



# Optical sensors, 2022: introduction to the feature issue

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**Abstract:** This feature issue of *Optics Express* highlights contributions from authors who presented their latest research at the OPTICA Optical Sensors and Sensing Congress, held in Vancouver, British Columbia, Canada from 11–15 July 2022. The feature issue comprises 9 contributed papers, which expand upon their respective conference proceedings. The published papers introduced here cover a range of timely research topics in optics and photonics for chip-based sensing, open-path and remote sensing and fiber devices.

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## 1. Introduction

The OPTICA Optical Sensors and Sensing (OSS) Congress [1], held in Vancouver, British Columbia, Canada, brought together experts from several related areas of optics and photonics research. Specifically, the co-located OPTICA topical meetings were Fourier Transform Spectroscopy (FTS), Hyperspectral Imaging and Sounding of the Environment (HISE), Optical Sensors (SENSORS), and Optics and Photonics for Sensing the Environment (ES). The conference program included a diverse group of plenary, invited, and contributed speakers from around the world who discussed current trends at the intersection of light, photonics, and sensing.

The joint feature issue comprises 9 total publications all published in *Optics Express*. In the following sections, we introduce each paper and provide context for how they fit within the broader OSS Congress themes.

## 2. Chip-based sensing: waveguides, crystals and new materials

There continues to be an increase in studies involving chip-based sensing architectures. As mentioned in previous roadmaps and reviews, advances in source, detector and planar waveguide technologies have opened up new avenues for chip-scale optical sensing but have not been widely adopted in the developments of optically based chemical and biological sensors. [2] Exciting new developments in on-chip components provide invaluable opportunity for optical sensors to evolve in the near future, but multidisciplinary efforts will be required to ensure sensor architectures with the appropriate specificity, adaptability and sensitivity are created. Commercial viability of these sensor types raises debates over the manufacturability versus capability for a variety of sensing applications.

This special issue highlights the activity in chip-based optical sensing as 5 out of the 9 articles involve study of optical sensing in planar geometries such as waveguides, microdisks or photonic crystals. Even though chip-scale optical platforms have enabled exciting fundamental research in optical sensing, fabrication of on-chip components has yet to make the full transition beyond university-based cleanrooms. This potentially has to do with lack of flexibility in silicon photonics processing in photonics foundries especially regarding non-CMOS-compatible

materials. With the capability to leverage different wavebands (in the visible, near-infrared, infrared, and mid-infrared) for sensing applications, there is potential in expanding the common optical materials used for sensing to include new low-loss infrared material sets such as  $\text{CHF}_3$  etched low loss GeSbSe-[3] waveguides and extended use of more standard SiN and Ge mainstays for a highly adaptable Fabry Perot sensors [4]. Finally, we continue to witness more examples of chemical and biological sensors with excellent sensitivities and more integrated features on sensing platforms that can be flexible making them fully adaptable to many chemical, biological and multiplexed sensing modalities [5, 6, 7].

### 3. Active open-path and remote sensing: combs and vibrometry

Active open-path and remote sensing of gases and objects often requires spatially coherent light sources of varying types for both coherent and spectroscopic purposes. Over the past decade, optical frequency combs (OFC) have continued to move beyond the laboratory setting combining not only optical coherence but high resolution and broad optical bandwidth. These characteristics have established OFCs as one of the premier techniques applicable to sensing environments gases and emissions in the field. [8] now report work towards a flexible dual frequency comb (DFC) source based on the gain-switching of mutually injection-locked semiconductor lasers. This highly adaptable source would enable detection of key gases like  $\text{CO}_2$ ,  $\text{NH}_3$  and  $\text{H}_2\text{O}$ .

Laser Doppler vibrometers (LDVs) are extremely sensitive devices traditionally used for ground and acoustic vibration sensing from a stationary platform, since platform motion of the LDV would compromise measurements. In an attempt to mitigate this shortcoming for ranging LDV measurements, [9] combines a laser array, a digital CMOS line scan camera and real-time processing to provide platform-motion-immune LDV measurements, thus extending the usefulness of this highly sensitive technique.

### 4. Fiber devices: biomedical advances

The use of fiber optic devices in medical settings has become commonplace including surgical rooms throughout the world. Intra-arterial catheter guidance is instrumental to the success of minimally invasive procedures, such as angioplasty. However, traditional device tracking methods, such as electromagnetic or infrared sensors, exhibits drawbacks such as magnetic interference or line of sight requirements. In the work by [10], shape sensing of bends of different curvatures and lengths is demonstrated both asynchronously and in real-time using optical frequency domain reflectometry (OFDR) with a polymer extruded optical fiber triplet with enhanced backscattering properties. The improved accuracy of these in-situ fiber devices over relevant fiber lengths bodes well for continued improvement of fiber device in the medical application space.

### 5. Outlook: Optical Sensors and Sensing Congress 2023

The next Optical Sensors and Sensing Congress will take place in Munich, Germany from 30 July –3 August 2023. The OPTICA Optical Sensors and Sensing Congress will concurrently run five OPTICA topical meetings in one location. Even with the dramatic effects of COVID, this Sensor meeting and congress have continued to grow in size and vibrancy. It is hoped that special issues like this one will continue this trend and provide the community with a vibrant meeting for exchanges the newest and best ideas from across the globe.

Finally, the joint feature issue guest editors, along with all the congress and topical meeting co-chairs, would like to thank our numerous committee members as well as the OPTICA professional staff for their support in creating a fantastic scientific program for inaugural OPTICA Optical Sensors and Sensing Congress 2022.

**Disclosures.** The authors declare that there are no conflicts of interest related to this article.

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