Composite Intensive, Multi-material BIW Structures

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CYTEC AT A GLANCE

Sales by Business:
- Aerospace Materials: 50%
- Industrial Materials: 16%
- In Process Separation: 20%
- Additive Technologies: 14%

Sales by Region:
- North America: 48%
- Latin America: 13%
- Asia Pacific: 31%
- Europe: 8%

- $1.9b
  2013 Sales

- 36 Sites
  In 13 Countries

- 4,400+
  Global Employees

- 1,800+
  Patents
CYTEC AT A GLANCE

Product Portfolio
Applications Engineering

TOUGHENED STRUCTURAL THERMOSETS
RESIN INFUSION
ENGINEERING THERMOPLASTICS
CARBON FIBERS
TEXTILE & PREFORM
STRUCTURAL ADHESIVES

TRADE STUDIES
DESIGN FOR MANUFACTURING
PRODUCT FORM FOR AUTOMATION
CRASHWORTHINESS & INTRUSION
TOOL DESIGN
SPECIALIZED CHARACTERIZATION

M&P Trade-off
Design
Materials
Mfg Processes

Units Produced

Cost per part, $K
Historically, Fun, Fast, Exclusive, Very Expensive, but with huge CO$_2$ emissions & materials & manufacturing processes wholly unsuited to mass production.
LEGISLATION DRIVERS

Chart 1 UK new car CO₂ emissions and EU targets

Vehicle Lifecycle CO₂ Emissions

- **UK average**
- **EU targets**

- **130g/km by 2015**
- **95g/km by 2020**

Source: SMMT New Car CO₂ report, 2014

Source: Ford (GoCarbonFibre 2012)
Detailed OEM discussions, to understand key needs

Collaborative and detailed cost models to target the technology developments.

House of Quality evaluations with OEMs to define and prioritise new material performance.
TECHNICAL & COMMERCIAL CHALLENGES

Composite Industry Challenges

- **Technology**
  - Fibre – the right type
  - Textiles
  - Snap-cure Formulated Resins
  - Thermoset & Thermoplastic CFRP
  - Preform technologies
  - Matched die moulding processes
  - Automation
  - Adhesives
  - Recycling

- **Supply Chain**
  - Maturity
  - Programme Cost Focus
  - Material Capacity
  - Collaboration

Automotive Industry Challenges

- **Legislation**
- **CFRP Engineering**
- **Multi Material Solutions (Metals & CFRP)**
- **Vehicle Architecture**
- **Design for Manufacture**
- **Assembly plant design**
- **Programme Cost**
- **FEA (Static, Quasi Static, Dynamic, Drape, NVH)**
- **Bonding strategy**
- **NVH**
- **Repair/Insurance Rates**
• New Technology Development
• Collaboration
• Steep learning curves for both Composite & Auto Industries
• Supply chain development is essential
1. CO₂ & fuel economy will always remain challenges.

2. New powertrain (EV/HEV) technologies are only a part of the answer.

3. Steel will still be the dominant material for many years.

4. Composite material use will dramatically increase and will be affordable.

5. Multi-Material BIW solutions offer most cost-effective technical solutions.

6. Composite materials must be combined with powertrain downsizing & parasitic reduction.

7. Life Cycle Analysis must be considered to ensure we fix the CO₂ problem – not just transfer it.

8. OEMs & composite material supply chain must collaborate to create the necessary Design for Manufacturing structural solutions.
TECHNOLOGY ROADMAP
Continual Technology Developments

Affordable Mass Produced Composite Structures

- Closed Mould Technologies
- Preform & Lay-up Automation
- Thermoplastic Composites Materials & Process Solutions
- Large tow CF, NCFs & Textiles
- CFRP-Centric Part Designs
- Snap Cure Prepregs
- Snap Cure HP RTM
- Recycling Technologies
- CFRP Bonding Solutions & Integrated Structures
- Class ‘A’ Solutions
- Thermoplastic Composites Materials & Process Solutions

SYSTEM COSTS:

- £1,000 vpa
- £5k vpa
- £25k vpa
- £50k vpa
- £>100k vpa

TIME

Specific Stiffness

The Goal:

- Metal BW
- F1 supercar’s tubs etc.
Automotive Priorities

- Weight reduced structures
- Affordability
- Mass production

Composite Technology Needs

- Technology
  - Fibre – the right type
  - Matrix
  - Prepreg / Thermoplastic (TP)
- Automation
- Adhesives
- Recycling
- Supply Chain
  - Maturation
  - Programme Cost Focus
  - Material Capacity
  - Collaboration

The Automotive Challenges

- Legislation
- CFRP Engineering
- Multi-Material Solutions (Metals & CFRP)
- Vehicle Architecture
- Design for Manufacture
- Assembly plant design
- Programme Cost
- EEA (Static, Quasi Static, Dynamic, Drape, NVH)
- Bonding strategy
- NVH
- Repair/Insurance

Commercial Focus – Total System Cost

1. Design for Manufacture → Structural architecture → CAPEX
2. Design for Manufacture → Throughput → CAPEX
3. Design for Manufacture → Automation, Scrap/Waste → OPEX
4. Design for Manufacture → Material content → OPEX
Serial Automotive Products

- Snap cure, structural HP RTM resins, ~ 3 mins
- Tg 130 deg C
- Rapid injection
- Excellent mechanical properties

- Snap cure structural prepreg resins, 1 - 4 minutes
- Low and high Tg systems
- 2d, automated pre-forming
- Rapid processing
• High volume DfM approach to multi-panel, CFRP & Metal BIW.

• Split lines defined by load path management, crash requirements, tooling complexity and panel cost.

• Typical metal BIW >300 panels

• Integrated multi material BIW ~ 25 – 30 panels

• Significant reduction in Capex

Source: Delta Motorsports
MATERIAL, TECHNOLOGY & PROCESS DEVELOPMENTS

- Multi Panel, bonded assembly design.
- Composite DfM.
- Designed for matched die tooling processing
- Adhesives key to performance
- Focused FEA structural optimisation
Snap cure structural composites, extreme drape performance. Standard door structure.

Tooling in progress

Advanced structural door designs, snap cure composites

Source: IAV & Formtech Composites
- Battery Tray structure
- MTM23
- Self releasing resin chemistry
- \(<< 3\) minute cure
- 150°C tool
- \(~ 4,000\) vpa
- Crash tests
- Shock loading
- Fire resistance
- Zero VOC emissions
- Over-charge “ballistic type” protection

Source: General Motors
DOOR RING REINFORCEMENT

Technology Alternatives:
1. Compression moulded prepreg or
2. HP RTM
MATERIAL, TECHNOLOGY & PROCESS DEVELOPMENTS

Technology Needs
- Snap cure CFRP
- High Drape Textiles
- Drape control repeatability
- Pre-form automation
- Automated tool loading
- Waste recycling

Rapid Cure Epoxy Systems

- LTM26
  - Fully commercialised
  - Both ideally suited to press moulding
  - Short outlife – 2 days

- Snap Cure Prepreg
  - Recommended system for rapid cure

VE Hybrid – MTM23

- Hot melt, styrene free
- Vinyl ester hybrid
- Proven on GF, CF developments ongoing
- Zero VOC
- Cured Tg = 90°C
- Rapid cure & exceptional outlife
- Some mechanicals aren’t as good as epoxy
- Significantly lower exotherm wrt epoxy
Technology Needs
- Snap cure CFRP
- High Drape Textiles
- Drape control repeatability
- Pre-form automation
- Automated tool loading
- Waste recycling

MATERIAL, TECHNOLOGY & PROCESS DEVELOPMENTS

Dielectric Analysis

Tg vs cure time

Snap cure Press Cure Tg Data

130°C
140°C
150°C
MATERIAL, TECHNOLOGY & PROCESS DEVELOPMENTS

Technology Needs
- Snap cure CFRP
- High Drape Textiles
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- Pre-form automation
- Automated tool loading
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Comparing Resin Systems

- **Tensile**
  - 2020
  - MTM57
  - LTM26
  - Snap cure prepreg
  - XMTR60 HP RTM

- **Compressive**
  - 2020
  - MTM57
  - LTM26
  - Snap cure prepreg
  - XMTR60 HP RTM

- **Inter-Laminar Shear**
  - 2020
  - MTM57
  - LTM26
  - Snap cure prepreg
  - XMTR60 HP RTM

- **In-Plane Shear**
  - 2020
  - MTM57
  - LTM26
  - Snap cure prepreg
  - XMTR60 HP RTM
**MATERIAL, TECHNOLOGY & PROCESS DEVELOPMENTS**

**Technology Needs**
- Snap cure CFRP
- High Drape Textiles
- Drape control repeatability
- Pre-form automation
- Automated tool loading
- Waste recycling

- Textile drape characterisation
- NCFs, x-ply, wovens, FW etc
Technology Needs
- Snap cure CFRP
- High Drape Textiles
- Drape control repeatability
- Pre-form automation
- Automated tool loading
- Waste recycling

- Empirical investigation on textile movement
- FEA comparison of textile movement
- Textile movement (shear force, lock angle etc)
MATERIAL, TECHNOLOGY & PROCESS DEVELOPMENTS

Technology Needs
- Snap cure CFRP
- High Drape Textiles
- Drape control repeatability
- Pre-form automation
- Automated tool loading
- Waste recycling

Effective supply chain partnerships, with key Automotive supply chain, drive total system solutions, that address the OEM’s technical and commercial needs.
MATERIAL, TECHNOLOGY & PROCESS DEVELOPMENTS

Technology Needs
• Snap cure CFRP
• High Drape Textiles
• Drape control repeatability
• **Pre-form automation**
• Automated tool loading
• Waste recycling

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**Deposition rate**

- **Hand laminating** (~1kg/hr)
- **Current automation solution** (~30kg/hr)
- **New automation development** (~00s kg/hr)

**Time**
MATERIAL, TECHNOLOGY & PROCESS DEVELOPMENTS

Technology Needs
- Snap cure CFRP
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- Pre-form automation
- Automated tool loading
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MATERIAL, TECHNOLOGY & PROCESS DEVELOPMENTS

Chopped CF → Chopped CF + matrix blend → Carded sliver → NCF production

• Thermoplastic or Thermoset solution
• Recycled, chopped CF with TP
• No pre-consolidation
• Mould ~ 290°C

• Thermoset prepreg solution
• Recycled, uncured, waste/scrap CFRP
• Press moulded parts
AUTOMATED CFRP PART MANUFACTURE
MATERIAL, TECHNOLOGY & PROCESS DEVELOPMENTS

Gen 1 materials
Legacy: 2020, 997, MTM49-3 etc

Gen 2 materials
Snap cure, reduced cost: MTM???, XMTR50, MTM23, Recycled materials

Gen 3 materials
Cost reduced, EF%&* etc + new textiles, new fibres, net edged, zero waste systems

Gen 4 materials

SYSTEM COSTS

TIME
CHALLENGES for COMPOSITE INTENSIVE, MULTI-MATERIAL BIW STRUCTURES

• Supply chain collaboration
• DfM
• Create materials for mass production & rapid processing
• FEA codes that Analyse it correctly
• Automation
• Use the right material, in the right place, at the right volume.
• Minimise and recycle scrap
• Commercially competitive

It is possible. It’s happening.