High performance composite and polymer solutions for green, new mobility

Michael Rockel, Head of Greater China Sales & Marketing
LANXESS High Performance Materials Business Unit
Chengdu, September 13
LANXESS – a global specialty chemicals group

Specialty chemicals company
- Spin-off from Bayer in 2004
- Specialty chemicals portfolio: chemical intermediates, specialty chemicals and plastics

Global success story
- 74 sites worldwide
- Approximately 19,200 employees in 25 countries
- Global sales of EUR ~9.7 billion in 2017

Strategy of profitability and resilience
- Strengthening of leading position in medium-sized markets
- Consolidation in Europe, expansion in USA and Asia
China is one crucial cornerstone of LANXESS global business

- **17** subsidiaries (including 3 joint ventures)
- **5** offices
- **9** R&D Centers
- **9** production sites
- **Around 1,900** employees
- LANXESS’ continuous investment in China demonstrates its firm confidence in the Chinese market and the long-term commitment
High Performance Materials at a glance – Leading supplier of engineering plastics

Key figures
- Sites: 3 in APAC, 2 in China
- Employees: ~1,600
- Customers: ~600

Brands
- Durethan®
- Pocan®
- Tepex®
- PA 6, PA6,6
- PBT
- Composite

Applications

Markets & growth drivers
- Market position: Among global top 5
- Key industries: Automotive, electric/electronics

Global Presence
- Global compounding network
- Backward integrated supply
- Product and application development
High Performance Materials – innovation building blocks

Automotive

Lightweight Technologies
Under the Hood
Alternative Powertrain

Electric/Electronic

Industrial E/E
LED & Lighting

Exterior
Interior
Automotive E/E
Consumer Electronics
Household Appliances

Pictures: LANXESS, BMW, Daimler, Intercontec, Vorwerk
HPM is a core business of LANXESS

HPM China

- 4 offices (Shanghai, Guangzhou, Beijing and APAC HQ in Hong Kong) & 4 home office locations (Tianjin, Baoding, Shenzhen, Suzhou)
- 1+1 production sites 60KT + 25KT (Q2 2019)
- 1 R&D Center in Wuxi
- 1 CAE Development and Part Testing
- Around 180 employees
- LANXESS’ continuous investment in China demonstrates its firm confidence in the Chinese market and the long-term commitment

New project in Changzhou
Phase 1: One line, 25KT
Investment: USD 25 mio
Master plan: 130KT
Startup: Q2 2019
LANXESS e-mobility scenario
Global view

Key takeaways

- Worldwide increased development of electrified powertrains to fit CO₂ targets after 2023
- MHEV as immediate action with lowest costs for slight CO₂ reduction
- Long-term focus on BEV and PHEV
- Still 83% of powertrains with ICE in 2035, but 90% electrified
- China being the leading driver of electric mobility
Challenges for e-Mobility

- Freedom of design
- Weight reduction
- Cost reduction
- Safety
- Recyclability
- Integration of functions
- Complex combinations of requirements
- electromagnetic shielding
- thermal conduction
- contact corrosion
- stiffness/strength
- tightness
- flame retardancy
- chemical resistance
- electrical properties
- …

[Source: BOSCH, Kostal, Eberspächer]
Material and technology development for e-mobility

- Lightweight applications
- Flame retardancy
- Thermal conductivity
- Electromagnetic shielding
Lightweight technology toolbox LANXESS

Motivation

- Weight has significant influence on design of power train, brake system, body…
- Weight has significant influence on energy consumption
- Energy consumption influences the design and the costs for the battery system
- Consequent lightweight design has big potential for weight saving and cost reduction (less costs for battery invest – kWh)

LANXESS Lightweight technology toolbox

Increasing requirements on stiffness (e.g. NVH)

- Plastic Metall Hybrid plus BKV30/BKV60
- High pressure forming-PMH BKV60
- Full plastic BKV60
- TEPEX® hybrid PA GF

Increasing requirements on strength (e.g. crash)

Die cast Al hybrid plus BKV60

Plastics and composites – the key for electric mobility
Technology and material solutions for lightweight design

**High modulus grades**
- High stiffness, glass fiber content up to 60%
- Conventional injection molding process
- Low wall thickness possible because of excellent flowability
- First frontend entirely made of polyamide (w/o metal inserts)

**Plastic metal hybrid**
- Best of both worlds: plastic stiffening (ribs) allows for lower metal sheet wall thickness
- Freedom of design, small tolerances, consistently high reproducible quality
- Functional integration (clips, fasteners etc.)
- Advanced hybrid technology with adhesive bond for even better performance

**Thermoplastic composites**
- Continuous fiber with thermoplastic matrix – tailored to customer application
- Very high strength and energy absorption, high stiffness
- Functional integration by combination with injection molding process
- Short cycle times (~ 1 min), mass production
- No corrosion, simple recycling
Material solutions for lightweight design
Durethan® EasyFlow and XtremeFlow grades

Progression of key properties

Increased Flowability
High modulus materials + increased flowability (only XF)

Ideal for lightweight applications

Polyamide compounds with increased flowability

- Longer flow path
- Reduced cycle time
- Less energy consumption
- Reduced costs
- Enhanced surface quality

Highly reinforced polyamide compounds

- GF and/or CF loading
- Up to 60% GF results in high stiffness (modulus) and strength
- Various heat stabilizations available
Selection of serial/development applications in the alternative powertrain – Battery system

**Battery housing: Impact Protection**
- Durethan® BKV60H2.0EF DUS060 (PA 6 GF60)
- Weight reduction/ metal substitution
- Function is guaranteed in contact with electrolyte
- High mechanical strength (Pole Crush Test)

**Battery housing: Component**
- Durethan® BKV30FN04 DUSLHC (PA 6 GF30 FR)
- Mechanical forces & creeping due to cell breathing
- High risk of contact corrosion: Low halide content
- V-0, halogen-free, CTI 600

**Cell module: Support structure**
- Durethan® BKV45FN04 (PA 6 GF45 FR)
- Non-halogen FR system (UL94 V-0 at 0.4 mm)
- Low warpage and high dimensional stability to assure assembly
Material and technology development for e-mobility

- Lightweight applications
- Flame retardancy
- Thermal conductivity
- Electromagnetic shielding
Fire protection in plastics – Increasing need for flame retardant polymers is expected

**Challenge**

- E-Mobility requires more electric parts
- Higher voltage (up to 800 V)
- Increasing fire safety requirements in electrical engineering, electronics and transportation sector
- Eco-toxicological properties gain importance

**Reasons for fires in cars**

- Leakage
- E+E
- Ignition
- Exhaust system
- Aggregate system
- Ignition of insulation
- Fires caused by accident
- Unexplained

**Increasing FR requirements in vehicles**

[Source: SV-Büro Lang, presented at SKZ Kongress „Fuse box meets dryer“]
Main market segments for flame-retardant thermoplastics, today – and tomorrow?

Adaption of E/E standards to e-mobility

- E/E: Main fire safety standards have major influence on the grade selection
  - Main standards are:
    - UL94V
    - IEC 60695 (GWFI, GWIT)
  - With the upcoming trend of E-mobility, fire safety standards are under discussion (e.g. UL-2580 Battery system)

**GWIT/GWFI** | **UL 94 V** | **FMVSS***
---|---|---
* FMVSS: federal motor vehicle safety standards
LANXESS portfolio has dedicated answers to increasing need for flame retardant polymers

**Challenge**
Increasing demand for FR properties

- Increasing fire safety requirements in electrical engineering, electronics and transportation sector
- Eco-toxicological properties gain importance
- Compatibility of flame retardant system and polymer matrix to maintain mechanical properties and processing

**Solution**
Wide FR product portfolio for nearly every need

- Powerful product portfolio using effective state-of-the-art FR systems (halogen-free and halogen containing) with no red phosphorous
- Tailored solutions for diversity of applications
- Listing at international bodies, like UL, VDE etc. on top of RoHS conformity

<table>
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<tr>
<th></th>
<th>Halogen</th>
<th>Non-halogen</th>
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<tr>
<td><strong>Durethan</strong></td>
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# Selection of serial applications with FR materials in the alternative powertrain

## Connectors and cable brackets
- Durethan® BKV20FN01 (PA 6 GF20 FR)
- Non-halogen FR system (UL94 V-0 at 0.75 mm)
- High toughness and surface quality
- Chemical resistance according to LV124

## Housing Battery Management System
- Pocan® AF4130 (PBT+ASA GF30 FR)
- UL94 V-0 at 0.75 mm (halogen containing)
- Low warpage
- Good mechanical properties (Snap Fits)

## High-voltage connectors
- Durethan® BKV45FN04 (PA 6 GF45 FR)
- Non-halogen FR system (UL94 V-0 at 0.4 mm)
- High mechanical performance (15900 MPa)
- Improved long-term heat stability and flowability

[Sources: VW, Hella, Kostal]
Materials and technology development for e-mobility

- Lightweight applications
- Flame retardancy
- Thermal conductivity
- Electromagnetic shielding
Thermally conductive and electrically insulating polyamides

**Motivation**

- Higher demand & increasing density in electronics: Increasing use of thermally conducting plastics ~0.8-1.5 W/mK sufficient

- Restricted performance of electrical devices by low heat release in case of temperature sensitive components, e.g. battery cells

- Substitution of metals by thermally conductive plastics enable freedom of design and higher productivity

[Source: BMW, Bosch]
Basic principles of thermally conductive plastics

Property dependence of the filling degree

- Thermal conductivity
- Stiffness
- Electrical conductivity
- Strength
- Strain

Target area for thermally conductive plastics
Thermally conductive Durethan grades

Exemplary temperature reduction depending on thermal conductivity

Transient CFD analysis

Simulation of heat transmission

Standard plastics

Durethan BTC
Thermally conductive and electrically insulating polyamides – LANXESS product portfolio

**Product description**
- BTC65H3.0EF (PA 6 MD65)
- BTC75H3.0EF (PA 6 MD75)
- Injection molding
- Thermal conductivity (through-plane) up to 1,0 and 1,4 W/mK, respectively

**Product description**
- TP723-620 (PA 6 MD68 FR)
- Thermal conductivity up to 2,5 W/mK (in-plane)
- UL94 V-0 at 0.75 mm
- Reflectivity > 90% (at 450 nm)
- Copper- and halide-free heat stabilization (to avoid contact corrosion

**Thermal conductivity**

<table>
<thead>
<tr>
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<th>BKV 30</th>
<th>BKV 60 EF</th>
<th>BTC6 5 H3.0 EF</th>
<th>BTC7 5 H3.0 EF</th>
<th>TP723-620</th>
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<tbody>
<tr>
<td></td>
<td>PA 6 GF30</td>
<td>PA 6 GF60</td>
<td>PA 6 MD65</td>
<td>PA 6 MD75</td>
<td>PA 6 MD68 FR</td>
</tr>
</tbody>
</table>

**Almost isotropic thermal conductivity**

- 1,4 W/mK
- 1,7 W/mK

- Fast heat dissipation in all directions

2) Durethan® BTC75H3.0EF, special machine and tool protection required

**Housing cross section**
### Selection of serial applications with FR materials in the alternative powertrain

<table>
<thead>
<tr>
<th>Air Blower Component</th>
<th>Passive cooling element in HV-connector</th>
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</thead>
</table>
| ▪ Durethan® BTC75H3.0EF, PA 6 with 75 % special mineral filler  
  ▪ Improved thermal conductivity enables temperature reduction at electronic device by 8 °C / prevents overheating  
  ▪ Operating temperature: -40 °C to 80 °C, peak temperature: 120 °C  
  ▪ Improved flowability  
  ▪ Halide free formulation prevents contact corrosion | ▪ Durethan® TP723-620, PA 6 with 68 % mineral filler  
  ▪ Passive cooling element in direct contact with high voltage  
  ▪ Electrically insulating  
  ▪ Thermal conductivity >1 W/mK  
  ▪ Thin walls  
  ▪ Fire protection, classification V-0 |

[Sources: VW, Hella, Kostal]
Material and technology development for e-mobility

- Lightweight applications
- Flame retardancy
- Thermal conductivity
- Electromagnetic shielding
Drivers and trends:
- Increasing miniaturization, use of digital assemblies
- Growing amount of sensitive electronic components

Requirements:
- Restrict electromagnetic interferences (EMI) to protect electronic devices
- Main applications for EMI
  - Battery system
  - Power electronics
  - E/E components

Duplication of EMI level every 3 years

EMI in the near- as well as far-field range

1 Estimation of Schaffner EMV AG
Tepex® bridges the gap between high end composites and cost-effective production for high volume applications

**Advantages**
- Tailored fibre orientation
- High stiffness and strength
- Reliable processing enabled by fully automated manufacturing process of Tepex® sheets and parts manufacturing
- Combination with injection moulding
- Short part production cycle times (< 60 sec.)
- Recycling
- Unlimited shelf-life

**Price-Performance Ratio**

Costs

Performance

- High-end Composites
- Long fibre reinforced plastics
- Short fibre reinforced plastics
- Unreinforced plastics

**Cost effective thermoplastic composite solution for mass production**
What is so special about Tepex®?

Plain, semi-finished product (sheet) based on a thermoplastic polymer (matrix)

Reinforcement is a fabric or any kind of other continuous fiber made of glass, carbon (or aramid)

Material is fully impregnated and consolidated, i.e.:
- the fibers are completely coated with the polymer
- there is no remaining air inside the material

This is the difficult and important bit!

Advantages

- Short cycle time (<60s)
- Highly reproducible process
- High functional integration possible

- Recycling easily possible
- No storage issue
- parts without post-processing after moulding
Innovations in the field of alternative powertrain
Electromagnetic shielding with plastic materials

Potential solutions

- **Compounds**
  (carbon fibers, metal coated CF, CNT, steel or metal fibers, aluminum flakes)

- **Coatings**
  (thermoplastic resin containing graphite or metals, galvanization, PVD, flame spraying)

- **Continuous fiber reinforced thermoplastics** with EMS layer

- **Advanced processing**:
  - In-Mold-Decoration (IMD)
  - In-Mold-Labelling (IMD)
  - Insert-Molding (IM)

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Innovative LANXESS material

ASTM D 4935 (TEM cell measurement)

- **low frequency range (10 - 30 MHz)**
- **high frequency range (30 - 1000 MHz)**

<table>
<thead>
<tr>
<th>Material</th>
<th>Average Shielding Effectiveness [dB]</th>
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<tbody>
<tr>
<td>PA6 GF30 (unmodified)</td>
<td>-100,00</td>
</tr>
<tr>
<td>PA6 GF30 + metal coating</td>
<td>-80,00</td>
</tr>
<tr>
<td>PA6 GF30 conductive modified</td>
<td>-60,00</td>
</tr>
<tr>
<td>Tepex modification</td>
<td>-40,00</td>
</tr>
<tr>
<td>CF reinforced PA 6, no coating process</td>
<td>-20,00</td>
</tr>
<tr>
<td>Advanced composite, e.g. for power electronics and battery housing</td>
<td>0,00</td>
</tr>
</tbody>
</table>
Technology development projects – TEPEX® with electromagnetic shielding properties

Melting polymer and cooling it down under pressure

Polymer
Textile (and EMS layer) *

Impregnation + Consolidation

Cutting + Packaging

*EMS layer: Metal mesh (Cu, steel), metal film (Al, Cu, MuMetal), carbon fleece or shielding fleece
Integration of composite sheet into the injection molding process

- Handling
- Heating
- Forming
- Injection
- Cooling
- Removal

Overmolding

Mold temperature

Tepex temperature

Time

Temperature
Potential and short to mid term very promising applications for thermoplastic composites in Automotive

Interior
Airbag housing
(Electronics) Carrier
Seat pan/structure
Door module
Pedal box

Car body/mounted parts
Trunk well
Frontend
Spare wheel well

Many projects in development, Several mass productions targeted, ranging between 5000-300,000 pieces/a
LANXESS innovative solutions for alternative powertrains

Electrified vehicles implicate novel applications with complex requirements

Experience from thermoplastics in E/E and automotive industry applications can be transferred to automotive NEV products

Solutions already available e.g. for FR, TC…
Investigations done: E.g. resistance against electrolyte, EMS

Already applications for e-powertrain in the market
Please contact us at:
Polymers@lanxess.com