Singlemode Kilowatt Fibre Laser with Adjustable Beam Profile and M^2

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Fibre lasers (FLs) have transformed many industrial processes due to their exceptional properties, including high beam quality, power scalability, flexibility, and compactness [1]. The forthcoming digital manufacturing revolution and Industry 4.0 require the development of so-called "smart fibre lasers" [2] with expanded and new capabilities such as tailorable output beam shape. Adjustable output beam profile is of particular interest in material processing applications, such as cutting, welding, and for additive manufacturing where fine control of the spatial laser-material interaction is desirable. Recently, high power multimode (MM) continuous wave FLs with adjustable beams have been demonstrated using a mechanical switch [3], the combination of several individual lasers [4], and by bending a graded-index fibre splice [5]. In all these cases, multimode input beams are transformed into higher M^2 multimode "donut" or flat-top output beams.

In this paper we present for the first time a robust kW-class FL with singlemode (SM) output from a MM delivery fibre and adjustable beam profile. The output beam can be configured from a diffraction-limited Gaussian profile into a higher M^2 ring-like shaped mode or flat-top profile. The schematic of our FL is shown in Fig. 1 (a). It consists of a SM 2kW FL oscillator that is connected via a mode field adaptor to a MM 50µm core 0.22NA fibre. We first precisely excite [6] the fundamental mode LP_{01} of the MM fibre and we use an adjustable mechanical mode coupler to transform the beam. This is followed by 10m of MM delivery fibre and terminated by standard delivery optics. By carefully designing the refractive index change induced by the mode coupler, we can convert, controllably and dynamically without measurable loss, the input LP_{01} mode into a specific higher order mode such as ring-shaped LP_{31} or LP_{41}. This is unique to our approach and differentiates it from previous configurations [3-5], which only provide highly multimode donut beam shapes. Moreover, with appropriate design parameters, a mixture of modes can be excited to form more complex beam shapes. Figure 1 (b) shows experimental results of M^2 and beam profile as a function of the mode coupler settings. Here, the M^2 can be changed from ~1.12 to ~7, limited by the delivery fibre, the mode coupler design, and the output optics.

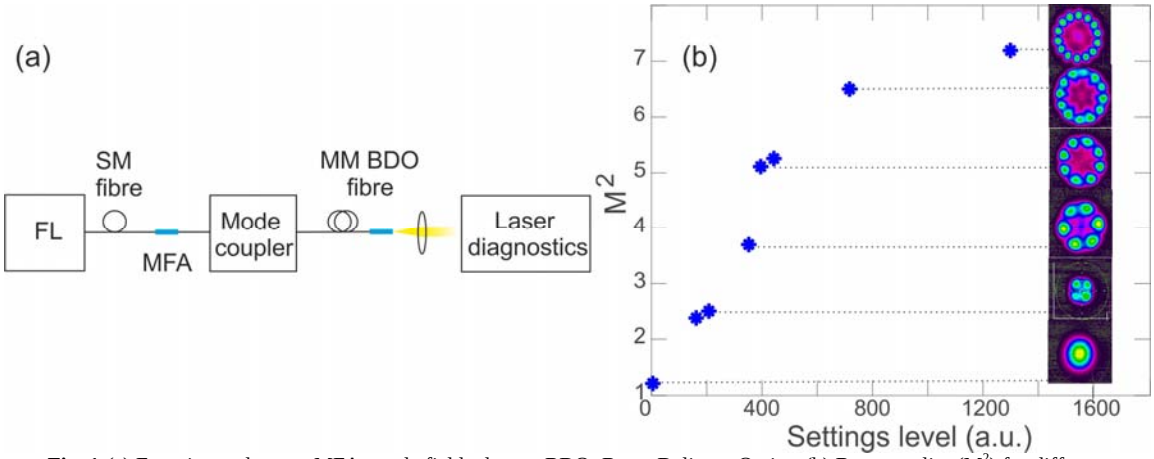

Fig. 1 (a) Experimental setup; MFA: mode field adaptor, BDO: Beam Delivery Optics. (b) Beam quality (M^2) for different settings; Inset: corresponding measured beam profiles.

The output beam profile is extremely stable during dynamic perturbations, manipulation or coiling of the delivery fibre, thus making this approach attractive for practical robotic deployment. Additional technical information and material cutting results will be presented at the conference.

References

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