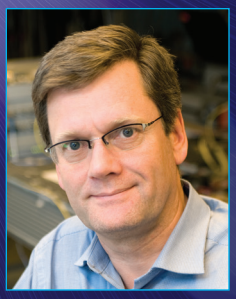
A LOOK AHEAD

Optics in 2023 & Beyond

Each December, OPN looks at interesting research results of the past year. But what about the year ahead? We asked several contributors to our "Optics in 2022" feature for thoughts on areas that might advance in 2023.



SPACE COMMUNICATION

We will in the next years see rapidly increasing activity in research and development on laser-based solutions in space communication, since these can enable the much higher capacity needed in the relative near future. This does not only include inter-satellite links, but also to and from the moon and eventually Mars. We can expect record-breaking studies showing feasibility of unprecedented data rates (Gbit/s) to/from Mars by use of advanced optical solutions such as adaptive multi-aperture optics and super-sensitive optical receivers.

Peter Andrekson, *Chalmers Tekniska Högskola, Goteborg, Sweden*

METAPHOTONICS

Metaphotonics emerged recently as a rapidly developing research field that employs many ideas of traditional optics enriched with new functionalities provided by metamaterials. In 2023 and beyond, we will see more demonstrations of practical metadevices with on-demand shaping of arbitrary light fields. Dielectric resonant metasurfaces will be employed for efficient spatial and temporal control of light with multipolar resonances and bound states in the continuum for implementation of metaphotonics concepts in nonlinear optics, quantum photonics, nanolasers and biosensing.

Yuri Kivshar, *Australian National University, Canberra, Australia*

NEAR-IR SPECTRAL SENSING

In 2023 and beyond, a spectral revolution will take place. Novel miniaturized chip-based spectral sensors with reduced complexity will enable *in-situ* and portable sensing, without the need for spectral reconstruction. This technology will allow the determination of material properties in many application fields such as in agriculture, process control and health care solutions. Moreover, we foresee an integration in for example smartphones, making the invisible world surrounding us visible to everyone.

Kaylee Hakkel, *Eindhoven University of Technology and MantiSpectra B.V., Eindhoven, Netherlands*

HIGH-DIMENSIONAL QUANTUM NETWORKING

Multi-frequency light is only beginning to be explored for distribution of entanglement in quantum networks. In 2023 and beyond, optical frequency will be considered not only as a resource for multiplexing of quantum information encoded in traditional degrees of freedom (DoF) such as polarization, but also as a means of encoding the quantum information itself. Supported by custom integrated-photonic circuits, we will see growing demonstrations of parallelized, reconfigurable and high-dimensional quantum networking over deployed fiber optics.

Andrew Weiner, *Purdue University, West Lafayette, IN, USA*

METASURFACE OPTICS

Metasurface optics has presented great potential for boosting the performance of imaging systems over the past decade and is now moving from the laboratory to the market. In 2023 and beyond, metasurfaces will be seamlessly integrated with cutting-edge image sensor and processing technologies. This could enable consumer cameras to capture what the human eye cannot see, such as spectrum, polarization and more. It will be exciting to find out what people see through such "meta-eyes."

Masashi Miyata, *NTT Corp., Atsugi, Kanagawa, Japan*

STRUCTURED LIGHT

Structured light, speckle patterns or complex fields in general are fascinating optical fields with vast potential for fundamental and applied physics. Tools of AI will empower us to have a better understanding of it. The power of deep learning will help to discover the underlying features of complex fields, which will guide us in the development of desired optical devices. Data-driven complex-field research will be the focus in 2023 and beyond.

Vijay Kumar, *NIT Warangal, Telangana, India*

Photos: Courtesy of the researchers
Infographic: John Zavada and Alessia Kirkland