SESSION 8 « ADVANCED MATERIALS AND NANOTECHNOLOGIES AS KEY ENABLERS FOR SMART PLASTICS AND COMPOSITES »

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IPC, established December 1\textsuperscript{st} 2015, is the French Technical Centre for Innovation and Expertise in support of Industry.

Opened to industrials, IPC takes part in the setup of partnerships and helps to create synergies between actors of the plastics and composites branches.

OUR OBJECTIVES
Improving the competitiveness of the industry through innovation
Giving access to latest technological means for industrials.
INNOVATION PLASTURGIE COMPOSITES

IPC is established in four sites in France: Oyonnax, Chambéry, Laval and Alençon
120 employees (researchers, engineers, technicians): multi-competencies teams

Market share

- 22% VARIOUS
- 25% AUTOMOTIVE
- 25% AEROSPACE DEFENSE
- 15% MEDICAL
- 8% PACKAGING

Annual sales

<table>
<thead>
<tr>
<th>Year</th>
<th>Sales</th>
</tr>
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<tbody>
<tr>
<td>2010</td>
<td>5.9M €</td>
</tr>
<tr>
<td>2011</td>
<td>6.3M €</td>
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<tr>
<td>2012</td>
<td>6.7M €</td>
</tr>
<tr>
<td>2013</td>
<td>8.2M €</td>
</tr>
<tr>
<td>2014</td>
<td>8.2M €</td>
</tr>
<tr>
<td>2015</td>
<td>9M €</td>
</tr>
<tr>
<td>2016</td>
<td>10M €</td>
</tr>
<tr>
<td>2017</td>
<td>12M €</td>
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</tbody>
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Collective actions setting-up

Services for companies

- 40%

Research & Development

(private R&D or collaborative projects)

- 60%

Our certifications

- CIR Agréé Crédit Impôt Recherche (CIR)
- SGS Certifié ISO 9001 v2008
- COFRAC ISO 17025
- Gulfstream
Market needs for advanced functionalities

- Optical properties
- Touch feel
- Traceability
- Integration of functions

- Lightweight
- Structure health monitoring
- Active aerodynamics
- Interface – sensors integration

Applications and target markets

- Consumer goods
- Buildings and Infrastructures
- Medical and Health
- Energy
- Packaging

- Smart windows
- Lightweight and smart structures

- Prostheses
- Antimicrobial systems
- Medicine packaging
- Multifunctional

- Solar
- $\text{H}_2$ Storage/ Fuel cell
- Batteries packaging
- Wind
- Interfaces

- Lightweight packaging
- Smart packaging
- Actives and antimicrobial packaging
- Biobased packaging
Limitations of state-of-the-art solutions for surface functionalisation

Coating solutions:

- Expensive
- Low durability
- Adhesion to the substrate
- Homogeneity of the nanodispersion
- Low recyclability of the functionalised products
- Harmful for human health and environment

=> development of **coating-free manufacturing technologies** for the production of highly functional polymer surfaces
A SMART COMBINATION OF THREE KETS
A smart combination of three KETs

For the replication of specially designed micron and sub-micron surface topographies:

- Antimicrobial
- Anti-scratch
- Self-cleaning
- Anti-squeak
- Anti-counterfeiting
- Aesthetic properties

Nanotechnology
(micro-/nano-structuring of surfaces)

Advanced manufacturing technologies
(advanced injection moulding)

Advanced materials
(ultra hard, very low friction tooling)
Nanotechnologies for the structuration of mould cavities

✪ Top-down VS bottom-up approaches
  - Top-down processes: micro-milling, micro-EDM, laser machining, etc.
  - Bottom-up processes: self-assembly of micro/nano-particles, UV-LIGA, etc.

✪ Multi-level structuration

✪ Bottleneck: mould and process integration
Advanced materials for tool-making

Different materials studied:
- Silicon
- Nickel
- Stainless steel

Same material for microstructured mould cavity and mould
- easier integration
- no CTE mismatch

Bottleneck: reliable replication of the micro-/nano-structures
Advanced manufacturing technologies

Heat & Cool technologies

Ceramic heater
- Advantages
  - Heat AND cool
  - Flexibility
- Drawbacks
  - Design of the mould
  - Ceramic brittleness

Induction
- Advantages
  - Very high heating rate
- Drawbacks
  - Design of the mould
  - Safety

High pressurized water
- Advantages
  - Easy set up
  - May be a curative solution
- Drawbacks
  - 180°C maximum
  - Requires well designed channels
Mould design with optimized thermal management

- Rapid heating and cooling technology
- Cooling channels design optimized by simulation
- Selective Laser Melting (SLM) technology
Advanced manufacturing technologies

- Ultrasonic assisted demoulding technology in order to reduce the distortion of micron and nano-structures on polymer parts surfaces during demoulding
  - 3D analysis by confocal microscopy
  - Damages limited to outer area of the watchglass
  - Influence of the angle between micro/nano-structure and demoulding direction
IMPRESS: a pilot line gathering these 3 KETs for micro-/nano-textured plastic parts

The IMPRESS platform:

- Injection moulding machine equipped with an expert system
- Required peripheral equipment:
  - Rapid heating and cooling: high pressurized water
  - CO₂ cleaning technology
  - 6-axis robot to handle the part and the CO₂ spray
  - Optical control
Microfluidic diagnostic chip

Micro-channels with anti- « coffee-ring » effect

Pillar: Diameter = 300 µm – Height = 100 µm – Hemispherical microstructures: Ø 30 µm
Aesthetic consumer goods

Decorative watch glass

Height = 25 µm – Diameter = 50 µm
Hydrophobic biomedical device

Anti-cell adhesive culture dish

Without nanostructures: \( \alpha = 94^\circ \)

With nanostructures: \( \alpha = 130^\circ \)

Height = 500 to 2 000 nm – Diameter = 200 to 1 000 nm
FURTHER RESEARCH TOPIC
A fourth KET to develop the next European lightweight materials innovation

- **Nanotechnology**
  - (micro-/nano-structuring of surfaces)

- **Advanced manufacturing technologies**
  - (advanced injection moulding)

- **Advanced materials**
  - (ultra hard, very low friction tooling)

- **Micro and nano-electronics**
  - (smart composites)

- Improved performance to meet a wide range of requirements for advanced composites in various applications:
  - Automotive
  - Aerospace
  - Construction
  - Etc.
A fourth KET to develop the next European lightweight materials innovation

- Lightweight
- Mechanical strength
- Micro- and nanostructured surfaces for advanced functions (e.g. self-cleaning, anti-microbial), aesthetics, sensing effects (haptic, optical ...)
- Smart textiles and fibres for self-responsive properties (self-healing, self-deicing ...)
- Interactivity with users through integration of printed electronics
HYPROD²: a pilot line gathering these 4 KETs for micro-/nano-textured smart composites

The HYPROD² platform:

1. REINFORCEMENT PREPARATION
2. COMPONENT MOUNTING ON SMART TEXTILE
3. PRINTED ELECTRONICS
4. IMPREGNATION SMART PREG
5. MULTI-LAYER ASSEMBLY
6. SMART & HYBRID PARTS MANUFACTURING
7. TAPE PLACEMENT PRE-PROCESSING
   POST-PROCESSING

Semi-product & preform
Moulding
IPC a competence centre in an Open Innovation Hub for tomorrow’s micro-/nano-textured plastics and composites

획 A “one-stop-shop” for:

- Design
- Materials and processes developments
- Prototyping and small/medium series production
- Industrial transfer
- Trainings for students and industrials
THANKS FOR YOUR ATTENTION !