VIAVI Solutions

White Paper

Optical Filters for LiDAR Systems

The Expanding Role and Requirements of Optical Filter Technology for Automotive Applications and other Sensing Systems

As technology companies and auto makers add new functionality to make cars more automated, LiDAR (Light Detection and Ranging) systems play an important role in ensuring that cars accurately sense and react to the environment around them.

The Growing Importance of LiDAR for Automotive Applications

LiDAR systems have been used for several decades in satellites, surveying equipment and in specialized photography. In the future, it's expected that LiDAR systems will be an integral part of automotive sensor suites for enhanced safety and driver assistance and in some limited roll outs of autonomous vehicles.

As a leading provider of patented optical filter technology for LiDAR systems, VIAVI Solutions has provided similar applications to the government and aerospace markets for several decades. In 2010, VIAVI began offering its optical filters to the consumer electronics market for gaming and computing, due to its ability to produce the filters at scale and with the highest precision and durability required for large-scale implementations. Because of the proven quality of its filters, VIAVI is now enabling the evolution of automotive safety.

How Time of Flight based LiDAR Works

LiDAR systems calculate the distance of objects in the environment by emitting a pulsed laser beam from a LiDAR camera. The beam of light reflects off of an object, and the time it takes for the light to travel back to the camera is captured by the optical filter. By measuring the returning light, the system can calculate the distance of objects. This approach is known as "time-of-flight" or ToF technology.

Optical Filter Requirements Essential for LiDAR Systems

The hurdles are high for vendors that want to provide optical filter technology for LiDAR systems, and criteria is particularly stringent for automotive applications. Three key optical filter requirements are critical for LiDAR systems to work most effectively in cars:

Must operate in high ambient light conditions. Changing light conditions and reflections from other car headlights can impact the accurate detection and measurement of surrounding objects by LiDAR systems. In order to gather the right data from the desired wavelength of light, the optical filter must effectively block out unwanted information that also travels back to the camera. To ensure accuracy, the

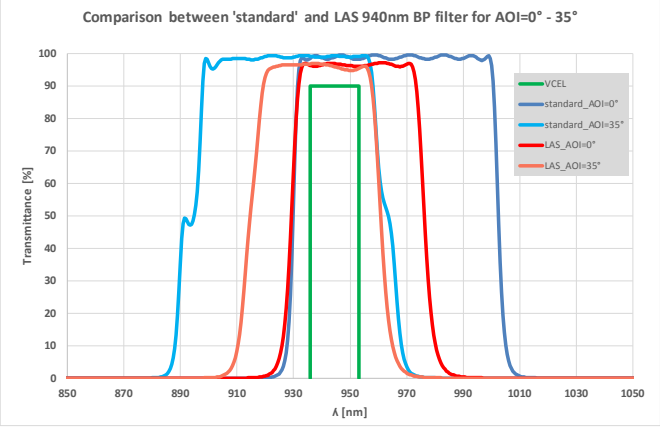
optical filter must be able to reliably function across a wide variety of changing light conditions.

Returning light emitted from the light source is low, so it's critical that it be captured efficiently. Because the emitted light is spread out over long distances in the environment and the reflective capabilities of surfaces vary widely, typically only a few particles of light containing the needed information return to the original light source. LiDAR systems are dependent on high-quality filter technology that can isolate the signal from just a few photons.

Must meet stringent durability requirements for automotive applications. Automotive requirements are very strict in terms of durability, in order to avoid safety recalls. All LiDAR components, including filters, must withstand severe temperature ranges between -40 and +125 degrees Celsius during testing and qualification. Equally as important, the ability to manufacture hundreds of millions of filters at scale and have them all operate consistently is critical.

Key Differentiators of VIAVI Optical Filter Technology

VIAVI optical filters address two major issues for LiDAR systems in self-driving car designs: enabling a light signal to travel further and the ability for the optical filter to operate at a high level of reliability in the brightest levels of sunlight. In LiDAR systems for automotive applications, every nanometer of bandwidth counts to avoid accidents or recalls. VIAVI optical technology filters light so that the signal-to-noise ratio can be improved by as much as 150 percent, to ensure the most accurate measurements.



Key product features include:

Optical precision for volume manufacturing. VIAVI provides Central Wavelength (CW) Control Specifications at +/-0.4 percent that are optimum for manufacturing filters in large volumes for cars. For example, a wavelength emitted at 905nm has a tolerance of +/-4 nm.

Superior optical performance with high accuracy. The passband capability of VIAVI filters operate at more than 95 percent transmission, on a scale where 0 percent equals no transmission of light and 100 percent represents transmission of all light. Out-of-band blocking, or light traveling outside of the desired transmission path, is more than OD4, or less than .01 percent, and can be more than OD6, or less than .0001 percent, if required. VIAVI filters also provide steep transitions for cut-on, the point where the filter starts to transmit light and cutoff, where the filter starts to block light, with a square bandpass essential for ensuring accuracy in autonomous cars.

Extensive reliability testing that complies to multiple industry standards. VIAVI optical filters pass rigorous testing for heat soaking (testing filters at high levels of humidity), temperature cycling (testing how filters withstand wide temperatures between a range -40 degrees and +125 degrees Celsius), manufacturability (testing electronics in a reflow oven to ensure they can withstand soldering temperatures required on electronic circuit boards), and MIL-C hardness and adhesion tests (typical quality tests performed on optical coatings).

VIAVI Optical Filters Move into a Variety of New and Demanding Applications

In parallel with LiDAR systems for external measurement, VIAVI is currently developing optical filter technology for in-cabin systems that measure the biometrics of the driver. In addition, the same VIAVI filter technology is moving into a variety of other areas as electronics become more intelligent, automatically recognizing and adapting to a variety of internal and external conditions. The proven quality, precision, durability and scale of VIAVI optical filters will help propel various phases of automated vehicles and other sophisticated sensing applications over the next decade.

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