Integrated Photonic Crystal Cavity for Terahertz Waves on a Free-Standing Silicon Platform

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Integrated silicon photonics allows for guiding of electromagnetic waves on very small dimensions, while also providing a low-cost technique for mass-scale production. HIGH DENS. Here we present a one-dimensional photonic crystal cavity, etched into a free-standing silicon waveguide, that achieves 3D confinement of the electromagnetic waves with a modal volume of the order of a cubic wavelength. Such a cavity can act as a very compact in-line filter or can be used as a refractive index sensor due to the dependence of its resonant frequency on the surrounding refractive index [1]. Furthermore, in contrast to typical integrated cavities, this one confines light inside one of the etched holes, allowing for strong light-matter interactions. In order to minimize material absorption, an SOI (silicon-on-insulator) wafer with 90 µm thick float-zone silicon with high resistivity was used, in which an air-cladded waveguide was etched [2]. This cladding also provides an optimal index-contrast and hence a good confinement of the mode. The waveguide is 210 µm wide, resulting in a confinement factor of 89%. Inverted tapers couple light in and out of the chip. The measurements consisted of a free-space S-parameter extraction with a vector network analyzer extension in the 500-750 GHz range. The coupling is realized using open rectangular waveguides (Figure 1, right panel), and a right angle (bending radius 3mm) was included in the waveguide to avoid direct coupling between the transmitter and receiver during measurements. The total losses after transmission (extracted from S21 measurement) were found to be 7 dB, which is nearly equal to the simulated coupling losses of the tapers, confirming low material absorption and bending loss. The air cladding is provided by etching the backside of the wafer and employing deep-reactive ion etching to define the waveguide, the photonic crystal and the anchors that suspend the waveguide. To minimize light leaking out of the waveguide cavity, Gaussian apodization [3] was employed through parabolic tapering [4] of the photonic crystal period. In the first iteration three cavities were designed with increasing radii of the holes, with likewise increasing resonant frequencies of 635.40GHz, 639.97GHz and 641.3GHz and quality factors of 2600, 1730 and 2600 respectively. This experimental demonstration achieves an important building block towards a fully integrated low-loss resonant THz sensing platform, allowing stronger light-matter interactions than previous reported designs.

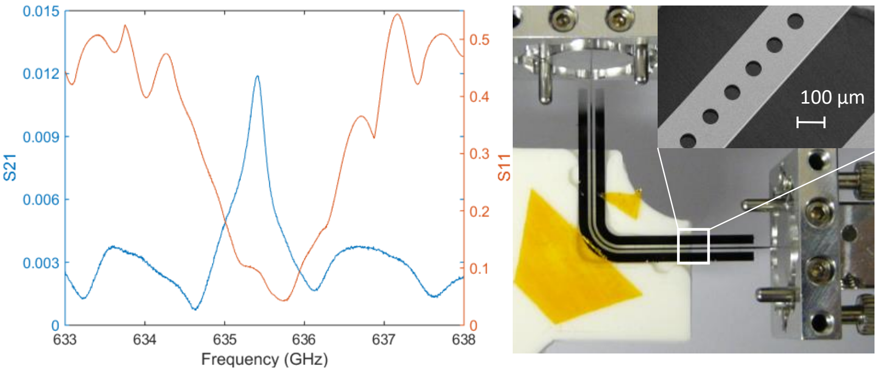


Fig. 1 Left panel: Normalized transmission and reflection through optical cavity. Right panel: Suspended silicon waveguide anchored to a substrate; Insert: SEM image of part of the photonic crystal cavity.

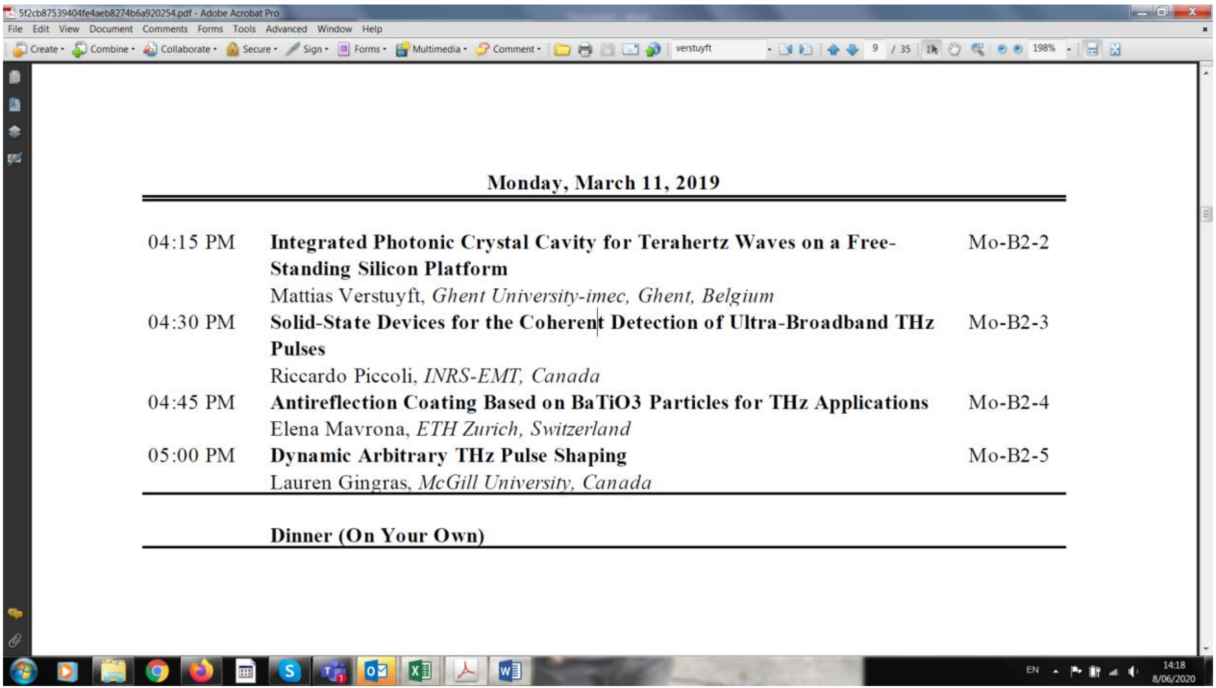
References

[1] Okamoto, et al. *Journal of Infrared, Millimeter, and Terahertz Waves*, *38*(9), 1085–1097, (2017).

[2] Bazin, A. *III-V Semiconductor Nanocavitieson Silicon-On-Insulator Waveguide : Laser Emission, Switching and Optical Memory*. (2013)

[3] Ranjkesh, N. et al. *IEEE Transactions on Terahertz Science and Technology*, *5*(2), 280–287, (2017).

[4] Xie, W. et al. *Journal of Lightwave Technology*, *32*(8), 1457–1462, (2014).



Monday, March 11, 2019

04:15 PM	**Integrated Photonic Crystal Cavity for Terahertz Waves on a Free-Standing Silicon Platform** Mattias Verstuyft, *Ghent University-imec, Ghent, Belgium*	Mo-B2-2
04:30 PM	**Solid-State Devices for the Coherent Detection of Ultra-Broadband THz Pulses** Riccardo Piccoli, *INRS-EMT, Canada*	Mo-B2-3
04:45 PM	**Antireflection Coating Based on BaTiO3 Particles for THz Applications** Elena Mavrona, *ETH Zurich, Switzerland*	Mo-B2-4
05:00 PM	**Dynamic Arbitrary THz Pulse Shaping** Lauren Gingras, *McGill University, Canada*	Mo-B2-5

Dinner (On Your Own)

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