

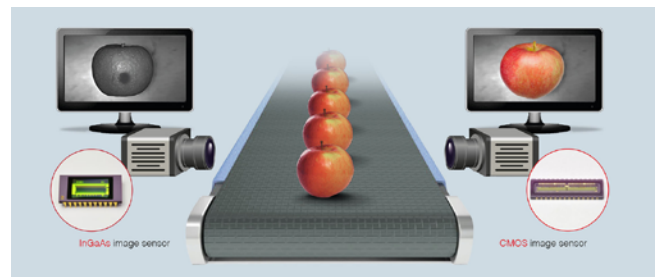
Photonics' vital role in modern manufacturing processes

Photonics technology plays a vital role in modern manufacturing processes, revolutionizing various industries by enabling faster, more precise, and efficient production. Photonics involves generating, manipulating, and detecting light and its properties; its integration into manufacturing processes has led to significant advancements. How is photonics technology utilized in manufacturing and what is its impact on different sectors?

Photonics technology finds applications in several aspects of manufacturing, including imaging, sensing, communication, and material processing. In terms of imaging, photonics-based cameras, and sensors are widely used for quality control, inspection, and metrology.

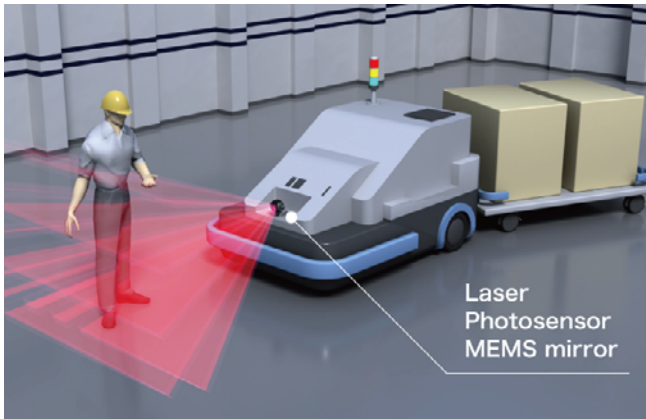
Defect detection

High-resolution cameras and advanced imaging techniques allow manufacturers to detect defects, measure dimensions, and ensure product quality during various stages of production. These imaging systems quickly identify flaws, scratches, or imperfections that may be invisible to the human eye, leading to improved product reliability. For example, different high-speed imaging devices can be placed strategically on the conveyor belt to optimize the food sorting inspection process. When fruits travel down the conveyor belt, they can be scanned using InGaAs and CMOS cameras. The **InGaAs camera** will show defects beginning to form under the skin that a human eye cannot see (using



infrared technology) while the **CMOS camera** will show visible defects. All defects detected will help filter out produce that should not reach the store.

Also of practical usage and seen in our everyday lives are optical sensors which fill our modern cars creating elegant interiors, interactive displays, and modular lighting. They have seamlessly been transforming our driving experience providing us with safety and comfort. Furthermore, they are essential for advancing LiDAR technology (light detection and ranging). LiDAR offers a multitude of applications for its precise measurements, detection, and monitoring that range from autonomous driving to helping manufacturers automate the quality control process or security. Quickly revolutionizing



AGV (Automatic Guided Vehicle) using LiDAR based technology.

the industry, LiDAR systems also utilize laser light to accurately measure distances, map surroundings, and detect objects. They are extensively used in robotics (e.g., moving objects), automated guided vehicles (AGVs), and intelligent manufacturing systems for real-time feedback and control. By integrating **LiDAR sensors** into manufacturing processes, companies enhance safety, optimize workflows, and achieve higher productivity.

The rise of laser technology

Laser technology has also brought significant advancements to material processing. **Laser-based systems** are extensively used for cutting, welding, marking, and surface treatment of various materials. Lasers provide a high-energy, focused beam of light that can accurately and precisely process materials, resulting in enhanced productivity and improved product quality. Laser cutting machines, for example, offer high-speed, contactless cutting of metals, plastics, and textiles, enabling complex and intricate designs with minimal material wastage. Laser welding



Laser machinery for metal cutting

provides a fast, efficient, and non-contact method for joining materials, while laser marking offers permanent and high-resolution product labeling and branding.

3D printing utilizes lasers and other light sources to selectively cure or melt materials layer by layer, creating complex three-dimensional objects. Photonics-based 3D printing enables the production of highly customized parts, rapid prototyping, and even the manufacturing of complex geometries that are difficult or impossible to produce with traditional methods. This technology has revolutionized various industries, including aerospace, automotive, and healthcare, by reducing production time, enabling cost-effective small-batch production, and fostering design innovation.

The era of communication

Finally, efficient communication and data transfer is also crucial to the manufacturing environments. **Fiber-optic communication systems** are widely adopted for high-speed, long-distance data transmission between machines, control systems, and remote monitoring stations. Fiber-optic cables, composed of thin strands of glass or plastic, enable the transmission of light signals carrying large amounts of data thanks to integrated transmitters and receivers. **Transmitter and receiver photo ICs** for example support a wide variety of transmission speeds over a long distance at high speed. This ensures reliable and secure communication, minimizing latency and electromagnetic interference. The ability to transmit data rapidly and without loss makes fiber optics a critical component of modern manufacturing infrastructure. Additionally, new developments in quantum optical communication can provide secure and encrypted communication with the use of low-noise, high-quality, and high-efficiency single photon emitters, and detectors

In summary, photonics technology has profoundly impacted manufacturing processes across multiple industries. Hamamatsu Photonics' extensive portfolio of components, modules, and systems provides innovative, high-quality, and high-performance solutions to the manufacturing industry. We will continue to utilize our expertise and 70 years of knowledge to advance photonics technology, to support further transformations in manufacturing processes, leading to increased productivity, reduced costs, and improved product performance.