Laboratory for Biomedical Imaging and Sensing

OASIS 8

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Miniature ultrasound detector arrays in silicon photonics using amplitude transmission monitoring

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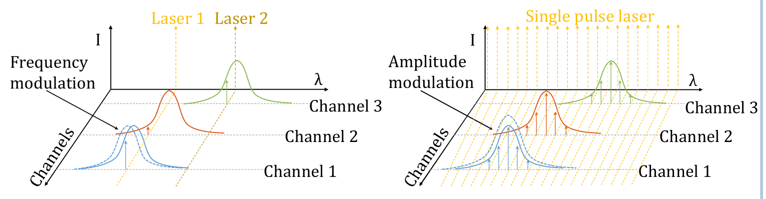
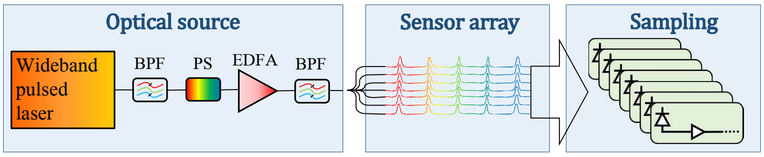
INTRODUCTION

Silicon-photonics holds the promise for a new generation of ultrasound-detection technology, based on optical resonators, with unparalleled miniaturization levels, sensitivities, and bandwidths, creating new possibilities for minimally invasive medical devices. While existing fabrication technologies are capable of producing dense resonator arrays whose resonance frequency is pressure sensitive, simultaneously monitoring the ultrasound-induced frequency modulation of numerous resonators has remained a challenge. Conventional techniques, which are based on tuning a continuous-wave laser to the resonator wavelength, are not scalable due to the wavelength disparity between the resonators, requiring a separate laser for each resonator. In this work, we show that also the Q-factor and transmission peak of silicon-based resonators can be pressure sensitive, exploit this phenomenon to develop a readout scheme based on monitoring the amplitude, rather than frequency, at the output of the resonators using a single pulse source.



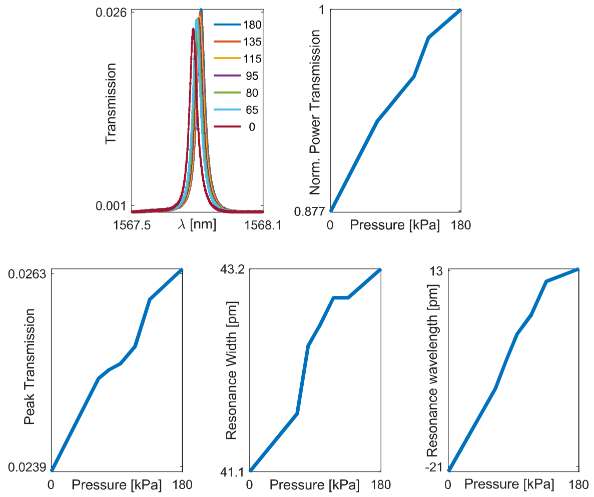
SYSTEM SETUP

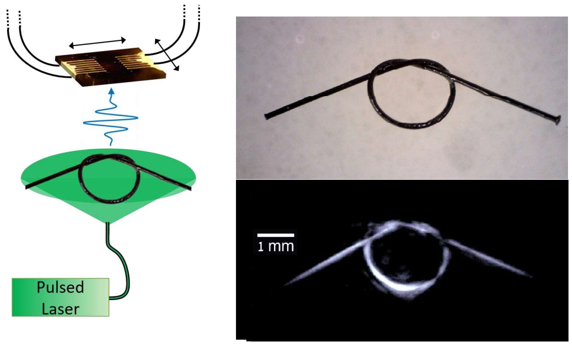
A simple system configuration used to detect the transmission modulation is constructed of a single wideband pulsed laser followed by filters and amplifier. The output of the source is split into 7 silicon-photonics waveguides, where in each waveguide 5 π-BG resonators were fabricated at different wavelength bands. The following sampling is merely an intensity detection.



RESULTS

This phenomenon and technique, termed pulse transmission amplitude monitoring (PTAM), is demonstrated under static pressure showing the modulation of the transmission amplitude, bandwidth and frequency. Furthermore, PTAM is demonstrated compatible with optoacoustic tomography.





CONCLUSIONS

PTAM requires a single pulse source, engineered to cover the wavelength span of the resonators, and a single photodetector per acoustic channel, making the technique scalable, potentially enabling simultaneous readout of hundreds of acoustic channels, as commonly performed with piezoelectric transducers. Using PTAM with large detection matrices, rapid three-dimensional optoacoustic and ultrasound imaging may be performed at unprecedented resolutions and rate.

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