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# The Optics Workforce: Looking to the Future

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Do concerns about job-killing robots and the uncertainties of the “gig economy” extend to optics and photonics?

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Frequently, the mainstream media in the United States and other developed countries trumpet the release of a new study or an opinion essay on workforce issues. Fears of job-killing automation, speculation about the growth of temporary and contingent employment, and concerns about worker shortages in scientific and technical fields form a constant backdrop to the usual worries of students as they wrap up their degrees and look to an uncertain future.

How can one look at this confused picture? Workers in optics and photonics in the United States, after all, are less numerous and harder for government agencies to track than, say, public school teachers and truck drivers. And they enter from different fields and have varying job titles.

"OSA estimates there are about 3,000 optics and photonics Ph.D.-track students enrolled in U.S. universities, but only one-third are actually in optics and physics programs," says Tom Hausken, OSA's senior industry advisor. The rest are in engineering and other programs. "The same goes for technicians and other levels; employers backfill the shortfall by training workers from other disciplines. Optics and photonics is a broad category, spanning everything from optical fiber to lighting fixture design, and much more."

Fortunately, a few information sources do exist to help optical scientists and photonics engineers assess the feasibility of their career goals. Examining the data—and networking with colleagues in organizations such as OSA—can balance out the mainstream-media hype about globalization, robots, the perceived disappearance of well-paying manufacturing jobs and the shortage of college students studying science, technology, engineering and mathematics (STEM).

## Looking at the big picture

"Optics and photonics" is an umbrella description for a diverse group of industries, ranging from precision lens manufacturing to worldwide communications networks, laser eye surgery and optoelectronic circuits. People enter the field through multiple educational routes—physics, engineering, even medical school or materials science—and their terminal degrees range from associate's to doctoral.

No single metric covers the entire U.S. optics and photonics workforce; however, several organizations study different career-related issues. The American Institute of Physics (AIP) Statistical Research Center tracks the educational attainment and subsequent employment of physics students. (OSA is one of AIP's member societies.) According to the center's data collection, the optics and photonics subfield made up about 9 to 11 percent of physics doctorates awarded annually between 2005 and 2015. The U.S. National Science Foundation's annual survey of earned doctorates does not distinguish between optics and the rest of physics, although its "electrical, electronics, and


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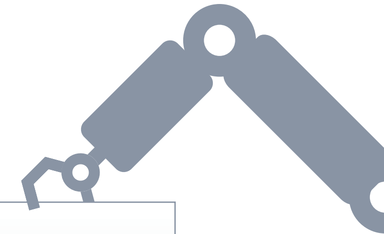

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communications engineering" category does include specialists in optical networks. SPIE conducts an annual survey of salaries in optics and photonics disciplines in the United States and around the world.

In 2015, AIP completed its first-ever study of physicists who worked in the private sector and who were 10 to 15 years past their doctorates. No matter what type of career the respondents found themselves in—physics research, the financial industry, engineering, computer science—they reported that their work involved complex problem-solving, project management and communicating their ideas to their peers.

## Rewarding breadth

Scientists are supposed to be able to explain their work effectively at different levels for different audiences, says Carlos López-Mariscal, founder and lead optical scientist of Underwater Photonics of Cozumel, Mexico (and a member of the OSA board). "Communication is the seeding process to collaboration," says López-Mariscal, a member of the inaugural 2016 class of OSA Ambassadors, who offer professional-development insights to student members. "Everyone you come across in life, they know something you don't know. That's my motivation to talk to other people. That's been a very instrumental skill in my career."

G. Groot Gregory, a technical marketing director at Synopsys Inc., USA, and an OSA board member, has spent his career working on modeling software for illumination design and imaging. In some respects, he says, workforce needs have not changed over the 30 to 40 years that he has been part of the optical engineering industry.

Optics is becoming so pervasive in different product applications that it's becoming common for scientists and engineers to gain some background in the discipline, even if they aren't specialists, according to Gregory. Non-traditional employers such as Facebook and Google, for example, are hiring optical scientists and engineers to build out their communications systems for moving data between their users. And Facebook recently acquired Oculus VR, a developer of virtual-reality displays that incorporate optical technology.

"There are specialists in all the fields, but having people that are aware and somewhat knowledgeable of the adjacent fields, particularly the ones they're working with in their team or their industrial environment, will be much more desirable," Gregory says. "It's a lot easier to talk to someone when you know their language."

The automotive industry has a growing reliance on optics, thanks to high-performance LED headlights and tail lights, not to mention potential additions such as collision-avoidance sensors and head-up displays. All of those areas require cutting-edge optics—and someone with expertise in them, Gregory says. In a large company, optical scientists or engineers will often concentrate on tasks in their field, but in a smaller firm, they may need to switch between optics and systems integration.

"There are a number of companies that will find themselves doing optics, and they will figure out that some people are trained in optics," Gregory says. "In other cases, they'll take somebody who might have some technical background—could be electrical engineering, could be mechanical engineering—and say, 'OK, here's your next task, and it's got something to do with light.'"

## The need for skilled technicians

Though newspaper headlines scream about the disappearance of well-paying blue-collar jobs from the United States, optics and photonics industry leaders agree that unmet demand for technicians in their field remains high. This correlates with a 2013 Brookings Institution study of the "hidden STEM economy," which contended that half of all STEM jobs are available to people who have less than a four-year college degree but who possess a significant level of knowledge in their field. These jobs pay an average of US$53,000, according to Brookings.

In general, optics and photonics technician positions require only an associate's degree—and some community colleges even allow students to begin work on these degrees while still attending a partner high school. These skills also lend themselves to

## Photonics21's European Viewpoint

European officials see photonics as a "key enabling technology" for the coming decades. To boost Europe's impact in the industry, stakeholders seek to increase cooperation between employers and academia and to create more lifelong-learning opportunities for experienced workers.

Within the European Union, Photonics21, a multinational association of industrial and academic stakeholders in the field, released a strategic roadmap for the decade. The document calls for improvements in Europe's photonics manufacturing infrastructure, both to encourage more product manufacturing on the continent and to support other sectors that depend on photonics technologies, such as telecommunications.

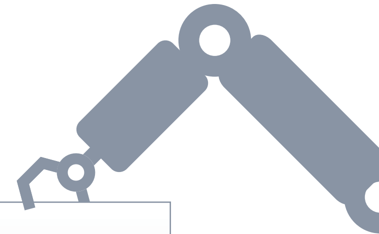
OSA estimates that the European photonics community has a workforce of 325,000 people directly employed in the field. Thanks to the importance of optical components in many other sectors from telecommunications to biotechnology, Photonics21 contends that photonics represents as much as 10 percent of the E.U. economy.

According to Roberta Ramponi—a professor at the Polytechnic University of Milan, Italy, and the chair of the Photonics21 work group on research, education and training—European photonics faces many of the same educational and training challenges as in the United States. Leaders have worried about shortages of students entering STEM fields, which are perceived to be more difficult academic subjects than others. That perception is changing, though, as more students realize they can get good-paying, interesting jobs in STEM fields.

Since 1999, most European universities have followed the Bologna Declaration, which sets common standards of comparability for bachelor's, master's and doctoral degrees among participating countries. However, Europe has fewer opportunities than the United States for training photonics technicians outside the university framework, and professionals have fewer opportunities to take retraining classes over the course of their careers.

The private sector of the European photonics community contains many more small and medium-sized enterprises than large corporations, and the Photonics21 public-private partnership set up within the EU's Horizon 2020 framework wants to provide funding to support innovative small businesses.

Ramponi has no idea how Brexit—the United Kingdom's planned departure from the European Union—will affect the European photonics community. Photonics21 has several hundred individual members from Switzerland and other countries outside the European Union, and Switzerland, for example, is well integrated with the EU's scientific and technical programs. Brexit is "something much more general than what can happen within the photonics community," she says.



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cross-training of people already employed in other specialties.

OSA Senior Member Brian Monacelli, a laser technology instructor at Irvine Valley College (IVC), California, USA, has been involved with IVC's laser and photonics technology program for more than a decade. Until around six years ago, the two-year college offered ad hoc light-technology classes, from LabView to holography, quickly assembling and teaching the courses at the request of local industry.

In 2011, however, representatives from a major optical glass producer told IVC that roughly 25 percent of the firm's technical workforce planned to retire in the next five to ten years. The company was willing to offer apprenticeships and on-the-job training to workers who already understood the fundamentals of making quality optical elements. With that need in mind, Monacelli and IVC revamped the curriculum into for-credit courses for certificate and degree programs and added a full-time faculty member. Three years ago, IVC received a US$190,000 award from the National Science Foundation to support the photonics-training initiative.

Demand for IVC's optics graduates has always exceeded the supply, according to Monacelli. One alumnus works for the National Ignition Facility at Lawrence Livermore National Laboratory. Other graduates find their opportunities in the numerous medical-device companies located in southern California.

## Back to school

Another two-year institution, Monroe Community College in upstate New York, is widely known for its optical systems technology program. Yet Monroe's first-in-the-nation associate's degree program almost didn't survive the early 2000s, when Eastman Kodak Co. was shedding its financial support. Enrollment was also declining because of Kodak's shrinking workforce, and the school's equipment was outdated.

According to Thomas Battley, executive director of the Rochester Regional Photonics Cluster in Rochester, N.Y., USA, Monroe's dean of technical education realized the program's economic importance to the area and renewed public interest by reaching out to local high schools. In 2011, Monroe secured US$750,000 in funding from the Corning Foundation and Sydor Optics, which helped the college hire more faculty and upgrade its laboratory equipment.

Alexis Vogt, a Monroe professor in optics technology, stresses that optics technicians work side by side with researchers and engineers and build the components that they design. "At one of my former companies, when the technician was out of town, the products literally did not get out the door," she says.

Some of Monroe's optical technology students already have bachelor's degrees, and even the occasional MBA, Vogt says. They have recognized the huge need at the technician level. Some people who have had full careers in other companies are now coming back to community college to study optics. Likewise, Monacelli says about 30 percent of the students in the IVC program are coming from a different discipline and being retrained in optical systems because they need the expertise for their work on robots or medical devices.

Now that Monroe's optics program is humming again, Vogt and her colleagues are seeking even more new ways to train technicians to match industry's needs. One option under consideration is an accelerated program that would condense a year's worth of classes into 22 weeks. Other possibilities include trying a cohort-based educational model and, beyond optics, joining a multidisciplinary workforce development program for the Finger Lakes region of New York.

Monacelli stresses the need for close industry ties. "It's one thing to understand the basics of ray tracing, but to teach it, for instance, using a code that isn't industry-standard code or a corporation-specific code, that's not really helpful," he says.

## The automation question

Of course, those seeking to build a career in optics and photonics face the same uncertainties as the broader workforce—tied to increasing automation, globalization and new forms of employer-employee relationships. With respect to the trend toward automation, at least, Hausken thinks that it constitutes

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a net benefit for the optics industry—even though automation may also take some jobs away.

For example, when the Great Recession hit in 2008, companies used the economic downturn to upgrade to more efficient, sometimes automated equipment, and thereby to benefit once the economy improved. That dynamic, while narrowing job prospects in some traditional sectors, often has more positive implications for optics and photonics. A manufacturer that brings in laser-cutting tools will produce more goods with fewer staff—thanks to optics. Self-driving vehicles—posited as the near-future threat to the jobs of delivery people and truck drivers—will be loaded with optical technology from lidar to LED lights to display screens. (Whether autonomous vehicles will indeed replace most cars and trucks on the road, though, is a question that goes well beyond the optics community, out to the larger arenas of politics and the economy. "I think to a huge extent this stuff is above our job grade," Hausken says. "Our little industry is not even a player in that.")

The optics industry also uses automation internally, Hausken says. Low-volume, customized jobs may require human-guided polishing and tweaking, but automation takes components to the next level of volume production. Over the last half century, computers have made lens design jobs much easier for engineers. Historically, optical engineers had to handle the complex calculations by hand, supported by mechanical adding machines and slide rules. Now, people without the rigorous traditional education can benefit from the advanced software that handles the calculations involved in building lenses.

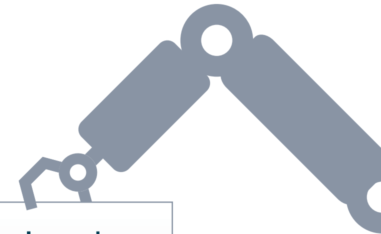
Many companies have improved their computer-aided manufacturing, Monacelli says, "but inevitably there's a human in the loop—there's someone who actually knows more about the system or knows something intuitively about the system that the computer just can't."

There are still jobs for machinists, but nowadays people with that job title are programming machines to shape metal and plastic components, Gregory says. Fewer workers may be needed, but the knowledge needed to use productivity tools is increasing. "Problem-solving is the thing that is going to keep someone employed," he adds.

## Globalization and the "gig economy"

In some U.S. and European political circles, globalization inevitably raises the specter of job losses for domestic workers. In optics and photonics, globalization is a done deal—simply part of the landscape. Gregory says his employer has roughly 100 offices around the world, and almost every company that manufactures tangible products has some footprint in Asia.

OIDA—originally the Optoelectronics Industry Development Association, and now renamed OSA Industry Development Associates—was founded over globalization concerns, but has moved past that issue to focus on networking, promotion and advocacy.



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Hausken says the global optics and photonics market is much more flat these days, with consumer and commodity products coming out of Asia and specialized products coming out of Europe and the United States. In optics, the United States is a reasonably diversified global player.

Decried almost as often as globalization is the "gig economy," in which workers try to cobble together a full-time income by juggling several part-time or freelance jobs, often without fringe benefits such as health insurance or retirement plans. More often in optics, scientists and engineers employed in industry have full-time jobs there, and their part-time teaching gigs are for personal and workforce development. Monacelli believes the connections should run both ways, with full-time academics maintaining their ties to industry by starting businesses or classroom collaborations.

"I've found, as a student, and a professor, that the best professors and the best students are the ones that bring a little industrial experience to the classroom, and actually help diversify the learning experience for the students," Monacelli says.

## The ultimate outlook

Hausken believes that the optics industry must continue to market itself to young people deciding on their careers. Many teenagers think of smartphone-app development and social networking as the "hot" technology careers—oblivious to the sophisticated optical hardware and communications technologies that make networked smartphones possible.

Improving the visibility of photonics must be done at the community college level, and colleges in turn have to market their programs to high schools, according to Hausken. Some community colleges may have only one person who cares about photonics, and as soon as the champion of photonics retires or tires of being an advocate, student recruiting drops.

Last October, Hausken visited a region in northern Michigan that had been known for fruit farming and heavy manufacturing, but is now more of a tourist destination. One of the few remaining manufacturing plants there has some nice semi-clean-room factory jobs for high school graduates, he says, but the company has trouble hiring and retaining workers—one lasted a single day on the shop floor. Many of the young ex-employees end up working at a pizza joint or in similar customer-service jobs.

"Why do they turn down a manufacturing job?" he asks. "It hasn't been sold to them. Young people have soured on manufacturing because of how their parents got burned."

People in optics and photonics, though, have not soured on their field. More than a decade after earning doctorates, 87 percent of physicists working in U.S. industry felt that their jobs were intellectually challenging, according to the AIP survey.

The interdisciplinary nature of optics and the endless capacity for learning and discovery continue to sell the field to everyone interviewed for this article. No one is worrying about joblessness. As Gregory says: "If you can design a lens, you can work for life." OPN

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