An All-Fiber Ultra-Low Numerical Aperture High Power Fiber MOPA System with an Output Power above 500 W

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Optical fiber technology has been developed dramatically in the last two decades. Especially, the invention of the Large Mode Area (LMA) fibers has made a great impact, and consequently the power scale of the fiber lasers started to increase exponentially [1]. However, at a certain point this increase has been saturated due to the non-linear effects such as Stimulated Raman Scattering (SRS) and Thermal Modal Instability (TMI). Therefore, a new approach has been proposed to mitigate these so called problems by decreasing the numerical aperture (NA) of the LMA active fiber so that it behaves like an intrinsically single mode fiber. In the literature, an active fiber having ultra-low (<0.04) NA, is proposed [2, 3] in 2009; and finally, the highest power, which is 4.3 kW, was demonstrated in 2017 [4]. However, all of these works based on free space orientation. In this letter, we demonstrate all-fiber and monolithic version of the high power low NA fiber laser system based on an Yb-doped active fiber having 26 µm/410 µm core/cladding diameters respectively with a NA of 0.032 which has also been verified experimentally.

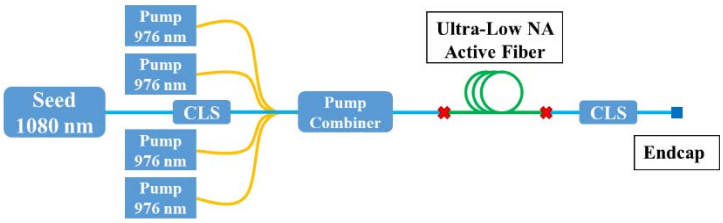

Fig. 1 Schematic illustration of the fiber MOPA system based on the ultra-low NA active fiber.

The refractive index profile of the preform, which has been produced by using MCVD (Modified Chemical Vapor Deposition) technique, is sketched in Fig. 1(a). After drawing the ultra-low NA active fiber out of this preform, the optical microscope image of the cross section of it is illustrated in Fig. 1(b).

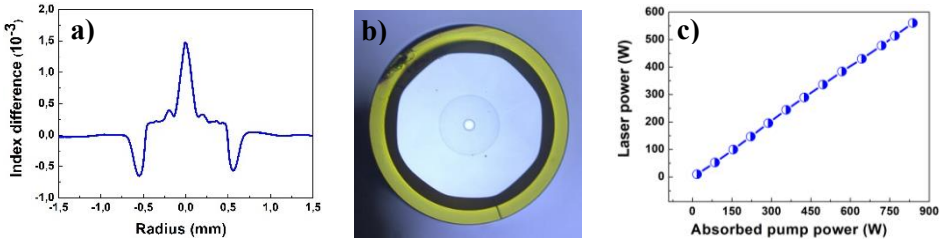

Fig. 2 Refractive index profile of the preform (a) and the optical microscope image of the cross section of the ultra-low NA active fiber (b) and the power characterization of the laser system above 500 W (c).

The high power performance of this ultra-low NA active fiber was tested in a MOPA configuration in which 1 W 1080 nm seed power has been amplified to the power level above 500 W. The schematic representation of the ultra-low NA fiber MOPA system is shown in Fig. 2(a) and the high power characterization of this system is as shown in Fig. 2(b). Beam quality measurement has been performed at this power level and M^2 values has been taken as M_x^2=1.22 and M_y^2=1.20 in both x and y coordinates respectively. Therefore, this preliminary work indicates that ultra-low NA fiber laser systems are promising for the power scale of the fiber lasers.

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