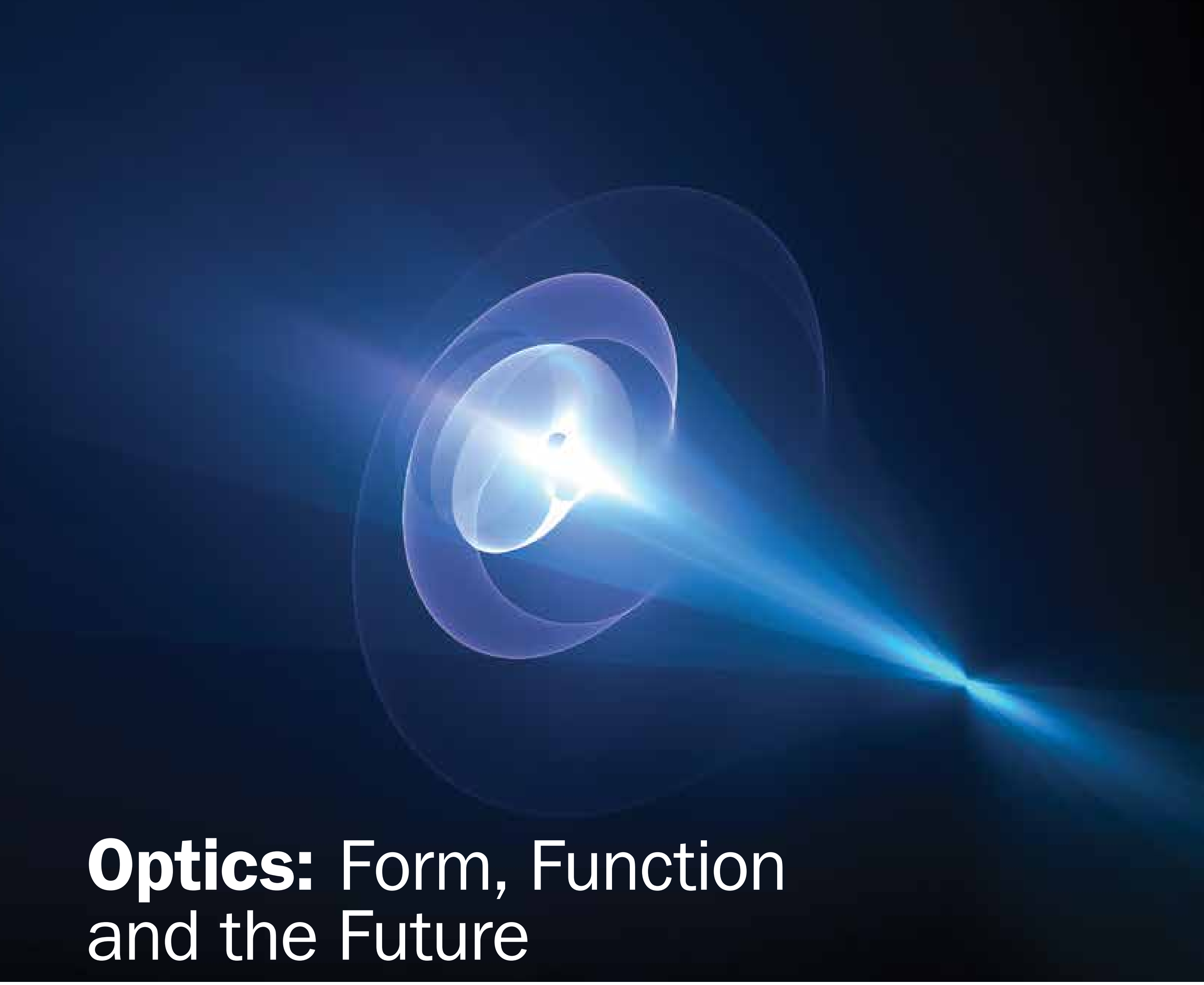

Optics: Form, Function and the Future

BY JUSTINE MURPHY
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For all of their diversity of form and function, the vast range of available optical components and optical fibers have much in common — materials, engineering and design, and techniques in fabrication and metrology. And they are among the critical enabling technologies of the future.

Today, optical technologies are integral to sensors, microscopes, lasers, cameras and more, and the list keeps growing. They are employed by the military for field detection in submarines and IR imaging on the battlefield. They can be found on factory floors and in surgical suites. The continuing commercialization of optical fiber has put it at the core of an increasingly connected world and nontelecom applications continue to expand, as well.

Several industry experts spoke recently with Photonics Spectra, reflecting on the state of the technologies when they first joined the industry, how the industry and optics have evolved in the years since, and what they think the future may bring. The experts are:

Jessica DeGroote Nelson, Ph.D., director of technology and strategy at Optimax Systems Inc. in Rochester, N.Y.

Amy Eskilson, president and CEO of Inrad Optics, based in Northvale, N.J.

Omur Sezerman, president, CEO and Chairman of the Board of OZ Optics Ltd. in Ottawa, Ontario, Canada.

Q: What were some notable technologies when you started in the industry? How has the field evolved since then?

Eskilson: The first large-scale commercial photonics application was gigabit-capable optical fiber for phone and data communications. Thousands of kilometers of high-capacity optical fiber was installed in the late 1990s to manage the expected demand for bandwidth, and investment dollars poured into the industry. I recall trade show exhibits in 2000 that seemed to be populated with as many financial sector attendees as end users. It turned out that the demand was overhyped, both for fiber installed in the ground and in the financial markets, leading to the telecom crash in 2001.

Over the last 25 years, it has been fantastic to watch and participate in the ongoing commercialization of optical technologies. Because of its highly fragmented and often customized nature, understanding the true size and scope of the photonics marketplace has been difficult. However, when we aggregate just a few of the broadly deployed technologies enabled by photonics — smartphone cameras, optical communications, medical lasers for everything from cardiac ablation to tattoo removal, fiber lasers and high-power lasers for industrial applications — the cumulative impact is staggering. Most importantly, the industry is still young. This is what is so very exciting about the work we do every day.

DeGroote Nelson: Magnetorheological finishing (MRF) had just been commercialized by QED Technologies, along with other deterministic processes developed, and more importantly, commercialized. It was a very important advancement to the entire optics manufacturing market, particularly for aspheres.

In the field of optical manufacturing, optical fabrication and metrology techniques push each other to new limits all the time, and I've seen quite a number of changes and advancements. For example, CNC deterministic manufacturing allowed for easier manufacturing of aspheric components. Initially, fabricators were limited to spherical nulls, profilometry, or if they were fortunate, a computer-generated hologram (CGH).

The advancement of stitching interferometry, high-precision profilometry, and more readily available CGH made fractional wave aspheric measurement possible. Advances like this continue to happen as optical designs become more complex and require higher performance. Many designs are more compact and off-axis, which is pushing optical manufacturing to produce freeform optics.

Sezerman: Originally, fiber optics was supported by the military and medical applications, where they were very expensive to use. Telecom and datacom markets opened up because of the invention of low-cost and low-loss fibers, lasers, detectors, optical amplifiers and wave division multiplexing. The military used it originally for skew communications because it's impossible to tap into a fiber optic communication line without being detected. Also, fiber optics is immune to magnetic radiation because light is not affected by nuclear bombs or electromagnetic interference. Later on, the military got into the sensor end of it and used fiber optics for sensing for gyroscopes and missiles, and also for magnetic field detection for submarines and interferometry.

Another application was using fibers and high-power lasers in surgery as a scalpal. Most of the time, [surgeons] used knives and then had to heat them up to stop the bleeding. With the high-power laser with the fiber, you cut and also burn the tips of the arteries at the same time to stop the bleeding. They were also used for medical endoscopes or for machinery endoscopes to find hard-to-see places.

Q: What are you working on currently, and what are the implications of that work?

Eskilson: At Inrad Optics we focus on high-barrier-to-entry and niche technologies well suited to our unique capabilities — specifically crystalline materials development, certain high-precision optical components, complex optomechanical assemblies, and optomechatronic subassemblies. We have found that there is an unmet need in the marketplace for companies willing to work collaboratively with their customers on multidimensional optical projects.

The development of stilbene, a fast neutron scintillator crystal for nuclear threat detection, is a great example of such collaboration. We partnered with Lawrence Livermore National Laboratory, and were funded by the U.S. Department of Homeland Security, to develop a material that has the potential to make an extraordinarily positive impact on society.

DeGroote Nelson: At Optimax, we are working on developing new manufacturing and testing techniques for freeform optics. Freeform optics will allow designers more freedom in their optical designs for lighter-weight, and more compact and off-axis designs. One specific application is monolithic freeform systems, where multiple freeform surfaces are polished into one monolithic piece of material. The benefit of these systems is that all of the alignment and surface registration is completed during the manufacturing process, and additional alignment between the surfaces is not necessary during assembly.

Sezerman: We are expanding our product lines. Half of our products now are telecom, and the other half are nontelecom; of the nontelecom, applications include medical, industrial sensors, oil and gas utilities, and always research and development for universities and new products.

We've gotten into terahertz imaging and sensing. I call terahertz a "Superman" vision because it can see through things that x-rays cannot see through. I see terahertz at a stage where fiber optics was 30 years ago — it was very raw and undiscovered.

We are also working on a number of fiber optics components for OCT applications. We work on two-micron components, which is an upcoming wavelength for sensors and sensing applications, and also for medical applications. And we work on fiber optics products like high-speed polarization controllers and scramblers, and broadband tunable filters. We talk about high-speed delay lines, motorized and nonmotorized. In terms of applications, we work on five or six visible light color combiners — red/green/blue and other visible wavelengths. And then we developed test equipment like back-reflection and ER meters for nontelecom wavelengths.

We're also developing sensors for perimeter and border security, which is very important lately with everything that's going on in the world. You can sense any intrusion through a border, or an airport or hospital. So instead of putting up an actual wall, just put up an optical wall. Sensors would be a lot cheaper than physically putting up a wall.

Q: What do you envision for the future of optics?

Sezerman: I think fiber optics is here to stay, so what you see right now with smartphones and smart buildings — smart everything — is supported by a fiber optics backbone. Sometimes the last 10 or 20 miles away are covered by Wi-Fi, as fiber is not laid through the home — and not because we cannot do it, but if you're in a highly populated area, digging up and putting fiber into a home could be become very cumbersome and expensive. So people use the Wi-Fi solution.

Wi-Fi, in conjunction with the backbone of fiber optics, is the reason why you see smartphone use and applications increasing. And now everyone is doing things online; anybody who is 35 [years old] or younger likes to do online shopping. So, I see more applications like that, where people will be able to do a lot more things from their homes.

Eskilson: I think it is becoming a bit easier for new optical technologies to navigate through the stage often referred to as the "valley of death" on their way to commercialization. Traditionally, many technologies have stalled and/or foundered after the basic science is proved and before the application-driven commercial products appear. I believe that public/private partnerships are essential in bridging this chasm.

The integration of the digital and optical worlds is a huge step forward that will provide step changes in the areas of quantum computing, integrated photonics and lab-on-a-chip devices. All of these advances will hopefully lead to lower-cost quality of life improvements that can be accessed by communities the world over, especially in second and third world areas of the globe.

DeGroote Nelson: We are in the information age, and the information is spreading faster than ever, which is pushing technology development faster. For example, where it took 20 years for aspheres to develop, I think that it will take 10 for freeforms.

Research and development are more collaborative than ever, and ease of digital communication is helping to accelerate it. Commercial use of optical technologies, cameras, sensors, augmented reality, etc., are going to push a lot of designs to become more compact, and our need for additional information (small satellites, etc.) and ease-of-use technologies (autonomous vehicles, etc.) will require more unique lightweight optical designs.

As long as we still need light, we are going to need optics, and the future looks very bright!

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