Innovations in Automotive Plastics
“Applications”

Based on SPE Awards

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• This 1-piece aftermarket epoxy/carbon fiber spoiler provides a premium carbon composite appearance and enables the same aerodynamic performance as production 3-piece spoilers with different aero variants while also reducing mass by 40%.

• The spoiler’s unique design and proprietary tooling combines solid wickerbills and an open cavity blade plus integral threaded inserts to facilitate manufacturing and assembly.

• The 1-piece construction offers a cleaner appearance due to reduction of fasteners. The spoiler is offered in both clear coat with exposed weave and painted in carbon flash metallic paint.

OEM/Vehicle
General Motors Co.
2016 Chevrolet Corvette
System Supplier
deBotech, Inc.
Material Processor
deBotech, Inc.
Material Supplier
Solvay
Resin
Solvay Epoxy MTM57
Tooling/Equipment Supplier
deBotech, Inc.
Production 3-Piece Spoiler

Accessory 1-Piece Carbon Fiber Spoiler
Three of 5 glass positions on this vehicle feature chemically tempered glazing that's part of a thin, hybrid laminate solution with an interlayer of solar-control PVB film that reduces glazing weight approximately 37% while lowering heat transmittance to keep interiors cooler.

Versus conventional 0.20 in./4.96 mm thick laminates featuring 2 layers of soda-lime glass (SLG) with a PVB interlayer, the new construction features standard-thickness layers of SLG and PVB plus a very-thin (0.03 in./0.7 mm) layer of chemically tempered glass for a total thickness of 0.14 in./3.56 mm.

The resulting laminate is thinner, lighter, tougher, and offers optical advantages.
Ford GT Light Weight Glazing Positions

Three of the five glass positions utilize Chemically Tempered Glazing (Gorilla Glass).

Doors and Body – Carbon Fiber
What is Ion Exchange Chemically Tempered Glass (Gorilla Glass)

**Technology Overview**

Gorilla Glass is a fusion formed, chemically strengthened glass that is tougher and optically advantaged vs. standard glass.

- **Fusion**
- **Chem Strengthened**
- **Available in 4+ billion devices**

**Unlike SLG, GG has no draw line distortion**

Photos with point light source at 60 degrees: *Prox* specially float line at lower TPD.

**Optically Advantaged**

- The failure load of SLG is less as it gets thinner:
  - **GG**
    - 125 at 1.1 mm
    - 82 at 0.7 mm
    - 64 at 0.5 mm
  - **SLG**
    - 23 at 1.1 mm
    - 10 at 0.7 mm
    - 6 at 0.5 mm

**Tougher**

- 5x improvement
- 8x improvement
- 10x improvement
Painted fascias are prone to chip and peel, which leads to warranty costs and customer unhappiness. Additionally, painting adds significant cost with negative environmental impact. Instead, a high-gloss, weather- and mar-resistant, MIC TPO material matched to vehicle body panel color. Rigorous testing was conducted to assure the material was resistant to stone pecking and road chemicals and would not change shape when exposed to high heat. Additionally, a lens-grade mold with SP1 diamond polish and gating designed to minimize knitlines was used. The resulting part is 10% lighter, offers $800,000 USD annualized savings, and harmonizes with exterior painted components.
Development impetus: Painted fascia are prone to chip and peel which drives warranty costs and customer complaints.

Fusion

Escape

Escape

Fascia warranty exceeded $1.1M for paint related defects.
Ford completed vigorous part level and vehicle level testing to assure the material was chemically resistant, could withstand stone pecking, and wouldn't change shape when exposed to high heat, among other tests.
A new appearance is achieved for this front grille by using "varied contouring" (variable wall thicknesses) on the B side of this injection molded, tinted PC part,

which subsequently is UV coated on the A side and receives a 3-coat paint system on the B side.

The end result is a unique 3D look on a 2D surface.
A new appearance was achieved for the Chevy Bolt grille using “varied contouring” on the backside and applying an innovative “layering of materials”. The varied contouring creates a unique color appearance because of thickness variation.
Painted Grille: Top (A surface)

- Hardcoat
- Polycarbonate
- Primer
- Paint-Color
- Black Back coating

Bottom (B surface)
1. Injection Mold part – Tinted polycarbonate Two Tone color is caused by only the molded part’s thickness difference.

2. Finished part with Coatings
• This all-composite design without metallic reinforcement is the first AGS-capable, injection-molded PP-LFT FEM bolster used on a heavy-duty pickup platform.

• Replacing steel and plastic/metal hybrids at a 3 lb/1.4 kg and $3 USD savings/vehicle,

• The design offers parts consolidation with locating features that aid fit & finish, improves airflow, while meeting structural requirements for part deflections of <1mm on this 8,500 lb/3,856 kg class vehicle.
Body Exterior
P558 Ford Super Duty
PP LFT Structural Front End Module With Active Grille Shutter Capability
Part with Components Attached (less Grille/Lamps)
Body Exterior
P558 Ford Super Duty
PP LFT Structural Front End Module With Active Grille Shutter Capability
Part with Components Attached (with Grille/Lamps)
• This console design converts from 2 cupholders plus a bin to 4 cupholders with the help of a patented slider tray assembly for greater user flexibility without the need to remove and stow components when not in use.

• The design of the injection molded PC/ABS cupholders accommodates beverage containers ranging from small coffee cups and water bottles to large all-day beverage containers while reducing weight 70% vs. the outgoing model and lowering costs $3 USD depending on content replaced.
Slider Tray Design Details:

Material: PC/ABS Sabic Cycoloy XCY620
Slider Assembly: Sonic Weld
Lubricant: Harves Drysurf

To solve the challenges of conventional seat construction, which limits console storage and rear-seat leg room, this product eliminates molded urethane foam from the seat back and replaces it with an all-plastic shell featuring a larger concave region that enables optimum occupant comfort.

An innovative suspension system also is used that consists of a forward plastic seat back panel attached to the frame via spring joints. The technology can increase front console width by ≈ 0.8 in./20 mm and reduce seatback thickness by ≈ 2.1 in./52 mm or reduce overall vehicle cost $35-$40 USD and mass 3-4 kg.
Ultrathin Seat Back

Production Use:

- 2017 Chevrolet Bolt will launch (Late 2016) with UTSB technology in the front seats.

The front seats are “the most highly engineered ever by General Motors,” to save weight without sacrificing comfort, Tavel said. They’re thin and light, with more springs and less cushioning than conventional seats.  

Forbes

The Bolt is cute — it’s designed as a small crossover SUV — but there’s an incredible amount of space inside, thanks to the design of the flat battery pack mounted beneath the floor and thin, sculpted front seats that give rear passengers extra leg room. Even a six-foot-two journalist who climbed in the back had plenty of head-and legroom. Families would have no trouble buckling three car seats in the back.  

Automotive News

The battery pack is flat and mounted beneath the floor, freeing up interior space. GM designed the interior to maximize the ease of entry and exit via a low floor and slimmed-down seats that it developed in-house. The materials have a refined feel but were made to withstand the additional wear and tear that might come from shared use, lead designer Stuart Norris said. 

Detroit Free Press

The front seats are “the most highly engineered ever by General Motors,” to save weight without sacrificing comfort, Tavel said. They’re thin and light, with more springs and less cushioning than conventional seats.  

Forbes: Joann Mullin, Forbes Staff, Jan 7, 2016

Automotive News: Mike Colias, January 11, 2016 @ 12:01 am
OEM & DESIGN RESPONSIBILITY
• General Motors

VEHICLE:
• Chevrolet Bolt

SEAT JIT SUPPLIER:
• Magna Seating

COMPONENT SUPPLIER:
• US Farathane Corporation

MATERIAL SUPPLIERS:
• Advanced Composites
• BASF

RESINS:
• GMW15548P-PP/PE-M15-Type 6A
• GMW15548P-PP/PE-M20 Type 4
• GMW16582P-PA6-GF15

TOOLING SUPPLIER:
• Toolplas Systems Inc
• Reportedly, this is the thinnest full-size, deep-draw injection molded IP in North America at 1.9 mm/0.07 in.

• It was achieved by injection molding a 30% glass-reinforced LFT-PP. Versus the 2.4 mm/0.09 in. microcellular molded benchmark,

• This design was 14% lighter, saved over $1 USD in materials as well as the microcellular-foaming investment, and helped optimize packaging.

• Mold filling analysis with fiber orientation was used for accurate warpage predictions and to develop tooling countermeasures to facilitate part molding.

OEM/Vehicle
Ford Motor Co.
2017 Lincoln Continental

System Suppliers
Faurecia Interior Systems
Detroit Manufacturing Systems Ltd., LLC

Material Processor
Faurecia Interior Systems

Material Supplier
SABIC

Resin
STAMAX 30YK270E 30% GFPP

Tooling/Equipment Supplier
Lamko Tool & Mold Inc.
Unique Solution: 2017 Lincoln Continental

- Full structural IP retainer for D segment
- Complex geometry to support multi-piece topper and decorative panel attachments

Thinnest instrument panel 1.9 mm material thickness
Predictive Correlation

Fill pattern / fiber alignment critical to part performance
Thanks to integrated composite designs, this "perfect position seat" suspension system delivers tuned suspension to optimize occupant comfort by cradling the upper back and providing side-torso support, which flexes to accommodate various occupant sizes.

Special attachment features facilitate assembly and service time.

The design also creates a robust dynamic crash-energy management system for rear-impact protection.

Molded-in-color is used for A surfaces and craftsmanship. The system, for which 83 patents have been filed, reduces total seat weight by 8% and cost by 15% despite adding more features.
Ford and Lincoln Motor Companies took traditional automotive seats to the next level and produced a “seating experience” like no other that leaves the occupant saying “Wow!” to its distinctive styling and comfort... we created the “Perfect Position Seat” or known to our team internally as the “WOW seat”

Global seat systems must deliver occupant “Comfort DNA” to provide targeted support to reduce muscle-group tension and improve occupant blood-flow at high-stress body zones

Plastic composite upper and lower suspensions provide occupant upper back cradling and side torso support that flexes to accommodate various occupant sizes

Plastic composite suspensions integrate attachment features to enable plastic composite “Comfort Carriers” with seat trim/foam/feature assembly to attach and maintain occupant comfort and support
Modular Dual Layered Composite Suspensions For Upper and Lower Backs

Innovation Details

- Upper back composite suspension is an ULTRAMID B3EG3 15% glass-filled nylon back support over-molded to a cross-tube pivot assembly to provide a cradling embrace with integrated attachment features.

- Lower back composite suspensions are ULTRAMID B3EG3 15% glass-filled nylon supports fastened to the TPO seat back module assembly to provide lateral support and flexibility to individual occupant sizes.

- The upper and lower suspensions act like composite tapered beams with a tapered, smooth design out to its edges that are tuned to a needed force-deflection curve for occupant support.

- Enables “Quick-Connect” feature capability to allow the ADX-5017 18% Talc-filled TPO “Comfort Carrier” trim/foam/feature module assemblies to connect to the seat design easily.
• This is said to be the first application where a PA/glass composite has been used as a cross-member to support the rear differential and complete the rear cradle of a vehicle.

• By replacing traditional parts in steel or aluminum, the injection molded glass-reinforced PA 6/6 design offered parts integration opportunities, is cost neutral, reduces noise transmission from the driveshaft, and reduces mass 25%, helping improve fuel economy and reduce tailpipe emissions.

• The grade used has been optimized for dynamic loads and is controlled with tighter production specs.

OEM/Vehicle
Daimler AG
2016 Mercedes S-Class

System Supplier
ContiTech North America, Inc.

Material Processor
ContiTech North America, Inc.

Material Supplier
BASF Corp.

Resin
Ultramid A3WG10CR PA66 GF 50
From idea to production

Process simulation for Mercedes rear cross member

Process Simulation
Fiber Orientation
Mechanical Simulation

INTEGRATIVE SIMULATION

AUTODESK® MOLDFLOW

PROCESS OPTIMIZATION

CAD

NVH Behavior

ABAQUS

SOLIDWORKS

NX
This challenging new design demanded a unique material with consistent properties after prolonged exposure to fuels, superior wear characteristics, a stable coefficient of friction over a wide temperature range, superior fuel swell and exposure resistance, and superior molding capabilities to properly fill tight-tolerance micro-features.

An injection molded 30% GR-PPA with PTFE micro-powder (to enhance wear characteristics) met all requirements. The application saved over $10 USD/vehicle and reduced energy consumption vs. the previous valve. The novel technology has led to 1 issued and 7 pending patents.
• This application is industry's first belt-integrated, outside door handle with switch activation to open both front and rear doors.

• The slender, minimalist, all-plastic, high-luster chrome-finish handle provides effortless operation, luxury feel, and quiet operation.

• The injection molded PC/ABS part with integrated zinc casting also features an e-handle with power-release switch to deliver a sleek, uninterrupted form that reduces mass 20% and cost 35% vs. conventional bond-on-bracket designs.
eHandle

- Industry first integrated vehicle belt handle provides uninterrupted design
- Intelligent 3 Pole Power door release switch for vehicle design WOW factor
- Integrated Zn casting structure enables minimalist handle while meeting all anticipated customer use requirements for strength, durability and reliability and incorporation of Lincoln embrace requirements
- eHandle provides effortless operation, luxury feel and quiet operation

Belt integrated e-Handle is a unique all new Lincoln signature exterior design
• Project goals were to find ways to reduce cost without reducing performance of the electric power-steering gear-assist mechanism by replacing a powdered metal pulley with an injection molded plastic one.

• A high-flow grade of 60% GR-PA 4/6 that produces a resin-rich surface for improved belt wear was selected.

• It offers significant cost savings and reduces mass over 50% vs. the metal pulley. Its assembly method eliminates 3 bolts, which are replaced by a retaining ring. The molded torque tooth provides secure orientation and excellent load-carrying capabilities.
This is the first use of a glass-reinforced PA material for strut-mount housings on all 4 corners of a vehicle and the first application of polyamide housings on the front and rear suspension systems.

The injection molded parts integrate common components for both front and rear mounts, and employ a special thread assembly method with a locking feature.

They reduce mass 30% vs. typical steel and aluminum parts and reduce noise transmission through the suspension system. Thanks to modular assembly, the design also offers greater tuning flexibility.

**OEM/Vehicle**
General Motors Co.
2016 Cadillac CT6

**System Supplier**
ContiTech North America, Inc.

**Material Processor**
ContiTech North America, Inc.

**Material Supplier**
BASF Corp.

**Resin**
Ultramid A3WG10CR PA66 GF 50
Performance

Single Path
- Single path for all loads

Dual Path
1. One path for strut axial loads
2. Second path for spring loads
3. Third path for jounce bumper loads

Complexity

Three Path
1. One path for strut axial loads
2. Second path for spring loads
3. Third path for jounce bumper loads

Portfolio of Top Mounts
Three Path Design
For the first time a set of top mounts made of glass fiber reinforced Polyamide has been realized for an upper range sedan. SOP was in 12/2015.
New Ideas for Lighter Vehicles

Top Mounts in Glass Fiber Reinforced Polyamide

Integration of common components and tooling for a highly tunable system.
To boost fuel efficiency and reduce emissions on classic small-block pushrod V8 engines, an inexpensive and simple technology called active fuel management (displacement on demand) was developed.

The efficient and precise electro-mechanical hydraulic system deactivates cylinder valves when power is not needed, then reactivates them when power is called for again.

An important component of the system’s solenoid control valves is injection molded, 30% GR-PEI, used for its high stiffness, creep resistance, thermal and chemical resistance, high knitline strength, and ability to be ultrasonically welded. The system improves fuel efficiency 5.5-7.5% and reduces cost 30% vs. metal.
Challenge

• Classic “Chevy Small-block” pushrod V8 loved by several generations of American drivers needed a drastic improvement in fuel efficiency and CO2 reduction.
GM Active Fuel Management System (Displacement on Demand) is a cost-effective approach with a well-documented improvement in fuel economy (5.5% – 7.5% EPE tests).

- The valve lifter oil manifold assembly is bolted to the top of the engine block beneath the intake manifold assembly.
- The oil manifold consists of four electrically operated and normally-closed solenoids. Each solenoid directs the flow of pressurized engine oil to the valve switch lifters.
- The oil pressure relief valve, located in the left rear area of the oil pan, regulates engine oil pressure to the lubrication system and the oil manifold.
• To meet more stringent fuel efficiency and tailpipe emissions requirements, engines increasingly are being downsized and turbocharged, but that raises temperatures and pressures that underhood components see during operation.

• For example, charge air ducts, which take air from the turbocharger to the throttle body, can see continuous-use temps as high as 220C and pressures as high as 207 KPa. Further, compact packaging space requires efficient designs.

• Switching to a heat-stabilized PA 6/6 capable of being 3D flashless blow molded reduced mass 30-40% and cost 20-25% vs. metallic designs.
• This is the first air-intake manifold launched in China using 35% GR-PP to replace PA 6/6.

• The application provides 25-30% cost reduction and 15-20% molded-part weight reduction while retaining properties at high temperatures and improving weld strength, and NVH by 5 dB.

• Unique technology involving finer glass fibers and special sizing helps meet performance requirements. Parts are vibration welded.

OEM/Vehicle
Volkswagen AG
2015 EA21 Engine 1.6L engines
System Supplier
Hua Tao Ltd
Material Processor
Hua Tao Ltd
Material Supplier
SABIC
Resin
SABIC G3135X PP
## G3135X ADVANTAGE

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<td>Cost</td>
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</table>

Images are courtesy of VW, SPE, and SABIC
VW EA211 Engine air intake Manifold
with SABIC® PP compound G3135X

Regulatory and corporate strategies
1. Developing markets -> 25-30% part cost reduction
2. Reduced CO₂ from 15-20% molded part weight reduction
3. First PPC air intake in Greater China

Engineering challenges
2. Validated PPC for global naturally aspirated engine
3. Balance and retention of properties up to 140°C
4. Unique fiber technology for optimized design

Manufacturing and quality improvements
3. Shorter cycle time, improved quality
4. Reduced inventory cost
5. Improved acoustics by 5.0 dB

Images are courtesy of VW, SPE, and SABIC
• Minimizing door intrusion during side impacts usually requires intensive body-structure countermeasures. Abdomen criteria for 5th and 50th percentile dummies are primarily driven by door-trim armrest stiffness during side impacts.

• This new door-trim armrest improves safety as a tuning component by acting as a load limiter and absorbing energy. Comprised of a skin, foam pad, PP-nonwoven trampoline fabric, ABS armrest substrate, and PP trampoline frame, the system is significantly softer than previous designs, substantially outperforming static and dynamic functional requirements without adding countermeasures, cost, or weight.

• Further, armrest durability improves 6x, and costs and weight are reduced $31.80 and 3.8 kg per vehicle.
OBJECTIVES:

Develop a Next Generation Door Trim Armrest Design to:

a. Deliver safety component lateral stiffness requirement
b. Meet armrest vertical load / lateral load SDS static and dynamic loading requirements
c. Optimize countermeasures to save cost and weight
d. Eliminate multiple CAE iterations and eliminate late design changes post FDJ

Background & Challenge

KEY TAKEAWAY:

- Delicate balance between functional and safety requirements
- Anticipating future potential FMVSS 214 requirement change, expected to be released late 2016
Next Generation Armrest Design Schematic
(P558 door trim)

Armrest Skin Cover
(i.e. PVC, leather...)

Armrest Foam Pad

Trampoline Fabric
(100% PP, nonwoven)

Trampoline Frame
(PP)

Armrest Substrate
(ABS)

Main Door Substrate

= Patentable criteria for next generation armrest design
• This patent-pending, plastics-intensive, modular composite front seat-cushion pan (in impact-modified 35% GR-PA), side-airbag deployment back panel (in talc-filled TPO), and power head-restraint drive nut (in POM) create a robust and dynamic crash-energy management system for front impact protection, side airbag deployment, and energy management for occupant impact protection.

• Further, the system enables modular assembly and scalable features for assembly ease. Already 83 patents have been filed and 12 granted on this innovative seat system.
Global seat systems must manage front and side impact (NCAP and FMVSS/ECE) requirements

- Ford requirements are more stringent
- Seat system must maintain front impact hip support and deceleration to achieve required dynamic performance
- Seat system must enable the side-impact airbag deployment times to assure side-impact protection performance
- Seat system must enable rear-impact dynamic occupant neck protection

Integrates these performance needs into modular cushion, back panel, and head restraint assemblies to enable optimized and standardized assembly operations and times.

Utilize integrated composite designs to meet objectives!
The modular composite seat pan is molded with Ultramid 35% glass-filled nylon with impact modifiers and specific hip load-management features to achieve front impact performance needs.

The modular composite back panel is molded with ADX-5017 18% Talc-filled TPO with vinyl wrapping and internal side airbag deployment features to achieve required side impact protection time and load support.

The power head restraint drive nut is molded with Delrin Acetal 100P to achieve needed load strength with needed geometries for mechanical fore/aft motion of the head restraint design.
For the first time, a polymer composite has replaced magnesium in a structural seat-cushion frame and under-seat storage lid for a front center 20% seat with integrated restraint system.

The application is weight neutral and lower cost (≈$4 USD/unit), and satisfies all safety and crashworthiness requirements.

Its flexible architecture allows for updates with future enhancements. Injection molded 40% LFT-PP is used to mold the frame, which also features an EPP antisubmarine foam block and a lockable ergo-latch. The assembly represents a significant reduction in carbon footprint vs. magnesium and has yielded 2 awarded and 2 pending patents.

**OEM/Vehicle**
Ford Motor Co.

**2016 Ford Super Duty**

**System Supplier**
Royal Technologies Corp.

**Material Processor**
Royal Technologies Corp.

**Material Supplier**
Celanese Corp.

**Resin**
Celstran PP-GF40-20

**Tooling/Equipment Supplier**
Vortec Tooling Solutions, Inc.