Beating The Diffraction Limit

Johanna Ernst
Professor Angela Seddon

Abstract
The physicist Ernst Abbe found in 1873 that any instrument used for optical imaging is bound by the diffraction limit. During the Summer Research Placement the Novel Photonics Research Group managed to produce a fibre capable of beating this limit.

Diffraction Limit
According to Abbe the smallest theoretical resolution that can be achieved is \( d = \frac{\lambda}{2n \sin \alpha} \), where \( d \) is the resolvable feature size, \( \lambda \) is the wavelength of the signal, \( n \) the refraction index of the sample and \( \alpha \) the half-angle suspended by the lens.

Fibre Tip Etching
In order to produce short, smooth fibre tips appropriate for the use within SNIM, T20A30S50 fibre was etched in piranha solution or in piranha solution with an additional protective solvent (right). Results of the etching processes can be seen in the table below.

<table>
<thead>
<tr>
<th>Tip name</th>
<th>Etchant</th>
<th>Fibre diameter (µm)</th>
<th>Water temperature (°C)</th>
<th>Time until neck off</th>
<th>Quality of resulting tip</th>
</tr>
</thead>
<tbody>
<tr>
<td>PiTAS1</td>
<td>Piranha</td>
<td>145</td>
<td>20</td>
<td>34 min 50 sec</td>
<td>Short (116µm), tip, small aperture (14µm)</td>
</tr>
<tr>
<td>PiTAS2</td>
<td>Piranha</td>
<td>145</td>
<td>19.6</td>
<td>19 min</td>
<td>Short (120µm), slightly uneven tip</td>
</tr>
<tr>
<td>PiTAS3</td>
<td>Piranha</td>
<td>145</td>
<td>19 - 19.6</td>
<td>21 min</td>
<td>Short tip, small aperture</td>
</tr>
<tr>
<td>Pi+TMPDTAS1</td>
<td>Piranha + protective layer</td>
<td>145</td>
<td>18.3 - 19.4</td>
<td>50 min</td>
<td>Longer tip (240µm), larger aperture (20µm), smooth surface</td>
</tr>
</tbody>
</table>

Future of SNIM
SNIM has got high potential usage in a broad field of applications, including medical diagnosis, chemical research and archaeological imaging.