### Contents

#### 2.7.2 Photopolymerisation of Synthetic Polymers
for Biomimetic 3D Structures .......................... 53

#### 2.7.3 Photoactivation of Hydrogels .................. 54

#### 2.8 Conclusion ........................................... 55

#### References .............................................. 56

#### 3 Biomimetic Photonic Materials by Direct Laser Writing .... 67
Mark D. Turner, Gerd E. Schröder-Turk and Min Gu

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Introduction</td>
<td>67</td>
</tr>
<tr>
<td>3.2</td>
<td>Three-Dimensional Direct Laser Writing</td>
<td>70</td>
</tr>
<tr>
<td>3.3</td>
<td>Chiral Structures in Self-Assembly and Circular Dichroism in Biology</td>
<td>73</td>
</tr>
<tr>
<td>3.4</td>
<td>Direct Laser Writing of 3D Biomimetic Microstructures</td>
<td>73</td>
</tr>
<tr>
<td>3.5</td>
<td>Conclusion and Outlook</td>
<td>77</td>
</tr>
</tbody>
</table>

#### References .............................................. 78

#### 4 Selective Laser Sintering and Its Biomedical Applications .... 83
Bin Duan and Min Wang

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>Introduction to Rapid Prototyping Technologies</td>
<td>83</td>
</tr>
<tr>
<td>4.1.1</td>
<td>Stereolithography Apparatus</td>
<td>84</td>
</tr>
<tr>
<td>4.1.2</td>
<td>Two-Photon Polymerization</td>
<td>85</td>
</tr>
<tr>
<td>4.1.3</td>
<td>Fused Deposition Modeling</td>
<td>86</td>
</tr>
<tr>
<td>4.1.4</td>
<td>3D Plotting</td>
<td>86</td>
</tr>
<tr>
<td>4.1.5</td>
<td>3D Printing</td>
<td>87</td>
</tr>
<tr>
<td>4.1.6</td>
<td>Selective Laser Sintering</td>
<td>87</td>
</tr>
<tr>
<td>4.2</td>
<td>Selective Laser Sintering</td>
<td>88</td>
</tr>
<tr>
<td>4.2.1</td>
<td>Principle of Selective Laser Sintering and Modification of Commercial SLS Machines</td>
<td>88</td>
</tr>
<tr>
<td>4.2.2</td>
<td>Materials for SLS</td>
<td>91</td>
</tr>
<tr>
<td>4.2.3</td>
<td>SLS Parameters</td>
<td>93</td>
</tr>
<tr>
<td>4.2.4</td>
<td>Optimization of SLS Parameters</td>
<td>93</td>
</tr>
<tr>
<td>4.2.5</td>
<td>Applications of SLS in the General Manufacturing Industry</td>
<td>94</td>
</tr>
<tr>
<td>4.3</td>
<td>Biomedical Applications of SLS</td>
<td>95</td>
</tr>
<tr>
<td>4.3.1</td>
<td>Physical Models for Surgical Planning</td>
<td>95</td>
</tr>
<tr>
<td>4.3.2</td>
<td>Medical Device Prototypes</td>
<td>96</td>
</tr>
<tr>
<td>4.3.3</td>
<td>Medical Implants and Prostheses</td>
<td>96</td>
</tr>
<tr>
<td>4.3.4</td>
<td>Tissue Engineering Scaffolds</td>
<td>97</td>
</tr>
<tr>
<td>4.3.5</td>
<td>Drug or Biomolecule Delivery Systems</td>
<td>101</td>
</tr>
<tr>
<td>4.4</td>
<td>Summary</td>
<td>103</td>
</tr>
</tbody>
</table>

#### References .............................................. 104
5 Biomimetic Assemblies by Matrix-Assisted Pulsed Laser Evaporation
Felix Sima and Ion N. Mihailcescu
5.1 Introduction .......................................................... 111
5.2 Biomimetic Design-Mimicking Aspects of a Natural Organism. .............................................. 114
5.3 Scaffold Fabrication and Deposition Methods ................... 115
5.4 Basics of MAPLE. ...................................................... 119
5.4.1 Experimental Conditions and Mechanisms of MAPLE......................................................... 119
5.4.2 Reliability ............................................................ 124
5.5 MAPLE: From the Origin to Biomimetics .................... 125
5.5.1 Application to Organics. ........................................ 125
5.5.2 Application to Organic–Inorganic Composites ............. 130
5.5.3 Application to Inorganics ....................................... 132
5.6 Conclusion and Perspectives ....................................... 133
References ........................................................................ 133

6 Laser Additive Manufacturing of Metals ......................... 143
Claus Emmelmann, Jannis Kranz, Dirk Herzog and Eric Wycisk
6.1 Process Basics ........................................................... 143
6.2 Process Parameters ..................................................... 146
6.2.1 Building Chamber Dimensions ................... 146
6.2.2 Layer Thickness ...................................................... 146
6.2.3 Scan Speed ............................................................ 147
6.2.4 Laser Beam Power .................................................. 147
6.2.5 Exposure and Scan Strategy ................................... 148
6.2.6 Hatching .............................................................. 149
6.2.7 Available Metals and Alloys for LAM ..................... 149
6.3 Part Quality ............................................................... 150
6.3.1 Density ................................................................. 150
6.3.2 Strength ............................................................... 150
6.3.3 Hardness ............................................................ 151
6.3.4 Residual Stresses .................................................. 151
6.3.5 Accuracy Grade .................................................... 151
6.3.6 Subsurface Quality ............................................... 152
6.4 Designs for LAM ......................................................... 152
6.5 Future Development ................................................... 154
6.6 Biomimetic Application Areas of LAM ......................... 155
6.7 Summary and Conclusion .......................................... 160
References ........................................................................ 161
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.2.2</td>
<td>Laser-Based Methodologies for Biomimetic</td>
<td>215</td>
</tr>
<tr>
<td></td>
<td>Tissue Engineering</td>
<td></td>
</tr>
<tr>
<td>9.2.3</td>
<td>Laser Processing of Artificial Biomaterials</td>
<td>220</td>
</tr>
<tr>
<td>9.2.4</td>
<td>Laser Processing of Natural Biomaterials</td>
<td>227</td>
</tr>
<tr>
<td>9.3</td>
<td>Conclusions and Outlook</td>
<td>230</td>
</tr>
<tr>
<td>References</td>
<td></td>
<td>232</td>
</tr>
<tr>
<td>10</td>
<td>Laser Processing of Natural Biomaterials</td>
<td>237</td>
</tr>
<tr>
<td></td>
<td>Wande Zhang, Peter H. Chung, Aping Zhang</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shaochen Chen</td>
<td></td>
</tr>
<tr>
<td>10.1</td>
<td>Introduction</td>
<td>238</td>
</tr>
<tr>
<td>10.2</td>
<td>Natural Biomaterials</td>
<td>239</td>
</tr>
<tr>
<td>10.2.1</td>
<td>Collagen</td>
<td>239</td>
</tr>
<tr>
<td>10.2.2</td>
<td>Agarose</td>
<td>240</td>
</tr>
<tr>
<td>10.2.3</td>
<td>Hyaluronic Acid</td>
<td>240</td>
</tr>
<tr>
<td>10.2.4</td>
<td>Matrigel\textsuperscript{TM}</td>
<td>241</td>
</tr>
<tr>
<td>10.3</td>
<td>Laser Processing Methodologies for</td>
<td>241</td>
</tr>
<tr>
<td></td>
<td>Biomaterials</td>
<td></td>
</tr>
<tr>
<td>10.3.1</td>
<td>Laser Processing System Setup</td>
<td>241</td>
</tr>
<tr>
<td>10.3.2</td>
<td>Laser-Induced Cross-Linking</td>
<td>243</td>
</tr>
<tr>
<td>10.3.3</td>
<td>Laser Ablation</td>
<td>248</td>
</tr>
<tr>
<td>10.3.4</td>
<td>Laser Activation</td>
<td>252</td>
</tr>
<tr>
<td>10.4</td>
<td>Summary</td>
<td>253</td>
</tr>
<tr>
<td>References</td>
<td></td>
<td>254</td>
</tr>
<tr>
<td>11</td>
<td>Future Perspectives</td>
<td>259</td>
</tr>
<tr>
<td></td>
<td>Emmanuel Stratakis, Anthi Ranella and</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Costas Fotakis</td>
<td></td>
</tr>
<tr>
<td>11.1</td>
<td>Future Perspectives of Biomimetics and</td>
<td>260</td>
</tr>
<tr>
<td></td>
<td>Laser Technology</td>
<td></td>
</tr>
<tr>
<td>Index</td>
<td></td>
<td>263</td>
</tr>
</tbody>
</table>
Laser Technology in Biomimetics
Basics and Applications
Schmidt, V.; Belegratis, M.R. (Eds.)
2013, XXI, 267 p. 82 illus., 50 illus. in color., Hardcover
ISBN: 978-3-642-41340-7