 m)
Strategy for Carbon Fiber Composite Materials

(2) Current status
Supply-chain of Carbon Fiber business

Precursor
Raw material of Carbon Fiber

Carbon Fiber

Intermediate material
Prepreg, Fabric, etc.

Composite
Molded products

End-products

Aircraft
Automobile
Pressure Vessel
Civil Engineering
Machine Parts
Medical Equipment
Sporting goods

Toray Carbon Fiber business

Prepreg

Weaver
(Fabric manufacturer)

Molding Maker
### Production capacity of each production base

<table>
<thead>
<tr>
<th></th>
<th>Societe des Fibres de Carbone S.A. (SOFiCAR) (FRA)</th>
<th>TORAY (Ehime/Ishikawa) (JPN)</th>
<th>Toray Composites (America) (TCA) (USA)</th>
<th>Toray Carbon Fibers America (CFA) (USA)</th>
</tr>
</thead>
</table>
| **Carbon Fiber (t)** | 3,400 \(\rightarrow\) 5,200  
(Jan, 2008) (Dec, 2008) | 7,300 \(\rightarrow\) 8,300  
(Jan, 2008) (Jul, 2009) | | 3,600 \(\rightarrow\) 5,400  
(Jan, 2008) (Dec, 2008) |
| **Prepreg (‘000m²)** | 10,800 \(\rightarrow\) 16,600  
(Jan, 2008) (Jan, 2009) | 11,400 \(\rightarrow\) 17,200  
(Jan, 2008) (Jul, 2008) | |

*1: Lines under construction are inclusive.  
*2: Composites are manufactured at Toray Shiga plant, SOFiCAR and TCA.
Our advantage

- Worldwide vertically-integrated operations, from Precursor to Composite materials
- 37-year long top supplier of high-performance carbon fibers
- 27-year experience in production of aircraft Prepreg
- Proactive R&D investment and technical development from Carbon Fibers to molding process
- Strong and reliable partnerships with customers from development stage
  (Aircraft, PC casing, Automobile, Sporting goods, Machine parts, etc)
## Our Characteristics

<table>
<thead>
<tr>
<th></th>
<th>TORAY</th>
<th>Regular tow competitors</th>
<th>Large tow competitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality / R&amp;D ability</td>
<td>Excellent</td>
<td>Fair – Good</td>
<td>Poor – Good</td>
</tr>
<tr>
<td>Global marketing system</td>
<td>Excellent</td>
<td>Good</td>
<td>Poor – Fair</td>
</tr>
<tr>
<td>Performance in the Qualified business</td>
<td>Excellent</td>
<td>Fair – Good</td>
<td>Poor</td>
</tr>
<tr>
<td>Sales price (High = Excellent)</td>
<td>Excellent</td>
<td>Good</td>
<td>Fair</td>
</tr>
<tr>
<td>Supply capacity</td>
<td>HP<em>1: Excellent  GP</em>2: Good (Excellent for future )</td>
<td>HP: Good GP: Good</td>
<td>GP: Excellent</td>
</tr>
<tr>
<td>Intermediate products, Composites</td>
<td>Excellent</td>
<td>Good</td>
<td>Poor</td>
</tr>
<tr>
<td>Main application</td>
<td>Aerospace HP industrial use High-grade sports</td>
<td>Sports Industrial use A part of Aerospace</td>
<td>Industrial use Wind power blade, Compound, etc A part of sports</td>
</tr>
</tbody>
</table>
Strategy of Carbon Fiber Composite Materials

(3) Strategy
**Business expansion policy**

- Promote business expansion in each market through **global production, marketing and technical services** as the world’s largest Carbon Fiber manufacturer.

<table>
<thead>
<tr>
<th>Year</th>
<th>Net Sales</th>
<th>Operating profit ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Around 2010</td>
<td>160 billion ¥</td>
<td>~ 20%</td>
</tr>
<tr>
<td>Around 2015</td>
<td>300 billion ¥</td>
<td>~ 20%</td>
</tr>
<tr>
<td>Around 2020</td>
<td>500 billion ¥</td>
<td>~ 20%</td>
</tr>
</tbody>
</table>

- Maintain firmly **largest share** by differentiation of TORAYCA’s **high-quality and high-performance**

- Try to expand **supply of Carbon Fiber with cost competitiveness** into industrial use market

- Differentiate in intermediate and composite materials and **promote business expansion with high profitability**
Basic Strategies

1. Business strategies by applications
   (1) Maintain and expand overwhelming advantages in aircraft application
   (2) Develop market and technologies as a pioneer in automobile applications
   (3) Enhance competitiveness in high-performance industrial market and establish overwhelming cost competitiveness in general-purpose market
   (4) Maintain high market share and increase revenue in high-grade sports application

2. Improve competitiveness in quality and cost through enhancement of technical capabilities

3. Expand supply capability by continuing proactive capital investment

4. Give consideration to recycle and global environment
Maintain and expand overwhelming advantages in aircraft application

**Boeing**
- Establish production lines for 787
- Develop and propose new materials for next generation aircraft

**Airbus**
- Secure stable supply for existing models
- Promote qualification test of our materials for A350XWB

**Regional**
- MRJ: Develop materials and molding technology
- Regional jet: Expand sales based at TCA

- Strengthen our sole-supplier position
- Become main supplier
- Exploit new aircraft Market
History of aircraft business in Toray

1971/1972  Started commercial production of Carbon fiber/Prepreg
1975      Selected as CF for secondary structure of Boeing 737
1981      Selected as Prepreg for secondary structure of 757 & 767
1982      Established SOFiCAR : Started CF production in Europe
1983      Selected as CF for secondary structure of Airbus A300
1987      Selected as CF for primary structure of Airbus A320
1989      Qualified as Prepreg for primary structure of Boeing 777
1992      Established TCA : Started Prepreg production in USA
1997      Established CFA : Started CF production in USA
2002      Selected as CF for primary structure of Airbus A380
2003      Started Co-development of materials for 787 with Boeing
2004      Signed MOU with Boeing on contract for supply to 787
2006      Signed comprehensive long-term agreement with Boeing
Overwhelming advantages in aircraft application

Heat resistance and Impact resistance

CFRP used for primary structures

Boeing 777
CFRP: Approx. 10t

Boeing 787
CFRP: Approx. 35t

Used CFRP at 50% out of all structure

Only Toray’s Carbon fiber and Prepreg are qualified as materials for primary structure of Boeing aircrafts

Basic strategies 1-(1)

Heat resistance

Impact resistance

Boeing 777’s primary structure specification

Toray’s development product

Materials in early 1970s

Materials in early 1980s

Material in early 1970s

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Basic strategies 1-(1)

Overwhelming advantages in aircraft application

Now co-developing new molding technology (A-VaRTM) for Mitsubishi Regional Jet (MRJ) with Mitsubishi Heavy Industries, Ltd.

◊ Points of technology (Compared with existing Prepreg laminated composite)
  1. **Excellent mold ability**: Easy to mold complicated shapes by using dry fabric (no need for chilled storage)
  2. **Excellent mechanical characteristic**: Achieve the same characteristic as using chilled Prepreg
  3. **Cost competitiveness**: No need for autoclave → Small capital investment

Skin / Stringer panel

Spar

Rib

Real-size vertical tail wing (Prototype)

A-VaRTM method

Vacuum

Resin injection

Oven curing

Dry fabric

A-VaRTM method

Advanced-Vacuum assisted Resin Transfer Molding

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Overwhelming advantages in aircraft application

Carbon Fiber Demand for commercial aircraft and our market share forecast

Unit: ton

- CF demand for commercial aircraft
- Our market share

Basic strategies 1-(1)

Overwhelming advantages in aircraft application

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Basic strategy 1-(2)

Develop market and technologies as a pioneer in automobile application

- Respond to environmental regulation and needs for weight saving
  - Comprehend trends in automobile industry
  - Study effect of weight saving by CFRP
  - Propose solutions to automobile manufacturers
  
  Create CFRP demand for automobile

- Enhance R&D for automobile
  - Integration of company-wide technologies
  - Develop low-cost material and mass production molding technology
  - Co-develop with customers

  Cross-organizational development
  Go into automobile filed drastically
Tightening emission regulations

CO₂ Emission regulations

- ACEA
- JAMA / KAMA
- Mileage standard in 2010
- Mileage standard in 2015

NOx Emission regulations

- Euro1
- Euro2
- Euro3
- Euro4
- Euro5
- Euro6
- Tier 0
- Tier 1
- Tier 2 Bin 5
- Tier 2 Bin 9
- Tier 3
- Tier 4
- Tier 5
- Tier 6
- Short-term
- Long-term
- New ST
- New LT
- Post New LT

• US standard is based on the draft passed by Senate recently, in which CO₂ limit is set to 35mpg (156g-CO₂/km) by 2020, reduced by 4% annually after 2020. Due to uncertainty of CO₂ limit on each year, we estimate decrease in linear manner from current limit (2008).
Trends in automobile industry

Environment / Energy
- Emission gas purification
- CO2 reduction
- Recycle
- Environment-friendly material

Safety / Comfort
- Fuel efficiency
  - Weight saving
- Vibration, Noise

Weigh saving project on main automobile manufacturer

<table>
<thead>
<tr>
<th></th>
<th>Project</th>
<th>Target</th>
<th>Outline</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOYOTA</td>
<td>Mass Innovation</td>
<td>10% weight saving by 2011 (Midsize sedan)</td>
<td>• Position CFRP as one of the method</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Reduce component • Resinification</td>
</tr>
<tr>
<td>Honda</td>
<td>*Vary by model</td>
<td>10% CO2 reduction by 2010</td>
<td>• CO2 reduction by LCA (include production)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Ahead in using Aluminum</td>
</tr>
<tr>
<td>NISSAN</td>
<td>Vision 2015</td>
<td>15% weight saving by 2015 (Average)</td>
<td>• Position CFRP as one of the method</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• 40% CO2 reduction by 2015 (vs 2005)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Completed main method for 10% mileage improvement</td>
</tr>
<tr>
<td>Mitsubishi</td>
<td>CLW30 (Challenge for Light Weight)</td>
<td>30% weight saving by 2010 (2010 model car)</td>
<td>• Start accepting supplier’s proposal for the development for next model</td>
</tr>
</tbody>
</table>
Hood weight comparison
(Unit: kg)

<table>
<thead>
<tr>
<th>Material</th>
<th>Hood body</th>
<th>Metal accessories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>17.9</td>
<td>1.6</td>
</tr>
<tr>
<td>Aluminum</td>
<td>10.4</td>
<td>1.6</td>
</tr>
<tr>
<td>CFRP</td>
<td>7.8</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Propeller shaft weight comparison (Unit: kg)

<table>
<thead>
<tr>
<th>Material</th>
<th>PS body</th>
<th>Metal accessories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>15.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Aluminum</td>
<td>12.0</td>
<td>1.6</td>
</tr>
<tr>
<td>CFRP</td>
<td>7.8</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Basic strategies 1-(2)
Business environment and issues in automobile industry
Basic strategies 1-(2)
Achievement of Toray’s CFRP propeller shaft

<table>
<thead>
<tr>
<th>Year</th>
<th>Car Model</th>
<th>Units</th>
<th>Reason for adoption</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>MMC Pajero</td>
<td>500,000</td>
<td>Crash safety</td>
</tr>
<tr>
<td>1999</td>
<td>New Pajero</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>Nissan FairladyZ</td>
<td>130,000</td>
<td>Light weight</td>
</tr>
<tr>
<td>2002</td>
<td>MAZDA RX-8</td>
<td>250,000</td>
<td>Light weight</td>
</tr>
<tr>
<td>2004</td>
<td>Aston Martin DB9</td>
<td>10,000</td>
<td>Light weight</td>
</tr>
<tr>
<td>2005</td>
<td>Aston Martin V8-Vantage</td>
<td>10,000</td>
<td>Light weight</td>
</tr>
<tr>
<td>2007</td>
<td>Nissan GTR</td>
<td>5,000</td>
<td>Light weight</td>
</tr>
</tbody>
</table>

Total 900,000 units!
General R&D center for Automobile and Aircraft

A&A center (Automotive & Aircraft Center)

Resin Development Center
【Existing】
Automobile Electronics Resin Development for IT / Industrial use

Automotive Center
【Open in Jun, 2008】
high-tech material, structure, system for automobile
Integrated development of Technology

Advanced Composite Center
【Open in Apr, 2009】
Development of composite for Automobile, Aircraft, IT and industrial use
Basic strategies 1-(2)
R&D enhancement through integration of cross-organizational technology

Fundamental reinforcement of development capability for automobile application

Integration of Toray Group technology

Establish Automotive Center as cross-organizational base

Automotive center (AMC)

Image [Open in Jun, 2008]

Advanced Material technology
- Polymer chemistry
- Organic synthetic chemistry
- Biochemistry
- Nanotechnology

Advanced processing technology
- High process of fiber and film
- Resin molding process
- Composite innovative molding
- Joint technology
- Micro-fabrication technology

Product design support
- CAE analysis technology
- Analytical evaluation technology
- Reliability and durability evaluation technology

Pursuit of ultimate performance through integration of material and technology

Proposal of innovative solution by Integrated technology
Enhancement of composite development function

Transfer composite development bases to Nagoya

Promote development innovation

- Design of composite products
- Deepening molding process technology
- Development of next generation composite products
- Integration of resin and chemical technology
- Collaborative development for automobile application
- Co-development system with customers
- Speed-up of development
- Collaborative development with AMC

Promote drastic expansion of composite products, especially in automobile and aircraft application

Advanced Composites Development Center
Advanced Composites Technical Dept.

Ehime plant
Shiga plant
Transfer to Nagoya plant
Advanced Composites Center (ACC)

Image【Open in Apr, 2009】
Approx. 60 MM cars

Super car
4K cars
Car Price
30 MM ¥

Super-luxury car
400K
10 MM ¥

Luxury car
3 MM
5 MM ¥

Popular car
Approx. 60 MM cars

World’s production: Approx. 64 MM cars

Use CFRP in parts
CF 100kg / car X 500K cars
CF demand: 50,000 tons

Use Carbon fiber (CF) in all body (100kg / car)
CF demand: 400 tons

Huge potential market
CF 100 kg / car X 6MM cars
CF demand: 600,000 tons
Basic strategies 1-(2)
CFRP application in automobile and effect of weight saving

**CFRP effects**

**Weight saving**
- Good Mileage → Ecology

**Better crash safety**
- Energy-absorbing

**Lower assembly man-hour / expense**
- Modularized by unification

**Better driving performance**
- Better vibration damping
- Natural vibration UP

**Safety improvement**
- Improvement of material fatigue

---

**Possible to reduce 400kg by CFRP**

Hood
Roof
Seat back
Headrest support
Front cowl
Door flame pillar
Front engine cover
Front strut tower bar
Mission center tunnel
Radiator core support
Engine parts
Crush box
Front floor tunnel
Front floor panel
Front dashboard
Under cover
Under support rod
Rear luggage back panel
Rear luggage side panel
Rear luggage floor
Door inner
Impact beam

**Average weight car model**
(Gasoline car, 4 door, FF)

1,380kg

**CFRP**

**Thermal cure CFRP:**
Panel, Reinforced member RTM method,
30% the weight of steel

**Thermoplastic CFRP:**
Press molding material
50 the weight of steel

---

**Issues**
- Total cost down
- Improvement of molding flexibility

---

**Countermeasures**
- Integration and systematization of material
  Combination with thermoplastic materials and joint technology, etc.

Solving issues, even as aiming for proposing new concepts by integration of CF characteristics (electromagnetic shielding, etc.) and those of other materials such as resin or IT-related materials.

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For more CFRP application…

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Enhance competitiveness and expand business scale in industrial application

Enhance cost competitiveness in general-purpose CF by growing in machine size
- Install world’s largest line (4000 tons/year)
- Develop low-cost molding method

Promote cost down
Maintain quality advantage in 24K fiber

Develop new application by technical marketing
- Enhance function of technical center in US and Europe
- Promote cooperation among government, industry and academia

Develop new application
Expand in high-performance field
Basic strategies 1-(3)
Enhancement of competitiveness and business scale in industrial use

Demand forecast in industrial application by business field

Unit: '000 ton

1st Step Until 2012
A. Increase outlets in high-performance field (High-price field), especially in high-strength fiber (T700S-12K) and thin fiber (T300)
B. Enhance cost competitiveness by large line
C. Develop low-cost molding method

2nd Step After 2012
A. Increase sales in automobile application with cost competitiveness
B. Expand composite business with low-cost molding technology

Create demand by switching from other materials

Further expansion of CF demand
Basic strategies 1-(3)

Expansion into high-performance field

- **Top panel for X-ray CT scanner**
  - Taking advantage of high modulus materials with **high radiolucent ratio**

- **Electrical cable core**
  - Weight saving → Long-span, fewer power pylon
  - Increase carrying capacity (larger aluminum cross-sectional area)
  - Taking advantage of **high-strength**

- **Robot hand for LC glass substrate (Fork)**
  - Taking advantage of **vibration dumping by high modulus**
Basic strategy 1-(4)

Enhance high-end sporting goods and maintain high market share

Maintain high profitability through expansion of high-value added products
- Respond to production shift to Asia as a top supplier for leading brand manufacturers in Japan and US
- Design and develop best suitable materials for sporting use

Expansion in high-value added products

Create new market and application
- Survey Vietnam and India market which can become production base of sporting goods following China
- Increase sales into new application such as bicycle, hockey stick, softball bat, etc.

Increase share by acquiring new demand
Basic strategy 2

Improve competitiveness in quality and cost Through Enhancement of technical capabilities

- Develop high-performance CF
  - Increase tensile strength
  - Increase tensile modulus

- Develop resin enhancing CFRP property
  - Develop nano-matrix resin

- Reduce composite molding time

- Expand technical center
Basic strategies 2
Pursuit of ultimate strength

Control of surface defect at nano-level

- Micron-size defect
- Sub-micron size defect
- Nano-size defect

Image of fiber surface at nano-size (AFM)

Size of defect
- Micron
- Sub-micron
- Nano

Tensile strength (GPa)

Timeline:
- 1970
- 1980
- 1990
- 2000
- 2010

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Basic strategies 2
Pursuit of ultimate modulus

Tensile modulus (Gpa)

Orientation 95%

Fiber Axis

Graphite Crystalline

Cross section (TEM)

Surface (STM)

Orientation 80%

Orientation 100%

Cross section 2nm

Cross section 6nm

Cross section 10nm

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Basic strategies 2
Reduction of composite molding time

Reduced composite molding time by developing ultrahigh-speed curing resin and high-speed resin injection technology in national project led by NEDO

Base material
Resin injection / curing
Removal

RTM
Base material setup 25 min
Resin injection 35 min
Resin curing 90 min
Removal 10 min
Total 160 min

New method
Total less than 10 min

High-speed resin injection technology (3-min injection)

Resin injection
Vacuum

It takes 3 min by multipoint injection

Achieved less than 10 minutes of molding by new method

Demonstration of 10 minutes molding in inner door panel

Ultrahigh-speed curing resin
(5-min curing)

Cure degree
(Resin viscosity)

0 3 5 35 90

Time (min)

Removable

Ultrahigh-speed curing resin
Blending chain transfer agent
Anionic polymerization

Existing epoxy resin
(Amine curing)

Resin flowable

*Based on isothermal condition

Reduced composite molding time by developing ultrahigh-speed curing resin and high-speed resin injection technology in national project led by NEDO

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Resin flowable

*Based on isothermal condition
### 4 worldwide R&D sites [R&D workforce: Approx. 350 workers]

<table>
<thead>
<tr>
<th>Site</th>
<th>Name of unit</th>
<th>Main function</th>
</tr>
</thead>
<tbody>
<tr>
<td>TORAY</td>
<td>Technical Dept. / Research institution, A&amp;A center</td>
<td>- Basic and general R&amp;D center</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Headquarter of R&amp;D</td>
</tr>
<tr>
<td>TCA</td>
<td>Technical center / Research institution</td>
<td>- R&amp;D for aircraft Prepreg &amp; resin</td>
</tr>
<tr>
<td>CFA</td>
<td>Technical center</td>
<td>- Develop industrial application in US</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- R&amp;D for Carbon fiber</td>
</tr>
<tr>
<td>SOFiCAR</td>
<td>Composite center</td>
<td>- Develop industrial application in EU</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Develop molding method</td>
</tr>
</tbody>
</table>

**TORAY**: General R&D center from yarn to composite material

**Overseas site**: Develop new application with market-based development function

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**Enhancement of Technical support / Solution**, Cooperation among government, industry and academia, Discover potential needs

**Expand business in high-performance field and composite business in which we can take advantage of our strength**

**Core business**
- Commercial aircraft
- Pressure vessel
- Civil engineering, sports, etc.

**Long-term Growing business**
- Automobile
- Electrical cable
- Robot
- Uranium centrifuge, etc.
Basic strategy 3

Expand supply capability by continuing proactive capital investment

Continue capital investment in worldwide
- In Japan: 1 line precursor / 1 line CF / 1 line Prepreg – under construction
- In USA: 1 line precursor / 1 line CF / 1 line Prepreg – under construction
- In EU: 1 line CF – under construction

Plan to start local production of Precursor and Prepreg in Europe
- Establish first production line of precursor and Prepreg in Europe
  - Integrated production system from precursor to Prepreg
  - Reduction of transport cost

Install dedicated large machine for industrial application
- World’s largest dedicated machine with 4000ton production capacity
  - Cost-down by high energy efficiency and scale merit
  - Secure suitable supply
Basic strategies 3
Promote proactive capita investment ahead of competitors

Expansion plan of carbon fiber production lines
(As of end of year)

Capacity


Future vision
CFA
SOFiCAR
TORAY

Future vision Start in Jan, 2008
Ehime’s expansion

Start in Jan, 2007
SOFiCAR’s expansion

Start in Jan, 2006
CFA’s expansion

Start in Oct, 2004
SOFiCAR’s expansion

Under construction

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Basic strategies 3
Promote proactive capita investment ahead of competitors

Expansion plan of Prepreg production lines
(As of end of year)

Million m²/year

- **Future vision**
- **TCA**
- **TORAY**

- **Start in Jan, 2006**
  - TCA’s expansion
  - Ishikawa: 1 line

- **Start in Jan, 2007**
  - Ehime’s expansion

- **Under construction**
  - TCA: 1 line

- **Future vision**
  - 2008
  - 2009
  - 2010
  - 2011
  - 2012

**Capacity**
- 2004: 10.2
- 2005: 16.4
- 2006: 28.0
Basic strategy 4

Give consideration to recycle and global environment

Establish CF recycle technology
- Establish Collecting system
- Demonstrate recycle technology
- Verify business potential

Survey CF’s effect on global environment
- Survey CF’s LCA
- Analyze production energy of CF and reduce its energy
Basic strategies 4
Consideration to global environment

JCMA started establishing CF recycle system and studying its business

◆ Granted project of METI
  Theme: The energy reduction at carbon fiber manufacturing process
  * JCMA promotes “Proof research and development of carbon fiber recycling technology”

◆ Twentieth production energy compared with producing CF from raw materials (Estimation)

◆ CF recycle flow

◆ Schedule
  Apr, 2008  Start-up of a pilot plant
  Apr, 2008 – Mar, 2009  Demonstrated operation of recycle process and evaluation
  Summer, 2008  Start of user’s evaluation
LCA of aircraft and automobile (“TORAY model”)

LCA (Life Cycle Assessment): the assessment of the environmental impact of a given product or service throughout its lifespan.

Aircraft CO₂ emission

- Flight: 99%
- Material & parts production, Assembly, Disposal: less than 1%

(Based on 10-year operation)

Automobile CO₂ emission

- Drive: 84%
- Material & parts production: 13%
- Assembly: 4%
- Disposal: 1%

(Based on 10-year driving)

Most part of CO₂ is emitted during operation and driving.

Improvement of mileage by weight saving with using Carbon Fiber is a key to reduce CO₂ emission.
Basic strategies 4
Give consideration to global environment

LCA of aircraft and automobile ("TORAY model")

Aircraft CO₂ emission

- CFRP in use at 50% → 20% weight saving
- Annual 2,700 tons CO₂ reduction / aircraft

Automobile CO₂ emission

- CFRP in use at 20% → 30% weight saving
- Annual 0.5 tons CO₂ reduction / car

Amount of CO₂ emission reduction in Japan (CFRP in use)

- Japan 430 aircrafts (more than 100 seats): 2,700t/unit -year) : Approx. 1 MM t CO₂/year
- Japan 42MM cars (except mini cars): 0.5t/unit-year) : Approx. 20 MM t CO₂/year

Total: Approx. 21 MM t CO₂/year

Contribution to reduction of Japanese CO₂ emission (CFRP in use)

Equal to 1.5% of Japanese gross CO₂ emission – 1.3 billion ton CO₂/year

(Equal to 8% of Japanese transportation dept. CO₂ emission – 0.25 billion ton CO₂/year)

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Business Plan
Market share by application

- **Industrial**
- **Aerospace**
- **Sports**
- **Toray's sales Qty. (Plan)**

Unit: ton

<table>
<thead>
<tr>
<th>Year</th>
<th>Industrial Qty.</th>
<th>Aerospace Qty.</th>
<th>Sports Qty.</th>
<th>Toray's sales Qty. (Plan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>22,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>35,000</td>
<td>34%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>52,000</td>
<td>34%</td>
<td>35%</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>69,000</td>
<td>35%</td>
<td>35%</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>88,000</td>
<td>37%</td>
<td>35%</td>
<td></td>
</tr>
</tbody>
</table>

当社シェア: 34%

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Future business scale (Vision)

Net sales by product type

- Composite
- Intermediate products
- Carbon Fiber

Unit: Billion ¥

Net Sales by application

- Industrial Use
- Aerospace
- Sports

Unit: Billion ¥
Descriptions of predicted business results, projections and business plans contained in this material are based on assumptions and forecasts regarding the future business environment, made at the present time.

The material in this presentation is not a guarantee of the Company’s future business performance.
End of Presentation