Fibre-optical microlens fabricated by two-photon direct laser writing for confocal endoscopy imaging

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Fibre-optical microlenses have provided endoscopy with high flexibility and image quality [1]. However, it is a challenge for fibre-optical microlenses to achieve high resolution and miniaturisation simultaneously because of the limitations of manufacturing in shapes and dimensions. Two-photon direct laser writing (DLW) has been already implemented in the fabrication of low-resolution complex wide-field microlenses [2]. Here, we report a high-resolution miniaturised free-form focusing fibre-optical microlens, fabricated on the fibre facet by two-photon DLW [3]. Free-form focusing fibre-optical microlenses with NAs of 0.3, 0.6, and 0.9 are designed to be aberration-free at working wavelengths. Each fabricated micro-optics structure, including a microlens and a holder, only has an outer diameter of 40 μm and a length of 80–90 μm. The 0.9 NA microlens provides a resolution of 0.85 μm. The degraded resolution is analysed considering an extended light source and aberrations. With the 0.6 NA microlens, confocal endoscopy imaging of the fluorescents samples is achieved with a resolution of 0.81 μm. The presented fibre-optical microlenses can potentially be applied to the development of a high-resolution, extremely miniaturized endoscope.

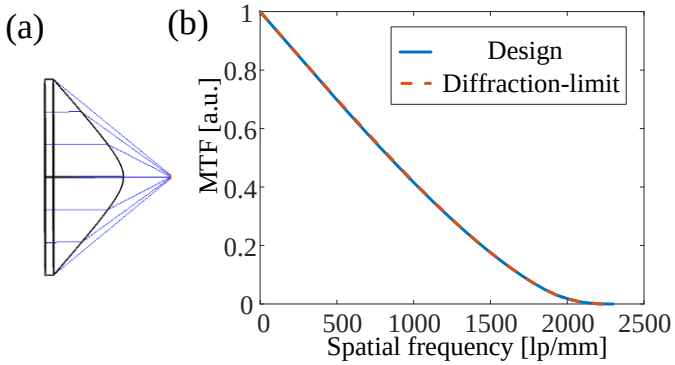

Figure 1: (a) The 0.9 NA microlens design. (b) Modulation transfer function (MTF).

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