INVITED SPEAKER

Fundamental thermodynamic noise in integrated photonic sensors

Nicolas Le Thomas[1]

[1]*Ghent University-imec, Gent, Belgium,*

Nicolas.LeThomas@UGent.be

Photonic sensors are taking an increasingly important place in the society. There are used in applications as diverse as diseases screening, food quality analysis, and environment sensing. One of the challenge is to make them always more smaller and lighter without jeopardizing their detection limit. It is particularly important if they are implemented in drones, mobile phones or satellites. In this context, silicon photonics is a key technology that enables to tackle miniaturization issues.

Decreasing the size of photonic structures contributes to enhance light-matter interactions and consequently the sensitivity of the sensor. However, it does not mean that the detection limit is concomitantly improved. The reason is that, at micron scale and at room temperature, thermodynamic fluctuations start to play a significant role in a solid in thermal equilibrium.

We have recently investigated the impact of the fundamental thermodynamic fluctuations on the optical properties of integrated silicon nitride waveguides [1] and silicon photonic crystal cavities [2].

By investigating the optical spectrum of laser light having propagating in optical waveguides, we have unveiled and elucidated the presence of a fundamental noise contribution in the high-frequency part of the spectrum. I will discuss a theoretical model that reproduces the exponential shape of this noise contribution that is several orders of magnitude larger than what earlier models predict. This discovery is of paramount importance for our understanding of noise in light-matter interaction, and also for setting the intrinsic detection limit of advanced optical sensors, in particular for silicon nitride waveguide-based Raman sensors.

By analysing the light scattered from integrated silicon photonic crystal cavities at different acquisition speeds, we have identified the fundamental detection limit of such optical cavities. I will show that the fundamental thermal fluctuations set an intrinsic detection limit. This intrinsic limit can be translated in term of cavity frequency shift and corresponds to $1/2000^{th}$ the linewidth of the optical spectrum for cavities of effective mode volume as small as $0.06 \mu m^3$. Taking into account this intrinsic limit, our results indicate that photonic crystal cavities could enable fast real-time chemical and biological sensing, as well as find applications in medical diagnostics and hazardous aerosol investigations.

References:

[1] N. Le Thomas, A. Dhakal, A. Raza, F. Peyskens, R. Baets, "Impact of fundamental thermodynamic fluctuations on light propagating in photonic waveguides made of amorphous materials", Optica 5, 328-326 (2018).

[2] K. Saurav, N. Le Thomas, "Probing the fundamental detection limit of photonic crystal cavities", Optica 4, 757-763 (2017).

Nano Network

Norwegian PhD Network on Nanotechnology for Microsystems

9th annual workshop

Norwegian PhD Network on Nanotechnology for Microsystems

Scandic Havna Tjøme

11 – 13 June 2018

www.nano-network.net