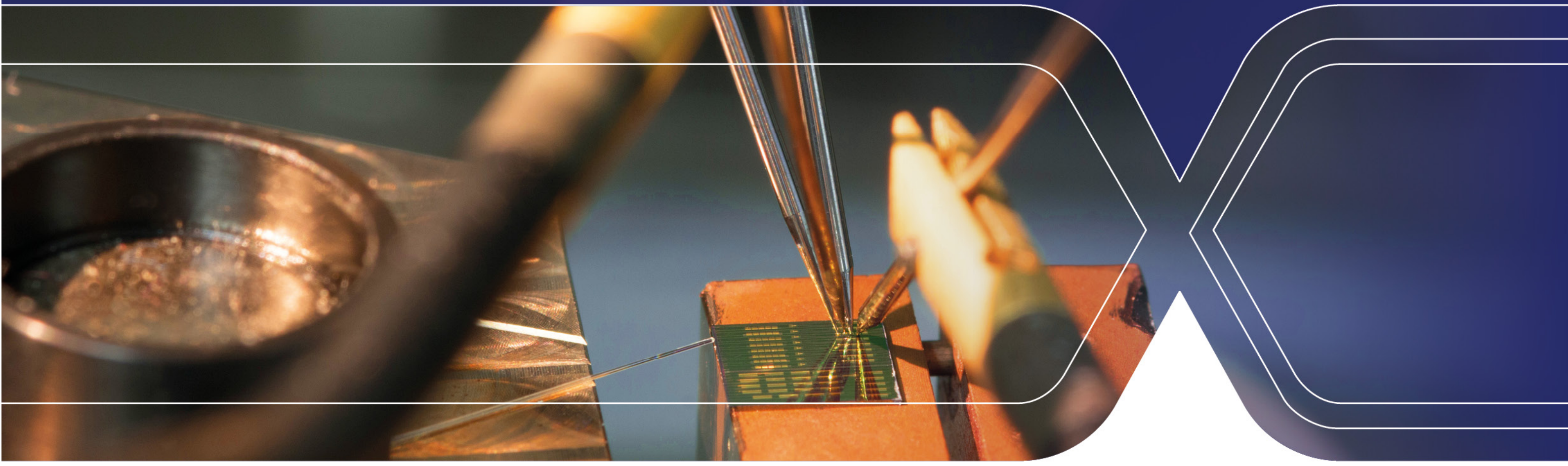
Application Note

Photonic Integrated Circuits for Lidar

JePPIX
Platform for Photonic Integration



PIC enabled Lidar

Lidar, short for light detection and ranging or “light radar”, is used to measure distances with high resolution and precision. This is achieved by illuminating the object with a scanning laser beam, and consequently measuring the reflections. Complete three-dimensional mappings can be made. Various techniques are used, such as pulsed, flash and frequency-modulated Lidar.

The opportunities for using Lidar are plenty, most notably in automotive, where it is used in advanced driver-assistance systems (ADAS) and in autonomous driving, providing a better resolution than radar. It is furthermore used in wind farms, to monitor wind speeds, and in remote sensing, mapping the environment and atmosphere.

A Lidar consists of a laser source, a laser beam scanner, and the detection optics. Traditionally, such systems were bulky and costly (see figure below). Over the last decade, pushed by the automotive market, the price of Lidar systems has come down by more than an order of magnitude. Solid-state Lidars are promising in bringing the cost down by another order of magnitude. Moreover, these Lidars are more robust, with no moving parts, and compact.

The opportunity for photonic integration

PICs offer some very concrete opportunities for Lidar. In solid-state Lidars, PICs can be used as the laser source. When combined with the on-chip components typically used in communications technology, pulsed lasers and frequency-modulated lasers can be realized. As an example, Blackmore[1] is bringing a frequency-modulated continuous-wave (FMCW) Lidar to the market, based on PICs. Such a Lidar provides both range and velocity measurements, through the Doppler effect. Coherent detection allows for highly-sensitive measurements, with high dynamic range. An added advantage is that PICs are designed for operation around wavelengths of 1550 nm, which is a sweet spot for Lidar due to eye-safety requirements. This allows the range to be extended significantly, to over 200 m, as argued by, e.g., Luminar[2].

InP Photonic Integrated Circuits (PICs)

Optical chips or PICs can contain tens to hundreds of optical components. While electronic integrated circuits (EICs) consist of transistors, capacitors, and resistors, a PIC consists of, for example, lasers, modulators, photodetectors, and filters, all integrated on a single substrate. Several application fields, such as data- and telecom, sensing, and lidar are already using or are considering the use of PICs for their products. This PIC technology is accessible to users without a cleanroom, through so-called multi-project wafer runs and open access foundries. InP based technology is commercially available through SMART Photonics and Fraunhofer Heinrich-Hertz-Institut. Access is individually coordinated by JePPIX.

[1] https://blackmoreinc.com/

[2] https://www.luminartech.com/

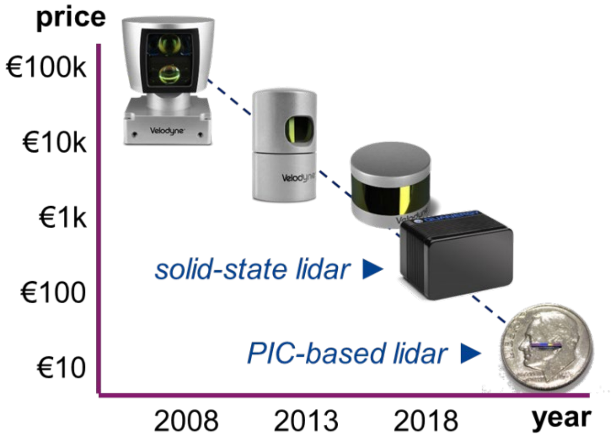


Figure 1: Evolution of the Lidar cost, including forecast. Source data: Velodyne, Quanergy and Massachusetts Institute of Technology.

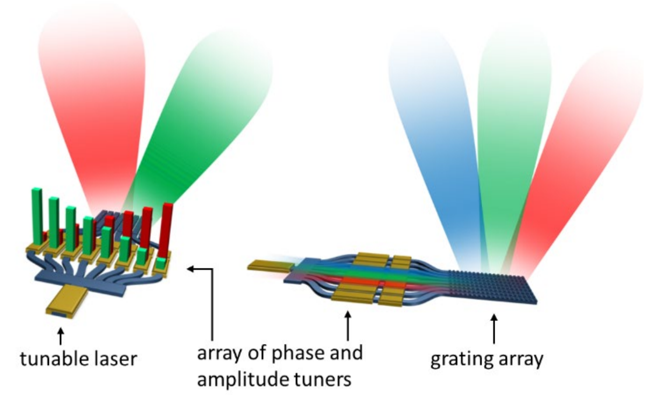


Figure 2: Schematic of an optical phased array, using optical phase control (left) and wavelength control (right) for beam steering[3].

PICs can also be used to replace the beam-steering part of the Lidar, through the use of optical phased arrays, as shown in the figure to the right. Much like phased-array antennas in wireless communications, such optical phased arrays can shape the laser beam and steer it fast for video-rate three-dimensional imaging[3]. The system has no moving components, as compared to using mechanical and micro-mechanical (MEMS) scanning devices, making it robust, and is lens-free. Laboratory-based implementations have already shown the feasibility, and the technology is now moving to the market, Analog Photonics[4] is pushing a silicon photonics approach, but such implementations can also be achieved in InP based PICs. Sources and detectors can be integrated on the PIC, with the potential of realizing a fully integrated, single-chip Lidar, and allowing unprecedented high volumes at low cost. Moreover, this technology allows for close integration with electronics.

Current technical developments

The PIC and overall system need to be carefully designed for the target application. The PIC technology platforms are mature now, accessible, for example, through our Pilot Line at high technology readiness level, but they have been developed mostly for telecom and datacom applications. Lidars require a different design approach, but the basic building blacks are available through our manufacturing-grade process design kits (PDKs). There are application-specific operational parameters that are different from the communications field. For example, for automotive applications, a target operating temperature range of −40 °C to 125 °C is often required. The PICs need to be designed for that, with adequate on-chip controls. Packaging of the PIC with electronics and, potentially, with fiber or free-space coupling, is eased by the availability of the packaging Pilot Line PIXapp.[5]. Specifically for optical phased arrays, the electronics for fast beam-steering into the 10s of MHz range, with many closely-integrated channels, require specific attention. Side-lobe suppression and beam width are design trade-offs for optical phased arrays[3].

Discuss your application with us

If you are interested in knowing more about the capabilities and use of InP PIC technology for AI applications, contact JePPIX. The JePPIX Pilot Line provides low entrance-threshold to mature-manufacturing, enabling high-TRL development in a scalable design kit driven process, taking open access InP PICs from proof of concept to industrial prototyping levels.

[3] https://doi.org/10.1515/nanoph-2015-0152
[4] http://www.analogphotonics.com/
[5] http://pixapp.eu/