Composites - Definition

Multi component, multiphase, inhomogeneous materials consisting of high strength, high modulus reinforcement phase, and tough but stiff matrix phase. Strong adhesion between these two, which remains reliable even at high strains and stresses is essential.
Composites - Structure

• Lamina, ply, layer

• Laminate
• Stacking/lay-up sequence
Why fibres? High specific area

- \( l/d \) very high: fibre
- \( l/d \) very low: disc/platelet
- \( l \approx d \): sphere
Why fibres? Volume effect

(A. A. Griffith)

Tensile strength [GPa] vs. d [μm]
Composites- Fibre-matrix adhesion

\[ \frac{d}{\frac{L_c}{2}} \rightarrow F \]

\[ \sigma \rightarrow l \]

\[ \frac{L_c}{2} \]

\[ \frac{L_c}{2} \]
## Matrix properties summary

<table>
<thead>
<tr>
<th>Property</th>
<th>UP</th>
<th>EP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density [g/cm³]</td>
<td>1.25</td>
<td>1.2</td>
</tr>
<tr>
<td>Modulus [GPa]</td>
<td>2.5...3</td>
<td>3.3</td>
</tr>
<tr>
<td>Strength [Mpa]</td>
<td>65</td>
<td>80</td>
</tr>
<tr>
<td>T&lt;sub&gt;g&lt;/sub&gt; [°C]</td>
<td>120</td>
<td>200</td>
</tr>
<tr>
<td>Shrinkage [%]</td>
<td>2</td>
<td>0.3</td>
</tr>
</tbody>
</table>
Composite technology BMEGEPT AGE1

Reinforcement structures and fibre types

Support slides

Gergely Czél

Spring 2017
Roving
Random mat
Fabric
Polar diagram

Roving

Bi-directional, balanced fabric

Random mat
Glass fibres

Manufacturing: Melt fibre spinning
Carbon fibres

Manufacturing: Carbonisation from precursor

Oxidation 200-300°C

Nitrogen atm. 1000-1500°C

Nitrogen atm. 2000-3000°C
# Fibre properties summary

<table>
<thead>
<tr>
<th></th>
<th>Glass</th>
<th>Carbon</th>
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</thead>
<tbody>
<tr>
<td>Density [g/cm³]</td>
<td>2.4-2.6</td>
<td>1.8-2.1</td>
</tr>
<tr>
<td>Modulus [GPa]</td>
<td>72-100</td>
<td>230-800</td>
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<tr>
<td>Strength [GPa]</td>
<td>2.5-4.5</td>
<td>6-3.5</td>
</tr>
<tr>
<td>Elongation at break [%]</td>
<td>3-5</td>
<td>2.2-0.5</td>
</tr>
<tr>
<td>Max T [°C]</td>
<td>600</td>
<td>1000</td>
</tr>
</tbody>
</table>