Carbon Fiber Composites
Solutions for High Volume Manufacturing

Dr. Joseph J. Laux
Director Business Development (EU) – Lightweight Composites
Magna Exteriors

March 2017
## Management Structure

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Division</th>
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<tbody>
<tr>
<td>Don Walker</td>
<td>Chief Executive Officer</td>
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<td>Magna Exteriors, Seating, Mirrors, Closures and Cosma</td>
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<td>VP Operational Improvement &amp; Quality</td>
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<td>John O’Hara</td>
<td>President</td>
<td>Closures Vision Systems Roof Systems</td>
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<td>BODY &amp; CHASSIS</td>
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<td>Jake Hirsch</td>
<td>President</td>
<td>POWERTRAIN</td>
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**SEATING**

- Mike Bisson
- Grahame Burrow

**EXTERIORS**

- John O’Hara

**VISION SYSTEMS**

- John Farrell

**ROOF SYSTEMS**

- Jake Hirsch

**BODY & CHASSIS**

- Swamy Kotagiri

**POWERTRAIN**

- Guenther Apfalter

**VEHICLE ENG**

- Guenther Apfalter

**FUEL SYSTEMS**
Not just bumpers!

CF Hood
- 50 K tow fiber epoxy resin
- 40% weight reduction

Hollow Vane AGS
- Increased performance
- Weight reduction
- In molding assembly

Radar Covers
- Electronics integration
- Multi-material molding
- Enabling technology

Energy Management
- Energy beams
- Crush cans
- Structural joining - RIW

Invisible PDC
- Improved styling
- Electronics integration
- Capital reduction

UV Cure
- Snap cure clear coats
- Energy savings
- Shortened paint line

Sub-Frame
- Structural materials
- Chassis applications
- Multilateral joining

Multi-material Body
- Cross group collaboration
- Multi-material integration
- Weight reduction

Door Modules
- Cross group collaboration
- Multi-material integration
- Weight reduction

Active Underbody
- Active aerodynamics
- Drag reduction
- Improved efficiency

Roof Modules
- CF Thermoplastic structures
- Adhesives
- Reinforcements

Liftgates
- IR welding
- Adhesives
- Reinforcements
- Composite frame

Capital reduction

Cross group collaboration

Multi-material integration

Weight reduction

Shortened paint line

Energy savings

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Improved styling

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Chassis applications

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Roof Modules

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Composite frame

Energy Management

Energy beams

Crush cans

Structural joining - RIW

Invisible PDC

Improved styling

Electronics integration

Capital reduction

Sub-frame
High Performance Composites

Lightweight as enabler for new functionalities in the vehicle
Composites

CF hood
Structural thermoplastic composites
Multi-material body design
Structural CF SMC
First ever, CF Compression Molded Class A Hood

- Delivered fully painted, assembled, high volume capable
  - 2016 Cadillac ATS-V – painted all colors
  - 2016 Cadillac CTS-V – painted all colors with decorative exposed weave inner panel
Class A Hood Assembly

OUTER
- 1.2 mm thick painted class “A”
- 6 Layer unidirectional material at [0/90/0]s
- Mass = 2.5 Kg

INNER
- 0.8 mm thick reinforcement
- 4 layer unidirectional material at [0/90]s
- CTS-V includes an exposed weave appearance (1.05 mm total)
- Mass = 1.9 Kg
Advantages

• Mass reduction of 20 – 30% versus Aluminum
• Improved high speed flutter and lift off
• Improved dent and ding performance
• Exceeds pedestrian protection requirements
• Material is corrosion resistant
Material Innovations Deployed on CF Hood

- Step change improvement in molding cycle over traditional autoclave & out of autoclave processes
  - Process eliminates manual lay-up of prepreg sheets typical of other processing technologies
- Proprietary fast cure, high Tg, pre-preg material enables higher volume applications
- Pre-preg material utilizes low cost industrial grade carbon fiber
- Two patents pending for pre-form / material handling and molding tool design
Next Steps for Magna CF Class A Development

• Continue to develop resin chemistry for:
  – Improved surface quality
  – Lower cost
  – Improve cure
  – 2 – 3 minute molding cycle times

• Prove out CF-SMC as an inner reinforcement to improve cost and cycle times
Multimaterial Body Design: Project Vision

TARGETS:

• Attractive concepts for lightweight structures in derivates:
  – Low investment
  – Low logistic & assembly costs
  – Modular lightweight design

• Joining solutions to integrate multi material parts into body structure

CONTENT:

• Testing: Implementation of multimaterial parts in our production line ➔
  Body Shop – Paint Shop – Assembly

• Assessment of mechanical properties for materials and joinings

• Design of structural part in body structure & simulation in complete body

• Simulation of materials and joining techniques

Mercedes-Benz G650 Maybach Landaulet, Source: Netcarshow

BMW 7er, Body structure, Source: BMW, Euro Car Body 2015
Challenges for simulation

Composites and hybrid materials

- Anisotropic or quasi isotropic behavior
- Multi material and hybrid design
- Optimization of layers
- Energy absorption by fine fragmentation (CFRP)
- Acoustic and structural vibration validation

Material
- Isotropic behavior

Geometry
- Shell and spaceframe design

Structural Durability
- Optimization of wall thickness

Crash
- Energy absorption by buckling (Al)

Acoustic
- Virtual concept investigations

Light metal alloys and high strength steels
Multi material design

- warm/cold joining technology
- ~80°C heating (e.g. outer panels)
- „Black & Color - Framing“
- final assembly

Component -> BIW structure -> Paint -> BIW final -> Assembly

- welding
- ~190°C heating (e-coat)
- general assembly hang on parts

Shell- and spaceframe design
CFRP-metal hybrid structures

Motivation

CFRP enables lightweighting, and our focus is on high volume applications.

Joining of composites in body shop is challenging.

Heat resistance for e-coating is limited.

Source: Kroll et al, TU Chemnitz
CFRP-metal hybrid structures
Investigations

Pre-screening of CFRP materials for “material tool box” finished

Mechanical pre-screening

Ultrasonic testing

Flexural testing

Tensile testing

E-coating & paint capability

No constant coating of material, no paint interactions with tested materials

Dynamic-Mechanical-Analysis for e-coating influence & heat resistance
CFRP-metal hybrid structures
Investigations: DTMA testing

DTMA according to ISO 6721-7: Torsion, f = 1Hz, ΔT/t = 2K/min

Change of $G'$ calculated for samples after e-coating process

EP_CF Prepreg #1
- $G'_0$: -2%
- $G'_0$: -25%

E-coating

APPLICAN

- $\Delta G'_0$: 8%
- $\Delta G'_0$: 16%

EP_CF Prepreg #2
- $G'_0$: -10%
- $G'_0$: -19%

E-coating

APPLICAN

- $\Delta G'_0$: -8%
- $\Delta G'_0$: -16%

EP_CF Prepreg #3
- $G'_0$: -10%
- $G'_0$: -80%

PUR_CF Prepreg #1

- $\Delta G'_0$: 2%
- $\Delta G'_0$: 25%

E-coating

APPLICAN

- $\Delta G'_0$: -2%
- $\Delta G'_0$: -25%

Author: Dr. J. J. Laux; S. Kaufmann
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CFRP-metal hybrid structures

Investigations: Joining

Metal-CFRP Joining

Evaluation of different in-mold joining technologies

Manufacturing of metal-CFRP plates for testing issues and evaluation of manufacturing behaviour

Evaluation of contact corrosion behaviour

Investigation of thermal warpage due to difference in CLTE

Solutions for metal-CFRP concepts are being investigated
CFRP-metal hybrid structures

Investigations: Flexural tests of hybrid samples

Flexural samples: 80 x 25 x 2,7 mm,

Upside: Alu After pressing + e-coating

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CFRP-metal hybrid structures

Potential applications

Picture of Metal-CFRP hybrid component, currently in progress

Possible applications using functional integration

Source: Bentley, Euro Car Body 2016
Meet and exceed material requirements for global automotive 2020 and beyond.
Future of Alternative Material Usage

• Innovative ways to optimize materials and processes and reduce production costs for future high volume production use
Please visit us at booth Hall 6 P12