Modern Cars need High Performance Polymers

Lightweight solutions with engineered materials for the automotive industry

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The Automotive Industry faces big challenges (megatrends)

- efficient energy use
- environmental protection
- competition
- legislation
- customers
- risks/prices
Global challenges:
More pressing than assumed

Importance


energy

greenhouse gas CO₂

emissions CO, NOₓ, HC, PM

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Modern Cars need High Performance Polymers
Global challenges: Efficient energy use (fuel efficiency)

Fuel price history in the USA, 1993-2011 ($/gallon)

Source: Bureau of Labor Statistics

Fuel price: more than doubled in 8 years
Global challenges:
Environmental awareness (reduced CO₂-emissions)

CO₂-emissions from transport (gigatonnes/year)

Source: Sustainable Mobility Project calculations

150 percent more CO₂ from transport in 50 years
Improving fuel economy by reducing weight

Consumption and CO₂-emissions to vehicle weight, 2006

Source: Boesenkool, SMEA Conference, Sheffield / Global Insight / Marketing Celanese

about 10 g/km less CO₂-emissions per 100 kilo weight reduction
Global challenges:
Environmental awareness (reduced CO$_2$-emissions)

US-standards for fuel efficiency (in miles/gallon) and monetary fine for falling below the standard

Source: CAFE Supplement, Juli 2011

Stricter laws require more efficient cars. Car owners are fined $550 for 10 miles less per gallon fuel.
**Economic challenges:**

**Cost-effective innovations**

**Customer needs**
- Increasing demands: quality, functionality, costs, safety
- Global markets, worldwide availability at diverging market requirements

**Environmental conditions**
- CO₂ emissions
- Energy consumption
- Resource protection

**Legislation**
- Stricter laws concerning emission, safety, consumption etc.
- Trend towards alternative drive systems (gas, e-mobility, hybrid...)

**Economic conditions**
- Budget constraints
- Globalization / emerging markets
- Material and energy costs

Source: Commodity Research Bureau
Celanese solution:
Replacing metal with Technical Polymers

Modern Cars need High Performance Polymers

Lower costs
Less weight
Less CO₂ emissions

© Celanese
Less fuel consumption and less CO₂-emissions due to weight reduction

Technical Polymers are lightest

Relative density (g/cm³)

- Copper
- Bronze
- Steel
- Cast iron
- Zinc
- Aluminium
- Magnesium
- Engineering polymers
Example for weight reduction and less fuel consumption:

Celstran® PP door module

Steel

Celstran® PP

weight reduction: about 8 kg
fuel consumption: lowered by about 4%
More than 40% weight and 25% cost reduction by replacing aluminium and optimizing production process: extrusion blow molding and assembly injection molding.

Example for weight reduction:
**Fortron® PPS**

Charge air pipe for turbo charger

Fortron® PPS replaces aluminium
Example: Rinspeed concept car BamBoo
MetaLX™ POM

Opportunity Painted ABS Housing VS MetaLX™ POM

MetaLX™ POM can save up to 38%

8 different manufacturing processes (including painting)

1 manufacturing process (injection molding)
Celstran® Tapes application

Rinspeed concept car BamBoo

Wheel arches
- Material: Celstran CFR-TP PP GF70 BLACK
- stock shape: Oxeon fabric canvas 1/1, made of 20 mm tapes
- Process: pressing

Underbody
- Material: Celstran CFR-TP PP GF70 BLACK
- stock shape: Oxeon fabric canvas 1/1 made of 20 mm tapes
- Process: pressing

Tailgate
- Material: Celstran CFR-TP PPS CF60
- Process: Tape winding

Rollbar
- Material: Celstran CFR-TP PPS CF60
- Process: Tape winding

© Celanese
Celstran® LFR-TP Tapes characteristics

Testing for impact strength (Joule)

- Well-qualified for parts subject to a high degree of stress
- Celstran® Tapes combine low weight, high stiffness and impact strength.
- High quality of impregnation without damaging fibers
- Eco-friendly and easy to process, recyclable

<table>
<thead>
<tr>
<th>Material</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LFT (3.0 mm)</td>
<td></td>
</tr>
<tr>
<td>UD-Tape LFT (0.5 + 2.5 mm)</td>
<td></td>
</tr>
<tr>
<td>UD-Tape (1.0 mm)</td>
<td></td>
</tr>
</tbody>
</table>
# Portfolio Tapes

## Polymers
- PEEK
- PEI
- PAA/PPA
- PA (6, 66, 46, 12)
- PPS
- PBT/PET
- PC
- PCABS
- ANS
- PPO
- TPU
- POM
- PEHD
- TPE/TPO/TPV
- PP
- PVDF

## Fibers
- Carbon fiber
- Aramid fiber
- Glass fiber: S-glass
- Glass fiber: E-glass
- Glass fiber: ECR-glass
- Stainless steel

## Additives
- Custom color
- UV stabilization
- Heat stabilization
- Impact enhancement
- Surface appearance
- Flow enhancement
- Paint adhesion
- Conductive particle
- Low emission
- Lubricity/wear enhancement
Feasibility with Under Body Cover, Fraunhofer ICT
Combination of Celstran® LFRT and Celstran® CFR-TP tapes

© Celanese

Modern Cars need High Performance Polymers
<table>
<thead>
<tr>
<th>Solution</th>
<th>Function/place</th>
<th>Application</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hostaform® POM</td>
<td>► Fuel contact</td>
<td>► Fuel filler neck</td>
<td>► Resistable to fuels</td>
</tr>
<tr>
<td></td>
<td>► Interior</td>
<td>► Door handle</td>
<td>► Hard and stiff</td>
</tr>
<tr>
<td></td>
<td>► Visible components</td>
<td>► Loudspeaker grill</td>
<td>► surface</td>
</tr>
<tr>
<td></td>
<td></td>
<td>► wiper</td>
<td></td>
</tr>
<tr>
<td>Celanex® PBT</td>
<td>► E/E</td>
<td>► Sensor housing, transmission housing</td>
<td>► stiff, good electrical properties</td>
</tr>
<tr>
<td></td>
<td>► Visible components</td>
<td>► Connectors</td>
<td>► surface</td>
</tr>
<tr>
<td>Celstran® LFT PP</td>
<td>► Interior, Exterior</td>
<td>► Door modules</td>
<td>► Functional integration</td>
</tr>
<tr>
<td>Celstran® LFT PA</td>
<td>► Structural components</td>
<td>► Frame for sun roof</td>
<td>► stiffness, high dimension stability</td>
</tr>
<tr>
<td></td>
<td></td>
<td>► Instrument panel carrier</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>► Air inlet grill</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>► bracket</td>
<td></td>
</tr>
<tr>
<td>Fortron® PPS</td>
<td>► Engine compartment</td>
<td>► Waterpump</td>
<td>► Temperature and chemical resistance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>► Parking brake</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>► Intake manifold</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>► Thermostat housing</td>
<td></td>
</tr>
<tr>
<td>Vectra® LCP</td>
<td>► Lighting</td>
<td>► Lamp socket</td>
<td>► Temperature resistance</td>
</tr>
<tr>
<td></td>
<td>► Sensor System</td>
<td>► MID -Sensors</td>
<td>► Electrical properties</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>► easyflowing</td>
</tr>
</tbody>
</table>
With more than 50 years of experience, Celanese positioned itself as an expert at lightweight solutions.

Anticipating customer needs: Our engineers and chemists are constantly developing product innovations.

Let your ideas be part of a future solution! – Together we'll develop tomorrow's innovations.
Thank you for your attention!
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Backup
Cost reduction: Manufacturing process

Sheet metal processing: 6 steps
shearing/punching, bending, finishing, assembly, painting, finished part

Die-casting: 6 steps
ingot, melting, casting, assembly, painting, finished part

Technical Polymers: 3 steps
granulate, injection molding, finished part
Cost reduction: Increased life expectancy of tools

<table>
<thead>
<tr>
<th>Material</th>
<th>Number of Shots</th>
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<tbody>
<tr>
<td>Aluminium</td>
<td>31.5E+05</td>
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<tr>
<td>Magnesium</td>
<td>3.0E+05</td>
</tr>
<tr>
<td>Zinc</td>
<td>4.5E+05</td>
</tr>
<tr>
<td>Technical Polymer</td>
<td>1.0E+06</td>
</tr>
</tbody>
</table>
Example cost reduction: Wiper system Hostaform®

aluminium

0.20 € savings on each part
(no bronze bearing, no finishing)

Hostaform® C 9021
# MetaLX™ in the Automotive Industry

## UV-Performance with Metallic Colors

**Grey Scale**

<table>
<thead>
<tr>
<th>5</th>
<th>0</th>
<th>± 0.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5 – 5</td>
<td>0.8</td>
<td>± 0.2</td>
</tr>
<tr>
<td>4 – 4.5</td>
<td>1.7</td>
<td>± 0.3</td>
</tr>
<tr>
<td>3 – 4</td>
<td>2.5</td>
<td>± 0.35</td>
</tr>
<tr>
<td>3</td>
<td>3.4</td>
<td>± 0.4</td>
</tr>
<tr>
<td>2 – 3</td>
<td>4.8</td>
<td>± 0.5</td>
</tr>
<tr>
<td>2</td>
<td>6.8</td>
<td>± 0.6</td>
</tr>
<tr>
<td>1 – 2</td>
<td>9.6</td>
<td>± 0.7</td>
</tr>
<tr>
<td>1</td>
<td>13.6</td>
<td>± 1.0</td>
</tr>
</tbody>
</table>

**SAE J1885 Conditions**

<table>
<thead>
<tr>
<th>Light cycle</th>
<th>Dark cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irradiation, W/m²</td>
<td>0.55</td>
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<tr>
<td>Black panel temperature, °C</td>
<td>89</td>
</tr>
<tr>
<td>Rel. Humidity, %</td>
<td>50</td>
</tr>
<tr>
<td>Cycle time, h</td>
<td>3.8</td>
</tr>
</tbody>
</table>

**Color change**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Color No.</th>
<th>UV acetal</th>
<th>SZ6</th>
<th>Satin Chrome</th>
<th>Chrome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Da</td>
<td>0.64</td>
<td>-0.64</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Db</td>
<td>0.82</td>
<td>-0.82</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>DE</td>
<td>1.05</td>
<td>1.05</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

- Test device: Xenon Arc Weatherometer
- Test method: SAE J1885 Interior Cycle
- Exposure 1,240.8 kJ/m²
Summary

► Application of Celanese Technical Polymers contributes to lower fuel consumption and energy-saving products.
► Technical Polymers in the automotive industry are usually the solution with the lowest demand for energy – and the lowest manufacturing costs.