SMART PHOTONICS
Independent InP Foundry

PHOTONIC INTEGRATED CIRCUITS FOR LIDAR

Highly-sensitive measurements, large dynamic range

LiDAR
Light Detection and Ranging (LiDAR) is a method for determining variable distance. Using a laser to target objects, it measures the time taken for reflected light to return to the receiver. It can also measure velocity using the same principle as radars in microwave frequencies. LiDAR applications are many and varied. It can be used to generate digital, 3D models of the earth's surface and ocean floor, make autonomous driving possible, or benefit mobile, terrestrial and airborne applications. This note describes the advantage of Photonic Integrated Circuits (PICs) in LiDAR.

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Why integrated photonics?

Originally designed for telecommunication applications, PICs are now a recognized way to solve more real-world problems. Why? Because they have a flexible set of building blocks; active and passive components that can be combined in different ways to deploy a variety of laser sources and complete on-chip circuits. Continuous wave and pulsed laser sources for light amplification, beam-steering and coherent detection with highly-sensitive measurements and a large dynamic range. The C-band wavelength also hits the sweet-spot between optical power and eye safety.

Indium Phosphide based Photonic Integrated Circuits

The key benefit of Indium Phosphide (InP) integrated circuits is monolithic integration. Laser sources and amplifiers, together with modulators and various passive elements, can all be integrated on one flat surface, or PIC. So, when LiDAR is implemented via a Frequency Modulated Continuous Wave (FMCW), the transmitter can be decomposed into a widely tunable laser which is linearly chirped (frequency swept), an amplification stage to further amplify the laser output, and an Optical Phased Array (OPA), for beam steering. But the real strength of InP monolithic integration is the design flexibility that this offers. In this transmitter example, the receiver can consist of a power combiner and a balanced detector, which heterodynes part of the laser output with the back-scattered (reflected) light.

For LiDAR, the most important tunable laser metrics are linewidth, output power and tuning range. Linewidths in the order of 100 kHz are desirable as more will result in poor spatial resolution. In our integration platform, we have widely-tunable lasers (Figure 1, 2 and 4.) The tunable laser in figure 4 has demonstrated up to 75 nm (Figure 4 and 5.), and narrow linewidths in the order of 100 kHz (Figure 1 and 2). However, customers can tailor designs to their exact needs.

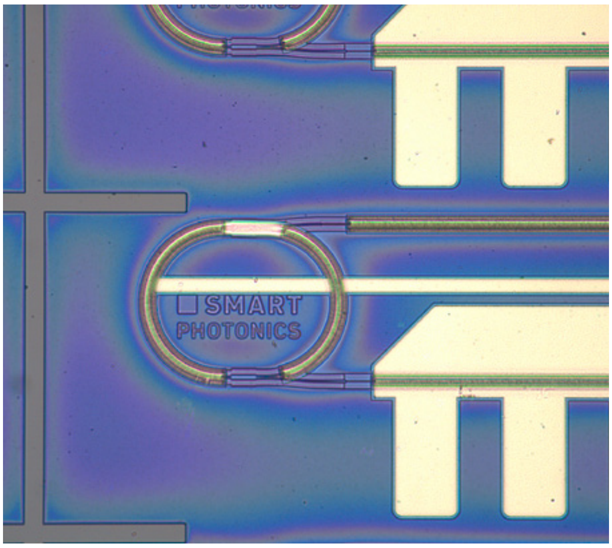


Figure 2. Tunable lasers SMART Photonics

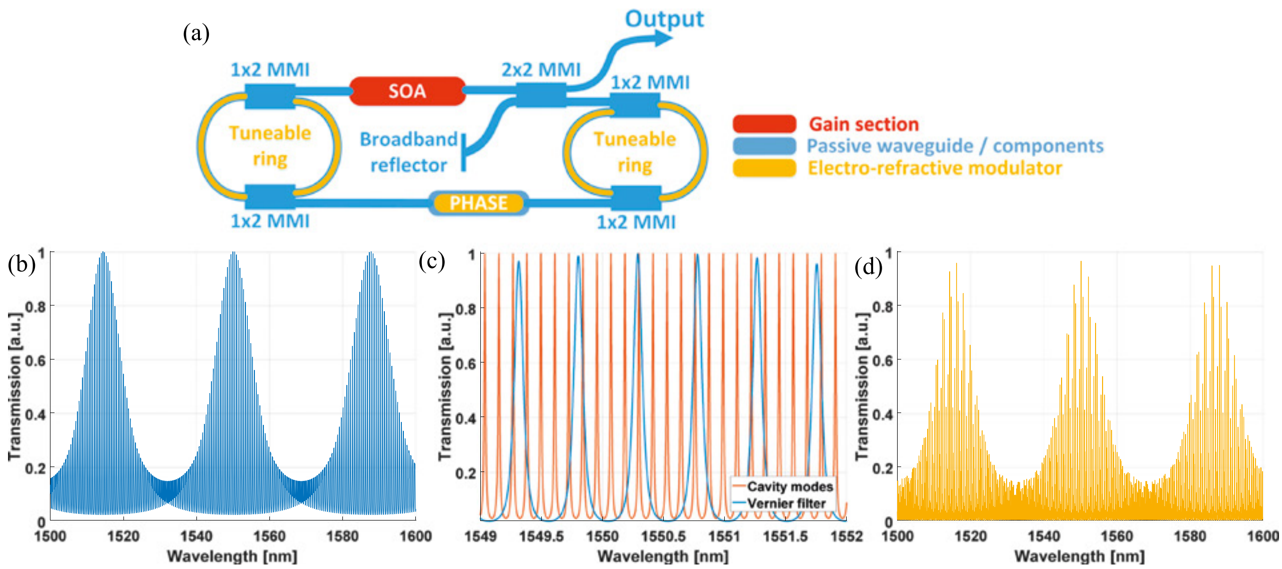


Figure 1. (a) Schematic of the tuneable ring laser with the two electro-optically tuned ring resonators and phase section and a broadband reflector to enforce unidirectionality, (b) calculated transmission profile of the Vernier filter (two ring resonators) with total 35 nm FSR, (c) close-in of the calculated transmission profile of the Vernier filter (blue) and longitudinal cavity modes (orange), and (d) example of a calculated Vernier filter transmission combined with the cavity mode selection resulting in single mode selection.

S. Andreou, K. A. Williams and E. A. J. M. Bente, "Electro-Optic Tuning of a Monolithically Integrated Widely Tunable InP Laser With Free-Running and Stabilized Operation," in Journal of Lightwave Technology, vol. 38, no. 7, April 1, 2020.

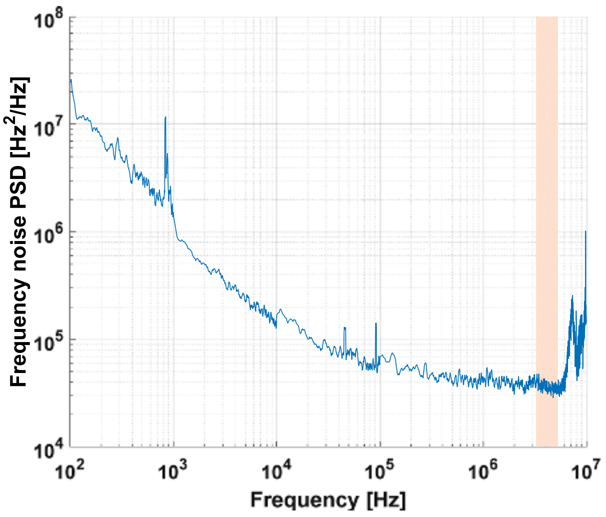


Figure 3.

Thanks to our monolithic approach, customers also have the freedom and flexibility to introduce booster amplifiers. The SMART Photonics platform delivers amplified laser sources of at least 50 mW and up to 80 mW optical power from a single SOA (Figure 6).

Lasers developed on SMART Photonics InP integration platforms also have the benefit of linear electro-optical phase modulators, low, on-chip power dissipation for tuning purposes, and fast (nanosecond) switching times that are intrinsic to electro-optical modulators (Figure 4).

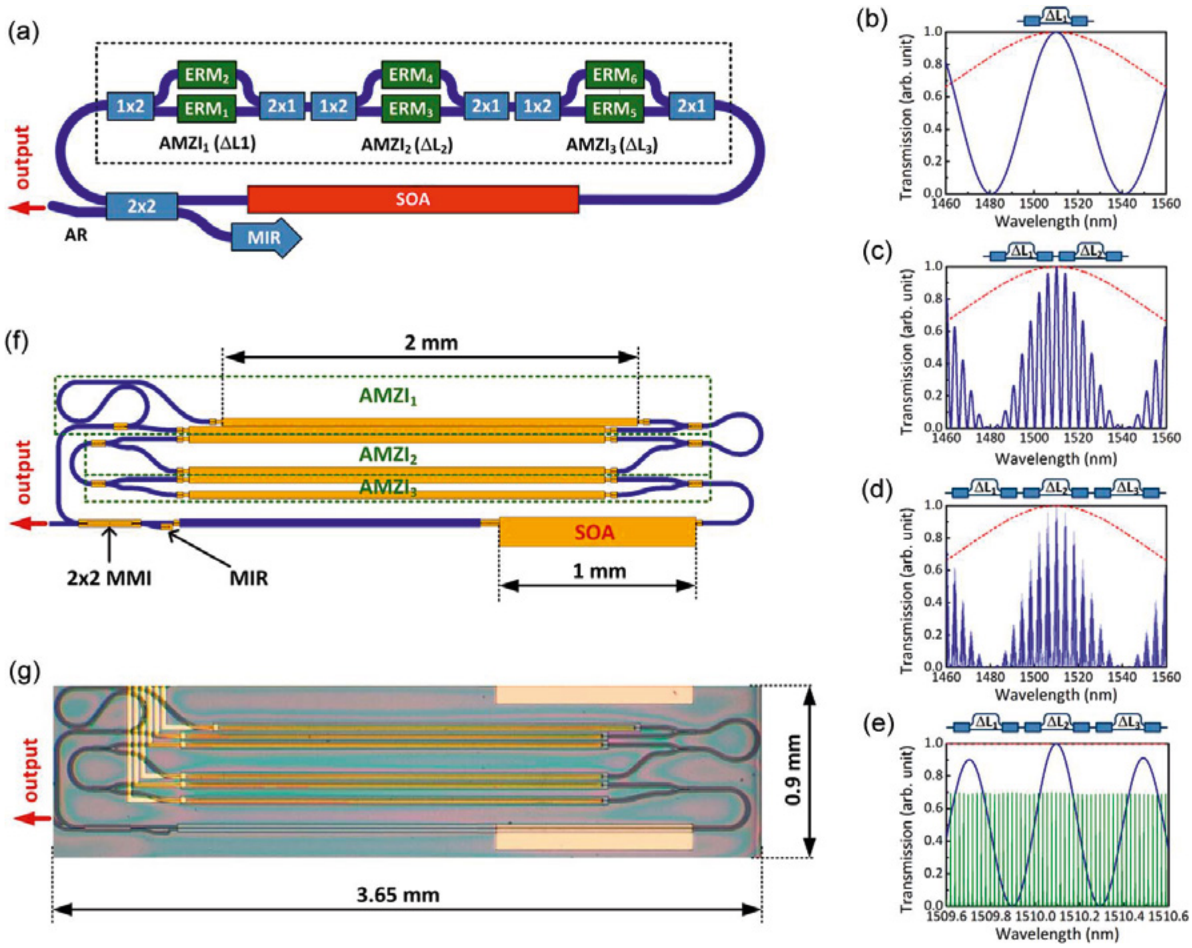
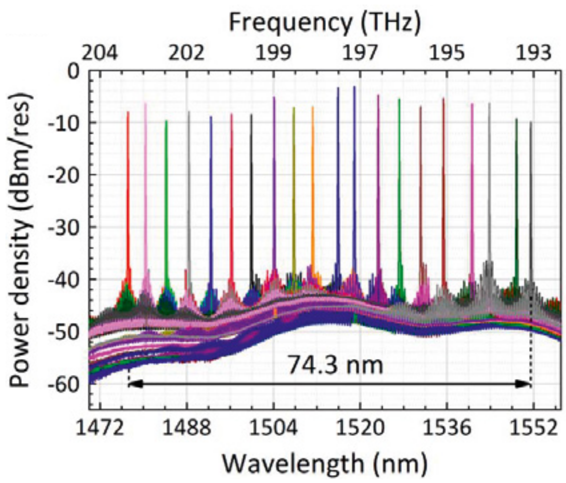


Figure 4. (a) Schematic of the extended cavity ring laser with an intra-cavity wavelength filter consisting of a three AMZI stages (dashed box), an SOA, a 2 _ 2 MMI coupler used for coupling out the optical signal in both directions, and a multimode interference reflector (MIR) connected to one of the outputs that ensures uni-directional operation of the laser and passive waveguides connecting all components. (b)–(e) The transmission spectra of the wavelength filter in blue overlapped with the gain profile indicated in red. (b) Single AMZI stage; (c) two AMZI stages in series; (d) three AMZI stages in series; (e) three AMZI stages in series over the wavelength span of 1 nm overlapped with longitudinal cavity modes in green. (f) Mask layout of the device with building blocks colored in yellow and passive waveguides in blue. (g) Microscope photograph of fabricated PIC with one extended cavity ring laser.

S. Latkowski et al., "Novel Widely Tunable Monolithically Integrated Laser Source," in IEEE Photonics Journal, vol. 7, no. 6, pp. 1-9, Dec. 2015, Art no. 1503709, doi: 10.1109/JPHOT.2015.2493722.



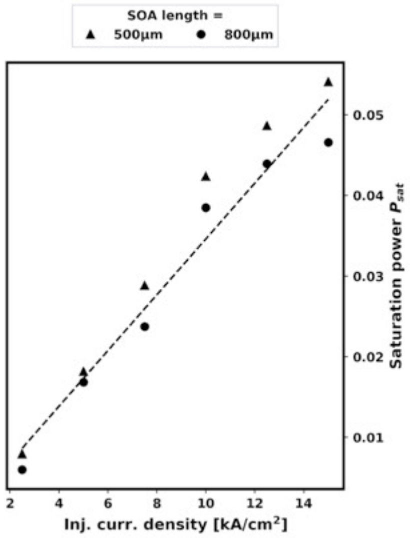


Figure 5. Twenty overlapped optical spectra (0.05 nm resolution) recorded with the SOA section DC biased at ISOA ¼ 140 mA (~2.2 times of the Ith) at room temperature, showing a tuning range of 74.3 nm.

S. Latkowski et al., "Novel Widely Tunable Monolithically Integrated Laser Source," in IEEE Photonics Journal, vol. 7, no. 6, Dec. 2015.

Figure 6. Power spectral density of the frequency noise of the laser at 120 mA SOA current lasing at 1548.6 nm. The orange area indicates the white part of the frequency noise which multiplied by π yields an intrinsic linewidth of 109 kHz.

S. Andreou, K. A. Williams and E. A. J. M. Bente, "Electro-Optic Tuning of a Monolithically Integrated Widely Tunable InP Laser With Free-Running and Stabilized Operation," in Journal of Lightwave Technology, vol. 38, no. 7, 1 April1, 2020.

Our approach

Our approach enables fast prototyping and cost-effective development with no compromise on performance or functionality. No in-depth knowledge of the technology is required; customers can simply custom-design PICs using the extensive library of building blocks in our Process Design Kit (PDK).

Next to dedicated runs, SMART Photonics offers a multi-project wafer (MPW) approach to produce PICs.

For further information, feel free to contact our sales representatives at the following email address:

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smartphotonics.nl/MPW

SMART Photonics

At SMART Photonics, our aim is to be the leading foundry and development partner in integrated photonics that works closely together with our customers to create innovative products that improve people's lives.