WGM Microrod Laser Fabricated by pulsed CO_2 Laser Micromilling

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Fabrication of high Q milled microrod resonators using a pulsed CO_2 laser, directly on Yb^{3+}-doped fibers, is demonstrated. Evanescently pumped WGM microlaser with ~9μW output power has been achieved.

Introduction

Whispering Gallery Mode (WGM) microlasers have been of a great interest owing to their low threshold and narrow linewidth lasing due to their high Q and small mode volume. Most of the fabrication methods [1-3] are non-controllable and non-reproducible which rely on fiber-tip melting, such as microspheres [3, 4] or splicing of small active-fiber stubs [3]. Microresonators are realized by heating up and melting the material using continuous wave CO_2 lasers. We use a method based on pulsed CO_2 laser which enables controllable ablation of fiber surface. We achieved precise control of the cavity length and ablation depth in a very short fabrication time, as a simplified one-step process to form a WGM microresonator from a Yb^{3+}-doped silica fiber.

Fabrication and Results

A sequence of CO_2 laser pulses is focused onto a rotating 240μm-diameter fiber with 200 μm doped core resulting in 20 μm ablation depth. To improve the surface roughness of the milled edges the structure was fire-polished by applying controlled electrical arcs (Fig. 1(a) inset). This improved the Q-factor from ~10^{+4} to ~$3\times10^{+6}$, and enabled lasing. A laser diode pump at 974.5 nm wavelength is launched into a 2 μm-diameter tapered fiber in-contact with the resonator and evanescently excites pump WGMs. Figure 1(a) shows the measured signal spectra collected through the same tapered fiber. The total signal power, calculated by summing up all lasing peaks (Fig. 1(b)), shows linear dependency to the launched pump power for the powers above a threshold of ~40 mW (absorption of ~1 mW). The optical-to-optical efficiency with respect to absorbed pump power is ~0.1%.

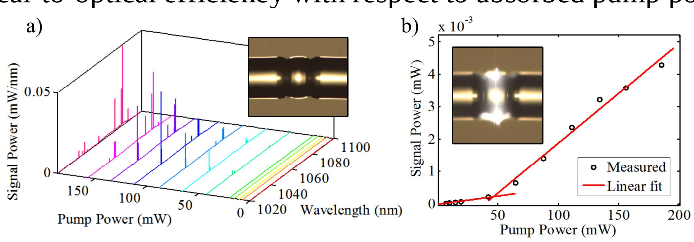

Fig. 1. a) Spectra of signal as a function of launched pump power (inset shows the fabricated microrod resonator), and b) total measured signal as a function of launched pump power (inset shows the light scattered at 70 mW pump power).

Conclusion

With this method, large number of identical microresonators in one-fabrication-step process, can be achieved. The controlled CO_2 exposure results in minimum ablation depths and does not compromise the fiber strength. Therefore, such microresonator structures, with two fiber stems attached naturally to the resonator ends, will enable a variety of future robust sensing applications and tunable telecommunication devices.

References

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