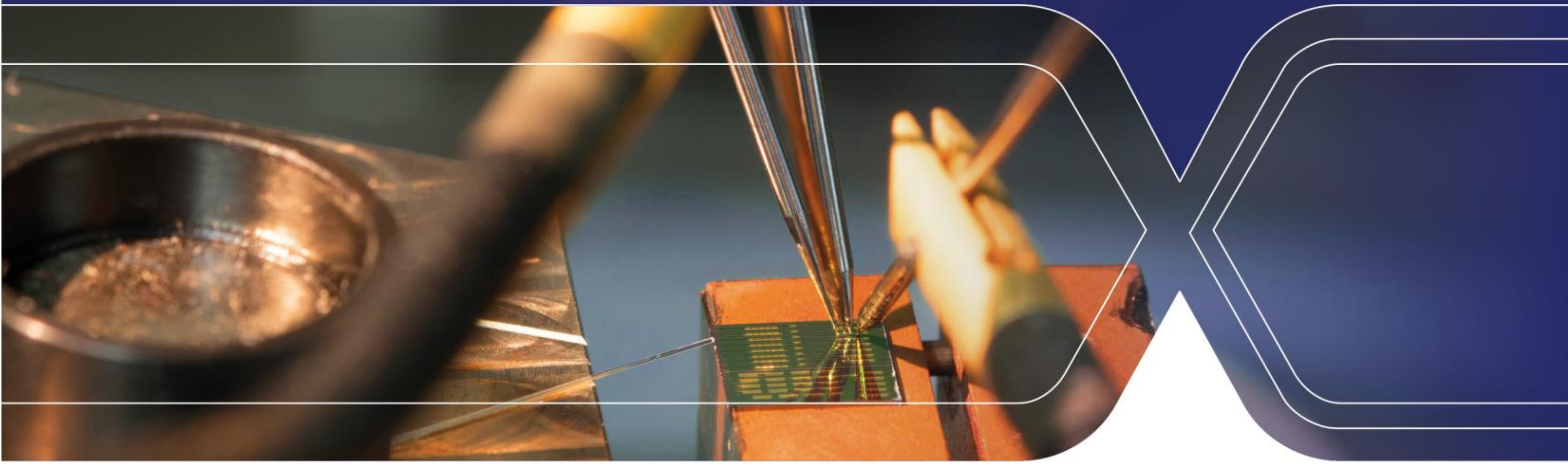
Application Note

Laser Sources for Silicon Photonics

JePPIX
Platform for Photonic Integration



Laser sources for silicon photonics

Silicon photonics promises highly integrated photonic integrated circuits (PICs), fabricated using a mature, CMOS-compatible, infrastructure. This leads, in principle, to robust, high-yield, and reproducible production of PICs. Foundries like GlobalFoundries, TowerJazz, and TSMC are running such processes at commercial level. Silicon photonics enabled products have found their way to the market for data communication, e.g., by Luxtera and Kotura, and later also for telecommunications, e.g., by Acacia and Elenion. Its scalability, i.e., high potential integration density of tens of thousands of components, is now being explored for applications in deep learning, neuromorphic computing, in-memory computing and even quantum computing.

However, most silicon photonics technologies lack integrated sources, and rely on external lasers as a light source. Such lasers are typically hybridly integrated, placed next to the silicon PIC[1], coupled through edge-emitting facets, or on top of the silicon PIC, coupled through vertical grating couplers. As silicon uses typically O-band and L-band light, i.e., the wavelength windows around 1310 nm and 1550 nm, indium phosphide (InP) lasers are sources of choice. Relatively simple datacom transceivers might only need one laser, emitting at one wavelength. For higher bandwidths, above 100 Gbps, multiple lasers can be used, for coarse wavelength-division-multiplexed (CWDM) links. Future Tbps links, such as AyarLabs' TeraPHY[2] optical I/O, require sources with 8+ ports, carrying 8+ wavelengths each.

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.

Opportunities for open access and generic technologies

Single-wavelength distributed-feedback (DFB) lasers and (externally modulated) laser arrays for, e.g., 4-channel, CWDM links are commercially available at die level. However, if more wavelengths are needed, at different spacings, or with different noise and power properties, then customization is required. Also, the physical placement of optical

[1] https://doi.org/10.3390/app6120426

[2] https://ayarlabs.com/products/

connections and electrical connections, i.e., the bond pad placement, can benefit from customization. The generic process for InP PICs, available through the JePPIX Pilot Line, has been set up for exactly that purpose.

On-chip arrays of DFB or distributed Bragg reflector (DBR) lasers can be designed, at arbitrary wavelengths within the gain bandwidths of the semiconductor optical amplifiers (SOAs). This allows for customization from, e.g., 20-nm spacing, for CWDM, to 25/50/100 GHz for dense WDM. Lasers can be individually optimized for target output power levels, for maximum energy-efficiency, which can be done by adjusting the SOA length and reflector strength by design. Using various mode-locked laser concepts, comb lasers can be realized, generating all required wavelengths with one source, typically at 25 or 50 GHz spacings. On-chip phase tuners allow for locking the wavelengths to the required grid, while on-chip photodetectors can be used for the monitoring, control and feedback loops. To allow for more complex sources, multiple single-wavelength sources can be multiplexed into a multiple of outputs, thereby providing multiple outputs, each carrying a set of wavelengths. For example, 16 lasers can be multiplexed over 16 output waveguides on an InP PIC, providing 256 optical channels for a silicon PIC. But given the flexibility and versatility of the generic JePPIX technology, more functionality can be added to the source InP PIC. For example, multiple widely-tunable lasers, i.e., covering the full C-band each, can be combined, to power silicon-based reconfigurable optical add-drop multiplexers (ROADMs). Also, modulators, both electro-absorption and Mach-Zehnder-based, can be added to the InP PIC source, for externally-modulated laser arrays.

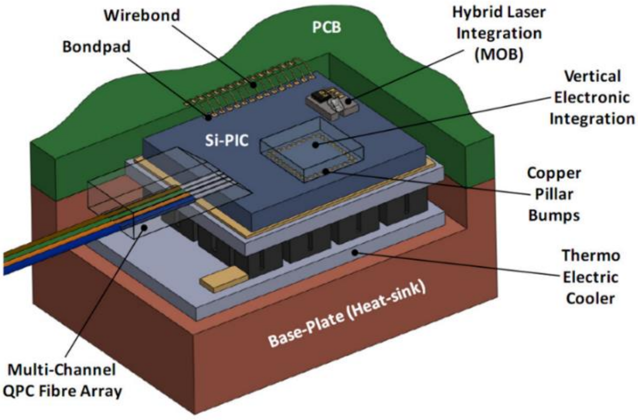


Figure 2: Schematic of a packaged silicon PIC with hybridly-integrated InP laser, based on a micro-optic bench. Image courtesy of Tyndall [1].

By combining all of these sources on a single PIC, control of wavelength and power becomes more easy, as control electronics can be intimately integrated, and thermal effects and process variations, will affect the whole PIC in a rather uniform way, thereby increasing the robustness of operation.

Adding light sources to a Si PIC is always a technical challenge, and often dominates the cost of the package. However, combining sources on a single InP PIC can limit the complexity and, thus, cost. Considerations include the need for an optical isolator, and the option to mount PICs side-by-side or on the surface. The latter can benefit from vertical grating couplers, which are available in some of our JePPIX platforms. Standard packaging solutions exist, for example as available through the PIXAPP packaging Pilot Line[3].

Discuss your application with us

If you are interested in knowing more about the capabilities and use of InP PIC technology for fiber sensing applications, contact JePPIX[4].

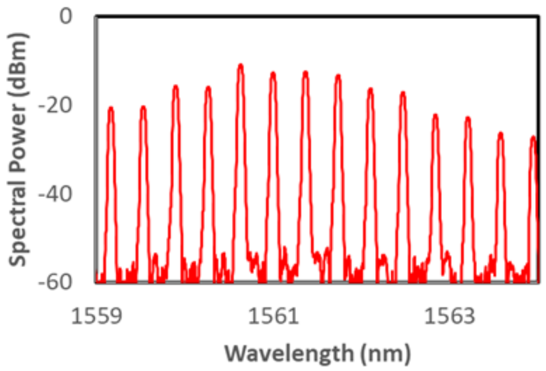


Figure 1: Output of an InP-based mode-locked laser diode, fabricated in the SMART Photonics platform. The comb of equally-spaced optical frequencies can be used as efficient WDM sources for a silicon PIC. Image courtesy of Aarhus University.

[3] https://pixapp.eu/

[4] www.jeppix.eu/pilotline