New materials for additive manufacturing - The automotive perspective

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GROUP MATERIALS LABS - Polymers & Glass
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- Transportation sector **materials evolution**

- **Innovation drivers** and AM materials **opportunities in automotive**

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  - Materials in use substitution with more performing materials
  - Materials with functionalized fillers

- Conclusions
Transportation sector materials evolution

Innovation drivers and AM materials opportunities in automotive

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Conclusions
Transportation sector

Very different scenarios…but a global market

FCA Group (EMEA, NAFTA, LATAM and APAC)
Today the car is assembled with 15,000 parts, extremely reliable and optimized in terms of safety and environmental impact, with the lower cost per kilogram respect to other high technological level consumer goods.
Materials breakdown evolution

- **Carbon Steel**: 47.2% (Y2000), 40.6% (Y2014)
- **UHSS**: 11% (Y2000), 20% (Y2014)
- **Cast Iron**: 20% (Y2000), 11.1% (Y2014)
- **Lightweight Alloys**: 7% (Y2000), 3.6% (Y2014)
- **Other Metals**: 7.6% (Y2000), 2% (Y2014)
- **Polymers**: 12.4% (Y2000), 14% (Y2014)
- **Elastomers**: 5.2% (Y2000), 4.5% (Y2014)
- **Glass**: 4% (Y2000), 2.6% (Y2014)
- **Others**: 3.5% (Y2000), 1.2% (Y2014)

Weight %
General materials properties

<table>
<thead>
<tr>
<th>Yield Strength (MPa)</th>
<th>Elongation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>2</td>
</tr>
<tr>
<td>400</td>
<td>10</td>
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<tr>
<td>600</td>
<td>20</td>
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<td>800</td>
<td>30</td>
</tr>
<tr>
<td>1000</td>
<td>40</td>
</tr>
<tr>
<td>1200</td>
<td>1400</td>
</tr>
</tbody>
</table>

Every material is improving keeping gaps with its «competitors»

- New PP
- New PA
- Al 7000
- TWIP
- New steel alloys
- Composites
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Conclusions
Drivers for Innovations

CO₂ problem / Global warming

The “last generation” engines allowed to achieve today targets

![Image of traffic and CO₂ emissions graph]

Each exceeding g CO₂/km will cost 95€ to the OEM

Individual customer demands

New style effects and personalization for high perceived quality

Limited resources

Environmental friendly materials and recycling improvements
## AM boost in Automotive Sector

### FUNCTIONS
- **LIGHTWEIGHT**
- **INTEGRATION COMPLEX PARTS**
- **CUSTOMIZATION**
- **HYBRIDS and MULTIFUNCTIONAL**
- **SUITABLE APPLICATIONS** for BODY, INTERIORS, ENGINE SYSTEMS and UNDER BONNET

### VISION
- **Spare parts and accessories management**
- **Lower costs in development phase**
- **Low volume parts production**

### CHALLENGES
- **Materials range and characterization**
- **Design strategies**
- **Manufacturing optimization**
- **Costs and environmental impact drivers**
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Conclusions
Polymers developments

Matrix and additives

Fillers/fibers

PP & PA

Improved functionalities

Improved mechanics

NOW Future Trend
AM Polymers development strategies

1. Development of same materials in use

2. Development of more performing materials instead of today used

3. Development of functionalized fillers for specific requirements and multifunctionality
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Strategy 1 – Development of same materials in use

Issues to be managed by robust design: porosity

Injection moulding of AM material (ABS)  FDM deposition (ABS)

- 5-10% weight

Flexural curves

![Graph showing comparison between ABS injected and ABS FDM flexural curves.](image)
Strategy 1 – Development of same materials in use

Issues to be managed by robust design: mechanical properties vs directions

**STATIC CHARACTERIZATION**

Tensile Test ISO 527/A
Tensile speed: 5 mm/min
Sample: ABS M30; T = 23°C

**HIGH SPEED CHARACTERIZATION**

Tensile Test ASTM D1022 Temp. 23°C
Tensile speed: 0.1 - 10 - 100 mm/s
Sample: ABS M30 (XZ; ZX direction)
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**Conclusions**
Strategy 2 – Use of more performing materials

Material: ULTEM
FDM technology

Material: PA12 GF
SLS technology

Materials are today available on the market
(e.g. PA6 GF, PA12CF, PEEK for both FDM and SLS)
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Strategy 3 – Multifunctional fillers

Improve thermal properties for current applications

PA6+ZD

Layered (sheet-like) silicate (thickness 1nm, diameter 50-500nm)
Reduced percentage of charge (2-10%)

1. Increase of thermal and mechanical properties
2. Better dimensional stability
3. Better rheological properties
4. Excellent surface aesthetic aspect
5. Better barrier properties
6. Reduction of weight
Strategy 3 – Multifunctional fillers

**Mechanical and thermal properties**

- **Tensile Modulus (NCH, T)**

  ![Graph showing Tensile Modulus (NCH, T) vs Temperature (C) for different RH levels (25C, 50C, 80C).]

  - **N**
  - **NCH 2**
  - **NCH 5**

**Dimensional stability**

- **PA 6.6 30 GF**: warpage 35mm
- **NANOCOMPOSITE PA**: warpage 1mm

**WEIGHT REDUCTION**

- **PA-GF**: 1.36 - 1.55 g/cm³
- **PA6+ZD**: 1.15 g/cm³

- Up to 25% weight reduction (PA6+40% mineral charge with similar properties PA 6 +ZD)
- Good aesthetic features (no painting)

**Rehological properties (process)**

- Homogeneous fillers dispersion
- Flow stroke
  - **PA6+30%GF**: 37 mm
  - **PA6+5%C30B**: 46 mm
Strategy 3 – Multifunctional fillers

Smart polymeric materials for new functionalities

Electrically conductive fillers

- Graphene-like structures
- Nanotubes

Main benefits:
- Metal wiring substitution
- Weight and cost reduction
- Assembling simplification
- Easy recycling at ELV
- Improved perceived quality

Full polymer devices integrating
- Wirings
- Electrical circuits
- Sensors
- Switches

Body, E/E, Interiors, Engine systems
Strategy 3 – Multifunctional fillers

Electrically conductive polymers

Graphene
GNP structures

Functionalization
Compounding

Injection moulding

CNT nanocomposites

Dashboard plastic part

Selective activation

Demonstrator prototype
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Conclusions

- Different classes of metallic and polymeric materials with several variations are today used in our cars and AM technologies must find proper way to be applied.

- AM strengths are represented by:
  - Design flexibility (any shape)
  - Increased range of materials with promising properties; different strategies can be followed: substitution 1:1 or use of more performing materials
  - Compatible with developments of multifunctional fillers to same and/or improved properties

- AM needs from materials perspectives:
  - Set up of robust methodologies to fully evaluate SoA materials
  - Proper re-design of components to pass all standards managing issues related to lower mechanical performances respect to injected parts and strong influence of direction deposition
  - Process parameters optimization

- Establishment of a stronger value chain working with materials providers and processes developers as today with well established industrial processes
Thanks for your attention!