Multimode Brillouin scattering in a long tapered photonic crystal fiber

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Stimulated Brillouin scattering (SBS) in optical fibers is a fundamental interaction between light and sound with important applications in telecommunications, microwave photonics and optical sensing [1]. It is also ultimately responsible for restricting the light power that can be transmitted in fibers. SBS has recently been investigated in small-core photonic crystal fibers (PCFs) with new intriguing characteristics induced by the wavelength-scale air-hole microstructure [2,3].

In this work, we report on the investigation of SBS in a long, adiabatically tapered birefringent PCF where core diameter gradually shrinks from 2.04 µm down to 800 nm. Our results show that the fiber tapering provides a broadband and multimode Brillouin spectrum and that the birefringence induces a large frequency shift of the whole spectrum. We further measure the Brillouin threshold power and demonstrate an increase of 6 dB compared to the same but untapered PCF.

Figure 1(a) shows the tapered PCF input cross-section and its longitudinal geometry. It has a length of 124 m with an external diameter decreasing linearly from the input to the output, from 200 µm to 80 µm. By injecting a narrow-linewidth laser at 1.55 µm, we have measured the Brillouin backscattering spectrum from this PCF by use of a fast photodiode and an electrical spectrum analyzer [3]. As can be seen in Fig. 1(b), we observe a broad Brillouin spectrum around 10.7 GHz including several resonance peaks, whereas we measured only one narrow peak in the untapered PCF [3]. These multiple resonances are actually due to the generation of several hybrid shear and longitudinal acoustic modes due to the fiber tapering, as we will shown by numerical simulations. We then measured a strong increase of the Brillouin threshold power of about 6 dB compared to the uniform fiber. If we consider now the overall spectrum, the full width at half maximum (FWHM) of Brillouin spectrum is nearly six times larger than the one in the uniform PCF, which is about 50 MHz. We thus believe that this type of adiabatically core-decreasing PCF opens another way for controlling and shaping the Brillouin spectrum and can find potential applications for mitigating SBS in fiber laser or amplifiers.

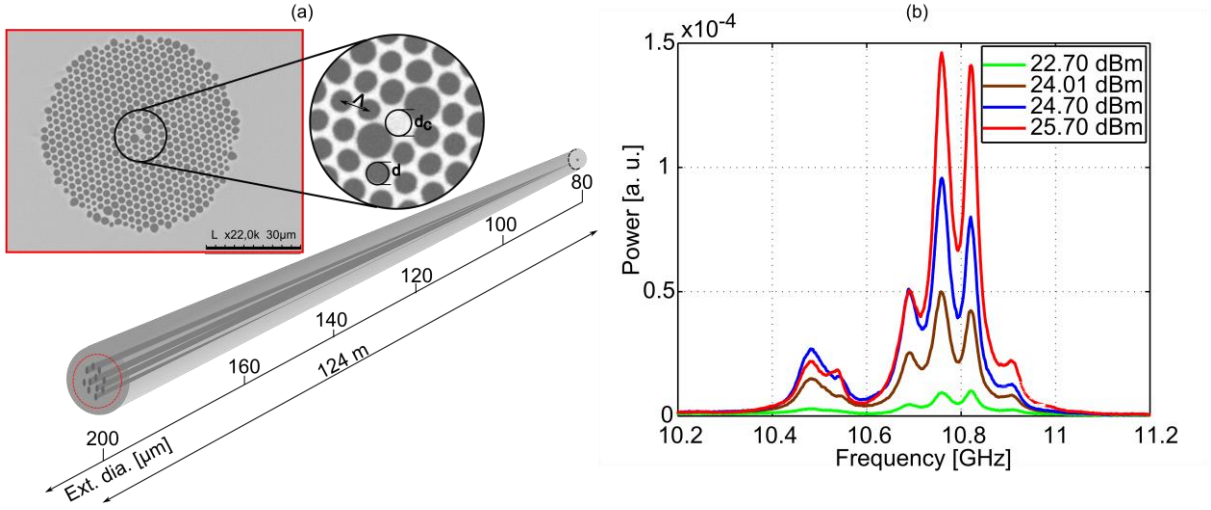

Figure 1: (a) Scanning electron microscope (SEM) image of the input cross section and longitudinal geometry of the tapered PCF; at this input, the core and hole diameter are respectively 2.04 µm and 1.9 µm; the pitch is about 2.5 µm; (b) experimental Brillouin spectra for increasing input pump power showing several resonances peaks due to the fiber tapering.

References

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