Optical and opto-acoustical metrology of silica tapered fibers for nonlinear applications

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Nanofibers obtained by tapering optical fibers are the subject of intensive research worldwide. We propose two techniques for shape and diameter measurements. The first is a simple improvement of classical imaging microscopy with resolutions below one micrometer, while the second relies on Brillouin spectroscopy with a sensitivity of a few nanometers.

1. Introduction

Tapered optical fibers have attracted a considerable attention since they were first proposed[1)]. They are readily obtained by heating and stretching standard optical fibers, such as telecom fibers. Nanofibers whose diameters are down to a few hundred nanometers over lengths of several centimeters are now routinely obtained by various laboratories. Their high transmissions, their inherent ability to concentrate light from the untapered section inside the nanofibre section, the presence of a strong optical evanescent field around the nanofibre section make them attractive for both fundamental physics and devices[2)]. For some of these applications, the approximate knowledge of the tapered fiber dimension is enough. However for other applications, such as parametric wave mixings, the knowledge of the fiber shape with an accuracy of a few nanometers is mandatory. It is worth noting that conventional techniques, such as scanning electronic microscopies, are not always suitable since they are destructive. For that reason, non-destructive measurement techniques are still under active development[3)]. We are developing two such techniques within our collaborative project FUNFILM "Functionalization of tapered Nanofibers for InLine Light Manipulation"[4)].

2. Principle

Both techniques can be performed in-situ, without manipulation or alignment of the optical nanofibre. The first technique is straightforward improvement of imaging microscopy. Over lengths of a few micrometers, the nanofibre is perfectly modeled by a cylindrical rod. Comparing experimental measurements with modeling thus allows sub-micrometer measurements over diameters down to 1 µm even with low numerical aperture microscope (NA= 0.28 in our experiments). The second easy to implement technique relies on an heterodyne detection of the Brillouin back scattered spectrum[4)]. Diameter measurements down to 500 nm with an accuracy of a few nanometers are reported.

This work is supported by the French National Research Agency (ANR) (FUNFILM-ANR-16-CE24-0010-03)

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