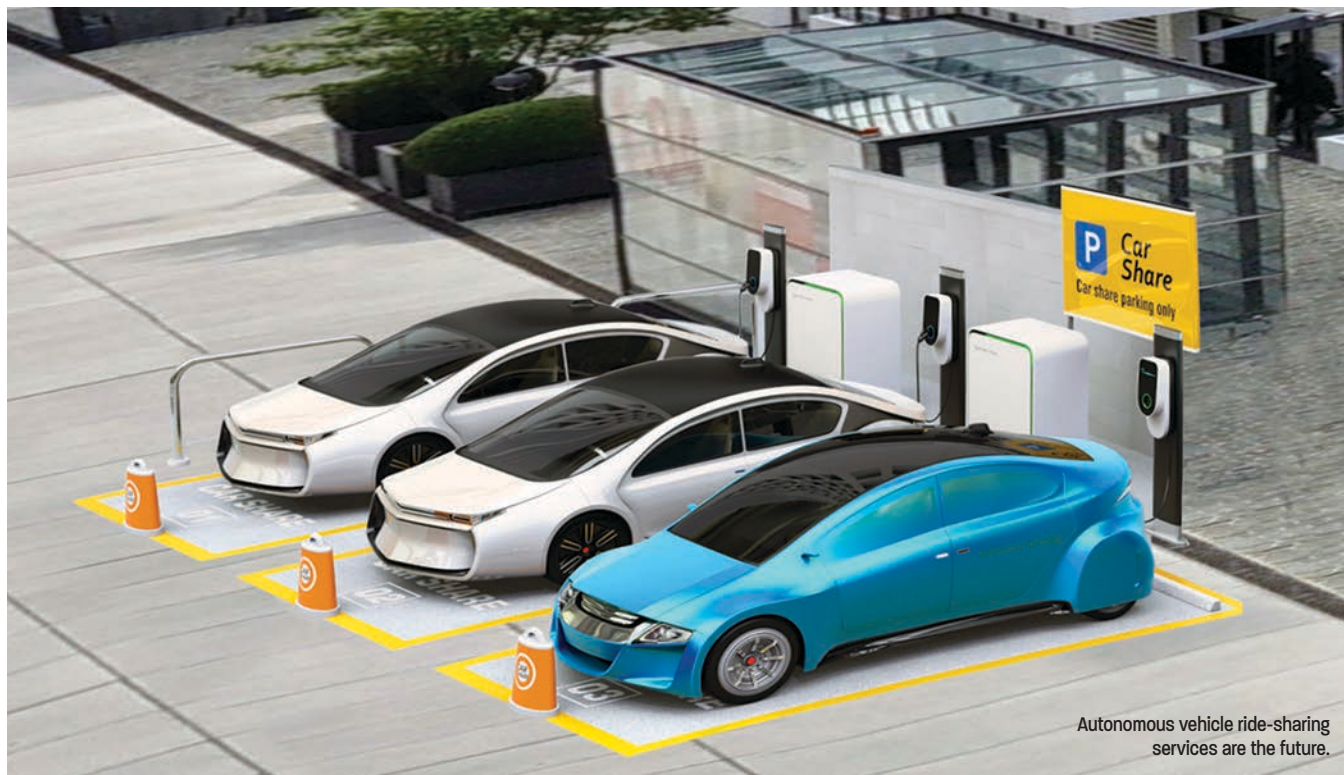


Evolution in automotive LiDAR: avalanche photodiodes and pulsed laser diodes perspectives



Autonomous vehicle ride-sharing services are the future.

Decades after Dr. McIntyre of **Excelitas Technologies—RCA Electro Optics** at the time—outlined for the first time the equations that defined the noise characteristics and behavior of avalanche photodiodes (APDs), these key LiDAR-enabling detectors have progressed tremendously.

Levels of performance have increased, and metal-can packages ensured operations in very harsh environments for applications in aerospace and defense for many years, and still do today. Over time, the global wafer volume capacity has increased, costs have come down, and, combined with new ways of packaging the APD dies at more attractive price points, have opened up attractive consumer applications. Moving away from metal-can into surface-mount packages, first in ceramic then laminate substrates, APDs have traditionally been operated in much more benign environments, such as laboratories or factories, in these new configurations.

The growing demand from the autonomous vehicle market space is changing the status quo, requiring high-volume, cost-effective packaging combined with high levels of reliability. Ultimately, from a deployment perspective, there are two distinct markets in the autonomous vehicle space.

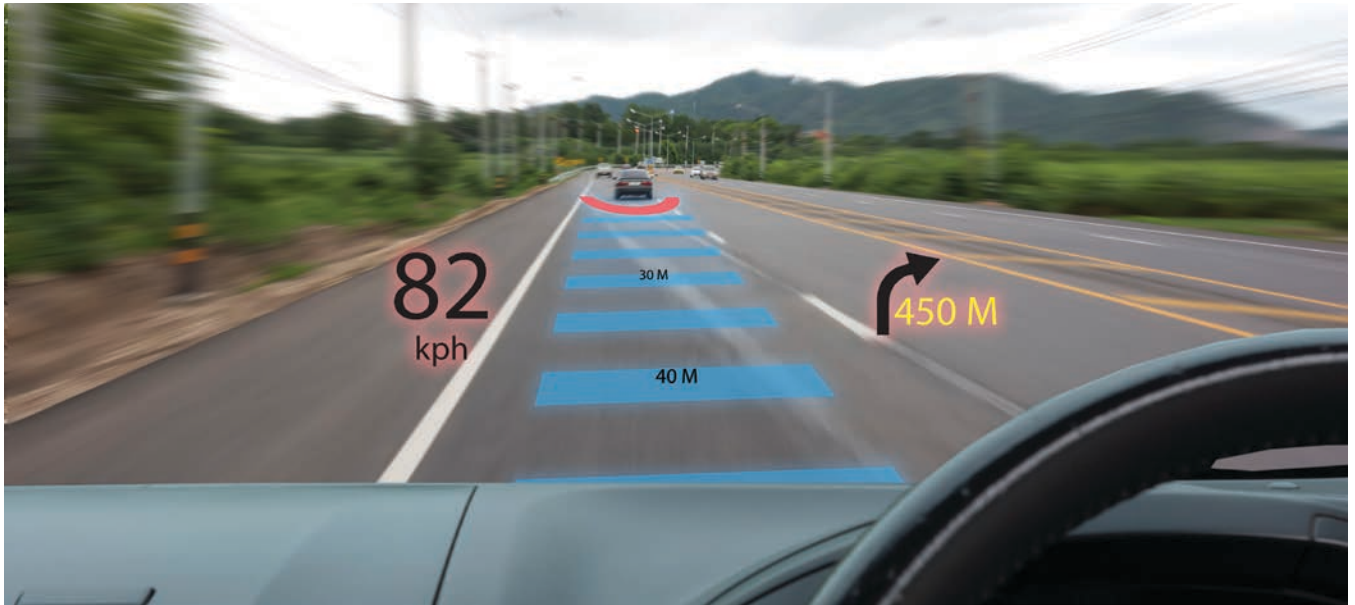
The first one is the ride-sharing or taxi service, where one will not purchase a vehicle but rather a service. Such vehicles have lower barriers to entry from a cost and system size perspective. On the cost side, since the vehicle will generate revenue over an extended period of time, it is much more of an investment than a personal vehicle. And on the esthetics side, even if the system remains bulky, this is of little consequence. For these reasons, we expect this market to flourish and take off faster than the consumer market.

It is easy to see why Level 5 autonomy deployments are most likely five years

away in personal consumer cars while these ride sharing services are already starting to expand today. And similar to other advances in automotive, the first vehicles to adapt such technology will be high-end luxury vehicles. This technology will eventually trickle down to their entry level models and then to a broader audience in the non-luxury market sales.

Desirable APD features include optical filtering, either directly on the chip surface or incorporated into the package. With direct coating, one must contend with the fact that the filter characteristics will vary in a significant manner depending on the angle of incidence of the incoming radiation due to its wide field-of-view. The sides of the chip are also not coated, opening a path for out-of-band radiation to generate photocurrent and, hence, increase the noise floor of the detector.

The race to high reliability and low cost will also see a market shift from a single



Long range (200 m+) forward-looking LiDAR is critical to enable deployment of autonomous vehicles.

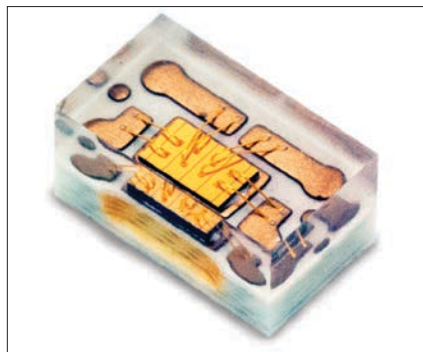
laser in rotating systems to multi-pixel arrays in solid-state configurations. New configurations in 1.5D (multiple columns, but a handful of rows in the matrix) and 2D are rising in popularity. In such configurations, one must have the ability to bring all the contact pads to the back of the matrix for ball bumping mounting onto carriers. In today's systems, these arrays are connected to TIAs (trans impedance amplifiers) located somewhere else on the PCB (printed circuit board). However, the level of integration will eventually increase, creating IC (integrated circuit)-based solutions. One needs only to study the evaluation of radar technology in the automotive space to see how that industry has evolved.

Similar arguments can be said about pulsed laser diodes, which have followed a similar evolution. The 905-nm pulsed laser diodes are matched up perfectly with the peak response of the paired silicon APDs, making for an optimal range-finding pair. On these active devices, a critical aspect of their performance and reliability is how they are driven to generate a light pulse. Parameters such as pulse width, pulse repetition rates,

and drive current will all impact the lifetime of the device and needs special consideration at the time of system design. Traditional range-finding systems have used pulse widths on the order of 50 to 100 ns, driving,



Small form factor SMD APD for high volume applications.



1x4 Pulsed laser diode array in compact SMD package.

for example, 30 A of peak current, which will generate on the order of 75 W of peak optical power at a pulse repetition rate of 1 kHz.

more than 200 m (660 ft) and resolution required on the order of 1 cm (0.4 in), shorter pulses and higher drive currents are necessary. Going to shorter pulses will help limit the heating effects of the lasers; however, driving larger currents will have the opposite effect. Of prime importance in the selected safe regime is the ability of the assembly to extract the heat from the laser chip. Failure to do so will severely limit the lifetime of the system. Thermal modeling then becomes a key skill in the design process and requires experienced staff to successfully accomplish.

All of these exciting developments will soon to be on our driveways. While these advances will be fantastic in many aspects, one has to wonder if space will be left for those of us who enjoy driving. Perhaps the automakers will leave an off switch so we can still enjoy taking the controls on our favorite back roads.

// **BY DENIS BOUDREAU**, Product Leader, Excelitas Technologies, wrote this article for AVT.

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