# Wavefront Shaping for Spatially Resolved Chemical Sensing in Photonic Crystal Fibre Microreactors

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Progress in wavefront shaping has allowed discrete modes to be excited in step index waveguides, graded index waveguides and photonic crystal fibres (PCFs) [1-5]. Here, new developments for the excitation of discrete modes in PCF are presented. The anti-resonant PCF of Fig. 1a is considered. The modes guided in this fibre geometry are calculated using a finite difference frequency domain (FDFD) solver adapted to modelling optical waveguides (Fig. 1b). Holograms for efficiently exciting these modes are generated using a bespoke Direct Search algorithm that exploit the inherent properties of waveguide modes (Fig. 1c). Experimental excitation of high-purity modes in PCF with efficiencies of up to 30% is demonstrated (Fig. 1d).

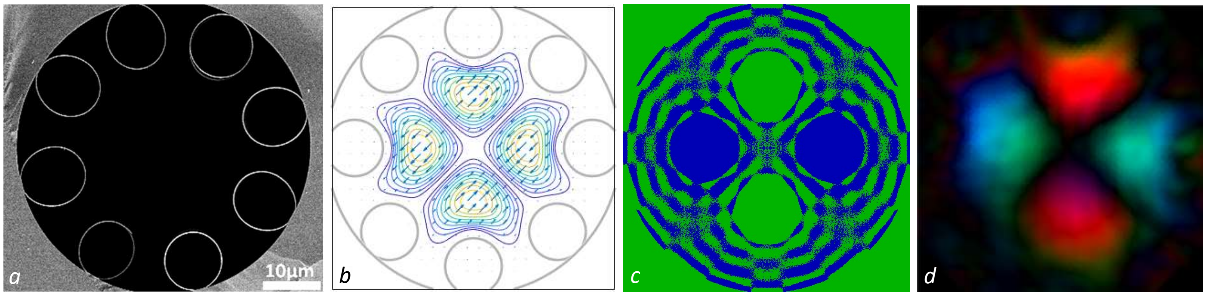


*Fig. 1. a) Scanning electron micrograph of anti-resonant fibre structure. b) $LP_{21}$ mode profile calculated using FDFD model. c) Hologram generated for excitation of $LP_{21}$ mode. d) Experimentally excited $LP_{21}$ mode, characterised using an off-axis interferometer.*

Looking ahead, the controlled excitation of discrete modes will enable spatially resolved probing of reactions within a microreactor. PCFs will be filled with liquid reagents to create photochemical chemical microreactors with extraordinary large light-matter interaction lengths, resulting in low detection limits [6]. The wavefront of the pump beam can be shaped to selectively trigger reactions close to the centre of the core channel or, or near its functionalised surface. Similarly, the wavefront of the probe beam can be shaped to gain spatial-resolved information regarding the reaction products (Fig. 2). We propose that a transverse map of the reaction products can hence be obtained by sequentially probing the reaction using different waveguide modes. This new optical method will enable a better understanding of surface adhesion and diffusive transport in microreactors, with key applications in heterogeneous catalysis and flow-chemistry.

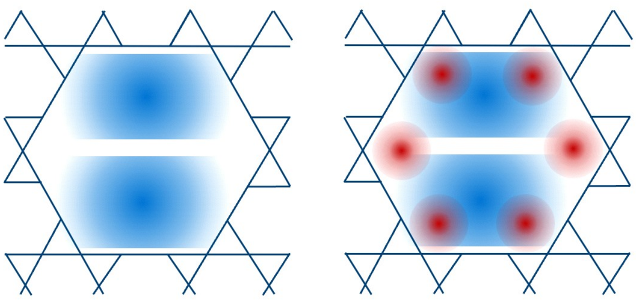

*Fig. 2. An $_{LP21}$ pump mode creates a reaction product that starts to diffuse through the PCF core (left). Probing in different higher-order modes can give spatially resolved spectroscopic information (right).*

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