Do it right, do it light!

Ultracom™ – thermoplastic composite system

Ultracom™ in the web:
www.plasticsportal.eu/ultracom

BASF
The Chemical Company
Do it right, do it light!

Thermoplastic composite system: Ultracom™

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BASF is expanding its activities in the field of engineering plastics with a new approach: It is called Ultracom™ and comprises a system consisting of three elements:

**Continuous fiber-reinforced semi-finished products – new portfolio**

The Ultracom™ system is based on the following semi-finished products:
- Ultralaminate™: laminates made of woven glass fiber fabrics, impregnated with Ultramid®, the polyamide (PA) from BASF
- Ultratape™: unidirectional, reinforced glass or carbon fiber tapes, impregnated with Ultramid®

**Overmolding materials – tailor-made plastics**

Essential elements of the Ultracom™ system are the overmolding materials from the Ultramid® range that have been individually matched to the semi-finished products. With these compounds, complex parts can be injection molded. These show a very high mechanical reinforcement with continuous fibers at precisely defined points and can incorporate specific functions because of the overmolding.

**Engineering support – essential element**

The Ultracom™ engineering support is of great importance to part developers of composite components. It covers an extensive range of services offered by the BASF application development. This includes
- support for part designs using BASF’s universal simulation tool Ultrasim®
- know-how in material processing and manufacturing of parts. This includes an injection molding pilot plant for near-large scale production and an automated laminate feeding as well as a sophisticated test part.
- the numerous possibilities of the BASF parts testing laboratory which specializes in fiber composites.
Ultracom™ – thermoplastic composite system

Ultracom™ is an integrated system which, in addition to the semi-finished products and the injection-molding compounds, also includes the development. This ranges from concept phase and design, via simulation and processing through to parts testing in order to enable efficient volume production at the customer (Fig. 1). With Ultracom® automotive structural parts can be designed with optimized cost and weight.
Ultracom™

Semi-finished product (composites)

Overmolding material (compounds)

Engineering service

Ultralaminate™
Ultratape™

Ultramid® COM

Ultrasim® + processing + parts testing

Fig. 1: Ultracom™ - the product and service system for continuous fiber-reinforced composites
Semi-finished products and injection molding compounds – a matched combination

The requirement on the material side for parts with optimized costs and weight is a matching material system: the tape or laminate and the overmolding compound must form an ideal combination and match each other in the part.

Overmolding materials must satisfy the typical requirements for injection molding while simultaneously allowing optimum bonding of ribs and fixing elements to the laminates or tapes.
Thermoplastic laminate
- Thermoplastic-impregnated fiber fabrics
- Better for quasi-isotropically loaded parts with large surfaces

Thermoplastic, unidirectional (UD) tapes
- Layered arrangements from fully impregnated fiber tapes
- Local reinforcement of injection molded parts along defined load paths

Overmolding compound based on polyamide

Fig. 2: Fibers, laminate, tape and overmolding compound – Ultracom™ as a matched material system
Thermoplastic laminates are fiber fabrics impregnated with thermoplastics. They only have to be cut to size and can then be used directly. Unidirectionally reinforced tapes are also impregnated with a thermoplastic matrix system. However, they must first be assembled and consolidated to create laminates suited for the application. The two continuous fiber-reinforced semi-finished products have different functions in parts: thermoplastic laminates are better suited to quasi-isotropically loaded hybrid parts with a large surface, while tape inserts are more suitable for the local reinforcement of injection-molded short glass fiber-reinforced parts. Figure 3 shows a typical application for a seat backrest.

Fig. 3: Schematic view of a seat backrest: The unidirectionally loaded edge areas which are marked in blue are given a tape reinforcement, whereas zones in the backrest area (red) which are subject to two-dimensional loading are better reinforced with laminates.
The available range for semi-finished products consists of Ultralaminate™ with glass fiber reinforcement (PA 6-based) and Ultratape™ with glass and carbon fiber reinforcement for unidirectionally loaded reinforcement structures. For applications with high demands on the stiffness, Ultramid® B3WG12 COM with 60% glass fiber reinforcement is particularly suitable as the overmolding compound. Where special demands are made on the impact strength of the part, Ultramid® B3ZG7 COM is used which is optimized for high energy absorption.

Possible material combinations are shown in Table 1. An overview of the current product range of semi-finished products and overmolding plastics is given in Table 2.

<table>
<thead>
<tr>
<th>Material combinations</th>
<th>Compound</th>
<th>and/or</th>
<th>and/or</th>
</tr>
</thead>
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<tr>
<td>High stiffness parts</td>
<td>Ultramid® B3WG12 COM</td>
<td>Ultralaminate™ B3WG13 WR01</td>
<td>Ultratape™ B3WG12 UD01</td>
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<tr>
<td>Impact requirements</td>
<td>Ultramid® B3ZG7 COM</td>
<td>Ultralaminate™ B3ZG10 WR02</td>
<td>Ultratape™ B3WC12 UD02</td>
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</tbody>
</table>

Table 1: Material combinations of semi-finished product and compound
<table>
<thead>
<tr>
<th>Tensile test (DIN EN ISO 527-4)</th>
<th>Ultralaminate™ B3WG13 WR01</th>
<th>Ultratape™ B3WG12 UD01</th>
<th>Ultratape™ B3WC12 UD02</th>
<th>Ultramid® B3WG12 COM</th>
<th>Ultramid® B3ZG7 COM</th>
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<td></td>
<td>Fabric twill 2/2 balanced, 600g/m²</td>
<td>GF UD</td>
<td>CF UD</td>
<td>PA6 GF60</td>
<td>PA6 GF35 impact modified</td>
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<td>E-modulus [GPa]</td>
<td>22</td>
<td>33</td>
<td>102</td>
<td>20</td>
<td>9.3</td>
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<tr>
<td>Tensile strength max. [MPa]</td>
<td>450</td>
<td>770</td>
<td>1,800</td>
<td>250</td>
<td>145</td>
</tr>
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</table>

Table 2: Ultracom™ range – semi-finished products and compounds
Comprehensive engineering service
Ultrasim®, processing know-how and testing expertise

Part design with Ultrasim®

Fig. 4: Ultracom™ engineering service: Ultrasim®, processing, parts testing
The ideal teamwork between application development, simulation, processing technology and a testing laboratory under one roof makes it possible to support the customer across the entire process chain: from determining the material characteristics right through to the serial production of parts. In this way, parts can be very efficiently developed together.
With the simulation tool Ultrasim® the behavior of parts made of thermoplastic laminates with woven glass fiber fabrics or tapes and polyamide over-molding compound can be calculated and reliably predicted through Integrative Simulation. The expansion of the Integrative Simulation to new material models and the underlying experimental results make thermoplastic composite parts based on laminates or tapes available for large-scale production (Fig. 5).

BASF’s Integrative Simulation also integrates the production process of the plastic part into the calculation of its mechanical performance. Building on a rheological FE simulation of the injection-molding process and a 3D draping simulation for the continuous fiber-reinforced laminate, the anisotropic fiber orientations at each point of the part are transferred to the corresponding areas in the mechanical part. For the areas which are reinforced with continuous fibers, a new, expanded numerical description of the material is used in Ultrasim®.

In the mechanical analysis, this description takes into account precisely the properties that are typical of the reinforced, thermoplastic materials:

- anisotropy
- non-linearity
- dependence on strain rate
- tension-compression asymmetry
- dependence on temperature
- different failure types and criteria

Ultrasim® supports the most important finite-element programs used in part development.

Just as important as the exact description of the material behavior at each point is the design of the component, i.e. the right selection and placement of the reinforcing fibers and the semi-finished product.
> New, expanded numerical description
> Correct selection/placement of reinforcing fibers and semi-finished product

Fig. 5: Design with Ultrasim® – filling simulation (left), draping simulation (right)
At its technical center for thermoplastics processing in Ludwigshafen, BASF operates a high-capacity production system which can be used to manufacture multifunctional composite test specimens with the in-mold forming/overmolding process (Fig. 6). The forming of the laminate (draping or also in-mold forming) takes place in the mold, followed by the overmolding. The process sequence for the automated manufacturing cell is parallelized so that the cycle time of around one minute is comparable to cycles achieved with standard injection molding.

This means that an essential requirement for the use of the process on a large scale is met. The laminate is heated up outside of the mold. This makes it necessary that the heated-up laminate inserts, which are rigid no longer, are safely transported and exactly positioned in the mold. For the positioning of the laminate, three clamping frames are used simultaneously in the manufacturing cell.
Heating station
Clamping frame with inserted laminate
Six-axis robot
Injection molding machine
Magazine for laminates
Automatic insertion of laminate into the clamping frame

Fig. 6: BASF manufacturing cell for in-mold forming and overmolding
With the Ultracom™ Demonstrator Part, a newly developed BASF test part, design possibilities as well as the characteristic features and possible challenges in manufacturing can be illustrated. On this test specimen, which measures around 40 cm x 40 cm and has about 20 individual functions, it is possible to replicate the particular features of actual composite manufacturing, e.g. long flow paths to fill the edge (Fig. 7). The test parts are produced without any post-processing, which means the laminates are completely overmolded.
A wide range of test facilities and their BASF experts are available for the validation of the part properties as well as for the experimental investigation of test specimens, samples and new composite parts. In addition to the standardized testing options such as testing with tensile, compressive, flexural or torsional loads, also test methods adapted to specific questions are being used. These include, for instance, investigating specific composite properties such as toughness with an adapted setup for thermoplastic composites, determining the mechanical properties as a function of the strain rate, and evaluating micro-mechanical phenomena, e.g. with acoustic emission tests for analyzing the initial material damages. Generally, all these tests can be executed under defined climatic conditions (temperature, moisture, storage in media etc.).

BASF also has expertise in the field of non-destructive testing methods. This involves, for example, the ultrasonic technique and computer tomography (CT). Like no other technology the CT can give a detailed insight into the internal structures and properties of material samples, parts and joinings.

Fig. 8: On the left can be seen a test specimen for characterizing the composition of laminate and overmolding compound; on the right is the associated CT image in which the fiber profile and the contact surface can clearly be seen.
Ultracom™ for parts in body and chassis

With continuous fiber-reinforced thermoplastic composite parts, the best possible combination of weight savings, cost efficiency and performance can be achieved for body and chassis.
Note

The data contained in this publication are based on our current knowledge and experience. In view of the many factors that may affect processing and application of our product, these data do not relieve processors from carrying out own investigations and tests; neither do these data imply any guarantee of certain properties, nor the suitability of the product for a specific purpose. Any descriptions, drawings, photographs, data, proportions, weights etc. given herein may change without prior information and do not constitute the agreed contractual quality of the product. It is the responsibility of the recipient of our products to ensure that any proprietary rights and existing laws and legislation are observed. (September 2013)