Agenda

- Hexcel overview
- Background to applications and solutions
- M77: snap cure matrix
- M77 HexMC: high performance moulding
- M77 PrimeTex: excellent surface finish
- Conclusions
Company Profile

- Technology leader in advanced composites
- Serving commercial aerospace, space & defense and industrial
- Net Sales 2013: $1.68 billion
- 5,500 employees worldwide
- 19 manufacturing sites (including JV in Malaysia)
- Headquarters in Stamford, CT, USA
- Listed on New York and Paris Stock Exchanges
Overview

- **Leading advanced composites company with 65 years of experience**
- **Excellent customer relationships**
- **Technology leader with a broad range of products and qualifications**
- **Leading positions in all of our markets**
- **Demonstrated operational excellence**

Hexcel 2013 Total Sales of $1.68 Billion

<table>
<thead>
<tr>
<th>Markets</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Commercial Aerospace</td>
<td>65%</td>
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<tr>
<td>Space &amp; Defense</td>
<td>22%</td>
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<tr>
<td>Industrial</td>
<td>13%</td>
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<table>
<thead>
<tr>
<th>Products</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Composite Materials</td>
<td>78%</td>
</tr>
<tr>
<td>Engineered Products</td>
<td>22%</td>
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<tr>
<td>Carbon Fiber</td>
<td>46%</td>
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<tr>
<td>Reinforcements</td>
<td>39%</td>
</tr>
<tr>
<td>Prepregs</td>
<td>15%</td>
</tr>
<tr>
<td>Honeycomb</td>
<td>15%</td>
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<table>
<thead>
<tr>
<th>Regions</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Americas</td>
<td>46%</td>
</tr>
<tr>
<td>Europe</td>
<td>39%</td>
</tr>
<tr>
<td>Middle East, Asia, Africa</td>
<td>15%</td>
</tr>
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</table>
Background

Automotive applications; thermosets and thermoplastics; prepregs
Automobile Sections and Parts

BODY IN WHITE

CHASSIS

STEERING and SUSPENSION

CLOSURES

INTERIOR

% of car weight

35%

20%

17%

10%

18%

Potential Carbon Part Areas

- Pillars (A,B,C)
- Firewalls
- Roof
- Chassis structures
- Cross beams
- Bottom chassis
- Floor

- Suspensions
- Wheels
- Prop/Drive shafts

- Side doors
- Hood
- Tailgate
- Fenders

- Seats body
- Seat frames

Thermosets

Thermoplastics

B.I.W and Chassis = 80% of metal substitution opportunities
Thermoplastics and Thermosets: Pros and Cons

Very difficult to generalise because of the wide range of materials

**Thermoplastics**: tough; shorter cycle times; can be reworked and recycled; difficult to bond; lower Tg; lower creep resistance

**Thermosets**: good mechanical properties; easier to bond; longer cycle times; difficult to rework and recycle

- **RTM**: lower cost but with lower Tg and toughness; outlife reflects two part system
- **Prepregs**: higher mechanical properties at higher cost; fully formulated (affects outlife); fully impregnated (consistent quality)

How can thermoset (prepreg) cycle times be minimised while retaining their advantages?
Prepreg: Film Impregnation

- Continuous fibre surface
- Heat table
- Consolidating rollers
- Cool table
- Light table

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M77

‘Snap cure’ matrix system
M77 Profile

M77 extends the limits for thermoset prepregs with a unique combination of properties

- ‘Snap cure’: 2 minutes at 150°C
- Long Outlife: 6 weeks at 23°C
- Controlled flow
- Hot demould
- High Tg: 130°C
- Good mechanical properties
- REACH compliant
- Toughness and adhesion
- Up to 100 bar

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M77 in the Industrial Product Range

HexPly® M77
Snap cure, environmentally friendly, high Tg

HexPly® M49
Best option for structural performance with good visual appeal

HexPly® M9.X / M10R
Industry standard

HexPly® M34
Fire resistance, low temperature cure

HexPly® M81
Flexible cure, structural performance, ultra high Tg

HexPly® M47
High Tg, structural performance

HexPly® M35-4
Flexible cure, structural performance

M77: unique ‘snap cure’
M77: Designed for Press Processing

M77 cure cycle for 3mm thick part

- Temperature (°C)
- Pressure (bar)
- Time (s)

- Bottom mould surface temperature
- Middle of part temperature
- Pressure

Mould closing (10'"
Mould opening and part ejection (10'"

Designed for high production rates
M77 Prepreg: Mechanical Performance

200gsm twill 2X2 3k carbon fabric

150 gsm unidirectional carbon tape

High mechanical performance with much shorter cure cycle
# M77 Prepreg: Adhesion to Honeycomb

## Nomex honeycomb A1-48-3 12.5 mm

<table>
<thead>
<tr>
<th>Product</th>
<th>Cure cycle</th>
<th>average</th>
<th>min</th>
<th>Max</th>
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</thead>
<tbody>
<tr>
<td>M77/56%/200T2/CHS-3k</td>
<td>20 minutes at 120°C; 3 bar autoclave</td>
<td>57.8</td>
<td>52</td>
<td>65</td>
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<tr>
<td></td>
<td>3 minutes at 150°C; 3 bar under press</td>
<td>49.1</td>
<td>42.1</td>
<td>55</td>
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<tr>
<td>Ref: 1458/50%/220T2/3K</td>
<td>180 minutes at 160°C; 3 bar autoclave</td>
<td>50</td>
<td>36</td>
<td>75</td>
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</table>

## Aluminium honeycomb 5052-3/16-12.5mm

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<th>Product</th>
<th>Cure cycle</th>
<th>average</th>
<th>min</th>
<th>Max</th>
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</thead>
<tbody>
<tr>
<td>M77/56%/200T2/CHS-3k</td>
<td>20 minutes at 120°C; 3 bar autoclave</td>
<td>37.1</td>
<td>34.4</td>
<td>42</td>
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<tr>
<td></td>
<td>3 minutes at 150°C; 3 bar under press</td>
<td>32.3</td>
<td>28.7</td>
<td>36.5</td>
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<tr>
<td>Ref: 1454/54%/193P/3K</td>
<td>90 minutes at 125°C; 3 bar autoclave</td>
<td>33</td>
<td>28</td>
<td>38</td>
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Good adhesion even with fast cure cycle
# M77 HexPly® Current Product Range

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<tr>
<th>Product type</th>
<th>Fabric</th>
<th>Item description</th>
<th>Product width [mm]</th>
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<tr>
<td></td>
<td>UD</td>
<td>M77/32%/1200/G</td>
<td>1200</td>
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<tr>
<td>Prepreg Glass</td>
<td>Satin weave</td>
<td>M77/55%/48P/G</td>
<td>1100</td>
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<tr>
<td></td>
<td>Satin weave</td>
<td>M77/52%/106P/G</td>
<td>1260</td>
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<tr>
<td></td>
<td>Multiaxial</td>
<td>M77/45%/160P/G</td>
<td>1100</td>
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<tr>
<td></td>
<td>Satin weave</td>
<td>M77/45%/296H8/G</td>
<td>1250</td>
</tr>
<tr>
<td></td>
<td>Plain weave</td>
<td>M77/38%/395P/G</td>
<td>1250</td>
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<tr>
<td></td>
<td>Multiaxial</td>
<td>M77/40%/LT570/G+F</td>
<td>1240</td>
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<tr>
<td></td>
<td>UD</td>
<td>M77/42%/UD90/CHS</td>
<td>616</td>
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<tr>
<td>Prepreg Carbon</td>
<td>UD</td>
<td>M77/38%/UD150/CHS</td>
<td>460</td>
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<tr>
<td></td>
<td>UD</td>
<td>M77/42%/UD300/CHS</td>
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<tr>
<td></td>
<td>UD</td>
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<tr>
<td></td>
<td>Twill</td>
<td>M77/42%/200T2/C</td>
<td>1250</td>
</tr>
<tr>
<td></td>
<td>Twill</td>
<td>M77/42%/600T2/C</td>
<td>1250</td>
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M77 Prepreg: Process Adapted for Automotive Parts

- **Short cure cycle**
  - (2 min at 150°C or 1.5 min at 160°C)

- **Demould**
  - in hot conditions (high Tg)

- **REACH compliant**

- **Controlled flow**

- **Long shelf life**
  - (6 weeks at 23°C)

- **No fridge**

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**M77: ‘snap cure’ for high production rate**
HexMC® and M77

High performance moulding with ‘snap cure’
What is HexMC®?

- UD prepreg precursor
- Slitting + chopping
- Random distribution
- Consolidation

HexMC® Mat

- 450mm wide roll
- 2000 gsm
- ≈2 mm thick

HexMC®: a quasi-isotropic molding compound for structural applications
Material highlights

- Stiffness comparable to a QI UD lay-up
- CTE compatible with carbon fiber structures
- Excellent fatigue and thermo-cycling resistance
- Notch insensitive (OHC, OHT)
- Very tolerant to damage and defects
- Unidirectional prepreg or fabric can be co-cured to improve stiffness / strength if needed
Examples of HexMC® Parts
M77 and HexMC®

- Conventional HexMC® is formulated to cure at 120°C in 15 minutes and can be de-moulded immediately
- M77 HexMC® can be cured at 150°C in 2 minutes
  - Tg is sufficient for hot de-moulding
- Mould release properties can be measured using a modified flatwise tensile test

HexMC with ‘snap cure’ enables high volume moulding of smaller, more complex parts
PrimeTex and M77

Excellent surface finish with ‘snap cure’
PrimeTex®: Innovative range of carbon fabrics which have been processed for a closed weave and uniform appearance

- Carbon fibre tows are woven flat and spread in both warp and weft directions
- PrimeTex® quality is measured through Open Factor (OF)

PrimeTex®, a new range of woven carbon fabrics
PrimeTex® 98 gsm – AS4 3K

M77 with PrimeTex fabrics - new combinations for excellent surface finish AND ‘snap cure’
PrimeTex®

BMW M3/M6 series composite roof

Outer Skin: 3K PrimeTex® 200 gsm PW

Inner Skin: 12K PrimeTex® 200 gsm PW
Conclusions

- M77 extends the boundaries of thermoset prepregs with a unique combination of properties
  - ‘Snap cure’ in 2 minutes at 150°C with long outlife
  - High Tg enables hot demoulding
  - Good adhesion and high toughness

- Such fast cure is well adapted to the volume manufacture of automotive parts

- ‘Snap cure’ can be combined with HexMC® for high volume moulding of smaller, more complex parts

- M77 on PrimeTex fabrics give new combinations for excellent surface finish and fast cure

M77: the ‘snap cure’ prepreg uniquely suited to high volume manufacture of parts
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