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.

April 2002

**NT21**
- Breakaway from Crisis -

**NT-Ⅱ**
- Establish foundation for further growth -
  - Offensive management postures

**AP-New TORAY 21**
- Corporate Structure Reinforcement defensive management postures

April 2004

-成就の目標
- ¥100 billion in Operating Income

April 2006

**AP-Innovation TORAY 21**
- Management based on Innovation
  - Challenges for further growth -

**IT-2010**
- Toward a Global Top Company of Advanced Materials

**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%

2002 April  2004 April  2006 October  Around 2010
Basic Strategies (by Business Category)

**Fibers & Textiles, Plastics / Chemicals**

- Developing global operations
- Promoting “New Value Creator”
- Developing downstream and processing business
- Expanding advanced materials (automobiles, environment/energy, etc.)

**Foundation Businesses**

1. Developing global operations
2. Promoting “New Value Creator”
3. Developing downstream and processing business
4. Expanding advanced materials (automobiles, environment/energy, etc.)

**Establish stable profit base**

**Promote advancement of foundation businesses**

**IT-related Products, Carbon Fiber Composite Materials**

- Focusing on growing markets (IT, automobiles, aircrafts)
- Prioritizing allocation of managerial resources

**Strategically Expanding Businesses**

- 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

**Strategically Developing Businesses**

- Strategically developing and expanding
Positioning of Carbon Fiber Composite Materials Business in IT-2010

**Consolidated Net Sales**

- **FY2006**
  - Carbon Fiber Composite Materials: 1,477.9 (B Yen)
  - Others: 68.6 (B Yen)
  - Total: 1,546.5 (B Yen)

- **Around FY2010**
  - Carbon Fiber Composite Materials: 1,640.0 (B Yen)
  - Others: 160.0 (B Yen)
  - Total: 1,800.0 (B Yen)

**Consolidated Operating Income**

- **FY2006**
  - Carbon Fiber Composite Materials: 84.3 (B Yen)
  - Others: 18.1 (B Yen)
  - Total: 102.4 (B Yen)

- **Around FY2010**
  - Carbon Fiber Composite Materials: 118.0 (B Yen)
  - Others: 32.0 (B Yen)
  - Total: 150.0 (B Yen)

- **Percentage Change**
  - 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

Inflation of oil prices
Improvement of fuel efficiency
Shift to alternative energy

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.

Clean Energy

Medical Equipment
PC Casing

Copyright 2008 Toray Industries, Inc. All Rights Reserved
# Carbon Fiber Market transition

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Thousand Tons / Year</td>
<td>Recession of aircraft industry</td>
<td>Launch of Boeing 787 project</td>
<td>Full-scale expansion in automobile application</td>
<td>Full-scale expansion in automobile application</td>
</tr>
<tr>
<td></td>
<td>Selected for second structure of Boeing 737</td>
<td>Full-scale expansion in industrial application</td>
<td>Recession of aircraft industry</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Selected as a material for Satellite</td>
<td>Expansion of communication satellite</td>
<td>September 11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Selected for second structure of Boeing 757 &amp; 767</td>
<td>Selected for primary structure for Airbus A320</td>
<td>September 11</td>
<td></td>
</tr>
<tr>
<td>Development of Golf Shaft and Fishing Rods</td>
<td>Tennis racket and Carbon Golf Shaft Boom</td>
<td>Selected for primary structure for Boeing 777 c</td>
<td>September 11</td>
<td></td>
</tr>
</tbody>
</table>

### Limited Field
- **Fishing rods**
- **Aircraft secondary structure**
- **Tennis rackets**
- **Golf Shafts**
- **Aircraft primary structure**
- **Pressure vessel**
- **Machine parts**
- **Engineering, Marine**
- **Large aircraft program**
- **Wind blade**
- **Automobile, Oil mine**

### Increase in application
- **Tennis rackets**
- **Golf Shafts**
- **Aircraft primary structure**
- **Pressure vessel**
- **Machine parts**
- **Engineering, Marine**
- **Large aircraft program**
- **Wind blade**
- **Automobile, Oil mine**

### Increase in Industrial Use
- **Cost reduction**
- **Large scale structure**
- **Variety in molding method**
- **Recycle of Carbon Fibers**

---

### Main Application Remarks
- **High Quality**
- **Increase of product type**
- **Progress in molding technology**
- **Recycle of Carbon Fibers**

---

Copyright 2008 Toray Industries, Inc. All Rights Reserved
Forecast of Carbon Fiber demand

Unit: ton

- Industrial Use
- Aerospace
- Sports

Previous Forecast
IR seminar in June, 2005

Updated Forecast

<table>
<thead>
<tr>
<th>Year</th>
<th>Industrial Use</th>
<th>Aerospace</th>
<th>Sports</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>22,000</td>
<td>25,000</td>
<td>27,500</td>
</tr>
<tr>
<td>2005</td>
<td>24,000</td>
<td>25,000</td>
<td>28,000</td>
</tr>
<tr>
<td>2006</td>
<td>28,000</td>
<td>25,000</td>
<td>30,500</td>
</tr>
<tr>
<td>2007</td>
<td>30,500</td>
<td>34,000</td>
<td>35,000</td>
</tr>
<tr>
<td>2008</td>
<td>34,000</td>
<td>37,500</td>
<td>40,000</td>
</tr>
<tr>
<td>2009</td>
<td>40,000</td>
<td>52,000</td>
<td>46,000</td>
</tr>
<tr>
<td>2010</td>
<td>52,000</td>
<td>60,000</td>
<td>40,000</td>
</tr>
<tr>
<td>2011</td>
<td>60,000</td>
<td>69,000</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>69,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Growth rate ('04 - '10 average)

- Market: 10% → 15%
- Industrial Use: 10% → 15%
- Aerospace: 15% → 24%
- Sports: 3% → 8%
Market classification of PAN-based Carbon Fibers

Classification by Mechanical characteristic 1

Classification by Mechanical characteristic 2

Tensile strength (Gpa)

Tensile modulus (Gpa)

Copyright 2008 Toray Industries, Inc. All Rights Reserved
Market classification of PAN-based Carbon Fibers 2

Carbon Fiber TORAYCA® series

<table>
<thead>
<tr>
<th>Tensile modulus (Gpa)</th>
<th>Tensile strength (Gpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 200 300 400 500 600 700</td>
<td>1.0 2.0 3.0 4.0 5.0 6.0 7.0</td>
</tr>
</tbody>
</table>

High-strength Carbon Fiber

High Modulus Carbon Fiber

Only TORAY

Competitors’ Products

Copyright 2008 Toray Industries, Inc. All Rights Reserved
Market structure of PAN-based Carbon Fibers

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**
- **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
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
Prepreg, Fabric, etc.

Intermediate material

Composite
Molded products

End-products

Toray Carbon Fiber business

Prepreg

Molding Maker

Weaver
(Fabric manufacturer)

Aircraft

Automobile

Pressure Vessel

Civil Engineering

Machine Parts

Medical Equipment

Sporting goods
Our Production base

Country

Japan
- TORAY Ehime Plant
  - TORAY
  - Ishikawa Plant (Under Construction)
  - Shiga Plant
  - Ichimura / Sowa Textile, etc.
  - Nagoya A&A center
  - Sakai Composite

USA
- TORAY
  - Toray Carbon Fibers America, Inc. (CFA)

France
- SOFiCAR

Composite
- Molded products

Precursor
- Raw material of Carbon Fiber

Carbon Fiber
- Prepreg, Fabric, etc.

Intermediate material
- Prepreg, Fabric, etc.

Raw material of
Carbon Fiber
- Prepreg, Fabric, etc.

Precursor
- Intermediate material

Intermediate material
- Composite
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>
<tbody>
<tr>
<td>Prepreg (‘000m²)</td>
<td>10,800 → 16,600 (Jan, 2008) (Jan, 2009)</td>
<td>11,400 → 17,200 (Jan, 2008) (Jul, 2008)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*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*1: Excellent</td>
<td>HP: Good</td>
<td>GP: Excellent</td>
</tr>
<tr>
<td></td>
<td>GP*2: Good</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Excellent for future)</td>
<td></td>
<td></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</td>
<td>Sports</td>
<td>Industrial use</td>
</tr>
<tr>
<td></td>
<td>HP industrial use</td>
<td>Industrial use</td>
<td>Wind power blade, Compound, etc</td>
</tr>
<tr>
<td></td>
<td>High-grade sports</td>
<td>A part of Aerospace</td>
<td>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**.
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
Basic strategy 1-(1)

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

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1971/1972</td>
<td>Started commercial production of Carbon fiber/Prepreg</td>
</tr>
<tr>
<td>1975</td>
<td>Selected as CF for secondary structure of Boeing 737</td>
</tr>
<tr>
<td>1981</td>
<td>Selected as Prepreg for secondary structure of 757 &amp; 767</td>
</tr>
<tr>
<td>1982</td>
<td>Established SOFiCAR : Started CF production in Europe</td>
</tr>
<tr>
<td>1983</td>
<td>Selected as CF for secondary structure of Airbus A300</td>
</tr>
<tr>
<td>1987</td>
<td>Selected as CF for primary structure of Airbus A320</td>
</tr>
<tr>
<td>1989</td>
<td>Qualified as Prepreg for primary structure of Boeing 777</td>
</tr>
<tr>
<td>1992</td>
<td>Established TCA : Started Prepreg production in USA</td>
</tr>
<tr>
<td>1997</td>
<td>Established CFA : Started CF production in USA</td>
</tr>
<tr>
<td>2002</td>
<td>Selected as CF for primary structure of Airbus A380</td>
</tr>
<tr>
<td>2003</td>
<td>Started Co-development of materials for 787 with Boeing</td>
</tr>
<tr>
<td>2004</td>
<td>Signed MOU with Boeing on contract for supply to 787</td>
</tr>
<tr>
<td>2006</td>
<td>Singed comprehensive long-term agreement with Boeing</td>
</tr>
</tbody>
</table>
Basic strategies 1-(1)

Overwhelming advantages in aircraft application

Heat resistance and Impact resistance

CFRP used for primary structures

Toray’s development product

Boeing 777’s primary structure specification

Boeing 777
CFRP: Approx. 10t

Materials in early 1980s

Material in early 1970s

Boeing 787
CFRP: Approx. 35t

High

Impact resistance

Heat resistance

High

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

Used CFRP at 50% out of all structure
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
Basic strategies 1-(1)

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

50% up
55% up
60% up
65% up


Copyright 2008 Toray Industries, Inc. All Rights Reserved
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**

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

**NOₓ Emission regulations**

- **Euro 1-6**
- **Tier 0-2 Bin 9**
- **Short-term (ST)**
- **Long-term (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
- Design
- Information-communication
- Playful spirit and fun

**Weigh saving project on main automobile manufacturer**

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Project</th>
<th>Target</th>
<th>Outline</th>
</tr>
</thead>
</table>
| TOYOTA       | Mass Innovation          | 10% weight saving by 2011 (Midsize sedan)   | • Position CFRP as one of the method  
                |                          |                              | • Position CFRP as one of the method  
                |                          |                              | • Reduce component  
                |                          |                              | • Resinification  |
| Honda        | *Vary by model           | 10% CO2 reduction by 2010                   | • CO2 reduction by LCA (include production)  
                |                          |                              | • Ahead in using Aluminum  |
| NISSAN       | Vision 2015              | 15% weight saving by 2015 (Average)         | • Position CFRP as one of the method  
                |                          |                              | • 40% CO2 reduction by 2015 (vs 2005)  
                |                          |                              | • Completed main method for 10% mileage improvement  |
| Mitsubishi   | CLW30                    | 30% weight saving by 2010 (2010 model car)  | • Start accepting supplier’s proposal for the development for next model  |
### Basic strategies 1-(2)

**Business environment and issues in automobile industry**

#### Hood weight comparison

<table>
<thead>
<tr>
<th>Material</th>
<th>Metal accessories</th>
<th>Hood body</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>6.2</td>
<td>1.6</td>
</tr>
</tbody>
</table>

#### Propeller shaft weight comparison

<table>
<thead>
<tr>
<th>Material</th>
<th>Metal accessories</th>
<th>PS body</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)
Achievement of Toray’s CFRP propeller shaft


Reason for adoption
Light weight

Development

Total 900,000 units!

Light weight

Development

Nissan GTR 2007
5,000 Units

Light weight

Development

Aston Martin V8-Vantage 2005
10,000 Units

Light weight

Development

Aston Martin DB9 2004
10,000 Units

Light weight

Development

MAZDA RX-8 2003
130,000 Units

Light weight

Development

Nissan FairladyZ 2002
250,000 Units

Crash safety

Development

MMC Pajero 1999

Development

New Pajero 2006

Copyright 2008 Toray Industries, Inc. All Rights Reserved
A&A center (Automotive & Aircraft Center)

- **Resin Development Center**
  - Existing
  - Automobile Electronics Resin Development for IT / Industrial use

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

- **Advanced Composite Center**
  - Open in Apr, 2009
  - Development of composite for Automobile, Aircraft, IT and industrial use
Fundamental reinforcement of development capability for automobile application

Integration of Toray Group technology

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

Establish Automotive Center as cross-organizational base

Automotive center (AMC)

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
Basic strategies 1-2
Breakdown of world’s automobile production and CF demand

- **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
[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

For more CFRP application…

Possible to reduce 400kg by CFRP

**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.

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

- **1,380kg**
- **970kg (-30%)**

Thermal cure CFRP:
- Panel, Reinforced member RTM method,
  30% the weight of steel
Thermoplastic CFRP:
- Press molding material
  50 the weight of steel

Possible CFRP parts:
- Seat back
- Headrest support
- Door frame 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
- Door inner
- Impact beam
- Rear luggage back panel
- Rear luggage side panel
- Rear luggage floor
- Rear luggage side panel
- Rear luggage floor
- Rear luggage partition
- Rear luggage back panel
- Rear luggage side panel
- Rear luggage floor
- Rear luggage partition
Basic strategy 1-(3)

Enhance competitiveness and expand business scale in industrial application

- Install world’s largest line (4000tons/year)
- Develop low-cost molding method

Enhance cost competitiveness in general-purpose CF by growing in machine size

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
Enhance high-end sporting goods and maintain high market share

- 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

Maintain high profitability through expansion of 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

Size of defect

Tensile strength (GPa)


Micron
Sub-micron
Nano

Image of fiber surface at nano-size (AFM)

Micron-size defect
Sub-micron size defect
Nano-size defect
Basic strategies 2
Pursuit of ultimate modulus

Tensile modulus (GPa)

Orientation 95%

Cross section (TEM)

Surface (STM)

Fiber Axis

Graphite Crystalline

Orientation 80%

1nm

2nm

6nm

10nm
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

Achieved less than 10 minutes of molding by new method

Demonstration of 10 minutes molding in inner door panel

Base material

Resin injection / curing

Removal

RTM

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)

Vacuum

Resin injection

Time (min)

0 3 5 35 90

Cure degree (Resin viscosity)

High

Low

Ultranspeed curing resin
(5-min curing)

Ultrahigh-speed curing resin
Blending chain transfer agent
Anionic polymerization

Existing epoxy resin
(Amine curing)

Removable

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

Achieved less than 10 minutes of molding by new method

Demonstration of 10 minutes molding in inner door panel

Base material

Resin injection / curing

Removal

RTM

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)

Vacuum

Resin injection

Time (min)

0 3 5 35 90

Cure degree (Resin viscosity)

High

Low

Ultranspeed curing resin
Blending chain transfer agent
Anionic polymerization

Existing epoxy resin
(Amine curing)

Removable

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

**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

**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 capital investment ahead of competitors

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

- **Future vision**: Start in Jan, 2008
- **CFA**: Start in Jan, 2006
- **SOFiCAR**: Start in Oct, 2004
- **TORAY**: Start in Aug, 2007

Capacity:
- 2003: 9,100
- 2004: 10,900
- 2005: 17,900
- 2006: Under construction
- 2007: Under construction
- 2008: 25,000 more
- 2009: Future vision
- 2010: Future vision
- 2011: Future vision
- 2012: Future vision

Copyright 2008 Toray Industries, Inc. All Rights Reserved
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

Under construction
TCA: 1 line
Ishikawa: 1 line

Start in Jan, 2007
Ehime's expansion

Future vision

Start in Jan, 2006
TCA's expansion

Future vision


Capacity
10.2 16.4 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
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 CO$_2$ emission**
  - Flight: 99%
  - Material & parts production, Assembly, Disposal: less than 1%
  - (Based on 10-year operation)

- **Automobile CO$_2$ emission**
  - Drive: 84%
  - Material & parts production: 13%
  - Assembly: 4%
  - Disposal: 1%
  - (Based on 10-year driving)

Most part of CO$_2$ is emitted during operation and driving

 Improvement of mileage by weight saving with using Carbon Fiber is a key to reduce CO$_2$ 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)
Business Plan
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