### Ormocer®s for micro-optical Applications

<table>
<thead>
<tr>
<th>Properties of the cured materials</th>
<th>Ormocomp</th>
<th>Ormocore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal stability</td>
<td>Weight loss &lt; 5 % up to 270 °C (5 K min⁻¹)</td>
<td></td>
</tr>
<tr>
<td>Thermal behaviour</td>
<td>Duromeric</td>
<td></td>
</tr>
<tr>
<td>Shrinkage (during curing)</td>
<td>5 - 7 % by volume</td>
<td>3 – 5 % by volume</td>
</tr>
<tr>
<td>CTE (20 - 100 °C)</td>
<td>60 ppm K⁻¹</td>
<td>100 - 130 ppm K⁻¹</td>
</tr>
<tr>
<td>Refractive index @ 635 nm</td>
<td>1.518</td>
<td>1.553</td>
</tr>
<tr>
<td></td>
<td>@ 800 nm</td>
<td>1.543</td>
</tr>
</tbody>
</table>

- **Optical transparency Ormocomp**
- **Ormocomp replicated 10x10 micro lens arrays**
- **Replicated sol-gel refractive microlenses on a VCSEL wafer substrate (Courtesy of Avalon)**
- **Optical grating (Courtesy of FU - Jena)**

### Ormocer®s for Innovative Technologies

**Ormostamp for transparent stamps manufacturing**
- Cost-efficient alternative to silica stamps
- Excellent fidelity to the master stamp
- Highly transparent to visible light down to 350 nm
- High resolution to sub-100 nm linewidth
- Convenient processing with standard lithography equipment
- Mechanically stable
- High thermal stability
- One-step or two-step fabrication possible

**Process flow UV moulding**

#### Transparent Stamp
- **Stamp**: Direct prototyping and micropatterning*
- **Main applications**:
  - **Moulded gratings**
  - **Micro lenses**
  - **Micro lens arrays**
  - **Optical couplers and connectors**
  - **Prisms**

#### Opaque Stamp
- **Stamp**: Direct prototyping and micropatterning*
- **Main applications**:
  - **Optical sensors and sensor systems**
  - **Displays**
  - **Optical measurement systems**
  - **Single elements or wafer scale**

**Main technology applications**
- Micro mechanics
- Micro sensors
- Micro fluidics

**Direct prototyping and micropatterning**
- Laser: 355 nm, 20 mW, 100 MHz
- Scanner: 100 mm focal distance, scanning area 50 x 50 mm
- Resolution: < 10 μm vertical 5 μm lateral
- Positioning with piezo actuators

**Principle Setup**

- **3D-layer by layer UV-direct prototyping**
- **Photonic crystals produced with 2-photon polymerisation**
- **Photonic crystals produced with 2-photon polymerisation**

* In collaboration with Laser Zentrum Hannover e. V. (Courtesy of Laser Zentrum Hannover e. V.)

**Microstructures replicated with a stamp made of Ormostamp:**

**mr-UVcur06 nanostructures imprinted with an Ormostamp mould**

**Micro item (chess tower) produced with 3D-layer by layer UV-direct prototyping**

**Windmill for fluidic media produced with 3D-layer by layer UV-direct prototyping**
### Ormocer®s for Planar Optical Wave Guides

<table>
<thead>
<tr>
<th>Properties of cured polymers</th>
<th>Ormocore</th>
<th>Ormoclad</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal stability</td>
<td>Weight loss &lt; 5 % up to 270 °C (5 K min⁻¹)</td>
<td></td>
</tr>
<tr>
<td>Film quality</td>
<td>Good planarisation properties</td>
<td></td>
</tr>
<tr>
<td>Water absorption</td>
<td>&lt; 0.5 %</td>
<td></td>
</tr>
<tr>
<td>CTE (20 - 100 °C)</td>
<td>100 - 130 ppm K⁻¹</td>
<td></td>
</tr>
<tr>
<td>Rms roughness</td>
<td>2 - 4 nm</td>
<td></td>
</tr>
<tr>
<td>Shrinkage (during curing)</td>
<td>2 - 5 % by volume</td>
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</tr>
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<td>Refractive index @ 635 nm</td>
<td>1.553</td>
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</tr>
</tbody>
</table>

### Ormocer®s (Hybrid Polymers) for Micro Optics

- Excellent transparency
- Excellent mechanical properties
- High chemical and physical stability
- Excellent pattern transfer fidelity
- Ready-to-use solutions
- Solvent-free

**Unique features of the Ormocomp, Ormocore, Ormoclad, Ormostamp, and materials for direct prototyping**

**Properties of cured polymers**

- UV-patternable (lithography/moulding)
- Exposure: i-line, broadband
- Tuneable refractive index (core/clad)
- Low optical loss at datacom wavelengths
- Thermally stable up to 270 °C
- 6 months shelf life

**Main applications**

- Single-mode wave guides
- Multi-mode wave guides
- Beam splitters
- Thermo-optical switches

**Refractive index tuning**

![Refractive Index Graph](image)

**Process flow for optical wave guides**

1. Coat Ormoclad, prebake
2. Flood exposure, PEB, remove of inhibition layer
3. Coat Ormocore, prebake
4. Waveguide patterning, PEB, development
5. Coat upper cladding, prebake, flood exposure
6. PEB, remove of inhibition layer, hard bake

**Ormocore** and **Ormoclad** photo-patternable inorganic-organic hybrid polymers

- Undercladding/core of a multimode waveguide on silicon (Courtesy of ACREO)
- Multilayer optical fan out (Courtesy of Fhg - IOF/Jena)