Image: Design-Relevant Level Definitions for Structured Materials

Albert E. Patterson
Design perspective on structured material (SM) levels

<table>
<thead>
<tr>
<th>Sub-microstructure</th>
<th>Microstructure</th>
<th>Mesostructure</th>
<th>Macrostructure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural material structure on atomic, crystal, or molecular level</td>
<td>Structure observable using an optical microscope, heavily influential on macro-scale properties</td>
<td>Designed or patterned structure, may be generated by element layout or designed inclusions/defects/voids</td>
<td>In design, typically the “useful level”</td>
</tr>
<tr>
<td>May be influenced by processing conditions</td>
<td>Strongly influenced by processing conditions</td>
<td>Solid, homogeneous materials do not have a mesostructure</td>
<td>Generally the final component or product that is to be made from the designed material</td>
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<td><strong>Examples</strong>: Polymer chains, grain structure details in metals</td>
<td><strong>Examples</strong>: Porosity, metal grain layout, scan structure in 3-D printed materials</td>
<td><strong>Examples</strong>: Honeycomb structure, metamaterial, unit cell-based lattice</td>
<td>For homogeneous solid materials, microstructure drives macrostructure properties (no mesostructure)</td>
</tr>
</tbody>
</table>

**Source of Dominant Properties**

- **Natural material**
  - Structure on atomic, crystal, or molecular level
  - May be influenced by processing conditions
  - **Examples**: Polymer chains, grain structure details in metals

- **Microstructure**
  - Structure observable using an optical microscope, heavily influential on macro-scale properties
  - Strongly influenced by processing conditions
  - **Examples**: Porosity, metal grain layout, scan structure in 3-D printed materials

- **Mesostructure**
  - Designed or patterned structure, may be generated by element layout or designed inclusions/defects/voids
  - Solid, homogeneous materials do not have a mesostructure
  - **Examples**: Honeycomb structure, metamaterial, unit cell-based lattice

- **Macrostructure**
  - In design, typically the “useful level”
  - Generally the final component or product that is to be made from the designed material
  - For homogeneous solid materials, microstructure drives macrostructure properties (no mesostructure)


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