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Side Pump Combiner Fabrication on a Photonic Crystal Fiber in (1 + 1) x 1 Configuration

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Pump combiners have been utilized to combine the power of the pump diodes in the high power fiber laser oscillator and amplifier systems. The common way of the fabrication of the pump combiners with signal feed-through are fused taper fiber bundle (TFB) which is based on end pump technique in which the signal fiber are also tapered along with the pump fibers [1]. Therefore, with these type of combiners pumping can only be achieved in one direction; however, recently it has been demonstrated that counter-pumping or bi-directional pumping mechanisms allow the power scaling up with lower non-linear interaction thresholds such as Stimulated Raman Scattering and most recently and importantly Transverse Mode Instability (TMI), such an effect that reduces the beam quality of the laser beam drastically [2]. Alternative one to the end pumping technique making both counter and bi-directional pumping possible is side coupler technique in which the fiber core remains uninterrupted and pump fiber points can be increased more freely than the other one. The most popular side pump combiner fabrication technique is the direct fusion method due to the suitability for high power laser operation [3, 4]. With this motivation, we have also intended to fabricate a side pump combiner for the first time on a photonic crystal fiber (PCF) in order to open a way to all-fiber monolithic systems with PCFs. For that purpose, we have used a home-made PCF having 45/360 µm core/cladding diameters respectively and a pump fiber having 130 µm cladding diameter. PCF has air holes with 12 µm diameters and a lattice constant of 25 µm and so the ratio of them would be, $\frac{d}{\Lambda} = 0.48$ before the CO_2 laser operation.

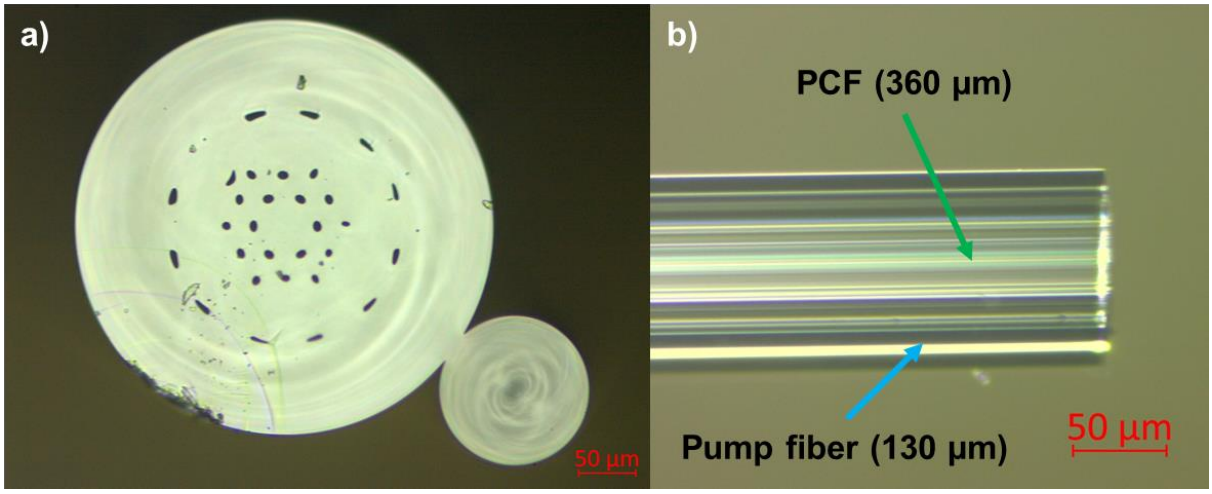

Fig. 1 (a) Optical microscope image of the cross section, (b) and the side view of the (1 + 1) x 1 side pump combiner on a photonic crystal fiber

Fujikura LAZERMaster LZM-100 glass processing system which has CO_2 laser inside has been utilized for this experiment. The energy of the laser has been arranged carefully for the sake of not collapsing the air holes inside the PCF. We have obtained a side pump combiner after energy optimization study whose optical microscope image of the cross section has been shown as in Fig. 1(a). After the laser operation the diameter of the air holes has been measured as 8 µm corresponding to a $\frac{d}{\Lambda} = 0.32$. Besides, the optical microscope image of the side view of the combiner has also been shown in Fig. 1(b). Finally, the pump power efficiency has been achieved as 84%.

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