COMMENTARY

PHOTONICS INSIGHTS

Optical micro/nanofibers: achievements and future directions

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Two decades ago, in 2003, Tong *et al.*[1] published a seminal paper that attracted many researchers working in the field of optics (and, particularly, the author of this Commentary) to the investigation and applications of optical micro/nanofibers (MNFs). In Ref. [1], Tong demonstrated a simple way to fabricate dramatically narrow–tens of nanometers in diameter–silica MNFs and their manipulation (e.g., bending them into a knot) at the microscale. While, at that time, optical MNFs were routinely used in photonics for the efficient coupling of light into microresonators[2,3] and supercontinuum generation[4], Ref. [1] suggested their much broader applications, such as building blocks for the nanofiber photonic circuits with a complex configuration assembled on a chip. A review of research in the field of optical MNFs completed by 2010 has been summarized in a book[5].

The recently published review article by Zhang *et al.*[6], numbering almost 600 references, provides a thorough and insightful overview of the developments in optical MNFs over the past two decades. This review is pivotal for anyone interested in the advancement of nanophotonics, as it compiles and critiques decades of research in a manner that is both comprehensive and comprehensible, making it a crucial read for both novices and experts in the field.

The review excels in its detailed presentation of the various fabrication techniques that have evolved over the years for producing MNFs. These fibers, notable for their sub-wavelength diameter and high-refractive-index contrast, require precise manufacturing methods to maintain their unique properties. The authors do an excellent job detailing processes such as flame brushing and taper drawing, which are critical for achieving the desired fiber geometry and optical qualities. Each method is discussed not only in terms of its historical development but also with an eye toward future improvements that could enhance efficiency and reduce costs.

A significant strength of this review is its deep dive into the linear and nonlinear optical properties of MNFs. The authors meticulously describe how these fibers manipulate light at the micro to the nanoscale, which is essential for many applications in modern technology. This section is technically rich and supported by a robust analysis of experimental data, providing a clear understanding of the underlying physics driving the functionality of MNFs. The discussion extends to the impact of these properties on practical applications like sensing and telecommunications, illustrating the real-world relevance of the theoretical work.

The applications of MNFs are covered extensively in this review, showcasing the versatility and wide-reaching implications of these fibers in various fields. From their use in near-field optics to their integration into fiber lasers, wearable tech, quantum applications, and optical sensors, the authors present a detailed overview of both current uses and potential future applications. This not only serves to inform readers of the capabilities of MNFs but also to inspire further research and development in areas that could benefit from their unique properties.

The authors provide a visionary outlook on the future of MNFs, discussing both the ongoing challenges and the potential breakthroughs on the horizon. This forward-looking perspective is particularly valuable as it sets the stage for future innovations and research directions. The review identifies key areas where further research is needed, such as improving the durability and stability of MNFs under different environmental conditions and scaling up production methods to meet industrial demands.

The organizational structure of the review is another commendable aspect. The authors have arranged the content logically, starting from basic concepts and building up to more complex discussions. This makes the review not only a valuable reference for experts looking to update their knowledge but also a clear introduction for newcomers to the field. The writing style is precise and technical, yet it remains engaging and accessible, a balance that is not easily achieved in scientific literature.

Overall, the review by Zhang *et al.*[6] is a tour de force in the literature on optical MNFs. It provides a holistic, insightful, and forward-looking review of the state-of-the-art, encapsulating the past developments, current technologies, and future prospects of MNFs. The review's depth, clarity, and comprehensive analysis make it an invaluable resource for anyone involved in nanophotonics. It is not only a reflection of the significant progress in the field but also a beacon guiding future innovations. It is highly recommended for anyone looking to understand the impact of MNFs in advancing optical technologies and their integration into next-generation photonic systems.

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References

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