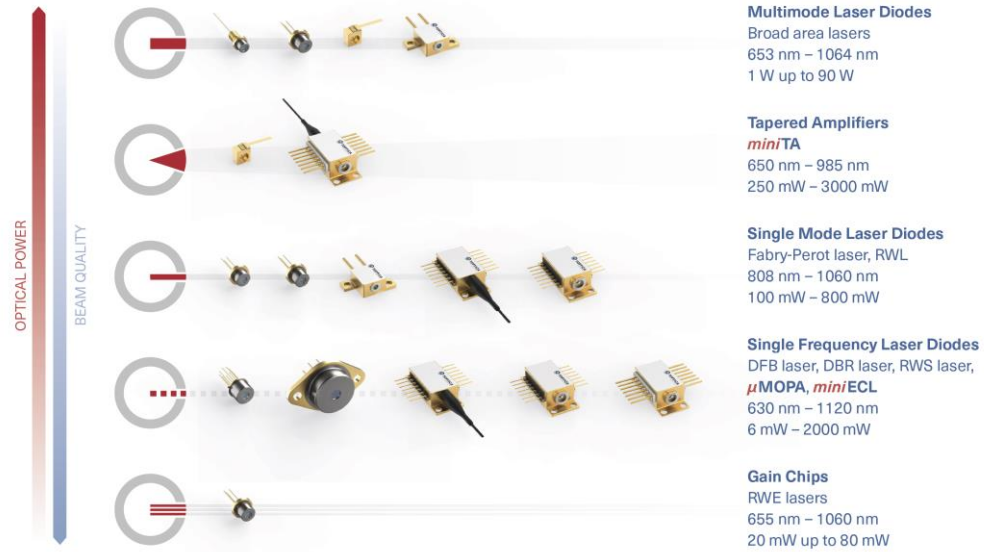
Packaging Challenges for single frequency lasers in the NIR / VIS

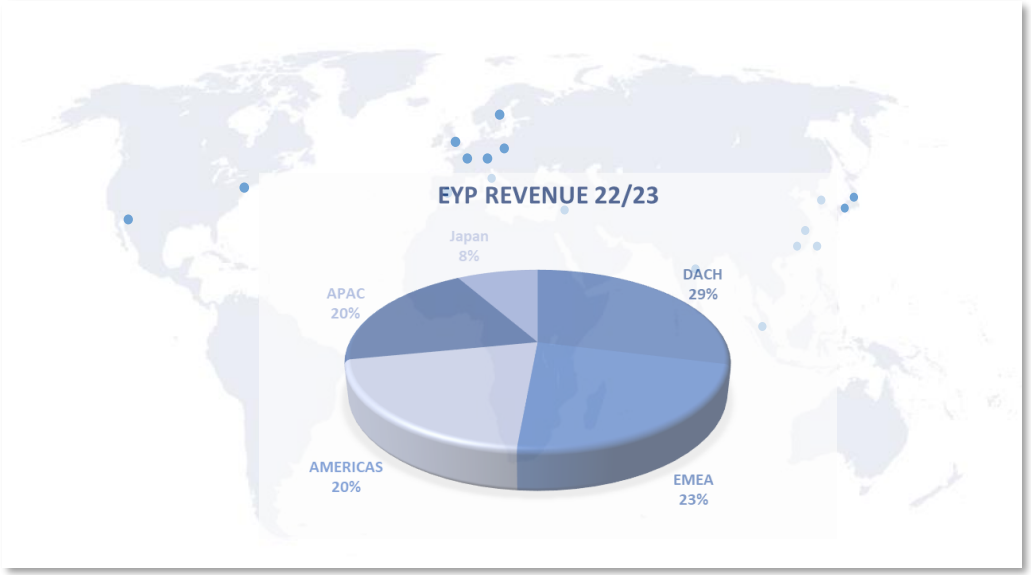
Björn Globisch, TOPTICA EAGLEYARD, Rudower Chaussee 29, 12489 Berlin

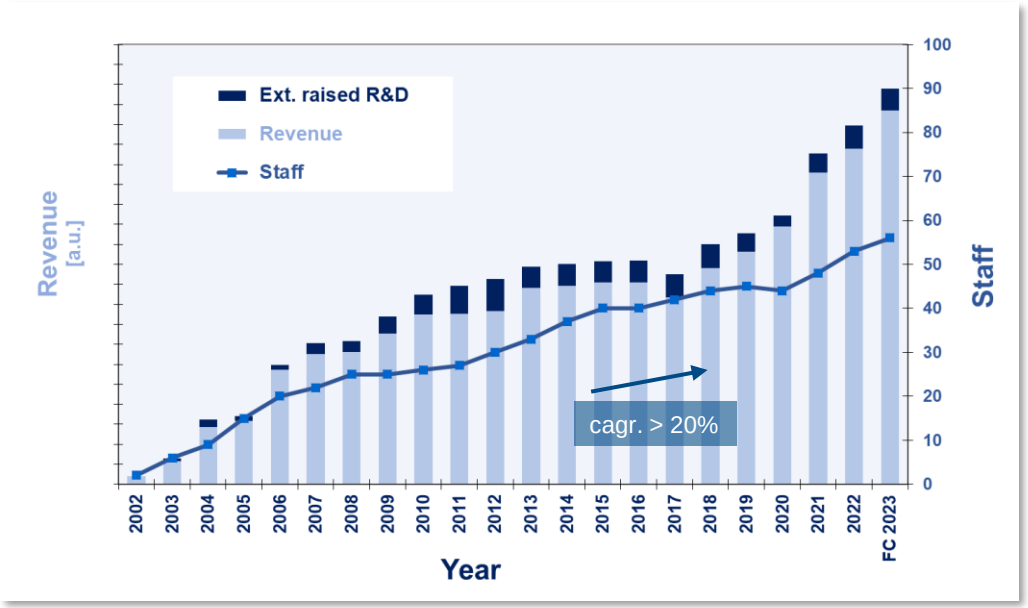
EPIC Technology Meeting @ Fraunhofer IZM in Berlin, 04./05.06.2024

TOPTICA EAGLEYARD AT A GLANCE

- Founded 2002 as a spin-off from Ferdinand-Braun-Institut/Berlin
- Member of TOPTICA group since 2013
- Portfolio:
  - High power single emitter laser diodes from 630 to 1120 nm (GaAs technology)
  - Five product families sorted by laser diode design







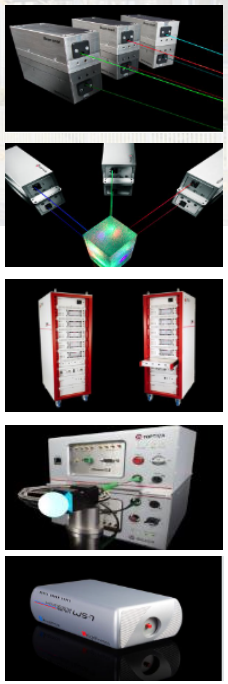
TOPTICA GROUP

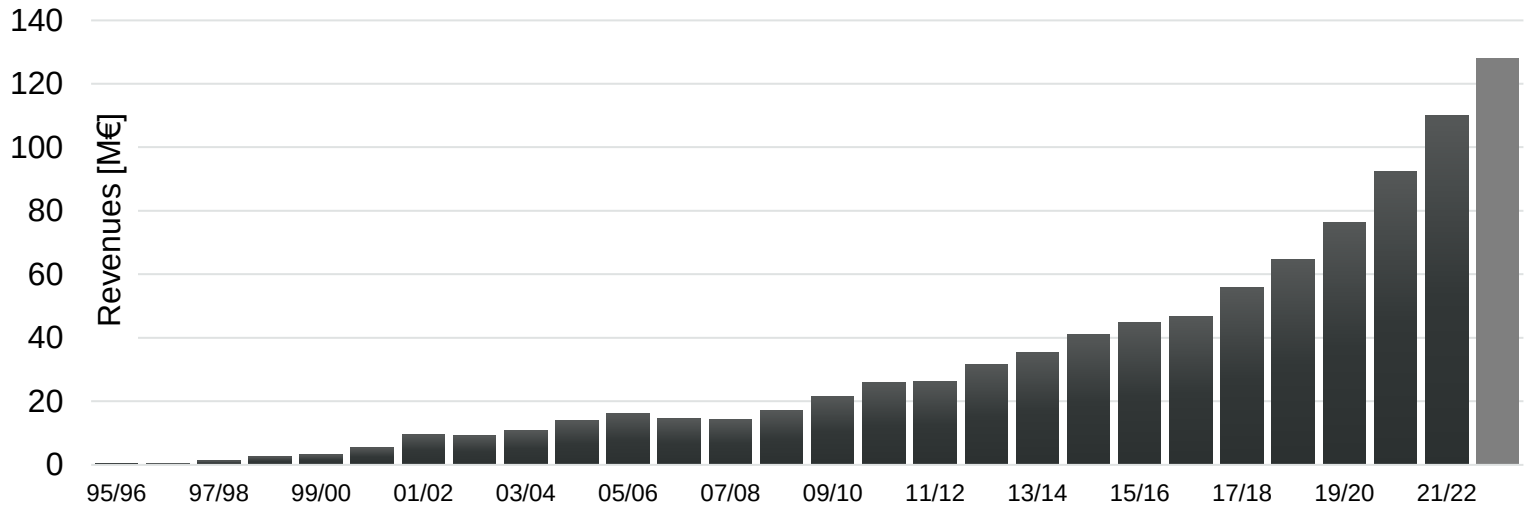
Technology

Diode Laser Systems	190 – 4000 nm
Ultrafast ps/fs Fiber Lasers	390 – 15000 nm
CW Fiber Lasers & Amplifiers	488 – 1570 nm
Terahertz Generation	0.1 – 6 THz
High Power Laser Diodes	630 – 1120 nm (TOPTICA EAGLEYARD)

Key Figures

Employees	480
Revenues	110 Mio € (119 Mio $)
Founded	1998

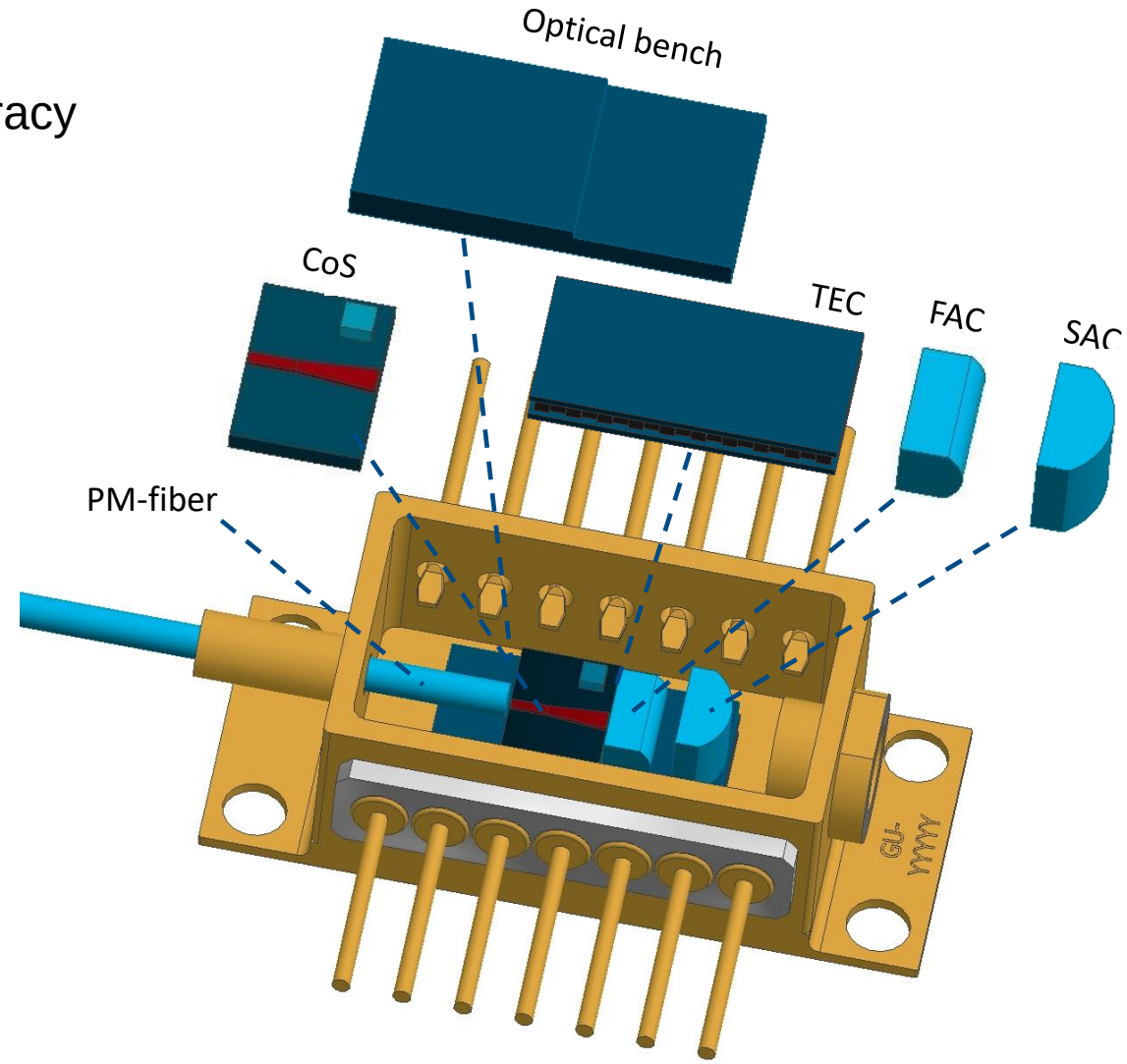




Micro assembly technology @ TOPTICA EAGLEYARD

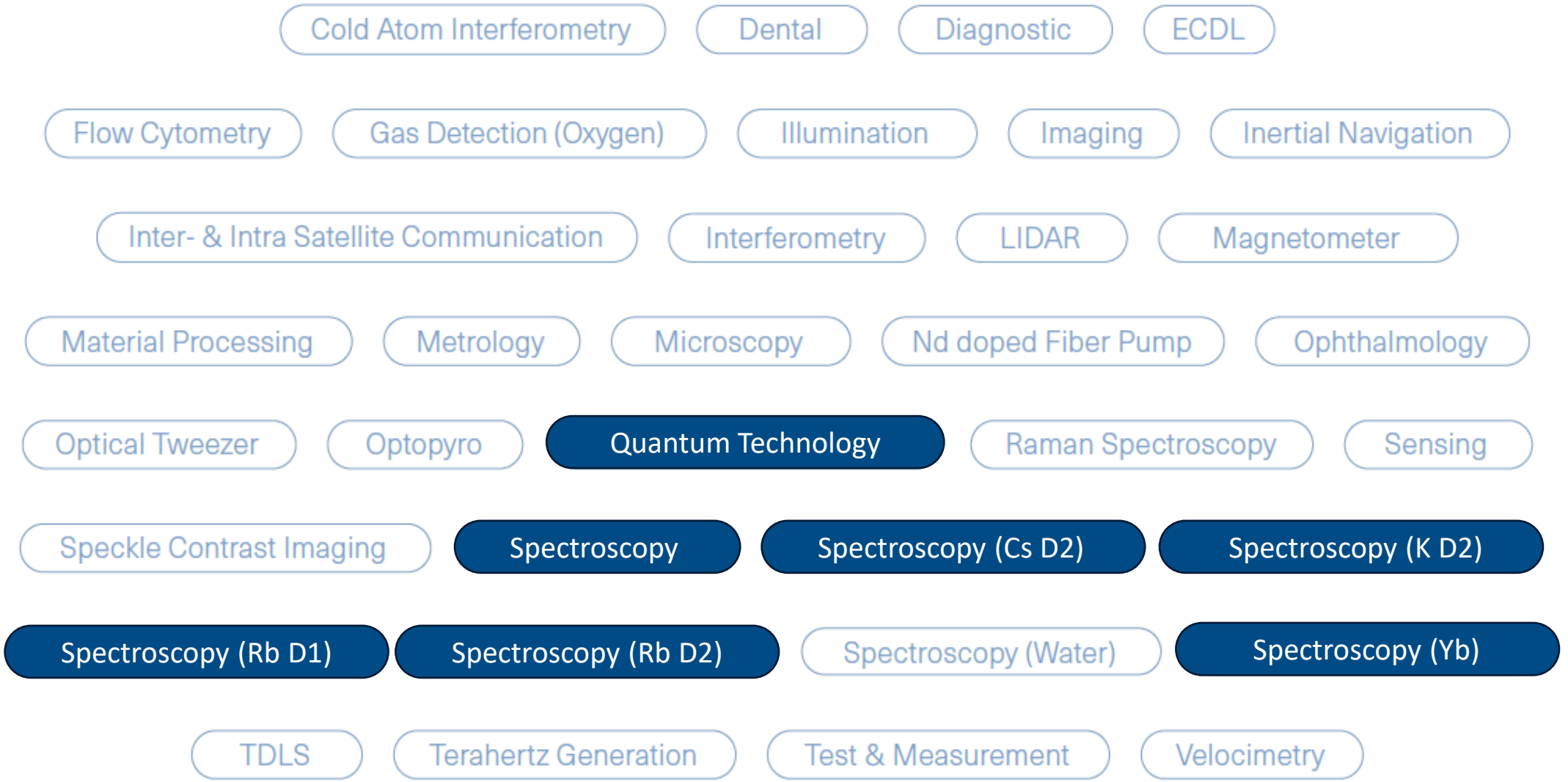
Core processes require µm to sub-µm accuracy

- Vacuum soldering
- Wire bonding
- Die attachment
- Active alignment
- Optical fiber-coupling
- Hermetic sealing
- Space qualified processes



Tapered amplifier in fiber-coupled 14-pin butterfly with collimated output beam.

APPLICATIONS



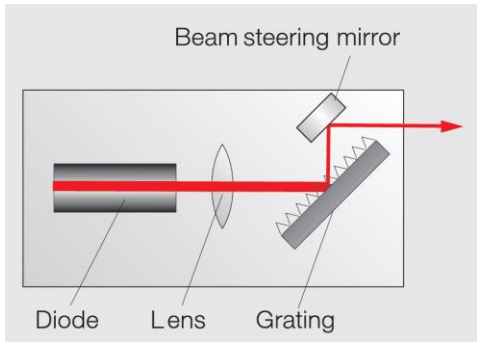
External Cavity Diode Laser (ECDL)

The **External Cavity Diode Laser** (ECDL) is the most versatile platform to realize highly coherent diode lasers

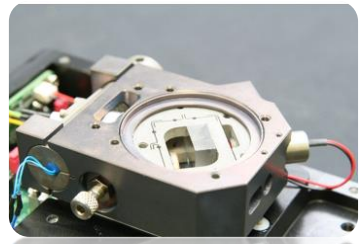
Laser Diode

- single spatial mode
- many frequencies
- spectrum many nm wide
- divergent beam

with external cavity



TOPTICA DL pro

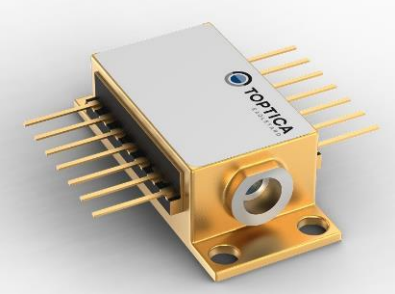


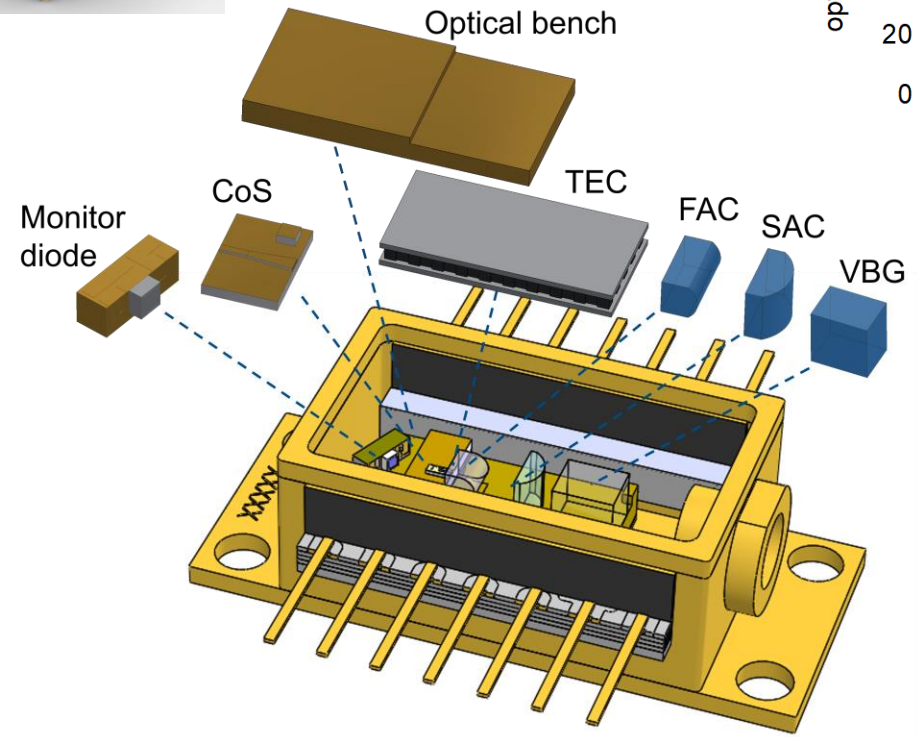
- single spatial mode
- single frequency
- large tunability, partly w/o mode hop
- linewidth down to 10 kHz (free running), below 1 Hz possible (with active control)
- possibility to stabilize in frequency
- collimated beam output or fiber-coupled
- remote control from PC

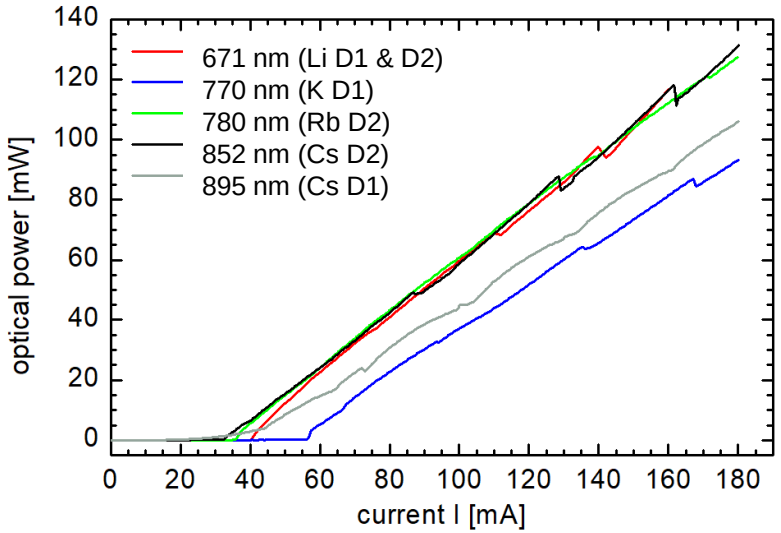
TOPTICA

*mini*ECL: ECDL in a 14-pin butterfly

Small linewidth (<100 kHz) & collimated output beam & optical power > 80 mW

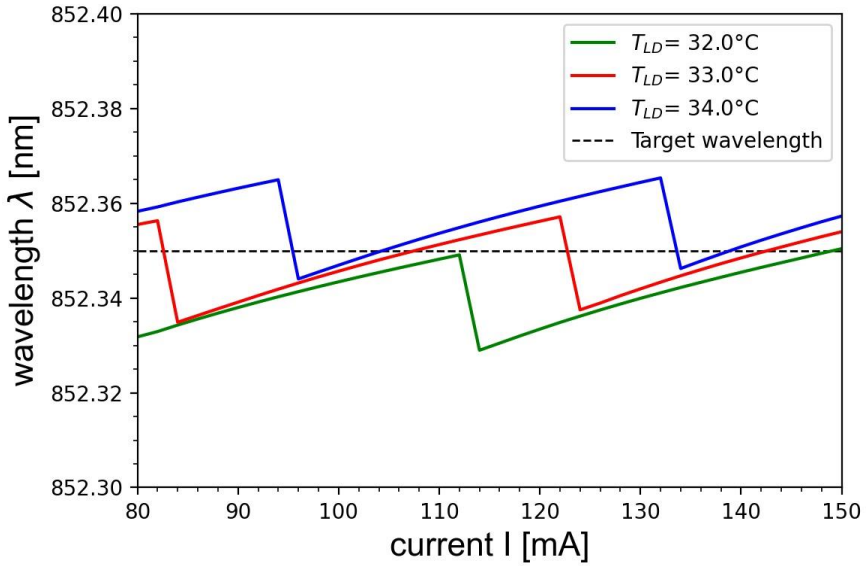




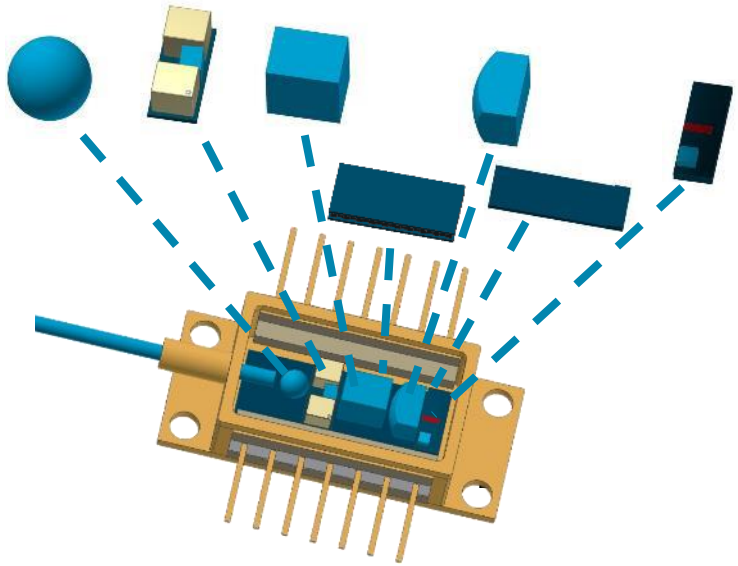


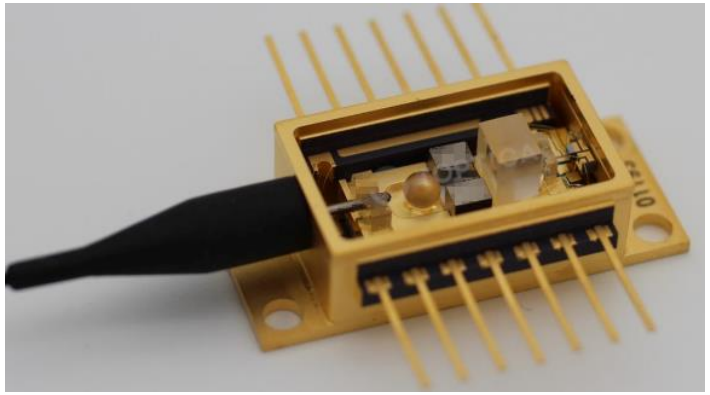
Output power > 80 mW

Single frequency operation at target wavelength



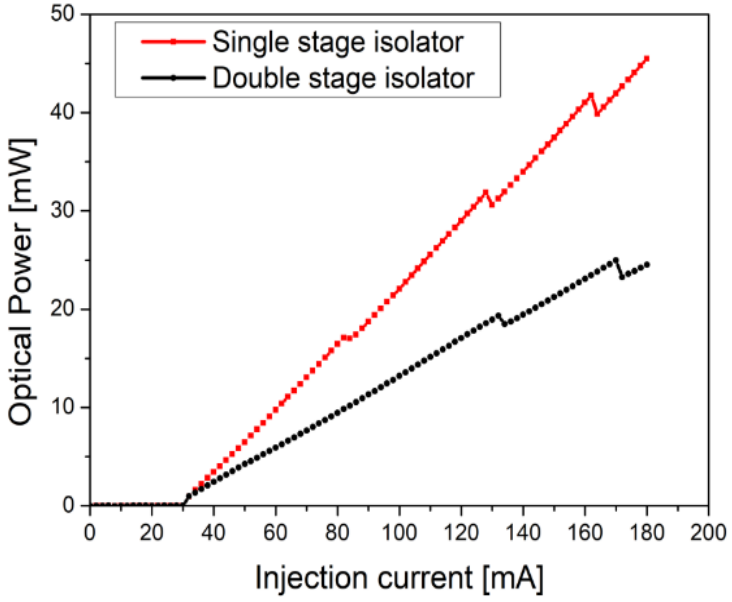
*mini*ECL: ECDL in a 14-pin butterfly with PM fiber coupling at 780.24 nm

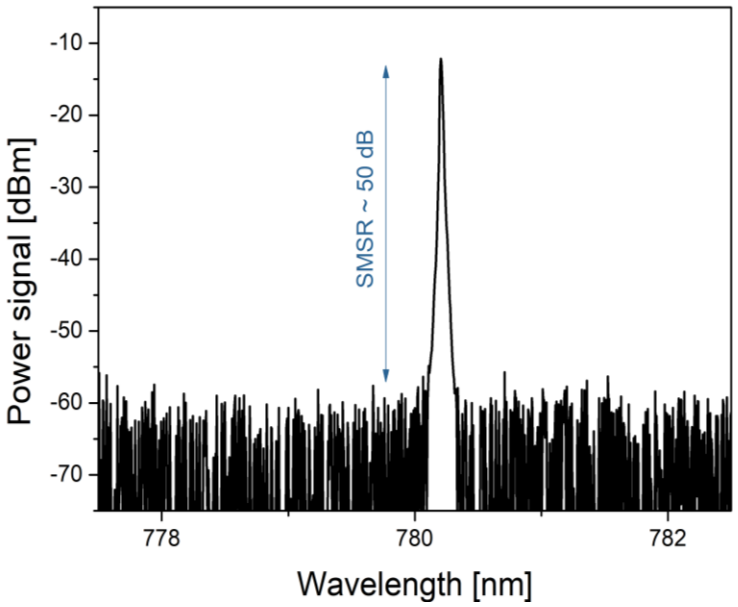


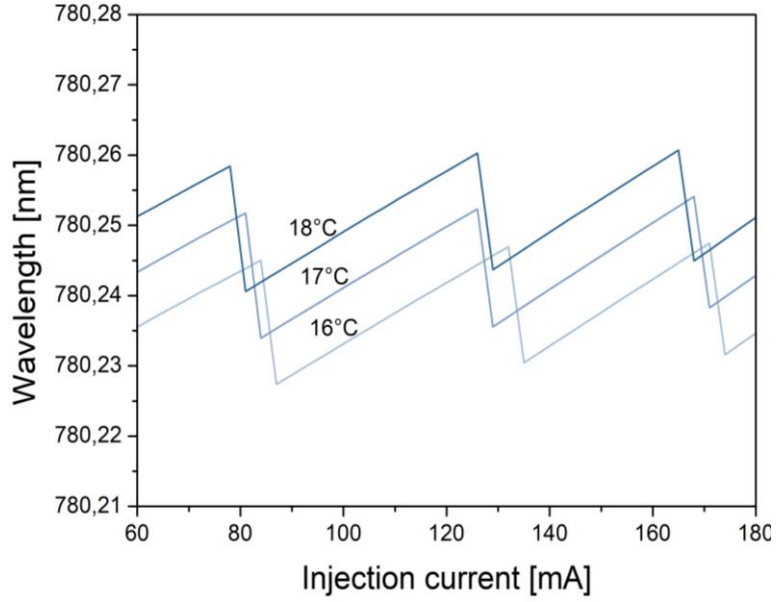


*mini*ECL with:

- PM fiber coupling
- Integrated single or double stage isolator
- SMSR ~ 50 dB

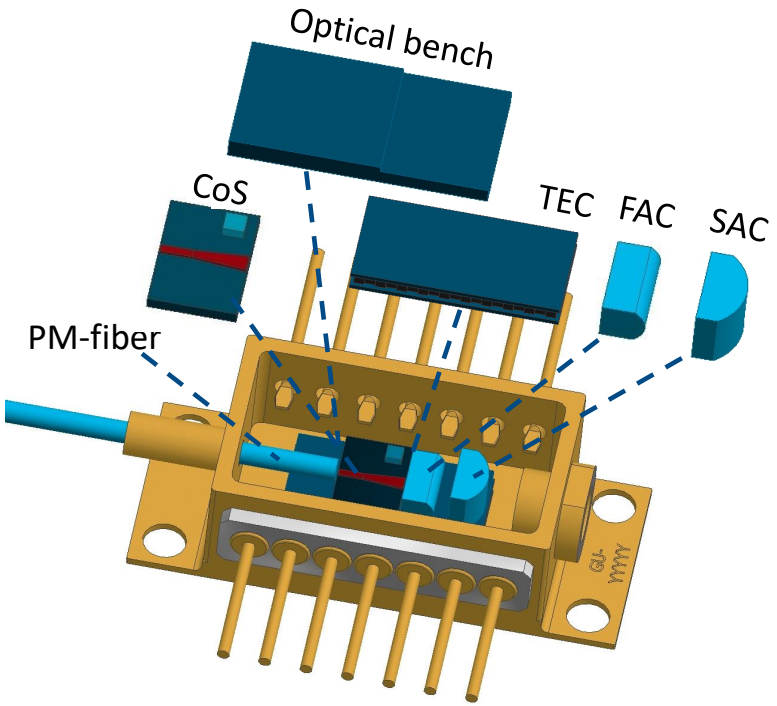


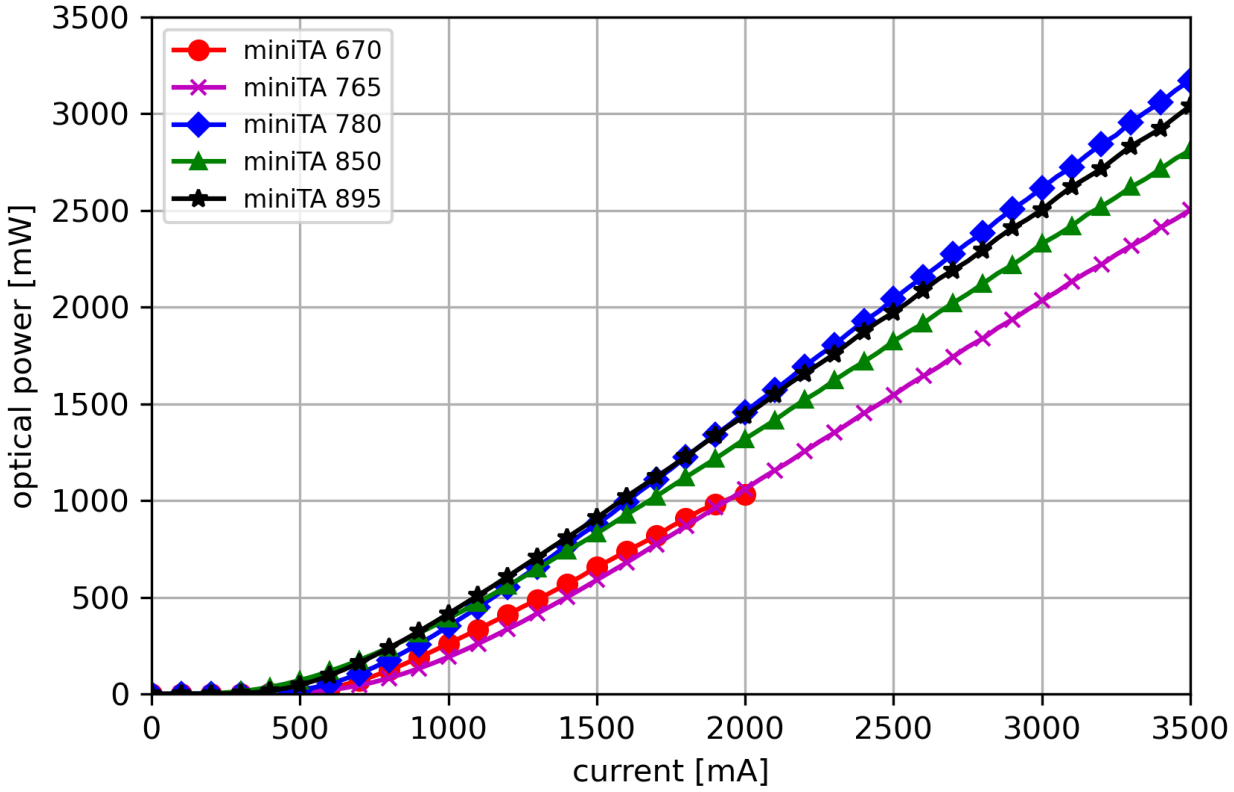




D. Brauda et al. “Low SWoP miniaturized fiber coupled external cavity diode laser (ECDL) with optical isolation as plug and play solution”, Poc. SPIE 12402 (2023).

*mini*TA: fiber coupled tapered amplifier with collimated output beam

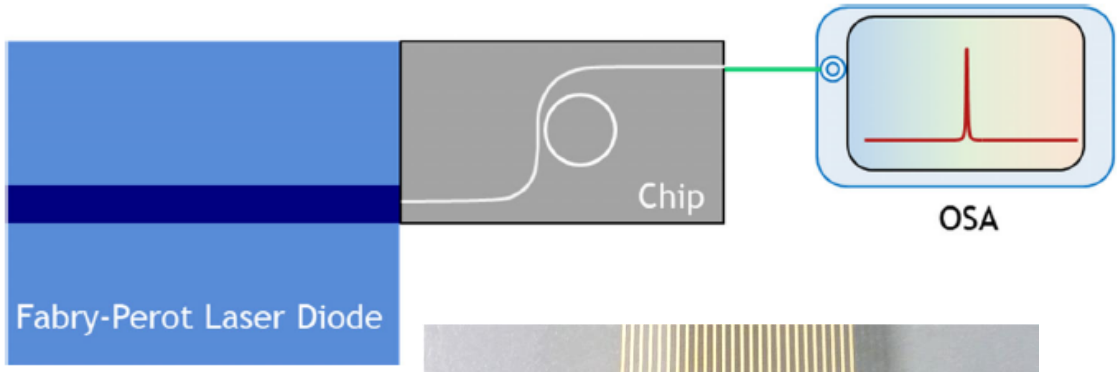


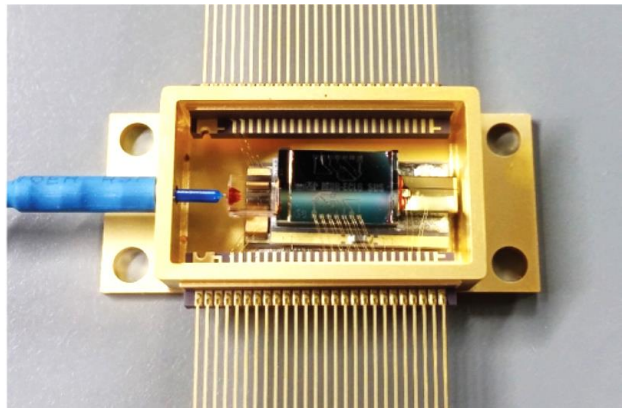


- Hermetic 14 pin-butterfly
- PM fibre coupled input
- Collimated output
- SMSR > 50 dB
- Integrated TEC and NTC

Output power > 3 W

Chip-integrated lasers: PIC Lasers



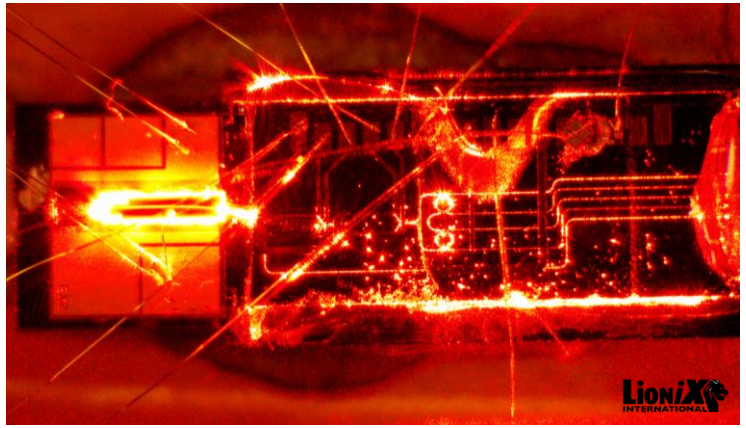


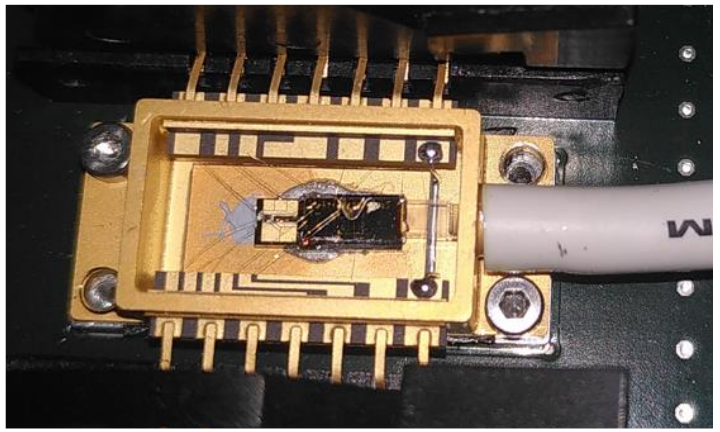
Advantages:
- Scalable (volume, power consumption)
- Perspective: cost-efficient mass production
- Broad wavelength tuning (>10 nm) & narrow linewidth (< 1kHz)
- Multi-wavelength sources

Challenges in the VIS / NIR:

1. Visible and NIR wavelength have significantly higher photon energies than telecom wavelength
   → Avoid adhesives in the beam path
2. For most applications > 40 mW ex fiber required
3. Optical isolators required for fiber coupling
   → Micro isolators available only for selected frequencies

Chip-integrated lasers: 640 nm Demonstrator

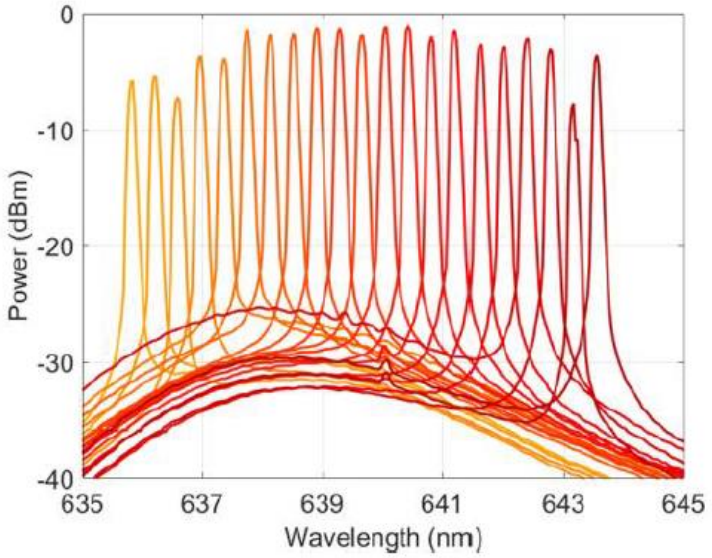


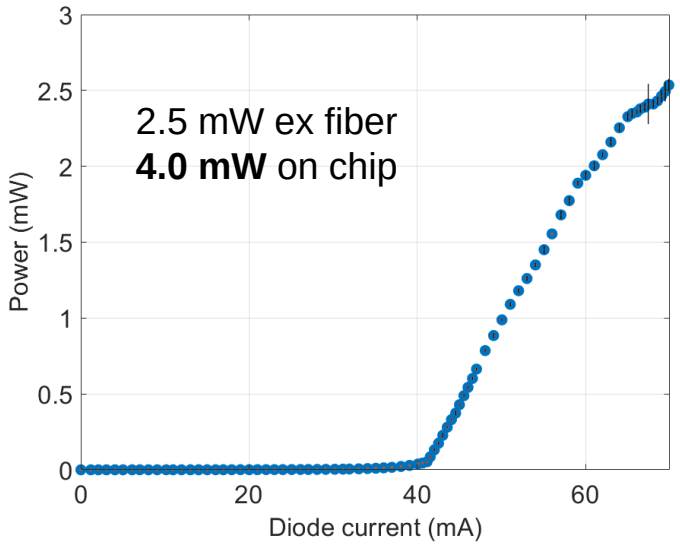


design goals:
- > nm frequency tuning
- < 100 kHz linewidth

thermal tuning via resistive heaters

Lisa Winkler et al., Proc. SPIE, Vol. 12424 (2023)
Lisa Winkler et al., CLEO Europe 2023



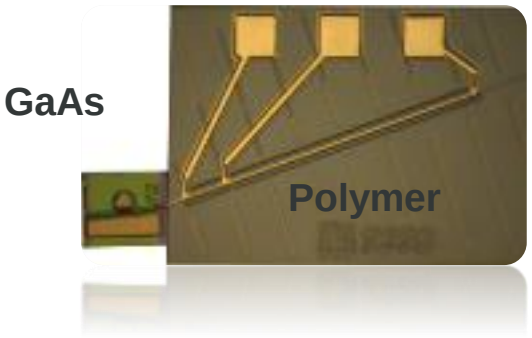


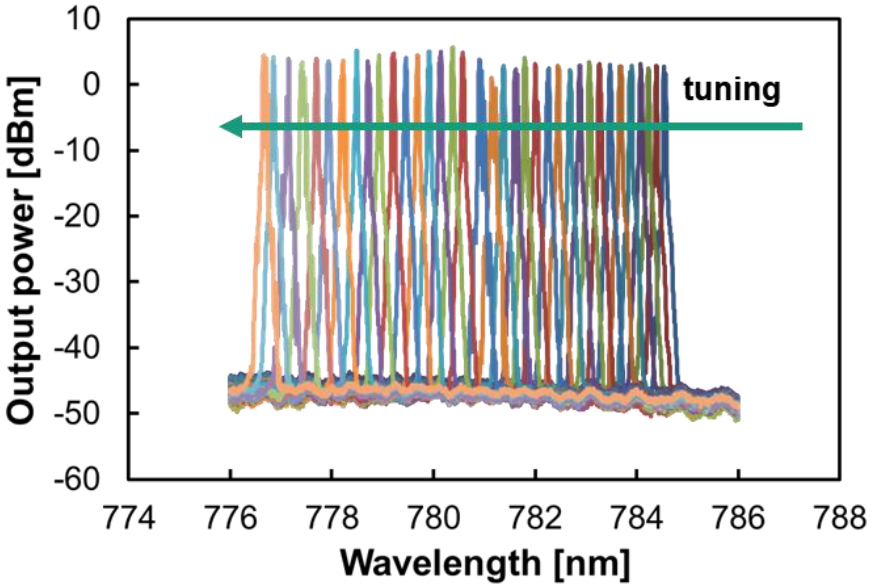
intrinsic linewidth ~10kHz

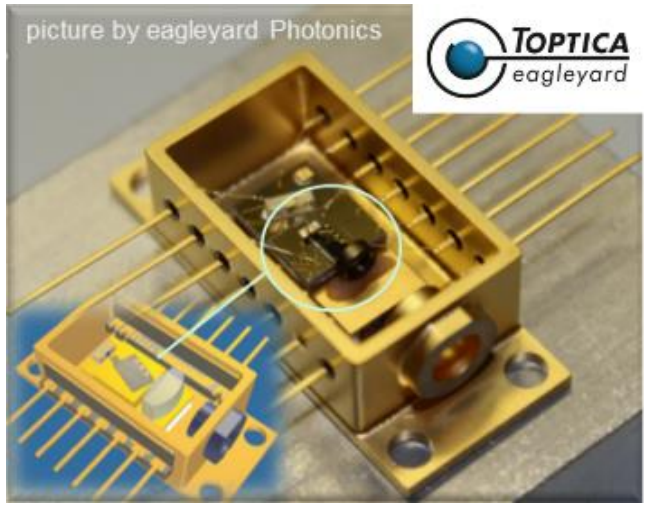
UNIVERSITY OF TWENTE.

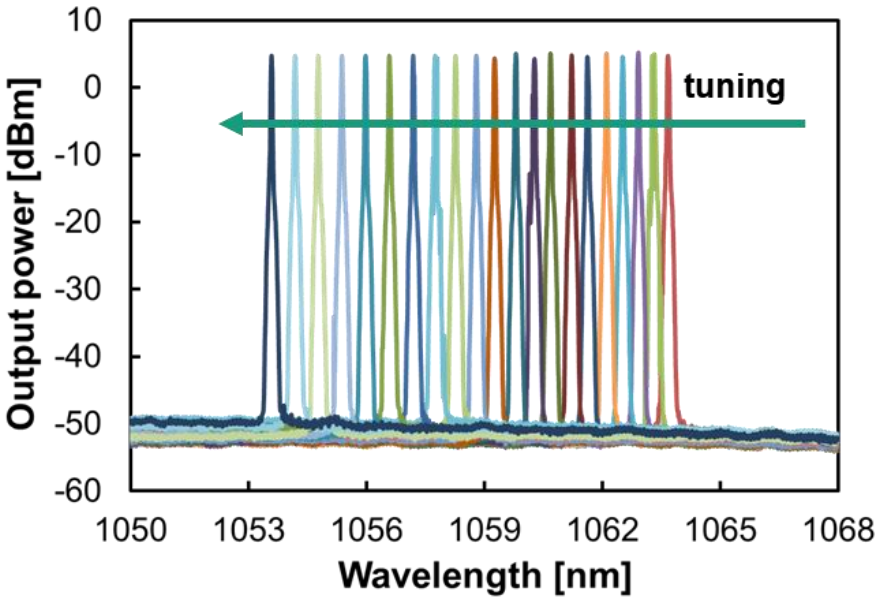
TOPTICA

Tunable laser at 780 nm and 1064 nm with GaAs gain chip









9 nm continuous tuning around

780 nm and 1064 nm

PolyPhotonics Berlin
Great in Optics – Small in Size

Bundesministerium
für Bildung
und Forschung

Fraunhofer
HHI

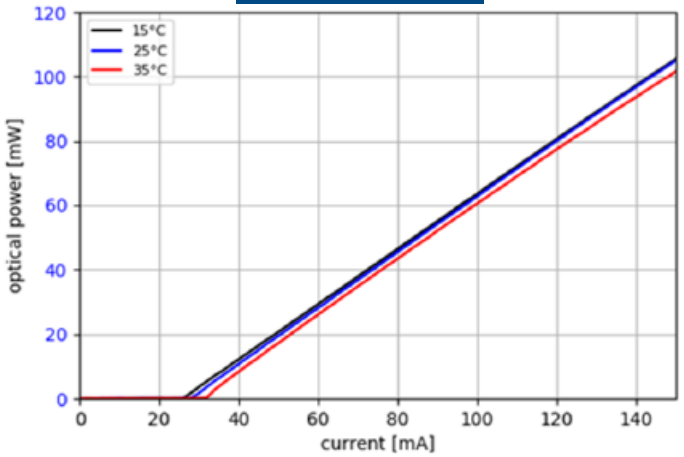
TOPTICA
EAGLEYARD

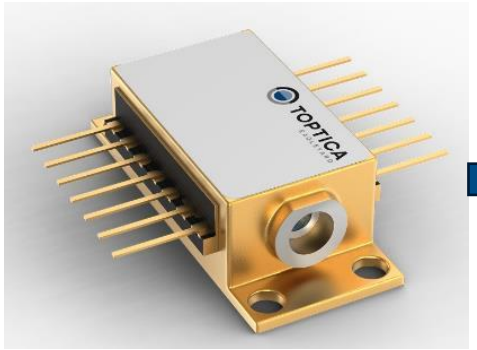
Alternative packaging techniques investigated with Fraunhofer IZM

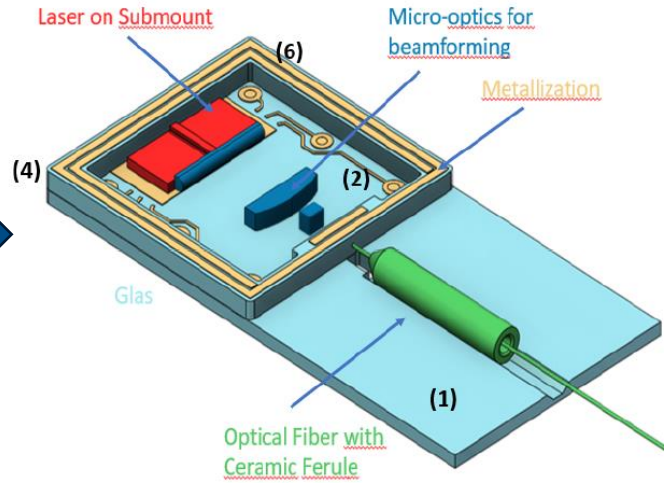
Microelectronic packaging approaches using glass substrates. Goal:

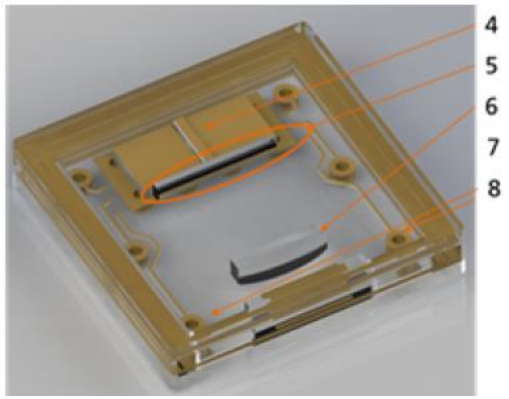
- Miniaturization
- More flexibility in package design
- Hermetic package only for the laser diode itself

DFB-Laser

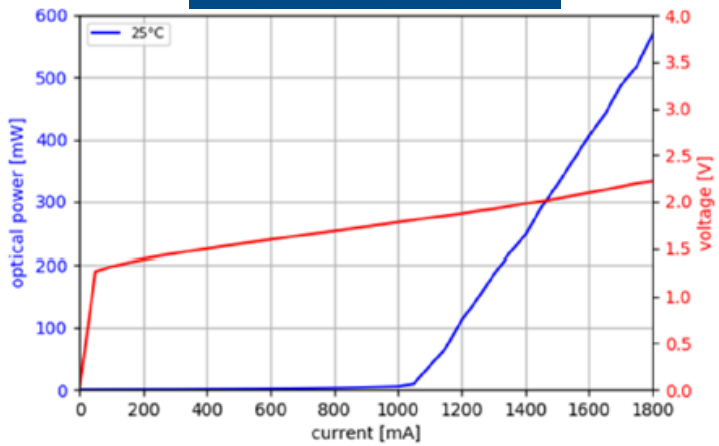






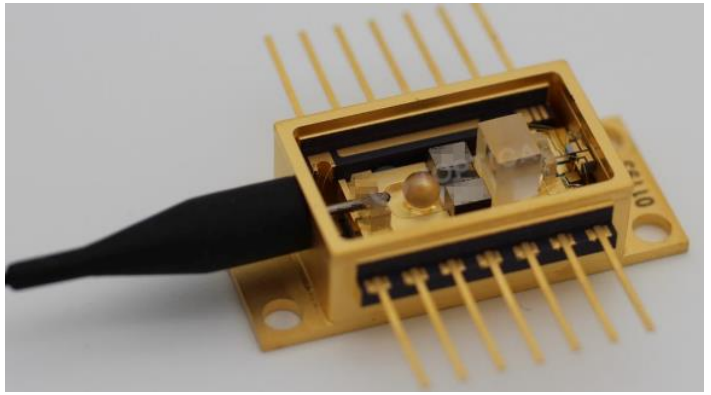


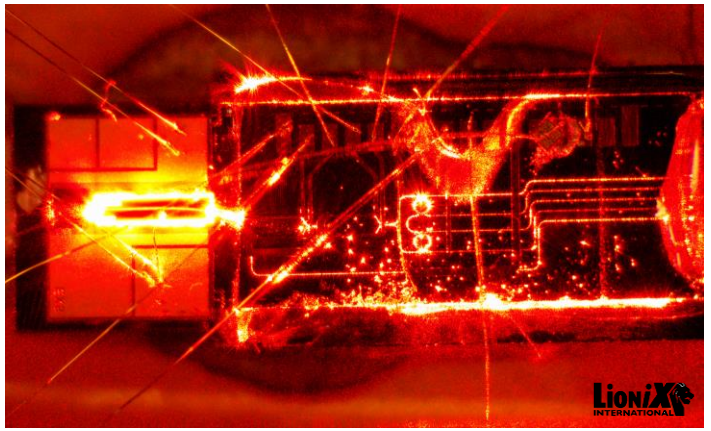
Tapered Amplifier



Summary and Outlook

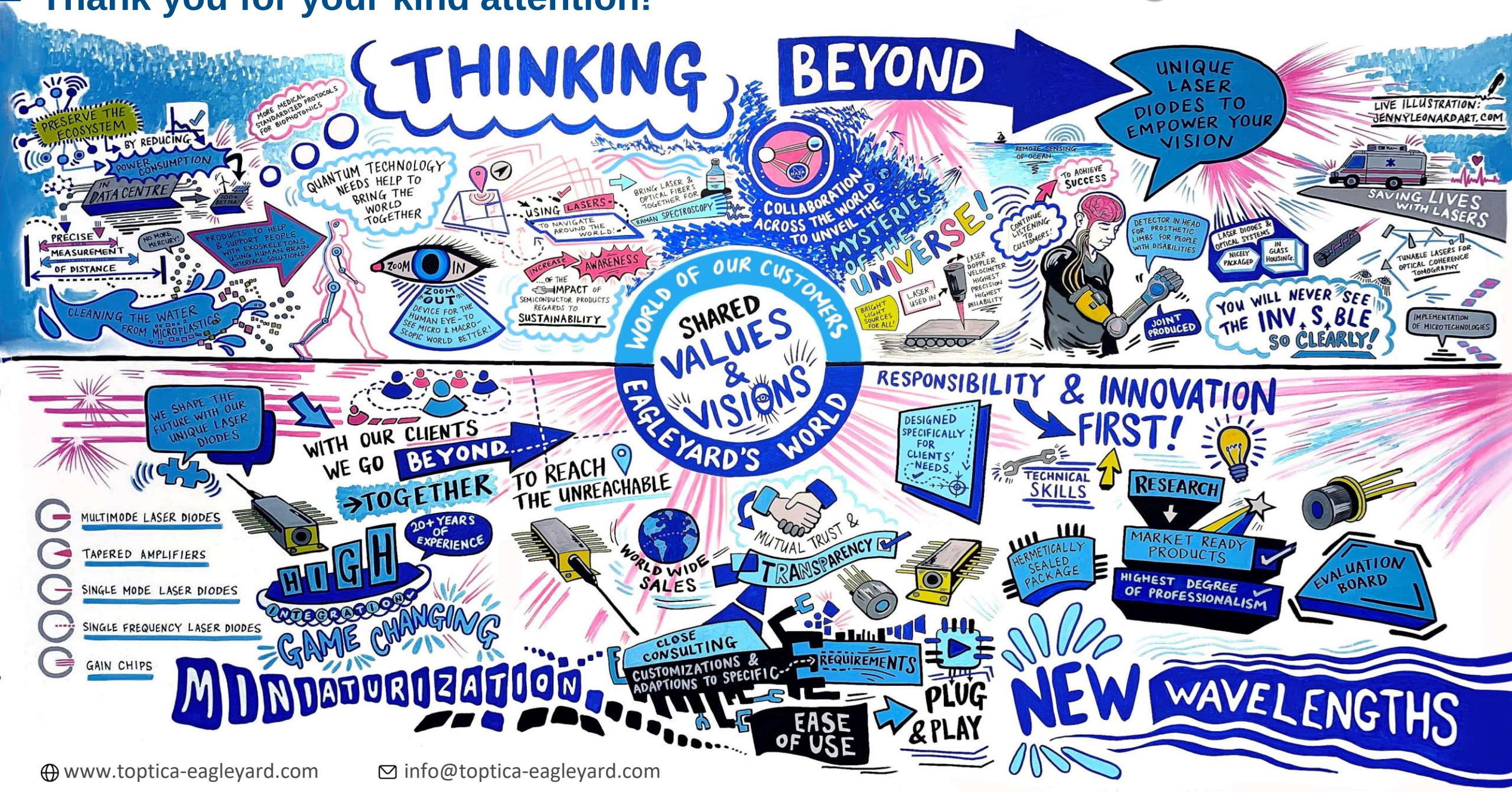
- Single frequency lasers with linewidth < 500 kHz have great potential for applications in spectroscopy, sensing and quantum technology
- Micro-assembled lasers using discrete micro-optics are state of the art in the VIS / NIR today
- Chip-integrated lasers promise great advantages in terms of tuning range, linewidth and scalability
- VIS / NIR lasers output power > 40 mW have additional packaging challenges due to the high photon energy and the unavailability of optical microisolators





New packaging concepts have to be developed to exploit the potential and address the challenges

Thank you for your kind attention!



www.toptica-eagleyard.com info@toptica-eagleyard.com