being developed to allow the acquisition of 3D images at far-higher-than-video frame rates, enabling augmented reality applications.

Fluorescence measurement

The fluorescent lighting that for years relied on fluorescent tubes, and more recently on LED lamps, converts UV or blue light into longer wavelengths to create a white-light output. Measurement of fluorescence is another area in which single-photon detection enables improved capabilities, particularly in biochemistry and medicine, where fluorescence is used to track and analyze biological molecules or processes by monitoring fluorescent emissions. Measuring the fluorescence of biological molecules or processes is also critical to biochemistry and medicine. Tagging cellular components with specific fluorophores allows the visualization and study of specific areas within a sample.

The use of single-photon detection enables fluorescence lifetime imaging microscopy, which measures the fluorescence lifetime of a fluorophore to create an image. This lifetime is independent of intensity variations in the laser source and in background light changes. So its measurement improves image clarity.

Time-correlated single-photon counting is a common method for extracting fluorescent lifetime information while compensating for source and background variations. Systems using CMOS-based single-photon avalanche diode arrays allow wide-field imaging for fast analysis and potentially lower system cost.

In flow cytometry, fluorescence-activated cell sorting is used to separate particular cells or particles from a larger population. Single-photon detection allows the use of lower-power and therefore less-expensive lasers. It targets single-molecule or nanoparticle detection, where the amount of light emitted is extremely low.

The quantum world

Single photons also find use in many quantum technology applications. However, for these applications to become practical enough for the real world, reliable single-photon detectors will be needed.

Such detectors are in demand for banking, infrastructure, military, and other application sectors requiring secure communications systems that are impervious to hacking or intrusion. Quantum key distribution allows an information transmitter and receiver to create complex and highly secure cryptographic keys in real time, by employing the quantum properties of single photons. Once the key is created, users are free to encode information, knowing that communications are secure.

Quantum key distribution systems are moving from laboratories and dedicated link demonstrators to real-world deployments. As these systems transition to commercial applications, single-photon detectors will become critical to the systems' success. While laboratory demonstrations relied on superconducting nanowires for detection, silicon and InGaAs APDs are the detectors of choice for deployed systems.

Quantum entanglement systems, another area of study in quantum technology, also rely on single-photon detection technology. Here too, APDs are becoming the detector of choice as systems move from the laboratory into commercial deployment.

The ability to detect and count single photons has enabled breakthroughs and discoveries in medical, industrial, aerospace, and military applications, among others. The action of photons in both chemical and physical reactions is useful for learning how energy and matter interact in all kinds of scenarios and under all kinds of conditions. Quantum technology applications are growing fast, and considerable potential exists for this game-changing technology to provide the information, imaging, and detection capabilities needed for future applications that have not yet even emerged.

Meet the author

Richard Simons is the product manager for low-light-level detection at Excelitas Technologies. He has an extensive background in photonics, with experience in high-power lasers, high-energy laser optics, fiber optics for telecommunications and sensors, lidar, and single-photon detection; email: richard.simons@excelitas.com.

Monroe Community College, Rochester, New York

LASER-TEC is the Center for Laser and Fiber Optics Education, founded in 2013 by the National Science Foundation (NSF) and headquartered at Indian River State College in Florida. It was established to help meet the goals of educating and sourcing domestic talent in the areas of optics and photonics. As a service to students, recent graduates, and prospective employers, Photonics Spectra runs a profile of one of the 35 LASER-TEC colleges each month.

Rochester-area employers have relied on Monroe Community College (MCC) since 1963 to educate generations of students to become optical technicians. Offering stackable certificate and associate degree programs, it is the only community college to offer an Associate of Applied Science degree in optical systems technology.

More than 700 optics technicians have earned associate degrees from MCC and are working in the optics and photonics industry throughout the U.S. Companies that have hired graduates from MCC's program include Bausch + Lomb, Coherent, Corning, Eastman Kodak, Excelis, IBM, IDEX, ITT Goulds Pumps, JML Optical, L3Harris, the Laboratory for Laser Energetics, Lockheed Martin, Optimax, OptiPro, QED Optics, Rochester Precision Optics, Spectra-Physics, Sydor Optics, Texas Instruments, and Xerox.

Programs

Optical Systems Technology Associate of Applied Science (AAS)

This two-year degree program prepares graduates for work in fields that apply light and optical principles.

The curriculum combines the study of optics with electronics to prepare students for careers in electro-optics and traditional precision optics fabrication. The course of study gives students the opportunity to operate much of the same precision equipment and state-of-the art optical systems used in industry. Skilled optics technicians work with engineers and scientists to inspect and test optical components and assembly systems using advanced technology tools. Graduates of this program work with scientists and engineers in research and development, design, production, quality control, and test and evaluation of optical components and systems, as well as with sales and service professionals.

Stackable Certificate in Optical Systems Technology

MCC's Optical Systems Technology Certificate program provides a solid optics background, with options to focus on manufacturing, testing, or electro-optics/photonics applications. The program can be completed in one year, and all certificate courses may be applied to the requirements of the AAS degree program for students who continue their studies.

Graduates of MCC's Optical Systems Technology program have the skills to:

- Evaluate optical systems using a number of geometrical and wave optics test procedures.
- Take standard measurements and evaluate typical electro-optic configurations.
- Understand and perform basic and advanced optical manufacturing techniques for today's precision optical components.
- Understand and perform basic and advanced metrology techniques for testing optical systems and individual optical components.
- Handle and clean an optical surface according to industry standards.
- Form an achromatic doublet by assembling, aligning, and cementing two optical elements.
- Use interferometers to measure optical components.
- Identify the centration and spacing of optical surfaces in an assembly using an optical centering system.
- Assess the optical performance of an optical system using an optical transfer function measurement system.
- Describe particulate control in a laminar flow clean environment.
- Interpret optical drawings.
- Prepare quality assurance and detailed laboratory reports.
- Inspect an optical surface to identify particles, scratches, and digs down to the micron scale.

How to recruit from this college

Campus recruiting visits are welcome. Companies interested in recruiting MCC optics students should contact the optics program director listed below. MCC will make available, free of charge, a private room in which to interview interested students. Graduates are available every December and May.

MCC is leading the effort to expand the precision optics manufacturing apprenticeship nationwide. Please contact us if your company is interested in participating in our apprenticeship program. Additionally, please contact us if you would like to hire one of our students as a summer intern.

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