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Lidar Emitter and Detector Technologies

Automotive industry demands are challenging manufacturers of pulsed laser diodes and avalanche photodiodes to create new and customized responses.

BY MATT ROBINSON
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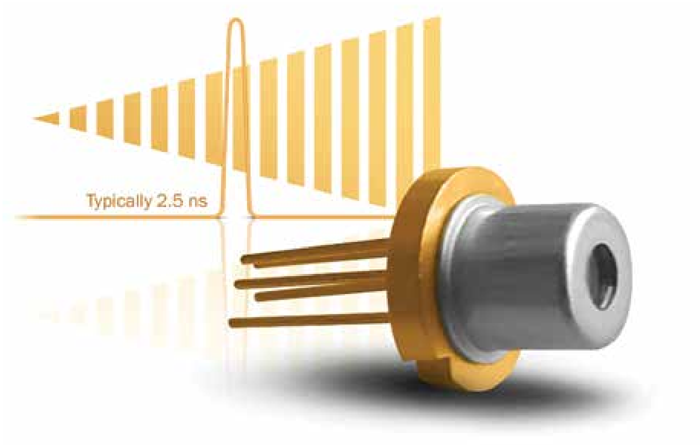
For many decades, lidar has been a successful technology for traffic monitoring and speed control. Self-driving transport vehicles in factory halls even use it for navigation. During all this time, the main components — namely pulsed laser diodes (PLDs) and the detecting photodiodes — have remained more or less the same. But increasing research in autonomous passenger vehicles has triggered new technological developments on both the emitting and receiving ends.

The automotive industry demands ever smaller form factors and the highest possible scanning resolution. The most feasible way to achieve the latter is to keep the pulse lengths of the emitting PLDs as short as possible. Through the use of additional electronics, the average pulse duration used to be ~5 to 10 ns. Recently, leading suppliers have come up with solutions to reduce this significantly. These new PLDs typically provide pulses between 2 and 3 ns at pulse frequencies of over 200 kHz. Higher pulse frequencies result in a higher density point cloud, providing a more detailed image of the vehicle's surroundings in a shorter time. The optical peak power of these PLDs ranges from 40 to 90 W.



PLDs that generate ultrashort pulses at high repetition rates enable faster and more precise 3D lidar scanning.

As with all components activated by electric currents, the inductance in the driver circuitry is one of the most limiting factors. This kind of parasitic inductance is typically associated with the current carrying conductors in a circuit or loop. The longer these conductors are, the higher the inductance they impart on the loop. Therefore, components must be as close together as possible. Only recently have engineers come up with an affordable, compact hybrid configuration that integrates a 905-nm laser diode along with the connected transistor and capacitor inside the same metal housing. The minimized inductance loop allows for shorter pulses and increased performance at lower operating voltages. To protect the electronics inside, the metal casing is in some instances equipped with an additional ground pin. This results in a Faraday cage that effectively protects the PLD from any electromagnetic interferences whenever it is activated.

To match the short pulses and high pulse frequencies, automotive suppliers also have to choose the right detector technology on the receiving end. In most lidar systems, silicon avalanche photodiodes (APDs) offer significant advantages when compared to conventional PIN photodiodes. PIN diodes use the photoelectric effect to create electron-hole pairs called "charge carriers," which supply a measurable photocurrent. APDs take this idea a significant step further; the charge carriers are accelerated in the electrical field and produce further electron-hole pairs through impact ionization. Thus, a single photon may produce an avalanche of hundreds or even thousands of electrons and generate a constant current, which can be measured by external electronic equipment.

To achieve the highest possible efficiency, APDs are commonly used in ar-

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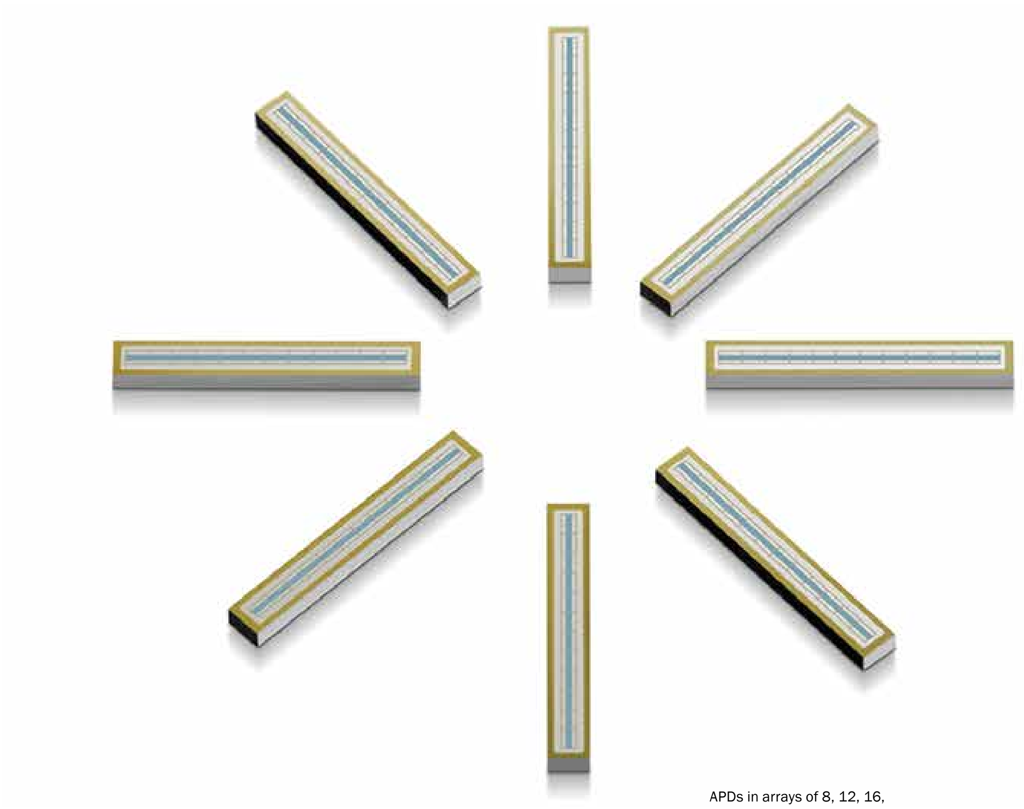

APDs in arrays of 8, 12, 16, or 64 elements are optimized to achieve a denser point cloud.

rays of 8, 12, 16, or 64 elements. Each corresponds to a specific laser in a PLD array. In addition to the number of emitting and receiving components, resolution is also affected by the pixel pitch, or the distance between the pixels. The most demanding task, however, is to make the sensor units as sensitive as possible so they are able to detect even the slightest level of the reflected photons. This is mainly a matter of achieving a good signal-to-noise ratio. APDs are the components of choice whenever they are able to boost the signal level without significantly increasing the overall system noise. Therefore, they are preferred whenever low light intensities at middle or high frequencies have to be detected. The optimum internal gain is selected when the detector noise is approximately equal to the input noise of the secondary amplifier (or load resistance), so the APD does not affect the system noise. Noise increases with the bandwidth of the system for PIN diodes as well as for APDs, which makes it important to reduce the bandwidth as far as is practicable. As an option, the background wavelength spectrum may be narrowed by an additional bandpass filter.

Most automotive system suppliers are currently testing various lidar options, as well as competing technologies such as radar, cameras, and ultrasound, creating a high demand for individually customized solutions on both the emitting and receiving end. Rather than large numbers of standard components, suppliers demand solutions that can be altered quickly to match customer specifications. This not only helps lidar manufacturers find the right specs for their respective solutions, it also contributes to the ongoing perfection of the overall technology.

Meet the author

Matt Robinson is sales director of pulsed laser diodes, photodiodes, and IR components at Laser Components USA Inc. and has been in the photonics industry since 1990; email: lasers@laser-components.com.

Images courtesy of **Laser Components**.

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