Only a Dream?
Polymers for 3D Printing- Easy to Process and Enabling Parts With the Same Strength as Injection Molded Parts
The LEHVOSS Group – 125 Years of Innovation

3 business areas:
- Polymers and rubbers
- Life science
- Special chemicals and industrial minerals

Lehmann & Voss & Co.
- Established 1894
- 125 years experience with chemical specialities and in material developments
- Family-run business in 4th generation

400 €MM revenue
- as of 120 €MM in plastics
- Equity ratio >> 50%
- Above average investments into growth

640 employees
- 16 subsidiaries world-wide
Innovation and market leader in carbon fiber reinforced, high-temperature, tribological and 3D printing materials

Leading material developer for high-end polymer solutions since 1983

Preferred material supplier of industry leaders worldwide

Innovation partner and strategic supplier of major OEMs and Tiers

Main markets: Automotive, Aerospace, Medical, Industrial, E&E, Sports

Serving all processing technologies

Solutions - Individually Engineered

CUSTOMIZED POLYMER MATERIALS
Unique Selection and Design for Best Cost/Performance

Customer Needs → Process and Material Selection & Design → Compounding

Polymers (examples)

<table>
<thead>
<tr>
<th>High Performance Polymers</th>
<th>Engineering Polymers</th>
<th>Standard Polymers</th>
</tr>
</thead>
<tbody>
<tr>
<td>PES, PEI, PSU, PPSU</td>
<td>PA 6, PA 66, PA 12, PA 6.10, PET, PBT, POM, PK</td>
<td>ABS, PP, PE-LD, PE-HD</td>
</tr>
<tr>
<td>PAEK, PEEK, PA46, PPA, PA9T, PPS, LCP</td>
<td>TPU, TPE</td>
<td>Amorphous, Semi-crystalline</td>
</tr>
</tbody>
</table>

Reinforcement
- Carbon fibers
- X carbon fibers
- Glass fibers
- Glass flakes
- Glass spheres
- Aramid fibers
- Mineral fibers
- Others

Additives
- PTFE
- Graphite
- Silicone oil
- Nano-additives
- CNT
- Metals
- Pigments
- Flame retardents
- Ceramics
- UV stabilizers
- Flow enhancers
- Others

- Injection molding
- Extrusion
- Compression molding
- Powder coating
- 3D printing

3,000+ formulations developed
3D Printing Materials – Customized Solutions for Industrial Production

**LUVOCOM® 3F Materials**

- Made for extrusion based processes
  - Fused Filament Fabrication
- Product: pellet / filament
- Simple geometries multi-material
- Composite functional materials

**LUVOSINT® Materials**

- Made for powder fusion processes
- Product: powder
- 100 % design freedom
- Nano-filled materials
3D Printing Materials – Strategy

LUVOCOM 3F
- Reduced anisotropy, easy to print
- Printing in non heated chambers

LUVOSINT
- Customized laser sinter powders
- Excellent printability

- All materials are tailored for 3D printing
- No raw materials but compounded materials
- Focus on serial production
- Matching injection molding strength requirements
- Certified quality and consistency
- Proven track record in actual applications
- 36+ years LUVOCOM experience is in our 3DP materials
3DP Development Labs in Europe, China and USA

10 FFF Printers + lab filament extruder

3 Sintering machines
Current FFF Printing Challenges

• Standard materials being used (injection/extrusion moulding grades)
• Poor processability (low repeatability, high scrap ratio)
• High anisotropy
• No engineering polymers available
• Poor surface finishing
Solution: Customized 3D Printing Materials

Part printed with LUVOCOM 3F PA^{HT} CF without warpage

Part printed with LUVOCOM 3F PA^{HT} CF without support.
LUVOCOM 3F – Unique Performance

Micro CT Analysis*

Standard PA6

LUVOCOM 3F PA\textsuperscript{HT}

<table>
<thead>
<tr>
<th>Printing Temperature</th>
<th>Porosity Measurement 1</th>
<th>Porosity Measurement 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>245°C</td>
<td>28.90%</td>
<td>27.73%</td>
</tr>
<tr>
<td>255°C</td>
<td>22.28%</td>
<td>22.08%</td>
</tr>
<tr>
<td>265°C</td>
<td>26.64%</td>
<td>26.45%</td>
</tr>
</tbody>
</table>

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<tr>
<th>Printing Temperature</th>
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<tr>
<td>255°C</td>
<td>2.08%</td>
<td>2.02%</td>
</tr>
<tr>
<td>265°C</td>
<td>3.42%</td>
<td>4.6%</td>
</tr>
</tbody>
</table>

*All specimens (4x4x4mm\textsuperscript{3}) were printed in the same machine using the same printing parameters (speed, extrusion width, extrusion multiplier, etc.)
Various grades

- 9742 (CF15): ca. 20% Offset
- 9743 (CF25): ca. 20% Offset
- ColorFabb (CF10): no Offset
Carbon fiber reinforced high temperature PA ($T_m = 250^\circ C$)

- PA6 similar mechanical properties but…
- …without moisture issues
- …without warpage issues
- 170 MPa strength and 15.5 GPa Young’s modulus
- Working temperature 150°C
- Max. short time temperature 180°C

Construction: Coupling part 3D printed on organo sheet

Directly 3D printed on CF organo sheet
Unreinforced, CF and GF reinforced PEEK

• Outstanding chemical and thermal resistance
• No heated build chamber needed
• No raft needed due to no warpage

Exhaust system for motor bikes with LUVOCOM 3F PEEK CF
Materials for High Deposition Systems

LUVOCOM 3F PA$^{HT}$CF25
No heated chamber needed!

Direct from pellets, up to 30 kg/h of deposition
Overview Material Portfolio* LUVOCOM 3F

<table>
<thead>
<tr>
<th>LUVOCOM 3F</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LUVOCOM 3F PP 9929 NT</td>
<td>Modified neat</td>
</tr>
<tr>
<td>LUVOCOM 3F PP CF 9928 BK</td>
<td>20% CF</td>
</tr>
<tr>
<td>LUVOCOM 3F TPU CNT 9902 BK</td>
<td>Electrically conductive</td>
</tr>
<tr>
<td>LUVOCOM 3F PET CF 9780 BK</td>
<td>15% CF</td>
</tr>
<tr>
<td>LUVOCOM 3F PA&lt;sup&gt;HT&lt;/sup&gt; 9825 NT</td>
<td>Modified neat</td>
</tr>
<tr>
<td>LUVOCOM 3F PA&lt;sup&gt;HT&lt;/sup&gt; 9936 BK</td>
<td>Modified neat. Smoother surface</td>
</tr>
<tr>
<td>LUVOCOM 3F PA&lt;sup&gt;HT&lt;/sup&gt; 9875 NT</td>
<td>Modified neat. Low water uptake</td>
</tr>
<tr>
<td>LUVOCOM 3F PA&lt;sup&gt;HT&lt;/sup&gt; CF 9742 BK</td>
<td>15% CF</td>
</tr>
<tr>
<td>LUVOCOM 3F PA&lt;sup&gt;HT&lt;/sup&gt; CF 9891 BK</td>
<td>15% CF. Low water uptake</td>
</tr>
<tr>
<td>LUVOCOM 3F PA&lt;sup&gt;HT&lt;/sup&gt; CF 9743 BK</td>
<td>25% CF</td>
</tr>
<tr>
<td>LUVOCOM 3F PA&lt;sup&gt;HT&lt;/sup&gt; GK 9874 NT</td>
<td>10% glass spheres</td>
</tr>
<tr>
<td>LUVOCOM 3F PA&lt;sup&gt;HT&lt;/sup&gt; 9826 BK</td>
<td>Tribological</td>
</tr>
<tr>
<td>LUVOCOM 3F PPS 9937 BK</td>
<td>Modified neat</td>
</tr>
<tr>
<td>LUVOCOM 3F PPS CF 9938 BK</td>
<td>15% CF</td>
</tr>
<tr>
<td>LUVOCOM 3F PEEK 9581 NT</td>
<td>Modified neat</td>
</tr>
<tr>
<td>LUVOCOM 3F PEEK CF 9676 BK</td>
<td>15% CF</td>
</tr>
<tr>
<td>LUVOCOM 3F PEEK GF 9761 BK</td>
<td>15% GF</td>
</tr>
</tbody>
</table>

*more materials on request!
LUVOSINT TPU X92A

- Ester based TPU
- 92 Shore A hardness
- Elastic and extremely durable
- Natural, white, black and customized colors
- Electrically conductive grade available \((1 \cdot 10^5 \, \Omega)\)

LUVOSINT TPU is established in 3D printed wearables and footwear

© adidas  © Under Armour  © PEAK Sport
LUVOSINT TPU in Orthopedics – Customized Parts

Directly from scan to print – fully digital process chain

Data generation

Data processing

3D printing

Finished part
LUVOSINT PP 9703 WT

- Easy-to-print PP
- Based on random-copo PP-R
- Tough and light-weight
- High chemical resistance
- Weldable
- Toughness modified grades on request

Automotive fluid containers

PP spare parts
LUVOSINT TPU is used in 3D printed AIRSKIN® safety technology
Summary LEHVOSS 3D Printing Materials

- Tailored polymers to 3D Printing for different processes
  - Improved layer bonding
  - Enhanced printability (warping control, increased speed)

- Broad material choice (high-performance, composites)

- Functional Materials (e.g. ESD, thermally and electrically conductive; tribological modified)

- Excellent mechanical performance

- Proven track record in serial applications

- Offering our experience and full project support
Any recommendations made for use of Seller's materials are made to the best of Seller's knowledge and are based upon prior tests and experience of the Seller believed to be reliable; however, Seller does not guarantee the results to be obtained and all such recommendations are non-binding – also with regard to the protection of third party's rights –, do not constitute any representation and do not affect in any way Buyer's obligation to examine and/or test the Seller's goods with regard to their suitability for his Buyer's purposes. No information given by the Seller is to be construed in any way as a guarantee regarding characteristics or duration of use, unless such information has been explicitly given as a guarantee.

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