# Temperature and strain dependence of Brillouin scattering in chalcogenide optical microwires

J-C Beugnot, C Jeannin, J C Tchahame, A Godet, A Ndao, T Sylvestre, R Ahmad, M Rochette

# Temperature and strain dependence of Brillouin scattering in chalcogenide optical microwires

**J-C. Beugnot[1], C. Jeannin[1], J. C. Tchahame[1], A. Godet[1], A. Ndao[1], T. Sylvestre[1], R. Ahmad[2], M. Rochette[2].**

*1. Institut FEMTO-ST, CNRS UMR 6174, Université Bourgogne Franche-Comté, Besançon, France*

*2. Department of Electrical and Computer Engineering, McGill University, Montreal (QC), Canada*

*Author e-mail address: jc.beugnot@femto-st.fr*

**Abstract:** We report the measurement of Brillouin spectrum in polymer-coated chalcogenide microwire as a function of temperature and strain variation. We show a negative variation of Brillouin frequency shift. The coating strongly modify the Brillouin frequency due to temperature.

**OCIS codes:** 060.4370, 190.3270, 190.5890

Chalcogenide-glass fibers offer a unique set of optical properties presenting an excellent platform for development of highly nonlinear optical devices for all-optical signal processing and mid-infrared applications. In optical fiber Brillouin scattering is a nonlinear process where two photons generate a co-propagating acoustic phonon through electrostriction. Enhanced stimulated Brillouin scattering (SBS) has also been evidenced in chalcogenide tapered optical fibers and in photonic chips [1, 2]. SBS is of particular interest because it has important implications in various fields ranging from optical fiber sensors to lasers. In this work, we report the dependence of Brillouin frequency shift on temperature and strain in polymer-coated chalcogenide (PMMA-As2Se3) tapered optical fibers with sub-micrometer waists (microwires).

Our study shows that the temperature coefficient is linearly proportional to the increase of temperature (-3.05MHz/°C). When the temperature increases, the Brillouin shift decrease (Fig. 1a) contrary to standard silica fiber (+1.1MHz/°C) [3]. Moreover, the theoretical temperature coefficient of chalcogenide glasses is equal to -1.17MHz/°C. The difference in thermal expansion coefficient in chalcogenide core and polymer cladding induces a strong thermal strain in PMMA-As2Se3 microwires. To verify this assertion, we measured the Brillouin gain spectrum dependence on strain (Fig. 1b). The Brillouin frequency shift change due to thermal strain is equal to -1.86MHz/°C and confirm the measurement of temperature coefficient in PMMA-As2Se3 microwires.

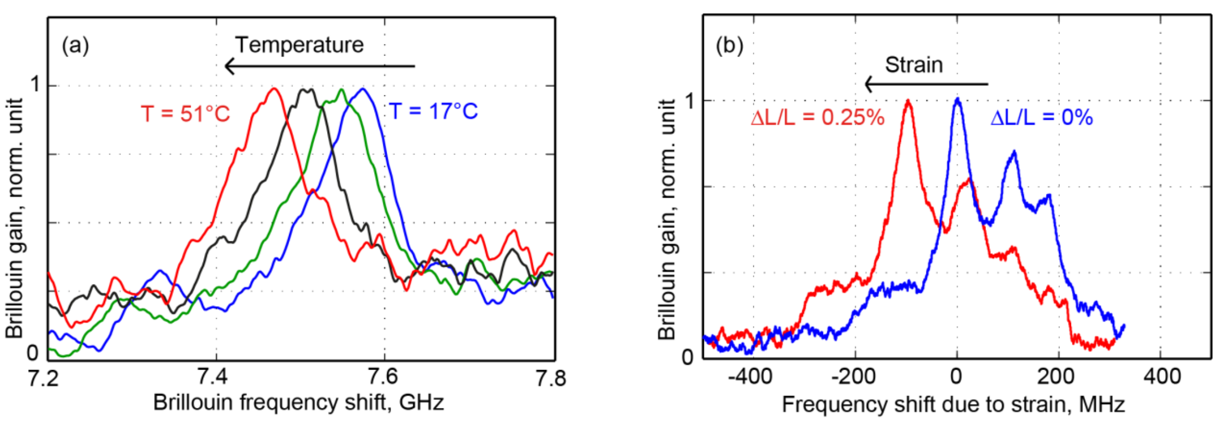


Fig. 1: (a,b) Experimental Brillouin gain spectra of a PMMA-As2Se3 microwire for different microwire temperatures and elongations, respectively.

We also demonstrate the possibility to design the microwire for sensing application by changing the dimension ratio between optical core and surrounding cladding. We simulate temperature-dependence coefficient of the Brillouin frequency shift in different core and cladding composition. The results are presented in Fig . 2. The thermal strain in jacketed fiber strongly depends on cross section ratio between core and coating.

For example, for a large PMMA coating in hybrid silica-PMMA fiber, the temperature dependence of the Brillouin frequency can be equal to 5 MHz/°C. And, for silica cladding surrounding chalcogenide waveguide, the thermal strain minimize the Brillouin frequency shift due to temperature to 0.3 MHz/°C.

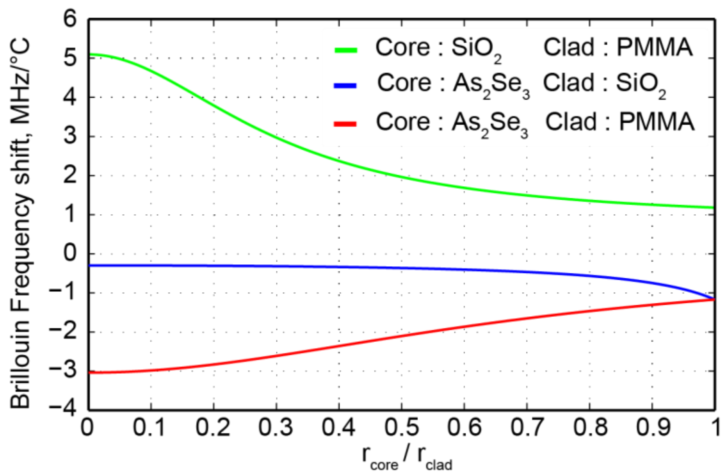


Fig. 2: Brillouin frequency shift as a function of ratio between core and cladding radius for different materials of optical microwires.

To summarize, we measured the Brillouin strain and temperature coefficient in chalcogenide fiber. The temperature and strain dependence of Brillouin frequency shift equal to -406 MHz/% and -1.17 MHz/°C, respectively. We demonstrate the possibility to design the microwire for sensing application by changing the dimension ratio between optical core and surrounding cladding. In hybrid microwires, the coating strongly modify the Brillouin frequency shift induced by temperature. Thanks to their robustness and desired mechanical properties, hybrid PMMA-As2Se3 microwires are promising candidates for the development of ultra-sensitive microwire sensor and athermal Brillouin sensor.

This work was supported by the Labex ANR program OASIS (ANR-14-CE36-0005-01).

[1] B. J. Eggleton *et al.*, “Inducing and harnessing stimulated Brillouin scattering in photonic integrated circuits,” Adv. Opt. Photon. 5, 536-587 (2013).

[2] J-C. Beugnot *et al.*, “Reduction and control of stimulated Brillouin scattering in polymer-coated chalcogenide optical microwires,” Opt. Lett., 39, 482-485 (2014).

[3] Kurashima *et al.*, “Thermal effects on the Brillouin frequency shift in jacketed optical silica fibers,” Applied Optics 15, 2219–2222 (1990).