Brillouin fiber spectrometer for metrology of tapered silica optical fiber

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Summary

We report a technique based on Brillouin scattering measurement to characterize precisely the geometry and the mechanical properties of tapered silica fiber. Our method relies on the Brillouin backscattering spectrum analysis that directly depends on the waveguide geometry.

Introduction

Tapered silica fiber have been investigated these last years and the measure of geometry remains a difficulty [1]. We describe a non-destructive method to characterize tapered silica fiber after fabrication. It's based on Brillouin backscattering measurement which relies the interaction between incident light and elastic wave coming from thermal noise in the waveguide. The Brillouin backscattering spectrum exhibits several elastic resonances due to hard boundary condition. All resonances evolve differently as a function of geometrical property.

Discussion

Optical microwires have been tapered from a standard telecom fiber (SMF-28) using the heat brush technique. We control the quality and the linear loss of the tapering process by measuring the optical transmission. Figure 1 shows a Fourier spectrum related to the transmission signal. It reveals several optical modes due to the high refractive index difference between the silica microwire and the surrounding air. Each mode branch can be identified as the optical beating depends on the effective refractive index difference between the two beating modes. As we can see on Figure1, for an elongation of 160mm, the microwire is monomode.

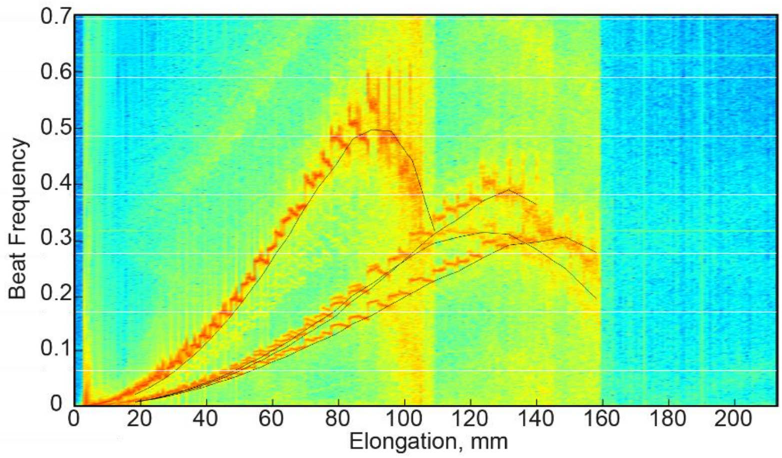

Figure 1 Experimental spectrogram of the transmission with visualization of higher mode exited.

For diameter smaller than 1.2 µm which correspond to the cut-off frequency for a silica rod surrounding by air at the wavelength of 1550 nm, the optical beating cannot help finding the geometrical properties of nanofiber. We used the elastic wave involved in Brillouin scattering process to estimate the diameter of the microwire thanks to an heterodyne detection to measure the Brillouin spectrum in the RF domain. Figure 2 shows the experimental Brillouin spectrum (blue) for a microwire diameter of 825 nm. The black curve in Fig. 2 shows a theoretical fit obtained from our model with a diameter of 825 nm. We obtain a good agreement between theoretical fil and experimental measurement.

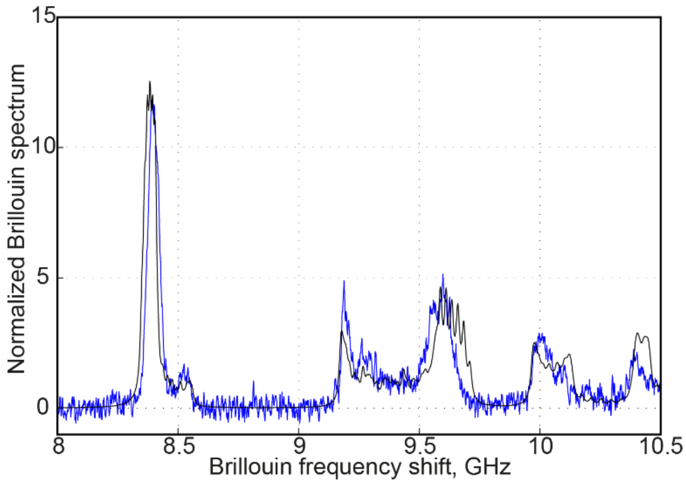

Figure 2 Experimental Brillouin spectrum (blue) versus the simulated one (black) for a diameter of 825 nm

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Conclusions

We proposed an original technique based on Brillouin backscattering that allows for the accurate diameter measurement of sub-micron tapered optical fibers. The combination of Brillouin scattering and optical beating measurement offer a toolbox to characterize tapered optical fiber in-situ and without manipulation. The sensibility of Brillouin scattering to temperature and strain can help to package the microwire into the box.

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