

## Eric J. Zhang

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### Education

|                   |  |                       |
|-------------------|--|-----------------------|
| 05/2013 - 10/2016 | Ph.D. (Electrical Engineering)           | Princeton University  |
| 09/2011 - 05/2013 | M.A. (Electrical Engineering)            | Princeton University  |
| 09/2006 - 05/2010 | B.A.Sc. in Engineering Science (Physics) | University of Toronto |

### Research Interests

Expertise in optical spectroscopy for trace-gas sensing, with application to environmental and medical monitoring. Specialization in polarization spectroscopy of paramagnetic species and integrated photonic chip sensors. Experience with development of adaptive spectral fitting algorithms for sensor precision and stability enhancement, and distributed sensor networks for methane emissions monitoring.

### Experience

|                   |  |
|-------------------|--|
| 11/2016 - 03/2019 | IBM T. J. Watson Research – Postdoctoral Researcher<br><i>Silicon integrated nanophotonics for trace-gas sensing</i>   |
| 09/2011 - 10/2016 | Princeton University – Ph.D. Candidate<br><i>Noise mitigation techniques for high-precision laser spectroscopy</i>     |
| 06/2015 - 09/2015 | IBM T. J. Watson Research – Research Internship<br><i>Methane absorption spectroscopy on a silicon photonic chip</i>   |
| 09/2012 - 01/2013 | Princeton University – Assistant in Instruction (AI)<br><i>ELE 351: Electromagnetic Field Theory</i>                   |
| 05/2009 - 08/2009 | University of Toronto – NSERC USRA<br><i>Modulation of fiber ring resonators beyond the relaxation resonance limit</i> |

### Professional / Extracurricular Activities

|      |   |                               |
|------|---|-------------------------------|
| 2019 | OSA Ambassador                              | -- Optical Society of America |
| 2019 | CLEO Committee – Active Optical Sensing     | -- Optical Society of America |
| 2015 | Graduate Student Committee (elected member) | -- Princeton University, NJ   |

### Awards / Funding

|      |  |
|------|--|
| 2018 | First Plateau Invention Achievement Award (IBM T. J. Watson Research)                  |
| 2016 | Patent Application Invention Achievement Award (IBM T. J. Watson Research)             |
| 2014 | Walbridge Fund Graduate Award (Princeton Environmental Institute)                      |
| 2014 | Alexander Graham Bell Canada Graduate Scholarship (NSERC CGS-D @ Princeton University) |
| 2011 | First Year Engineering Fellowship (Princeton University)                               |
| 2009 | NSERC Undergraduate Research Award (NSERC-USRA @ University of Toronto)                |
| 2006 | Wallberg Admission Scholarship (University of Toronto)                                 |
| 2006 | Queen Elizabeth II Aiming for the Top Scholarship (University of Toronto)              |

## Publications / Extended Proceedings

1. E. J. Zhang, Y. Martin, J. S. Orcutt, C. Xiong, M. Glodde, N. Marchack, E. A. Duch, T. Barwicz, L. Schares, W. M. J. Green, "Monolithically integrated silicon photonic chip sensor for near-infrared trace-gas spectroscopy," *Submitted to Proc. SPIE CBRNE XX (ID: SI19-SI211-28)*, (March 2019).
2. E. J. Zhang, C. C. Teng, T. G. van Kessel, L. Klein, R. Muralidhar, C. Xiong, Y. Martin, J. S. Orcutt, L. Schares, N. Sosa, G. Wysocki, W. M. J. Green, "Field deployment of a portable optical spectrometer for methane leak monitoring on oil and gas well pads," *Manuscript in preparation*, (2018).
3. E. J. Zhang, L. Tombez, C. C. Teng, G. Wysocki, W. M. J. Green, "An adaptive etalon suppression technique for long-term stability improvement in high index contrast waveguide-based laser absorption spectrometers," *Submitted to Electronics Letters (ID: ELL-2019-0901)*, (March 2019).
4. E. J. Zhang, C. C. Teng, T. G. van Kessel, L. Klein, R. Muralidhar, C. Xiong, Y. Martin, J. S. Orcutt, M. Khater, L. Schares, T. Barwicz, N. Marchack, S. Kamalpurkar, S. Engelmann, G. Wysocki, N. Sosa, W. M. J. Green, "Localization and quantification of trace-gas fugitive emissions using a portable optical spectrometer," *Proc. SPIE 10629, CBRNE Sensing XIX*, (2018).
5. E. J. Zhang, "Noise mitigation techniques for high-precision laser spectroscopy and integrated photonic chemical sensors," *Doctoral Dissertation*, Dept. of Electrical Engineering, Princeton University, Princeton, (2016).
6. E. J. Zhang, D. Sigman, and G. Wysocki, "In-situ optical subtraction using a differential dual-modulation Faraday rotation spectrometer for real-time nitric oxide isotopic analysis," *Manuscript in preparation*, (2016).
7. E. J. Zhang, S. Huang, Q. Ji, M. Silvernagel, Y. Wang, B. Ward, D. Sigman, and G. Wysocki, "Nitric Oxide Isotopic Analyzer based on a Compact Dual-modulation Faraday Rotation Spectrometer," *Sensors*, 15 (10), 25992-26008, (2015).
8. E. J. Zhang, B. E. Brumfield, and G. Wysocki, "Hybrid Faraday rotation spectrometer for sub-ppm detection of atmospheric O<sub>2</sub>" *Opt. Exp.* 22 (13), 15957-15968, (2014).
9. E. J. Zhang, W. D. Sacher, and J. K. S. Poon, "Hydrofluoric acid flow etching of low-loss subwavelength-diameter biconical fiber tapers," *Opt. Exp.* 18 (21), 22593-22598, (2010).
10. L. Tombez, E. J. Zhang, J. Orcutt, and W. M. J. Green, "Methane spectroscopy on a silicon photonic chip," *Optica* 4 (11), 1322-1325, (2017).
11. W. D. Sacher, E. J. Zhang, B. A. Kruger, and J. K. S. Poon, "High-speed laser modulation beyond the relaxation resonance frequency limit," *Opt. Exp.* 18 (7), 7047-7054, (2010).
12. C. Xiong, Y. Martin, E. J. Zhang, J. S. Orcutt, M. Glodde, L. Schares, T. Barwicz, C. C. Teng, G. Wysocki, W. M. J. Green, "Silicon photonic integrated circuit for on-chip spectroscopic gas sensing," *Proc. SPIE 109230G, Silicon Photonic XIV*, (2019).
13. A. Hangauer, J. Westberg, E. J. Zhang, and G. Wysocki, "Wavelength modulated multiheterodyne spectroscopy using Fabry-Perot quantum cascade lasers," *Opt. Exp.* 24 (22), 25298-25307, (2016).
14. Y. Wang, M. Nikodem, E. J. Zhang, F. Cikach, J. Barnes, S. Comhair, R. A. Dweik, C. Kao, G. Wysocki, "Shot-noise limited Faraday rotation spectroscopy for detection of nitric oxide isotopes in breath, urine, and blood," *Nature Scientific Reports* 5 (9096), (2015).

## Conference Presentations

1. E. J. Zhang, Y. Martin, J. S. Orcutt, C. Xiong, M. Glodde, T. Barwicz, L. Schares, E. A. Duch, N. Marchack, C. C. Teng, G. Wysocki, W. M. J. Green, "Trace-gas spectroscopy of methane using a monolithically integrated silicon photonic chip sensor," *Accepted to Conference on Lasers and Electro-optics S&I13 – Active Optical Sensing*, (Submission ID: 3161929), San Jose CA., May 2019.

2. E. J. Zhang, Y. Martin, J. S. Orcutt, C. Xiong, M. Glodde, N. Marchack, E. A. Duch, T. Barwicz, L. Schares, W. M. J. Green, "Monolithically integrated silicon photonic chip sensor for near-infrared trace-gas spectroscopy," *Accepted to SPIE-DCS 2019 CBRNE XX, Paper SI211-28*, Baltimore, MD. April 2019.
3. E. J. Zhang, Y. Martin, C. Xiong, J. S. Orcutt, M. Glodde, L. Schares, T. Barwicz, C. C. Teng, G. Wysocki, W. M. J. Green, "Integrated photonic on-chip sensor for methane fugitive emissions monitoring," *AGU 2018 Fall Meeting*, Washington DC., December 2018.
4. E. J. Zhang, L. Schares, J. S. Orcutt, C. Xiong, Y. Martin, T. Barwicz, C. C. Teng, M. Khater, G. Wysocki, W. M. J. Green, "Methane absorption spectroscopy with a hybrid III-V silicon external-cavity laser," *Conference on Lasers and Electro-Optics (Sth1B.2)*, San Jose, May 2018.
5. E. J. Zhang, C. C. Teng, T. G. van Kessel, L. Klein, R. Muralidhar, C. Xiong, Y. Martin, J. S. Orcutt, M. Khater, L. Schares, T. Barwicz, N. Marchack, S. Kamlapurkar, S. Engelmann, G. Wysocki, N. Sosa, W. M. J. Green, "Localization and quantification of trace-gas fugitive emissions using a portable optical spectrometer," *SPIE Defense and Security (DS105-44)*, CBRNE Sensing XIX, Orlando, April 2018.
6. E. J. Zhang, "Trace-gas spectroscopy of methane on a silicon photonic chip," *Energy Materials Nanotechnology Europe Meetings, (Invited Talk)* Budapest, 2017.
7. E. J. Zhang, J. Westberg, G. Wysocki, "Novel implementations of Faraday rotation spectroscopy – from in situ radical detection to studies of environmental nitrogen cycling," *International Symposium on Molecular Spectroscopy, 71<sup>st</sup> meeting*, Champaign-Urbana, June 2016.
8. E. J. Zhang, L. Tombez, J. S. Orcutt, S. Kamlapurkar, G. Wysocki, W. M. J. Green, "Silicon photonic on-chip trace-gas spectroscopy of methane," *Conference on Lasers and Electro-optics (SF2H.1)*, San Jose, June 2016.
9. E. J. Zhang, D. M. Sigman, G. Wysocki, "Analysis of nitric oxide isotopes via differential Faraday rotation spectroscopy," *Conference on Lasers and Electro-optics (ATh3J.3)*, San Jose, June 2016.
10. E. J. Zhang, S. Huang, Q. Ji, M. Silvernagel, B. Ward, D. Sigman, G. Wysocki, "Nitric oxide fractionation studies and isotopic ratiometry using time-multiplexed dual-modulation Faraday rotation spectroscopy," *International Conference on Advanced Vibrational Spectroscopy*, Vienna, July 2015.
11. E. J. Zhang, S. Huang, M. Silvernagel, G. Wysocki, "Transportable dual-modulation Faraday rotation spectrometer for time-multiplexed nitric oxide isotope ratiometry," *Conference on Lasers and Electro-Optics*, San Jose, May 2015 [Semi-Finalist; Maiman Outstanding Student Paper Competition].
12. E. J. Zhang, G. Wysocki, "Differential Faraday rotation spectrometer for detection of nitric oxide isotopes," *Laser Applications for Chemical Sensing and Environmental Applications (LW1D.6)*, Seattle, July 2014.
13. E. J. Zhang, Y. Wang, K. Aulak, J. Barnes, L. Tian, D. Grove, R. Dweik, G. Wysocki, "Dual-modulation Faraday rotation spectrometer for simultaneous detection of nitric oxide isotopologues," *Field Laser Applications in Industry and Research*, Florence, May 2014.
14. E. J. Zhang, F. Nuruzzaman, Y. Wang, D. Sigman, G. Wysocki, "Isotopic ratiometry of Nitric Oxide using a dual-modulation Faraday rotation spectrometer," *Conference on Lasers and Electro-Optics (SM1E.2)*, San Jose, June 2014.
15. E. J. Zhang, B. E. Brumfield, G. Wysocki, "Faraday rotation spectroscopy of O<sub>2</sub> using a distributed feedback diode laser and a static magnetic field," *Conference on Lasers and Electro-Optics*, San Jose, June 2013.

16. E. J. Zhang, J. Mikkelsen, J. K. S. Poon, “Cross-sectional geometry control of low-loss biconical fiber tapers using hydrofluoric acid flow etching,” *Conference on Lasers and Electro-Optics* (CW3L.3), Baltimore, May 2011.
17. W. M. J. Green, E. J. Zhang, C. Xiong, Y. Martin, J. S. Orcutt, M. Glodde, L. Schares, T. Barwicz, C. C. Teng, N. Marchack, E. A. Duch, S. Kamlapurkar, S. Engelmann, N. Hinds, T. Picunco, R. Wilson, G. Wysocki, “Silicon photonic gas sensing,” *SPIE-OFC (Silicon Photonics XIV)*, (invited contribution), March 2019.
18. C. C. Teng, E. J. Zhang, C. Xiong, Y. Chen, J. Westberg, W. M. J. Green, G. Wysocki, “Dynamic optical fringe suppression for silicon photonic sensors,” *Conference on Lasers and Electro-Optics* (SW3L.7), San Jose, May 2018.
19. J. Westberg, E. J. Zhang, A. Hangauer, G. Wysocki, “Wavelength modulated multi-heterodyne spectroscopy with quantum cascade lasers,” *International Conference on Intersubband Transitions in Quantum Wells*, Vienna, Sept. 2015.
20. B. Brumfield, E. J. Zhang, Y. Wang, G. Wysocki, “Quantum cascade laser based mid-IR Faraday rotation spectrometers for environmental, medical and combustion diagnostics,” *International Quantum Cascade Lasers School and Workshop*, Policoro, Italy, Sept. 2014.
21. C. Xiong, Y. Martin, E. J. Zhang, J. S. Orcutt, M. Glodde, L. Schares, T. Barwicz, C. C. Teng, G. Wysocki, W. M. J. Green, “Silicon photonic integrated circuit for on-chip spectroscopic gas sensing,” *SPIE Photonics West, (Invited Talk)*, Paper 10923-15 San Francisco, January 2019.
22. C. C. Teng, C. Xiong, E. J. Zhang, Y. Martin, M. Khater, J. Orcutt, W. M. J. Green, G. Wysocki, “Fiber-pigtailed silicon photonic sensors for methane leak detection,” *Conference on Lasers and Electro-optics* (AM3B.2), San Jose, May 2017 [Maiman Student Paper Competition: Finalist].
23. J. Westberg, L. Sterczewski, E. J. Zhang, A. Hangauer, G. Wysocki, “Multi-heterodyne spectroscopic techniques using Fabry-Perot quantum cascade lasers for trace gas detection,” *Conference on Lasers and Electro-optics*, Paper STh4J.4, San Jose, June 2016.
24. W. M. J. Green, C. Xiong, E. J. Zhang, L. Tombez, Y. Martin, J. Chang, T. Barwicz, M. Khater, G. Wysocki, H. Hamann, “Silicon photonics for on-chip trace-gas spectroscopy,” *3<sup>rd</sup> ACM International Conference on Nanoscale Computing and Communication*, Paper S6.2 (Invited Talk) New York, Sept. 2016.
25. G. Wysocki, Y. Wang, E. J. Zhang, B. Brumfield, A. Hangauer, M. Nikodem, “Fundamental noise limits in modern spectroscopic systems,” *Field Laser Applications in Industry and Research*, Florence, May 2014.
26. A. Hangauer, J. Westberg, M. Soskind, E. J. Zhang, G. Wysocki, “Noise properties in multi-heterodyne spectrometers based on quantum- and interband-cascade lasers,” *Conference on Lasers and Electro-Optics*, Paper SW1G.4, San Jose, May 2015.
27. A. Hangauer, J. Westberg, M. Soskind, E. J. Zhang, G. Wysocki, “Noise statistics in multi-heterodyne spectrometers based on interband- and quantum cascade lasers,” *European Conference on Lasers and Electro-Optics* (CH\_8\_5), Munich, Germany, June 2015.
28. W. M. J. Green, C. Xiong, M. Khater, Y. Martin, E. J. Zhang, Chu C. Teng, J. S. Orcutt, L. Schares, T. Barwicz, N. Marchak, S. J. Holmes, S. Kamlapurkar, S. Engelmann, G. Wysocki, “Methane trace-gas sensing enabled by silicon photonic integration,” *European Conference on Integrated Optics*, Valencia, Spain, May 2018.
29. W. M. J. Green, C. Xiong, M. Khater, Y. Martin, E. J. Zhang, Chu C. Teng, J. S. Orcutt, L. Schares, T. Barwicz, N. Marchak, S. J. Holmes, S. Kamlapurkar, S. Engelmann, G. Wysocki, “Methane trace-gas sensing enabled by silicon photonic integration,” *European Materials Research Society Spring Meeting*, Paper P.17.1 (Invited Talk), Strasbourg, France, May 2017.

30. C. Xiong, D. Gill, J. Proesel, J. Orcutt, Y. Martin, M. Khater, E. J. Zhang, W. Haensch, W. M. J. Green, "Silicon photonics for high-speed data communications and sensing," *Conference on Lasers and Electro-optics Pacific Rim, (Invited Talk)*, Singapore, 2017.
31. Y. Martin, J. S. Orcutt, C. Xiong, L. Schares, T. Barwicz, M. Glodde, S. Kamlapurkar, E. J. Zhang, W. M. J. Green, V. Dolores-Calzadilla, A. Sigmund, M. Moehrle, "Flip-chip III-V-to-Silicon Photonics Interfaces for Optical Sensor," *IEEE Electronic Components and Technology Conference* (accepted), Las Vegas, NV, May 2019.
32. W. M. J. Green, C. Xiong, L. Tombez, J. S. Orcutt, Y. Martin, J. Chang, T. Barwicz, M. Khater, H. Hamann, E. J. Zhang, G. Wysocki, "Silicon photonics for on-chip trace-gas spectroscopic sensing," *IEEE Photonics Society Summer Topicals Meeting*, Paper TuA3.2 (*Invited Talk*), Newport Beach, CA, July 2016.

### Invited Seminars / Workshops

1. E. J. Zhang, "Silicon photonic chip sensor for air quality monitoring applications," *INECC-IBM Workshop*, Mexico City, Mexico, November 2018.
2. E. J. Zhang, "Trace-gas spectroscopy of methane on an integrated silicon photonic chip," *Physical Sciences Seminar Series*, IBM Research, Yorktown Heights, New York, October 2018.
3. E. J. Zhang, "Trace-gas spectroscopy of methane on a silicon photonic chip," *OSA Chapter Meeting, (Invited Seminar)*, Princeton University, Princeton, New Jersey, December 2017.
4. E. J. Zhang, "Noise mitigation techniques for high-precision laser spectroscopy and integrated photonic chemical sensors," *Public Doctoral Dissertation Defense* (Princeton University), Princeton, New Jersey, October 2016.
5. E. J. Zhang, "Noise reduction techniques for precision spectroscopy," (*Invited Seminar*), National Research Council of Canada, Ottawa, Canada, June 2016.
6. E. J. Zhang, "Noise reduction techniques for precision spectroscopy," Thorlabs, Newton, New Jersey, July 2016.
7. E. J. Zhang, M. Silvernagel, F. Nuruzzaman, D. Sigman, G. Wysocki, "Differential Faraday rotation spectroscopy for nitric oxide isotopic analysis," *Mid-infrared Technologies for Health and the Environment Workshop*, Princeton, New Jersey, July 2014 [runner up: graduate student/postdoctoral talk competition].
8. E. J. Zhang, S. Huang, Q. Ji, B. Ward, D. Sigman, G. Wysocki, "Time-multiplexed isotopic ratiometry of nitric oxide via dual-modulation Faraday rotation spectroscopy," *Princeton Environmental Institute*, Princeton, New Jersey, April 2014.
9. E. J. Zhang, B. E. Brumfield, G. Wysocki, "Hybrid-FRS: high-sensitivity detection of paramagnetic molecules," *E-filiates Annual Meeting*, Andlinger Center for Energy and the Environment, Princeton, New Jersey, October 2013.
10. E. J. Zhang, B. E. Brumfield, G. Wysocki, "Towards shot-noise limited Faraday rotation spectroscopy of O<sub>2</sub> using static magnetic fields," *Mid-infrared Technologies for Health and the Environment Workshop*, Princeton, New Jersey, August 2013.
11. E. J. Zhang, J. K. S. Poon, "Fabrication of subwavelength diameter biconical fiber tapers," *Ontario on a Chip/MATCH Annual Symposium*, Toronto, May 2010.
12. E. J. Zhang, W. D. Sacher, J. K. S. Poon, "Fabrication of subwavelength diameter biconical fiber tapers," Electrical and Computer Engineering Departmental Seminar, (*Invited Seminar*), University of California (San Diego), San Diego, California, March 2010.
13. M. Silvernagel, E. J. Zhang, G. Wysocki, "Isotopic measurement of nitric oxide using a transportable dual-modulation Faraday rotation spectrometer," *Mid-infrared Technologies for Health*

and the Environment Workshop, Princeton, July 2014 [runner up – poster/flash presentation competition].

14. B. E. Brumfield, E. J. Zhang, G. Wysocki, “Low-power Faraday rotation spectroscopic O<sub>2</sub> sensor based on permanent magnets,” *Mid-infrared Technologies for Health and the Environment Workshop*, Baltimore, August 2012.
15. W. M. J. Green, C. Xiong, E. J. Zhang, L. Tombez, J. S. Orcutt, Y. Martin, J. Chang, T. Barwicz, M. Khater, G. Wysocki, H. F. Hamann, “Silicon photonics for on-chip trace-gas spectroscopy,” *MIRTHE+ Symposium on Regional Air Quality Monitoring in Safety and Security Applications*, (Invited Talk), New York, October 2016.
16. G. Wysocki, Y. Wang, M. Nikodem, E. J. Zhang, R. Dweik, “Modern laser spectroscopic technologies for metabolic studies,” *Precision Monitoring of Human Metabolism Workshop*, Princeton, New Jersey, February 2014.

### Patents / Invention Disclosures (alphabetical author list)

1. W. M. J. Green, L. Tombez, E. J. Zhang, “Resonator coupling modulation spectroscopy,” Docket No.: YOR820151082 (IBM Research), Appl. 15/008,664, U.S. Patent 9,476,770. Filed: Jan-28-2016, Granted: Oct-25-2016, (Patent Active).
2. W. M. J. Green, L. Tombez, E. J. Zhang, “Ensuring stable, precise, and accurate optical absorption spectroscopic trace gas concentration measurements in the presence of time-varying etalons,” Docket No.: YOR920151278US1 (IBM Research), Appl. 14/945,691, U.S. Patent 10,082,457. Filed: Nov-19-2015, Granted: Sep-25-2018, (Patent Active).
3. W. M. J. Green, C. C. Teng, G. Wysocki, E. J. Zhang, “On-chip spectroscopic sensors with optical fringe suppression,” Docket No.: YORP201702000US01 (IBM Research), Appl. 15/914,455, Filed: Mar-7-2018, (Patent Pending).
4. W. M. J. Green, C. C. Teng, G. Wysocki, E. J. Zhang, “Fourier domain dynamic correction method for complex optical fringes in laser spectrometers,” Docket No.: YORP201708060US01 (IBM Research).
5. W. M. J. Green, E. J. Zhang, “System and method for assessing spectroscopic sensor accuracy,” Docket No.: YORP201701730US01 (IBM Research).
6. W. M. J. Green, C. C. Teng, G. Wysocki, C. Xiong, E. J. Zhang, “Correcting laser ramping nonlinearities using an in-line frequency calibration reference for tunable diode laser absorption spectroscopy systems,” Docket No.: YORP201701870US01 (IBM Research).
7. M. Dittberner, W. M. J. Green, G. Wysocki, C. Xiong, E. J. Zhang, “Feed-forward spectral calibration methodology for line-scanned tunable laser absorption spectroscopy,” Docket No.: YORP201702000US01 (IBM Research).

### Industry Events (Exhibits + Tech Expos)

- ARPA-E Innovation Summit, *Annual Technology Showcase for IBM’s AIMS-MONITOR Program*, Booth 825, (Awardee No.: DE-AR0000540), Gaylord National Resort and Convention Center, National Harbor, MD, March 2018.
- ARPA-E Innovation Summit, *Annual Technology Showcase for IBM’s AIMS-MONITOR Program*, Booth 439, (Awardee No.: DE-AR0000540), Gaylord National Resort and Convention Center, National Harbor, MD, February 2017.
- Photonics West, *MIRTHE Exhibit: Faraday Rotation Spectrometer for Real-time Detection of Nitric Oxide (NO) Isotopes in Human Breath*, Booth 4236, Moscone Convention Center, San Francisco, CA, February 2014.

## Media Releases

- Voice of America (VOA), “Affordable chip pinpoints methane leaks,” [[Access URL](#)], Published Mar-27-2018.
- Society of Photo-optical Instrumentation Engineering (SPIE), “Silicon photonics spectrometer senses methane gas,” [[Access URL](#)], Published Oct-30-2017.
- Optical Society of America (OSA), “Tiny chip-based methane spectrometer could help reduce greenhouse gas emissions,” [[Access URL](#)], Published Oct-26-2017.

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