Brillouin scattering in nanofibers

Jean-Charles Beugnot

Université Bourgogne Franche-Comté, Institut FEMTO-ST, CNRS UMR 6174, 25030 Besançon, France
*corresponding author, E-mail: jc.beugnot@femto-st.fr

Abstract

Brillouin light scattering is a fundamental interaction between light waves and small acoustic vibrations which gives rise to inelastic light diffusion with a frequency shift by an amount that corresponds to the acoustic phonon frequency [1]. Due to their strong light confinement capabilities, optical fibers have been early recognized as an ideal medium to exploit the Brillouin scattering for applications in e.g., lasers, telecommunications, microwave photonics and optical sensing [2,3].

Introduction

The rich and complex dynamics of light and sound interactions in tiny optical waveguides has recently gained much interest because of their experimental realization in emerging key areas of photonics.

For instance, we demonstrate recently for the first time the generation of a new class of surface acoustic waves in a subwavelength-diameter silica nanofibers and term this new effect as surface acoustic wave Brillouin scattering (SAWBS) [4]. In such thin silica wires, boundary conditions induce a strong coupling of shear and longitudinal displacements, resulting in a much richer dynamics of light interaction with hybrid acoustic phonons.

Using numerical simulations based on electrostriction and experimental results, we show that SAWBS results from the stimulated optical excitation of Rayleigh-type surface-ripple waves propagating at a velocity of 3400 m/s along the optical nanofibers surface and giving rise to new useful RF sidebands around 6 GHz in the scattering spectrum. As these new acoustic resonances are strongly sensitive to microwire surface, SAWBS opens new interesting opportunities for various sensor applications.

We proposed an original technique based on Brillouin backscattering that allows for the accurate diameter measurement of nanofibers [7].

Acknowledgements

This work was supported by the French “Investissements d’Avenir” program, project ISITE-BFC (contractANR-15-IDEX-0003) and Agence Nationale de la Recherche (FUNFILM-ANR-16-CE240010-03.

References

[1] R. W. Boyd, Nonlinear Optics, (Academic Press, Boston, 4th ed, 2009).

[2] G. Agrawal, Nonlinear fiber Optics (Academic Press, Boston, 5th ed., 2012).

[3] A. H. Hartog, An Introduction to Distributed Optical Fibre Sensors (CRC, 2018).

[4] J-C. Beugnot, S. Lebrun, G. Pauliat, H. Maillotte, V. Laude, T. Sylvestre “Brillouin light scattering from surface acoustic waves in a subwavelength-diameter optical fibre,” Nature communications, 5, (2014).

[5] A. Godet, A. Ndao, T. Sylvestre, V. Pecheur, S. Lebrun, G. Pauliat, J-C. Beugnot, and K. Phan Huy, "Brillouin spectroscopy of optical microfibers and nanofibers," Optica 4, 1232-1238 (2017).