INSIGHT PAPER

CW-WDM MSA Compliant InP Laser Sources for Hybrid Silicon Photonic Integration

Established in 2020, the CW-WDM MSA (Continuous-Wave Wavelength Division Multiplexing Multi- Source Agreement) was formed to standardise WDM CW sources in the O-band for emerging advanced integrated optics applications that are expected to move to 8, 16, and 32 wavelengths.

Standardising higher wavelength counts is a crucial part of an emerging ecosystem which is enabling a leap in efficiency, cost, and bandwidth scaling compared to current technology for emerging applications such as AI, HPC, and high-density optics.

As a founding and Promoter Member of the CW-WDM MSA, Sivers Photonics work to develop the specifications, contribute and license IP, vote on the Standard, and actively promote the MSA. The first set of specifications was released on 4 June 2021. Having this agreed set of wavelength standards available across the industry is a huge step forward in allowing for the further development of advanced integrated optics applications.

The Promoter Members of the CW-WDM MSA are Arista Networks, Ayar Labs, Sivers Photonics, imec, Intel, Lumentum, MACOM, Quintessent, Sumitomo Electric, and II-VI.

Figure 1. Promoter Members of MSA

KEY HIGHLIGHTS OF THE CW-WDM MSA SPECIFICATION

- Frequency assignments for 8, 16 and 32 wavelength grid configurations with multiple grid spacings.
- Two physical configurations including a modular optical source with each output port carrying a single wavelength, and an integrated optical source with each output port carrying all the wavelengths.
- A range of output power classes targeting applications that require very low and very high output levels.
- Definitions of optical parameters and measurement methods, including relative intensity noise, side mode suppression ratio (SMSR), and linewidth.
- Fixed and flexible wavelength grid configurations to allow for deployment in a variety of environmental conditions.

Developing and standardising high-count WDM CW laser sources in O-band is crucial for emerging integrated photonic applications in advanced datacom and computing optics.

Sivers Photonics' uncooled CW DFB laser arrays provide an 8-channel solution with 400GHz channel spacing and > 50mW optical power output per channel, with 100 mW designs currently in development. While typical wavelength accuracy of +/- 50GHz is specified in the MSA, integrated on-chip heaters can also be added to produce tighter wavelength control when required.

Sivers Photonics' CW-WDM MSA devices are fabricated on the InP100 Product Platform in Sivers UK foundry, providing end-to-end design, manufacture and qualification for early phase prototypes and high-volume production. The platform InP100 platform is a common design and manufacturing framework for Indium Phosphide (InP) photonics devices, which uses established and reliable process modules to produce multiple device types. The platform enables the fabrication of InP array devices with a high yield and uniformity. With proven reliabilty, these devices are scalable to high volume manufacturing, reducing time to market.

Sivers Photonics' bespoke DFB laser arrays can be designed for traditional butt-coupling, as well as with an optimised device architecture for flip chip hybrid integration on Silicon Photonics. Available application specific features include high-accuracy vertical alignment surfaces, self-aligned waveguide and facet fiducials, optimised metal stack for flip-chip integration (including pre-deposited AuSn solder pads), and backside wafer patterning for alignment fiducial and device serialisation, making these the best laser arrays on the market for hybrid integration on SiPh.

Multi-wavelength CW laser sources along with Silicon Photonics can lead to co-packaged optics that are energy efficient, cost-effective and more scalable than discrete components to enable very high bandwidth interfaces to address increased global bandwidth requirements.

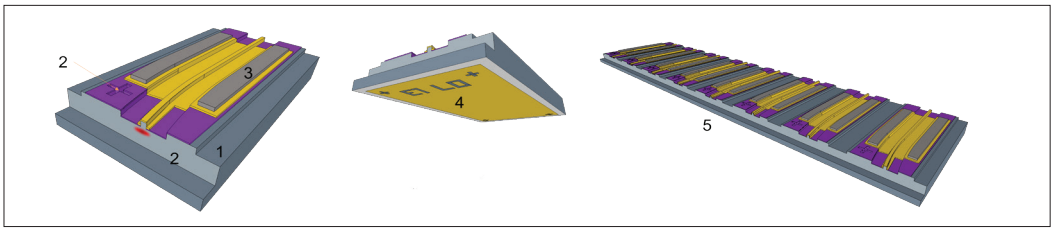


Figure 2. Optimised Lasers for Silicon Photonic Chip Assembly

KEY FEATURES	BENEFITS
1. Vertical alignment surfaces	±5nm height accuracy to optical mode centre
2. Etched facets with self-aligned front-side fiducials	High accuracy passive alignment to Si/SiN waveguides
3. Optimised metal stack with AuSn solder	No requirement for AuSn solder pads on Si PIC
4. Backside wafer patterning with alignment fiducials and IDs	Front to back image recognition for passive alignment and chip identification post-bonding
5. Array output format, individually addressable ports	Wide tunability range

PARTNERING WITH IMEC

As part of an ongoing collaboration project, Sivers InP DFB lasers have been bonded onto imec Si/SiN platform wafers, making Silicon Photonics accessible for a wider range of cost sensitive applications from optical interconnects, LiDAR, to biomedical sensing.

Initial results from first bonded devices:

- Single InP DFB chip center wavelength ~1550nm
- 4-channel DFB array with 200GHz channel spacing
  FC-bonding underway
- No Ripples on the L-I over temperature
- High-precision (0.5um) laser assisted FC bonder tool
- Bonding optimization ongoing to improve coupling efficiency - target of ≥ 2dB

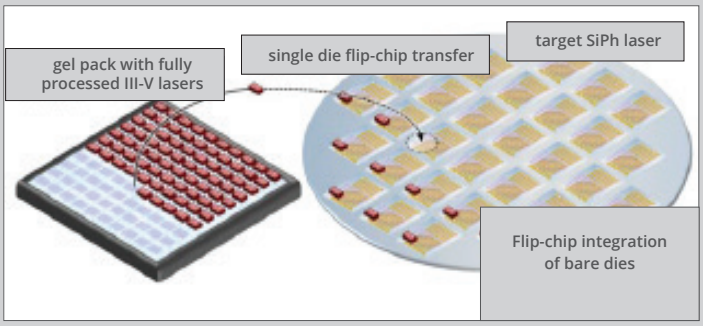
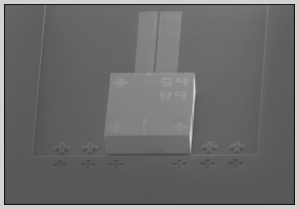
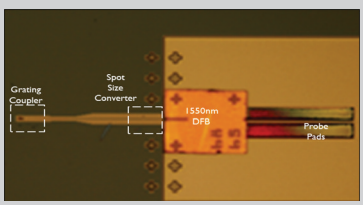


Figure 3. Sivers Photonics uses the flip-chip integration of bare dies to III-V materials





DFB laser diode arrays designed for use in CW-WDM MSA compliant applications

The laser design is a ridge waveguide (RWG) grown on n-type substrate with multi-quantum well (MQW) active layers and distributed-feedback (DFB) e-beam lithography grating layer. The facets are coated with a hermetic anti-reflectance layer on the front facet and a high reflectance coating on the rear facet.

Key Feautres of 8 Channel DFB Array

- 50mW per channel CW operation
- 400 GHz channel spacing around 1300nm
- Operating temp 20°C to 70°C
- AlInGaAs MQW active region

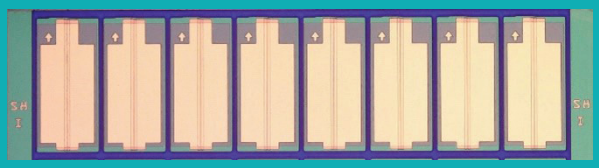


Figure 4. 8 x Channel DFB Array

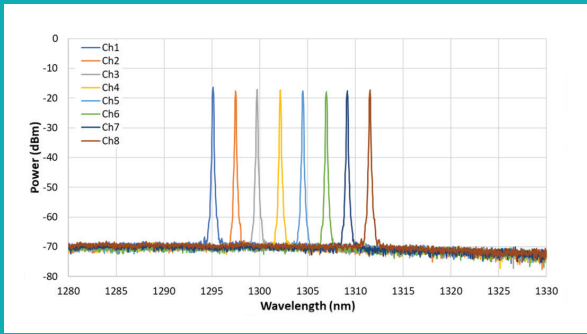


Figure 5. Optical Spectrum @ 45°C

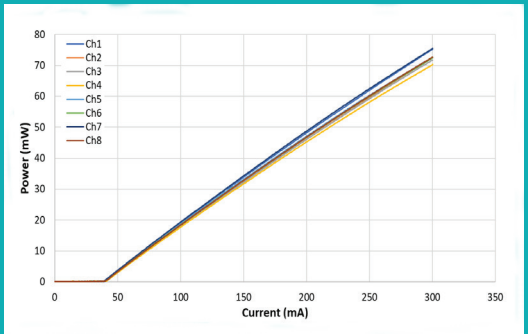


Figure 6. LIV Curve @ 45°C

Developing CW-WDM MSA Compliant Laser Arrays to Power Ayar Labs' Optical I/O Solution

Following the publication of the first set of CW-WDM specifications, Sivers Photonics announced the collaboration with Ayar Labs.

High power DFB laser arrays, built on the Sivers InP100 product platform, are currently in development and will form a crucial part in the supply chain for Ayar Labs' multi-wavelength SuperNova™ light source.

The SuperNova™ light source is the backbone of Ayar Labs' optical I/O solution, providing up to 16 wavelengths of light and powering up to 16 ports. Combined with Ayar Labs TeraPHY™ optical I/O chiplet, the solution provides up to 1000x the bandwidth at 1/10 of the power compared to electrical I/O alternatives.

The first optical source designed to be compliant with the CW-WDM MSA specification, SuperNova can be deployed across a wide range of applications including high-speed I/O, artificial intelligence, optical computing, and high density, co-packaged optics.

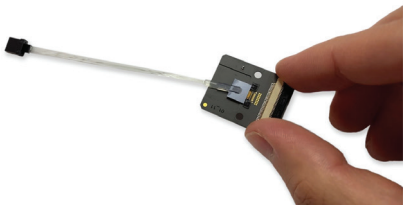


Figure 7. Ayar Labs SuperNova™ Light Source (Image: Coutesey of Ayar Labs)

"Sivers Photonics' bespoke DFB laser arrays based on the CW-WDM MSA spec are a critical component for our solution and move us one step closer to delivering optical I/O at scale"

Charles Wuischpard, CEO of Ayar Labs