

3-D point-cloud
captured with
Princeton Lightwave
Geiger-mode camera.

Courtesy of PLI

OPTICS INNOVATIONS

At Princeton Lightwave, Single Photons are in Focus

Yves Dzialowski and Mark Itzler

Princeton Lightwave pursues opportunities in single-photon sensing, offering new solutions to commercial and defense markets.

Princeton Lightwave Inc. (PLI) is one of many optics start-up companies that were heavily funded at the high-point of the U.S. telecom boom in the early 2000s. When the market went bust, PLI found itself with no customers and very little cash.

An opportunity brought PLI's investors and Yves Dzialowski together. Dzialowski had been the president of EPITAXX, a leader in telecom optical receivers. This eventually led to a reorganization of PLI that involved Dzialowski and a few other EPITAXX alumni. Complimented by these detector experts, and led by Mark Itzler, the PLI laser team

redeployed itself into the market, seeking defense and commercial opportunities.

Now, 10 years after the reorganization, PLI has become a technology leader in single-photon sensors based on avalanche photodiodes (APDs). These devices are enabling solutions for 3-D lidar imaging, high-precision mapping, free-space communications and quantum network security.

From telecom to defense

PLI's single-photon APDs are an offshoot of the EPITAXX team's earlier work in telecom. Their 10-Gbps APD

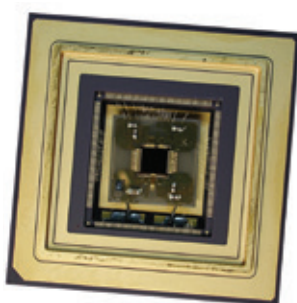
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receiver was designed around a widely used compound semiconductor material platform of indium gallium arsenide (InGaAs). The company's comprehensive understanding of APD device behavior, coupled with its focus on utilizing highly reproducible and scalable wafer-processing techniques, led to a high manufacturing yield for a complex device and gained EPITAXX a dominant market share in telecom receivers.

With Itzler at PLI, the focus shifted to single-photon detection and the specific behavior APDs exhibit when they are operated past their breakdown voltage—referred to as the Geiger mode. In this highly unstable state, avalanches can be triggered by the faintest incoming optical flux; just one photon is enough. The first application for these devices was quantum cryptography, where cryptographic keys are carried in strings of individual photons, making them secure against eavesdropping. PLI supplies single-photon detectors used in almost all fiber-based quantum networks in the United States, Europe and Asia.

PLI's reputation for single-photon detectors led to support from the U.S. Defense Advanced Research Projects Agency to develop a commercial single-photon lidar receiver based on technology from the MIT Lincoln Laboratory. PLI developed its Geiger-mode APD focal plane arrays with a focus on robust, scalable manufacturing, and brought to market a camera for use in 3-D lidar imaging.

PLI has gained a unique position in the defense industry as the leading manufacturer of Geiger-mode imagers. These focal-plane arrays of 4,000 InGaAs APD pixels, coupled with application-specific complementary metal-oxide semiconductor (CMOS) circuitry, are at the core of very-high-frame-rate cameras able to generate 3-D point clouds at 400 megapixels/s. The cameras are used for targeting, wide-area airborne mapping and long-distance ranging.



COMPANY INFO

URL

www.princetonlightwave.com

HEADQUARTERS

Cranbury, New Jersey, USA

PRODUCTS

InGaAs single-photon avalanche detectors, Geiger-mode cameras, lidars, diode lasers

From defense to commercial

Being a defense industry supplier has been a fast way for PLI to grow its business. But it is also finding commercial applications for single-photon technology—like the automotive industry's autonomous driving and driverless cars. Google and other auto manufacturers are planning the release, in the near future, of fully automated cars, thanks to leading-edge optical sensing techniques, especially lidars. Autonomous drones are another burgeoning market for 3-D lidars and advanced imaging systems.

PLI's competitive advantage is a solution based entirely on semiconductor devices, involving diode lasers delivering enough optical power to image at distances sufficient for autonomous driving, thanks to the extreme sensitivity of the single-photon detectors. Moreover, PLI's devices operate at a wavelength above 1,400 nm, which is safer to the eye than conventional 900 nm sources.

These commercial applications of 3-D lidar have target costs and volumes that are radically different from the defense industry. But the team already has the experience of a successful massive scaling of its APD technology for the telecom industry and believes that a wafer-scale semiconductor approach has excellent prospects for meeting the challenges of these new opportunities for widespread deployment.

Lessons learned

In order to be the best in its market space, the PLI team has learned that patience is the key to building a strong competitive advantage in a growing market with significant potential—as with the company's approach to 3-D imaging for the defense industry. At the same time, the company also needs to be attentive and take advantage of new opportunities, such as those in the automotive and drone segments. **OPN**

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