Silicon photonic sensor with intensity interrogation by employing the cascade of ring resonator and Mach-Zehnder Interferometer

Li, Z. Y.; Zou, J.; Zhu, Huihui; Zhang, Hui; Cai, H.; Yang, Z. C.; Jin, Y. F.; Hao, Y. L.; Liu, Ai Qun

2020

Li, Z. Y., Zou, J., Zhu, H., Zhang, H., Cai, H., Yang, Z. C., Jin, Y. F., Hao, Y. L. & Liu, A. Q.
(2020). Silicon photonic sensor with intensity interrogation by employing the cascade of
ring resonator and Mach-Zehnder Interferometer. 2020 Conference on Lasers and
Electro-Optics, Part F181-CLEO-AT 2020, JTU2F.12-.
https://dx.doi.org/10.1364/CLEO_AT.2020.JTu2F.12

<https://hdl.handle.net/10356/151469>

https://doi.org/10.1364/CLEO_AT.2020.JTu2F.12

Silicon Photonic Sensor with Intensity Interrogation by Employing the Cascade of Ring Resonator and Mach-Zehnder Interferometer

Z. Y. Li^{1,2}, J. Zou², H. H. Zhu², H. Zhang², H. Cai³, Z. C. Yang¹, Y. F. Jin¹, Y. L. Hao¹, A. Q. Liu²

¹Institute of Microelectronics, Peking University, Beijing 100871, China

²Quantum Science and Engineering Centre, Nanyang Technological University, Nanyang Avenue 50, Singapore 639798, Singapore

³Institute of Microelectronics, A*STAR (Agency for Science, Technology and Research), Singapore 138634, Singapore

Author e-mail address: li.zhenyu@pku.edu.cn

Abstract: A silicon photonic sensor with intensity interrogation by employing the cascade of ring resonator and MZI is proposed and theoretically investigated. Photodetector used instead of spectrometer leads to prospect of low cost sensor system.

1. Introduction

Wavelength interrogation is a widely used method to interrogate resonance wavelength shift of the optical ring resonator sensor. However, it usually requires a tunable laser source with super-narrow line-width or a high resolution optical spectrometer [1], which is very expensive and bulky, limiting the integration of ring resonator sensor system and the application of portable low-cost sensing detection. In order to reduce the cost, broadband source is used to excite ring resonator sensor and on-chip spectrometer such as arrayed waveguide grating is employed to interrogate the resonance wavelength shift [2]. And in recent years, due to a surge in demand for hand-held sensing devices in the application of various on-site testing, researchers for ring-based sensing system with low cost and high portability are still ongoing. In this paper, we present a new sensing architecture based on the cascade of a sensing ring and a Mach-Zehnder Interferometer (MZI). In order to reduce the detection cost, we employ a broadband light source as input of the sensing structure and the direct detection of light intensity ratio between the two output ports of the MZI readout unit is utilized to interrogate the sensing ring.

Fig. 1. Schematic of the proposed photonic sensor

Fig. 1 shows schematic of the proposed photonics sensor with the cascade of a ring sensing unit and a MZI readout unit. First, a broadband light source is employed to excite the sensing ring and a resonance peak occurs in its drop port. Then the resonance peak is launched into the input of the MZI, i.e. a Y-splitter, which divides the input light beam into two sub-beams with equal intensity. After propagating in different paths, these two sub-beams pass through a directional coupler (DC). Finally, data signals coming from two output ports of the DC are collected by two photo-detectors or an infrared camera.

2. Experimental Results and Discussions

Fig. 2 shows microscope picture of cascade of ring resonator sensor and MZI interferometer. For the MZI with two output ports, two arms have length difference.

Fig. 2. Microscope picture of cascade of ring resonator and MZI interferometer

For this sensor, we use temperature variation as environment change, which leads to effective refractive index change. The relationship between temperature and resonance wavelength is regarded as linearity in this range. Therefore, what Fig. 3 shows is able to transfer to the relationship between the resonance wavelength and output intensity signal. And in Fig. 3, it shows that output intensity signal is linear with temperature. Herein, it is reasonable to say that the output signal difference reflect the resonance wavelength shift used by new architecture in this manuscript.

Fig. 3. Experimental results of outputs signal versus temperature variation

3. Conclusions

In summary, we presented a silicon photonics sensor with intensity interrogation by employing the cascade of ring resonator and Mach-Zehnder interferometer. The direct detection of light intensity ratio between the two output ports of the MZI is employed to interrogate the sensing ring, which significantly reduces the cost compared to the conventional wavelength interrogation.

Acknowledgement

This work was supported by the Singapore National Research Foundation under the Competitive Research Program (NRF-CRP13-2014-01), the Singapore Ministry of Education (MOE) Tier 3 grant (MOE2017-T3-1-001) and Chinese Scholarship Council (CSC).

References

- [1] A. Yalcin, K. C. Papat, J. C. Aldridge, T. A. Desai, J. Hryniewicz, N. Chbouki, B. E. Little, O. King, V. Van, S. Chu, D. Gill, M. Anthes-Washburn, M. S. Ünü, and B. B. Goldberg "Optical sensing of biomolecules using microring resonators," *IEEE J. Sel. Top. Quantum Electron.*, 12(1):148-155, 2006.
- [2] N. A. Yebo, W. Bogaerts, Z. Hens, and R. Baets, "On-chip arrayed waveguide grating interrogated silicon-on-insulator microring resonator-based gas sensor," *IEEE Photon. Technol. Lett.*, vol. 23, no. 20, pp. 1505-1507, 2011.
- [3] Z. Xie, Z. Cao, Y. Liu, Q. Zhang, J. Zou, L. Shao, Y. Wang, J. He, and M. Li, "Highly-sensitive optical biosensor based on equal FSR cascaded microring resonator with intensity interrogation for detection of progesterone molecules," *Opt. Express*, 25(26), pp. 33193-33201, 2017.