Dow Automotive Systems
Adhesive Solutions for Vehicle Lightweighting

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March 2015

Dowautomotive.com
Why Mass Reduction?

Powertrain improvements alone cannot achieve the fleet fuel efficiency/emissions targets

- Mass reduction is vital for car makers to avoid fuel efficiency or emissions legislated penalties
  - 10% mass reduction = +6-8% fuel efficiency including secondary mass (and cost) reduction of powertrain / chassis
Why Adhesives?

Alternative, lighter weight materials of construction will be required. Adhesives are an enabler for joining dissimilar materials.

## Coefficient of Linear Expansion $\alpha$ of Substrates at 20° C, $\mu$m/m° C

<table>
<thead>
<tr>
<th>Material</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>11-13</td>
</tr>
<tr>
<td>Aluminum</td>
<td>21-23</td>
</tr>
<tr>
<td>Magnesium</td>
<td>26</td>
</tr>
<tr>
<td>Continuous CFC</td>
<td>0</td>
</tr>
<tr>
<td>CFC Molding Compound</td>
<td>5-20</td>
</tr>
</tbody>
</table>

(CLTE influenced by fiber content, fiber length and orientation)
Why Adhesives?

- **A challenge** for lightweight material implementation in vehicles is **effective joining technologies especially for dissimilar, lightweight substrates** such as high strength steel, aluminum, magnesium and composites.
- **Epoxy and polyurethane structural adhesives** are an enabling technology for dissimilar material assembly, where traditional joining techniques such as welding and riveting are limited in their applicability.

### Multi-Material Use

- Aluminium Sheet
- Cast Aluminum
- Aluminum Profiles
- Warm Stamped Steel
- Cold Stamped Steel

### Full Body Bonding

- CFRP Structure

### Module Bonding

- PC Blend
- LGF PP

### Light Weight Closures
Why Adhesives?

- Other benefits of structural adhesives:
  - **Increased load bearing capability, static and dynamic stiffness**
  - Leads to improved safety and crash behavior, reduced vibrations and noise, optimized ride, driving and handling characteristics and extending the vehicle life span and long-term value via higher durability.

- The value of lightweight is even more pronounced in **electric vehicles** as a way to offset the additional battery load (up to 900Lbs) and to extend the vehicle range.

  - Break the trend of increasing body weight
  - *Multi-material use in body shop*
  - *Bonding full aluminium vehicles*
In applications of structural adhesives where designers are optimizing for weight reduction, evidence suggests that **0.6 to 1.1 kg of mass can be reduced for every meter of structural adhesive applied.**

### Why are Structural Adhesives Effective?

- Reduce stresses in bonded joints, which improves vehicle durability
- Enables down gauging of steel, which reduces weight
- Higher loads can be sustained, which improves crash and safety performance

### Graph

- **Spot Welding**: Standard joining technique
- **Weld Bonding**: Adhesive bonding with welding secondary attachment

- Increased load-carrying capability allows down gauged substrate for weight reduction
Challenges for Lightweight Vehicles with Dissimilar Material Joining

**Joining**
- Thinner substrates
- Dissimilar Materials
- Earlier in manufacturing process
- Challenges:
  - Coefficient of linear expansion differences
  - Residual stresses
  - Component distortion due to thermal and mechanical loads
  - Impact of residual stresses on adhesion performance
- Strength, fatigue/durability, and corrosion
- Galvanic corrosion
- Hybrid joining (secondary attachment)

**Performance**
- Safety
- NVH performance
- Ride, handling comfort
- Fuel economy

Current and next generation adhesives facilitate solutions
Why Dow Automotive Systems?

**VORAFORCE™**
- resin matrix systems
- Tailored substrate surface chemistry for optimal performance
- Materials design and joint engineering to manage interrelationship between different substrates
- Down-engineering of composite components by leveraging adhesive joint
- Solutions for body shop or trim shop assembly

**DowAksa AKSACA™**
- carbon fiber and derivatives
- Optimization of interface between carbon fiber and resin
- Ability to create carbon fiber systems tailored for automotive composite applications

**BETAMATE™**
- and BETAFORCE™
- structural adhesives
- Adhesive bonding of cavity sections reinforced with structural foam
- Continuous bond-line contains structural foam within the cavity

**BETAFOAM™**
- structural foam
- Potential to reduce level of carbon fiber in the composite by leveraging reinforcement contribution of structural foam
- Acoustical contribution of foam in composite body

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Aluminum Bonding

Consideration for bonding Aluminum:
• Types of aluminum parts (sheet, extrusions, castings)
• Surface treatments
• Oxide layer formation, untreated aluminum
• Strength, fatigue/durability, and corrosion
• Galvanic corrosion
• Welding considerations of aluminum

Dow BETAMATE structural adhesives are the enabling joining technology on:
• 2012 Motor Trend Car of the year (Tesla Model S)
• 2013 Motor Trend Car of the year (GM Corvette Stingray)
• 2014 PACE award winner PACCAR (Kenworth T680 and Peterbilt 579)

…and we are proud to be the BETAMATE structural adhesive supplier on the 2015 FORD F-150
Composite Bonding: New Vehicle Approaches

- **Composites** are gaining traction in automotive production due to their **weight-saving potential**, yet they remain difficult to join.
- **Adhesives offer a reliable alternative** to traditional mechanical and thermal processes, which cannot be applied to these lightweight materials.
- Advanced bonding solutions such as **polyurethane structural adhesives** enable a continuous bond line and cohesive joining of surfaces.
- **Dow Automotive Systems** supplied BMW for the carbon fiber compartment of the BMW i3 with an individual joining solution basing on PU adhesives.
- This PU structural adhesive has been **individually designed and optimized for BMW’s process requirements**.
Future Structural Adhesives Bonding Applications – BETAMATE™

BETAMATE™ Epoxy Technology
Hybrid Technology and New Chemistries

Move assembly to body shop for large lightweight panels (roofs) and e-coat capable composites.

Assembly

SUBSTRATE

Steel, AHSS

Composites, Plastics

Aluminum

Structural Metal Bonding
Summary

**Structural Adhesives** enable vehicle light weight strategies by

- Bonding **dissimilar materials** including **carbon fiber reinforced composite materials** to many light weight substrates
- Managing **thermal expansion differences** with dissimilar materials
- Facilitating **down-gauging** and/or **down-grading** of steel for **cost and weight reduction**

The continuous bond line provides **improved load transfer** between sheet metal parts, resulting in **improved stress distributions**

Adhesives **enable dissimilar material joining** when traditional joining methods cannot be used and addresses **galvanic corrosion** concerns

**Benefits include**

- Bond many substrates, including metals and composites without priming
- Increase body stiffness (NVH), improves crash performance
- Increase vehicle body durability
- Compatible with other mechanical and thermal joining techniques
THANK YOU FOR YOUR ATTENTION!

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