High-performance γ-MnO_2 dual-core, pair-hole fiber for ultrafast photonics

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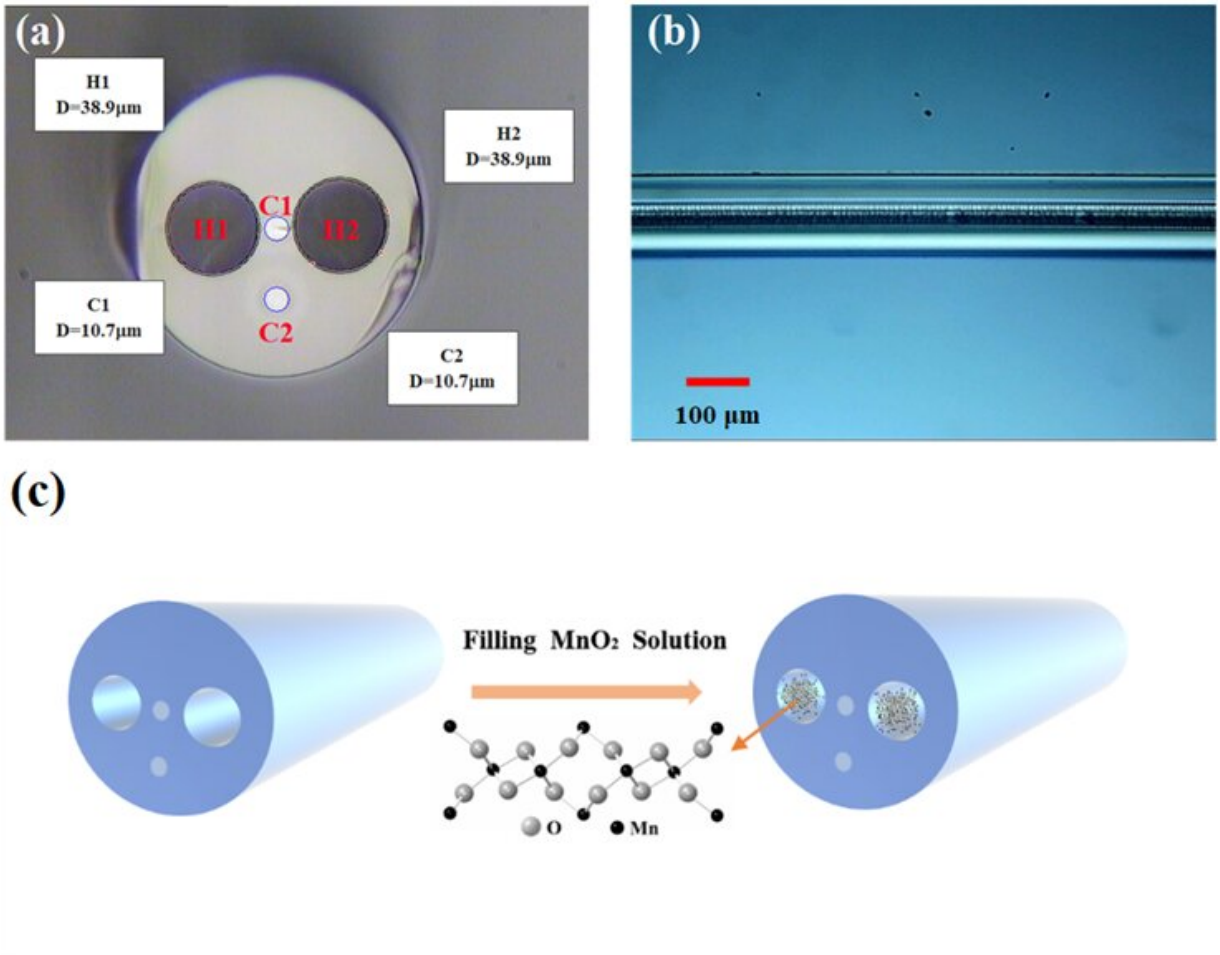
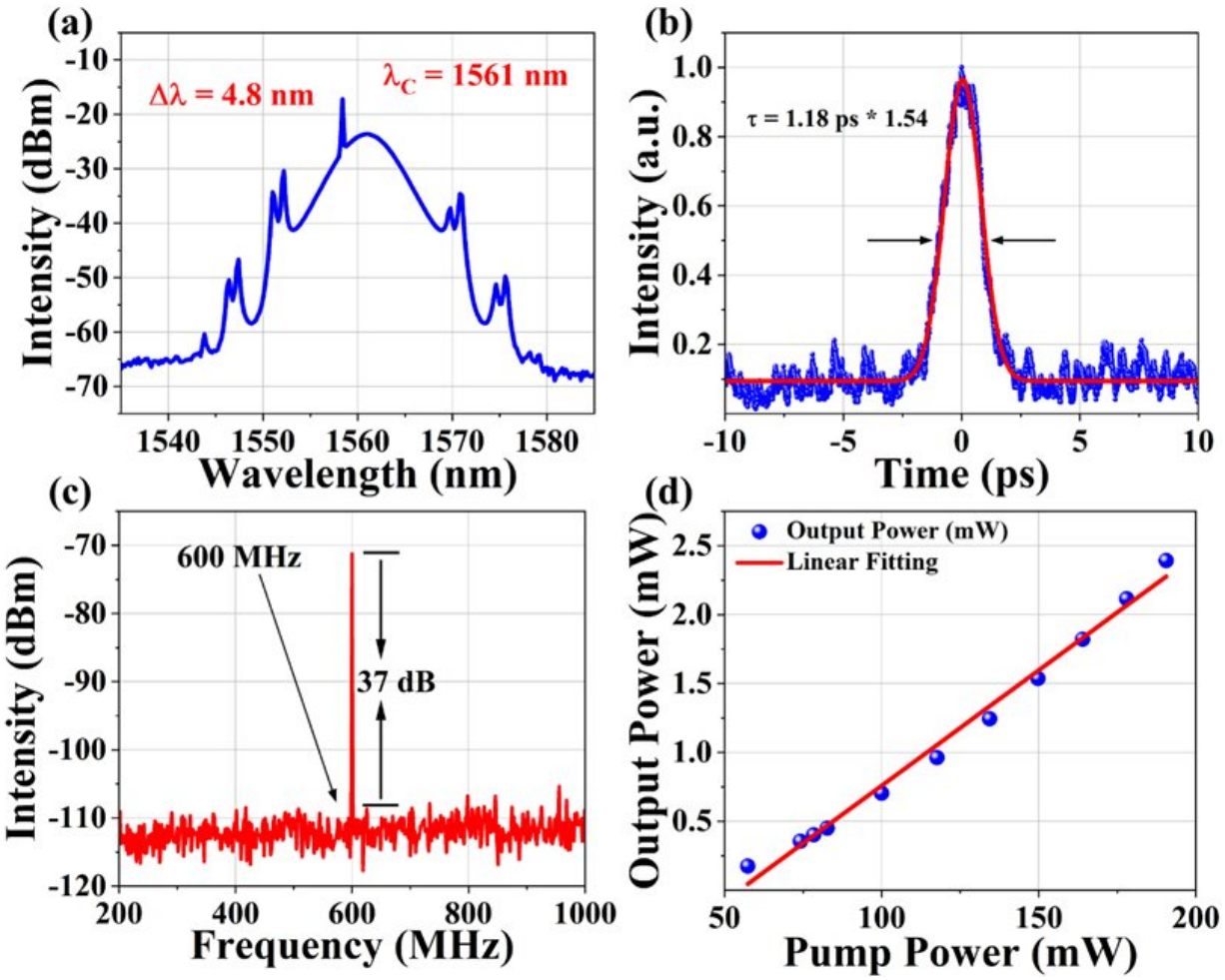


Structure and filling diagram of γ-MnO_2 dual-core pair-hole fiber. Credit: *Ultrafast Science*

Recently, the research team of Prof. Xiaohui Li at Shaanxi Normal University fabricated a section of γ-MnO_2 dual-core double-hole fiber by combining γ-MnO_2 with a special fiber, a dual-core pair-hole fiber, measuring its nonlinear absorption curve, and used it as a saturable absorber to produce an all-fiber mode-locked laser, which achieved about 1 ps pulse width and a repetition frequency of about 600 MHz.

The experiments show that this fabrication scheme has good stability and is suitable for the combination of other novel materials with specialty fibers, which greatly expands the applications of specialty fibers in ultrafast optics and sensing.

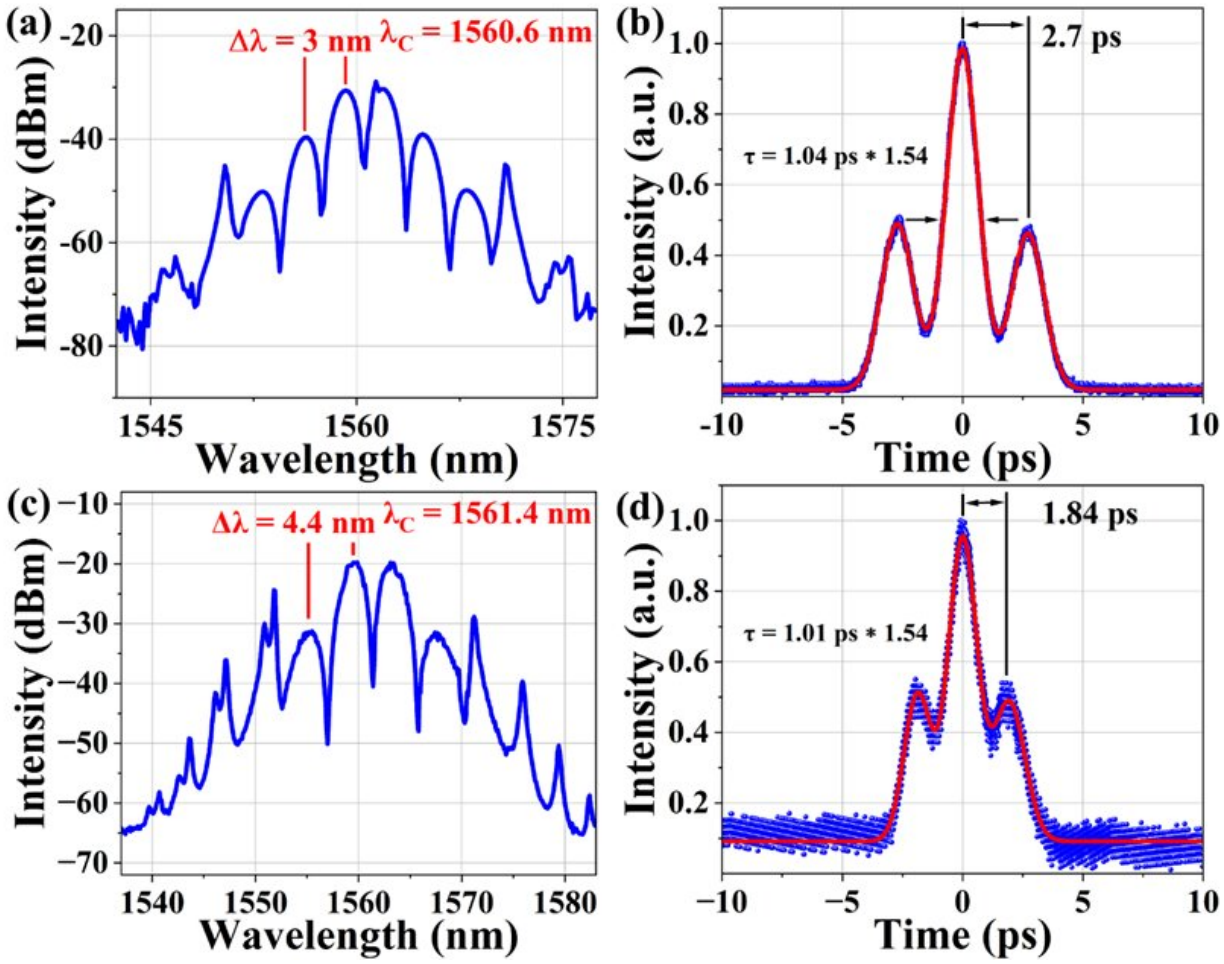


Harmonic soliton (a) spectrum (b) autocorrelation trace (c) RF spectrum (d) laser output efficiency. Credit: *Ultrafast Science*

Since specialty fibers have some excellent properties, the use of such properties can expand the scope of applications of specialty fibers. Li's group has accumulated some technical experience in the nonlinear optical properties of novel materials, but how to keep the nonlinear properties stable and reproducible is still valuable research. The fiber hole is filled with a suitable concentration of γ-MnO_2, the length of the filling is controlled, and the two ends are fused to a single-mode fiber, thus completing a sealed optical modulation device.

The successful implementation of this scheme depends on two points: the selection of special optical fibers and novel materials on the one hand, on the other hand, the control of the filling process.

The dual-core, pair-hole fiber was chosen because of its structure with the characteristics associated with photonic crystal fibers, which can endure higher power laser transmission; the larger diameter of the hole and the close distance to the center core, which is conducive to the integration with the material and the abrupt interaction between light and material; the side core positioned away from the hole and the center core, which has less impact on the light transmission.



Soliton molecules with variable modulation period. Credit: *Ultrafast Science*

And the center core diameter is not much different from the common single-mode fiber, which can reduce the difficulty of fusion splicing and reduce the fusion loss.

γ-MnO_2 is chosen as the filler material mainly because of its small band gap, a wide range of intrinsic absorption band, and its sea urchin-like structure with better light interaction and more excellent saturation absorption characteristics. In addition, the price is relatively low and

suitable for mass manufacturing.

In the filling process, anhydrous ethanol is used as the solvent, in which an appropriate amount of the novel material is dissolved to prepare a homogeneous dispersion, which is then filled using the capillary phenomenon. It is worth noting that the concentration of the dispersion is directly related to the effectiveness of the filling.

The results obtained from the experiments are basically consistent with expectations, but there are still some details that need to be improved, such as the effect of temperature on the filling effect during the filling process and the effect of hole size on the filling effect, etc. With the solution to these problems, eventually, this scheme will have a strict standard, which makes it have good repeatability and can be applied to more scenarios.

The study is published in the journal *Ultrafast Science*.

More information: Xiaohui Li et al, High-performance γ-MnO_2 Dual-Core, Pair-Hole Fiber for Ultrafast Photonics, *Ultrafast Science* (2023). DOI: 10.34133/ultrafastscience.0006

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