(Small) Tunable Laser Size Matters

Several applications in the optical network edge would benefit from upgrading from 10G to 100G DWDM or from 100G grey to 100G DWDM optics:

- **Business Services** could scale their enterprise bandwidth beyond single-channel 100G links.
- **Fixed Access** links could upgrade the uplinks of existing termination devices such as optical line terminals (OLTs) and Converged Cable Access Platforms (CCAPs) from 10G to 100G DWDM.
- **Mobile Midhaul** benefits from a seamless upgrade of existing links from 10G to 100G DWDM.
- **Mobile Backhaul** benefits from upgrading their links to 100G IPoDWDM.

The 100G coherent pluggables for these applications will have very low power consumption (less than 6 Watts) and QSFP28 form factors that are slightly smaller than a typical 400G QSFP-DD transceiver. To enable this next generation of coherent pluggables, the next generation of tunable lasers needs to reach another level of optical and electronic integration.

The Impact of Small and Integrated Lasers

Laser miniaturization and integration is not merely a matter of size; it's also vital to enhance the power efficiency of these lasers. Below are some examples of the ways small lasers can improve energy efficiency.

- **Lower Operating Voltage and Currents:** Smaller, highly-integrated laser designs normally require lower threshold voltages and currents than larger lasers.
- **Improved Heat Dissipation:** Compact designs reduce the distances light must travel inside the laser chip. This leads to fewer optical losses and heat dissipation.
- **Fewer Coupling Losses:** One of the hardest things to do in photonics is coupling between free-space optics and a chip. Highly integrated lasers combine multiple functions on a single chip and avoid this kind of coupling and its associated losses.

Photonic integration is vital to achieve these size and power consumption reductions. The more components can be integrated on a single chip, the more can losses be minimized and the more efficient the optical transceiver can become.

The Past Successes and Future Challenges of Laser Integration

Over the last decade, technological progress in tunable laser integration has matched the need for smaller footprints. In 2011, tunable lasers followed the multi-source agreement (MSA) for integrable tunable laser assemblies (ITLAs). By 2015, tunable lasers were sold in the more compact micro-ITLA form factor, constituting a mere 22% of the original ITLA package volume. In 2019, the nano-ITLA form factor reduced ITLA volumes further, as the module was just 39% of the micro-ITLA volume.

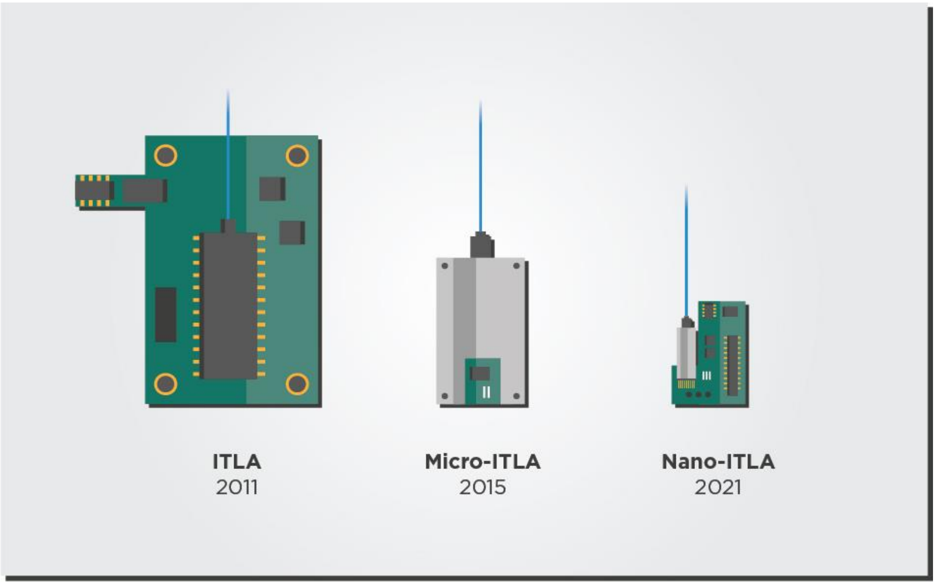

Figure 1: Evolution of tunable laser form factors for coherent optics (2011-2021). Figure inspired from a picture in Laser Focus World.

Despite this progress, the industry will need further laser integration for the QSFP28 pluggables used in 100G ZR coherent access. Since QSFP28 pluggables have a lower power consumption and slightly smaller footprint than QSFP-DD modules, they should not use the same lasers as in QSFP-DD modules. They need specialized laser solutions with a smaller footprint and lower power consumption.

	QSFP-DD	QSFP-28
		
Size	18.35 / 89.4 / 8.5mm	18.35 / 72.3 / 8.5mm
# of Interface Lanes	8	4
Power Consumption	Up to 14 W	Up to 6 W
DSP	Uses existing 400ZR DSPs	Requires new DSP development

Figure 2: Comparison between QSFP-DD and QSFP-28 form factors for 100G applications.

Achieving these ambitious targets requires monolithic lasers that ideally include all key laser functions (gain, laser cavity, and wavelength locker) on the same chip.

Pushing Tunable Laser Sizes Further Down

Reducing the footprint of tunable lasers in the future will need even greater integration of their parts. For example, every tunable laser needs a wavelength locker component that can stabilize the laser's output regardless of environmental conditions such as temperature. Integrating the wavelength locker component on the laser chip instead of attaching it externally would help reduce the laser package's footprint and power consumption.

EFFECT Photonics' laser solution is unique because it enables a widely tunable laser for which all its functions, including the wavelength locker, are monolithically integrated on a single chip. This setup is ideal for reducing power consumption and scaling into high production volumes.

This monolithic integration of all tunable laser functions allowed EFFECT Photonics to develop a novel pico-ITLA (pITLA) module that will become the world's smallest ITLA for coherent applications. The pITLA is the next step in tunable laser integration, including all laser functions in a package with just 20% of the volume of a nano-ITLA module. The figure below shows that even a standard matchstick dwarves the pITLA in size.

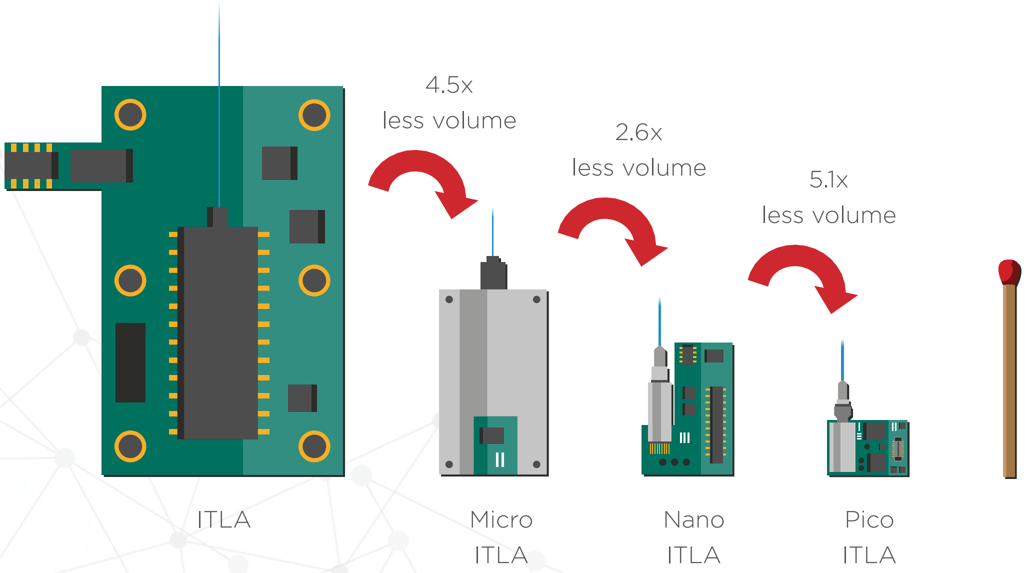

Figure 3: Volume reduction of ITLA form factors for coherent optics (2011-2023). A match of roughly 4cm in length is included for scale.

Takeaways

The impact of small and integrated lasers extends beyond mere size considerations; it crucially contributes to enhancing power efficiency. Smaller laser designs inherently operate at lower voltages and currents, offering improved heat dissipation and minimizing coupling losses. Photonic integration emerges as a pivotal factor in achieving these reductions, maximizing efficiency by consolidating multiple functions onto a single chip.

The journey towards 100G coherent technology in access networks requires compact and power-efficient coherent pluggables in the QSFP28 form factor and, with it, compact and power-efficient tunable lasers that fit this form factor. EFFECT Photonics is contributing a new step in this integration and miniaturization process with its pico-ITLA module. With a volume 20% that of a nano-ITLA module, the pITLA not only meets ambitious targets but also exemplifies the continuous push towards achieving compact, efficient, and scalable tunable lasers for the optical networking edge.

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