



THINKING BEYOND

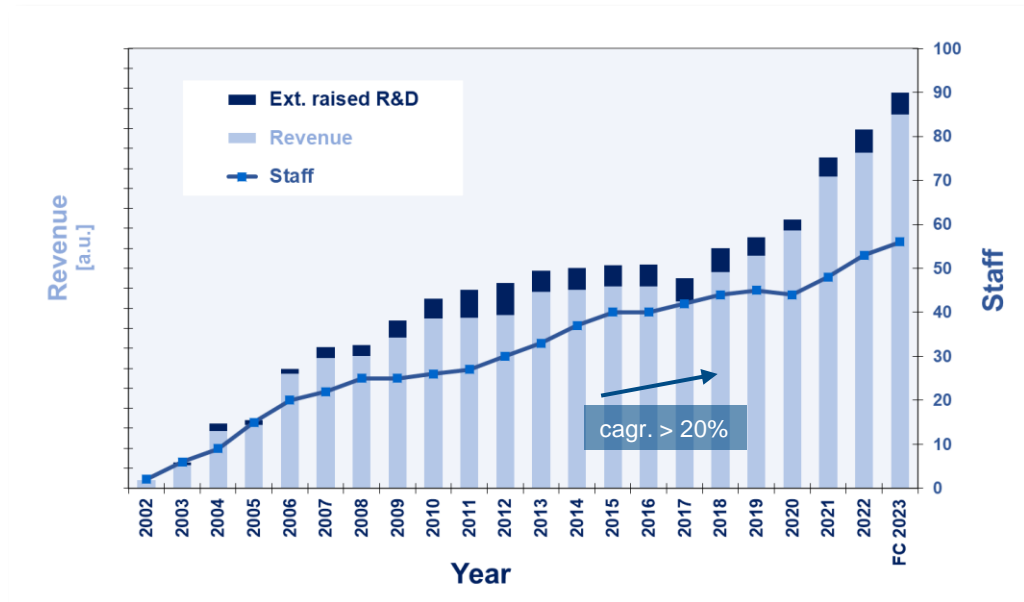
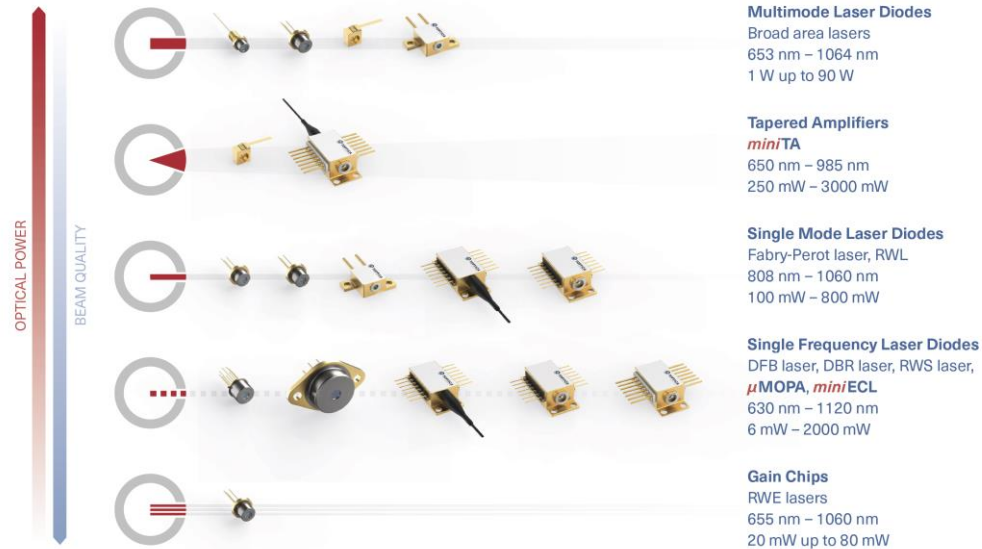
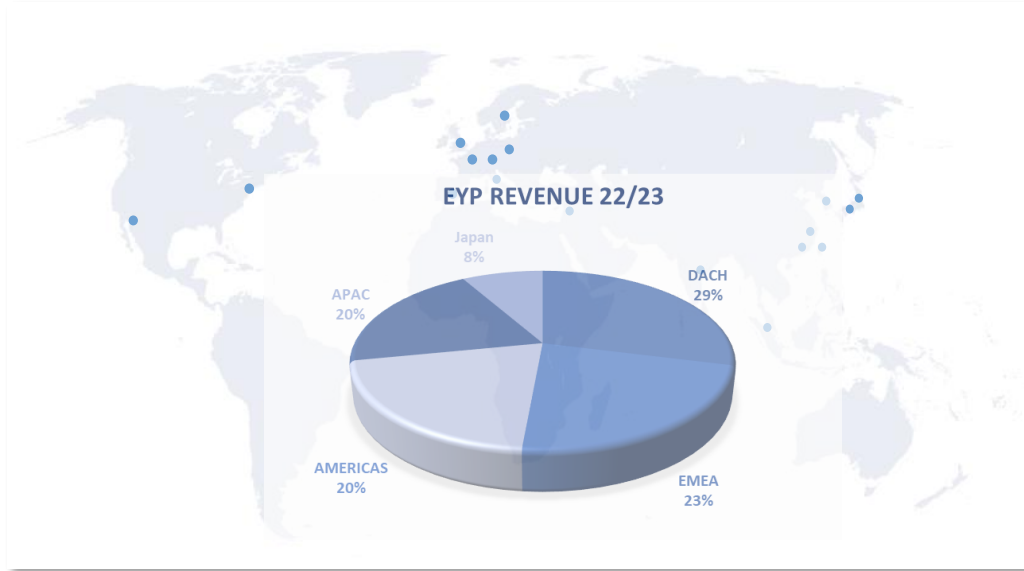
Packaging Challenges for single frequency lasers in the NIR / VIS

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

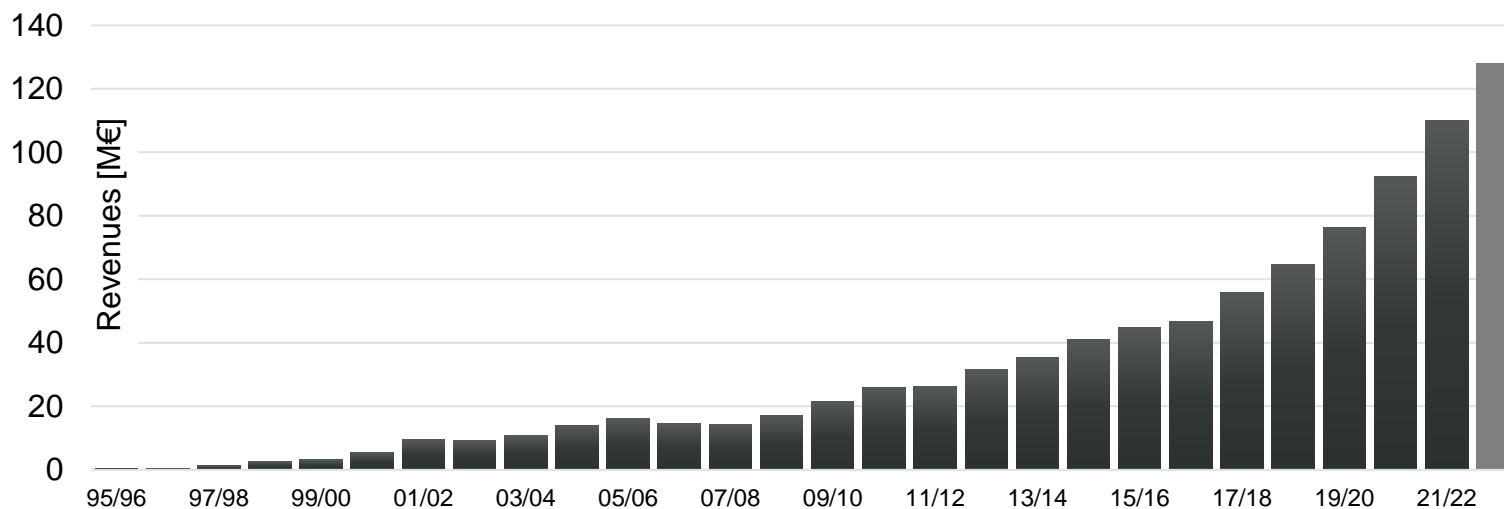
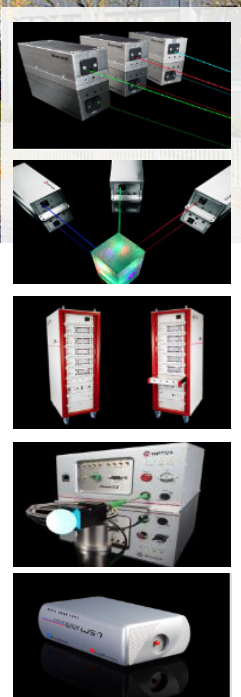


Technology

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)

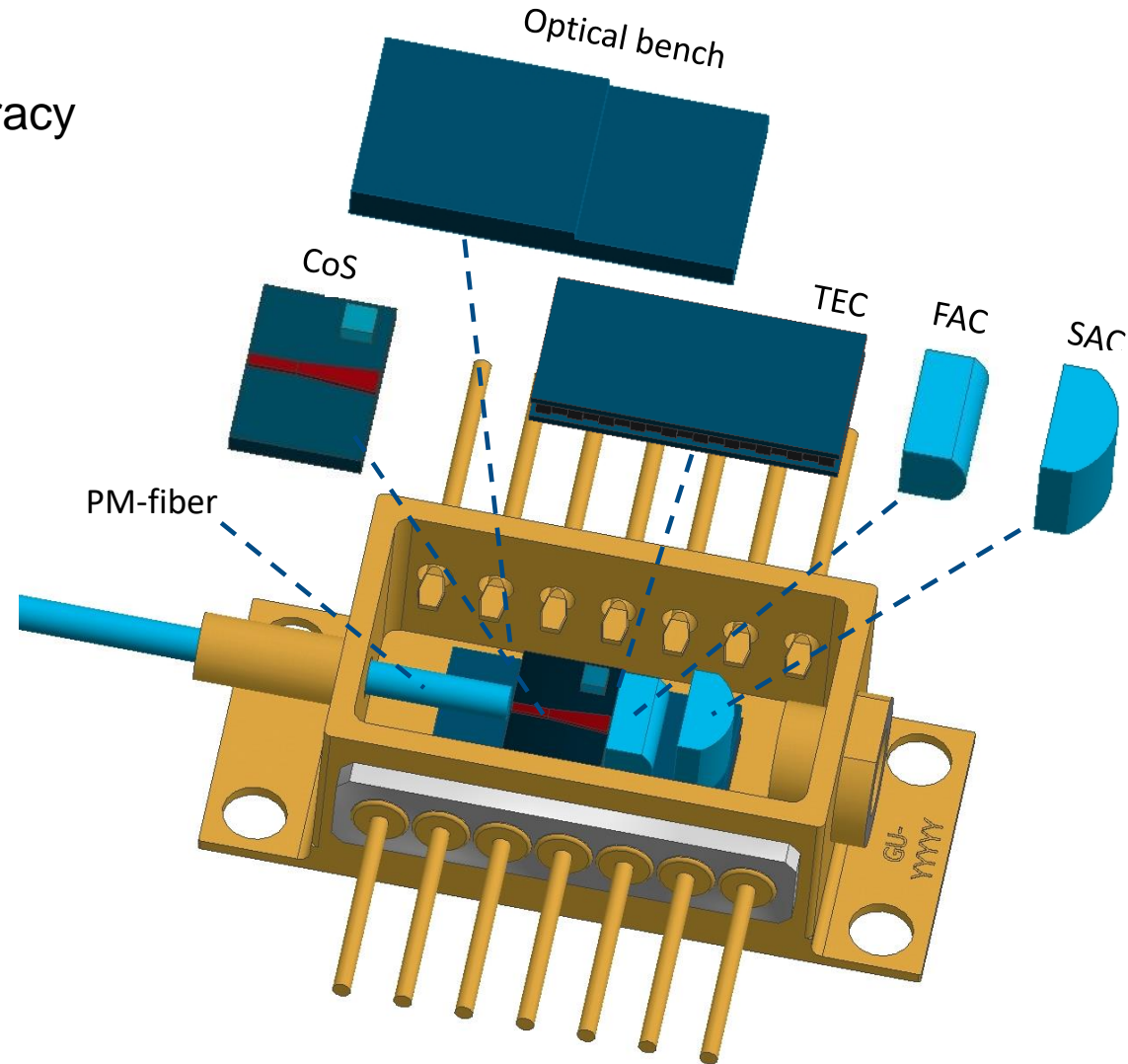
Key Figures

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



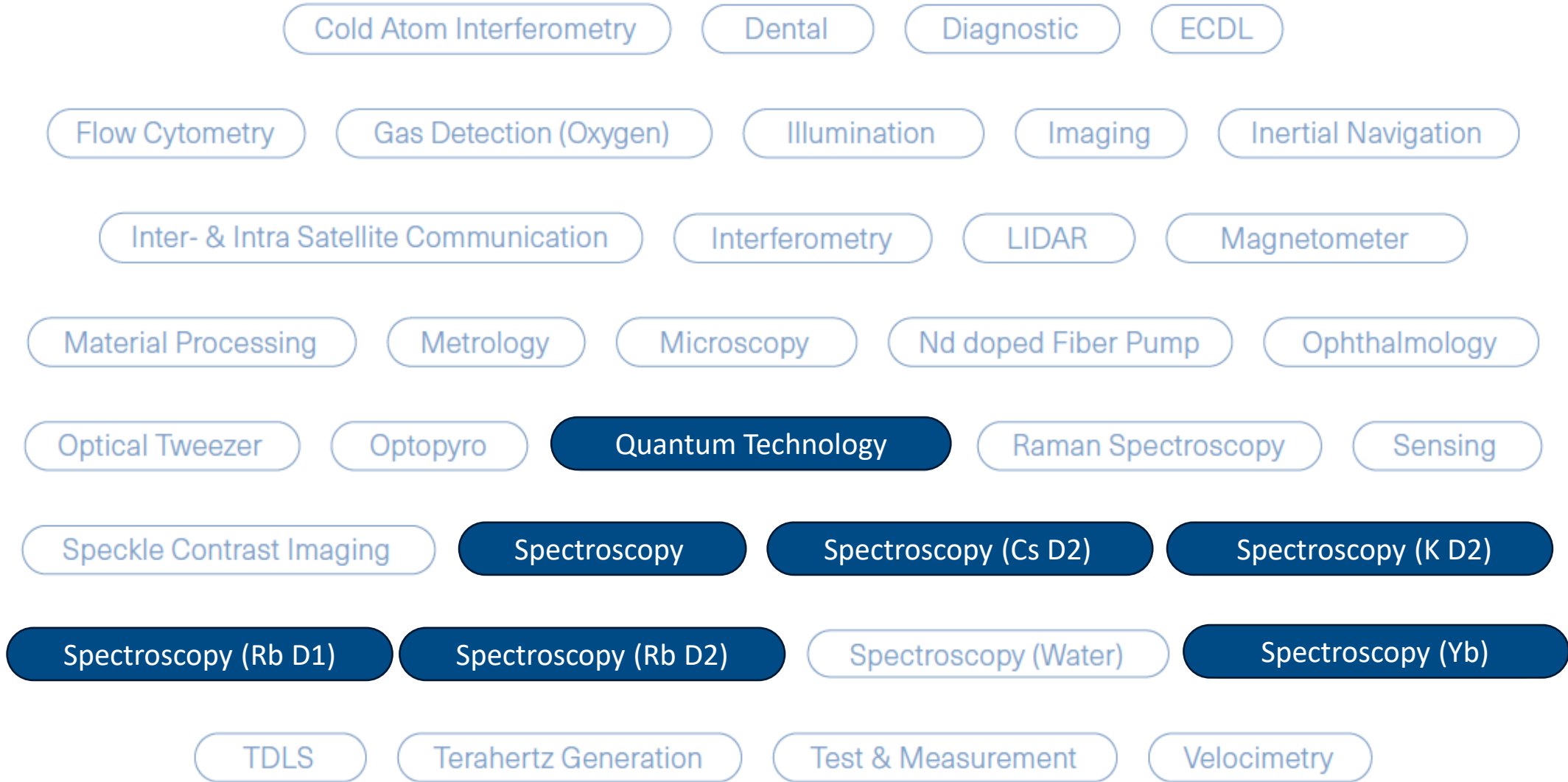
Core processes require μm to sub- μm accuracy

- 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)

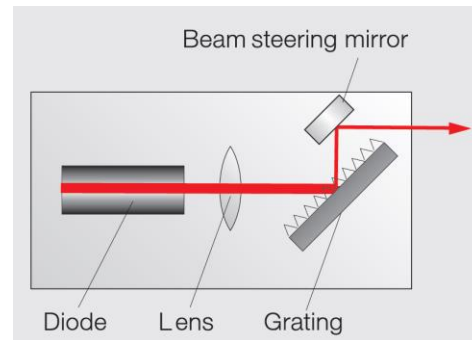
The **External Cavity Diode Laser (ECDL)** is the most versatile platform to realize highly coherent diode lasers

Laser Diode



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

with external cavity



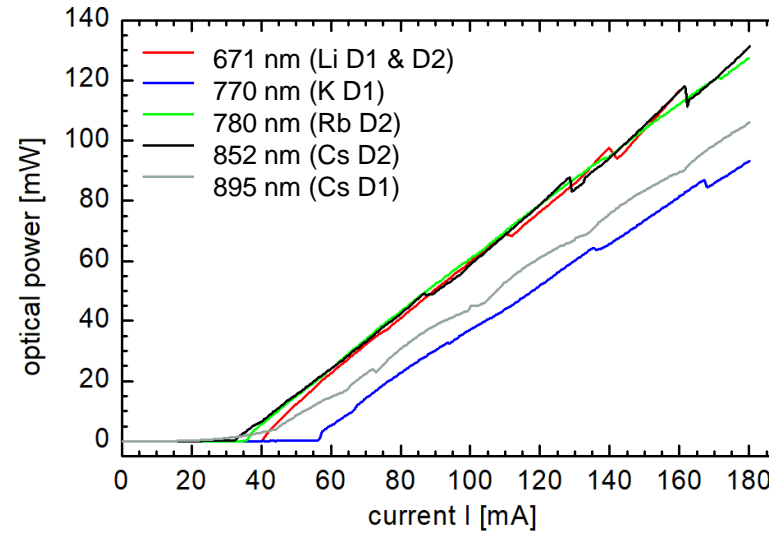
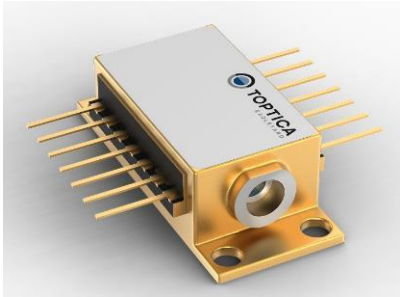
TOPTICA DL pro



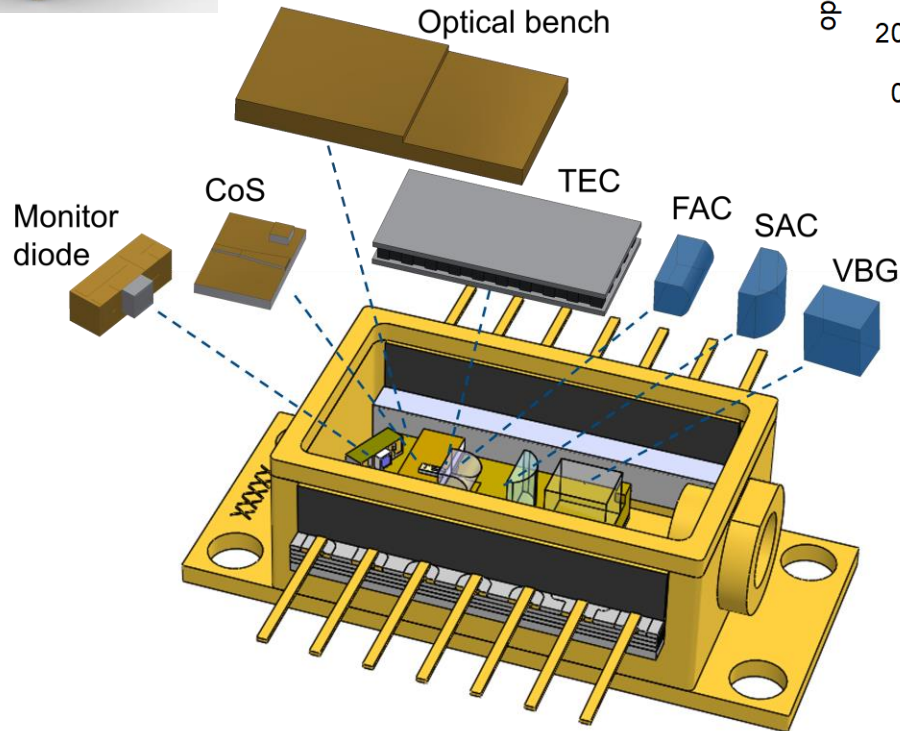
- single spatial mode
- single frequency
- large tunability, partly w/o mode hop
- linewidth down to 10 kHz (free running), below 1 Hz possible (with active control)
- possibility to stabilize in frequency
- collimated beam output or fiber-coupled
- remote control from PC

miniECL: ECDL in a 14-pin butterfly

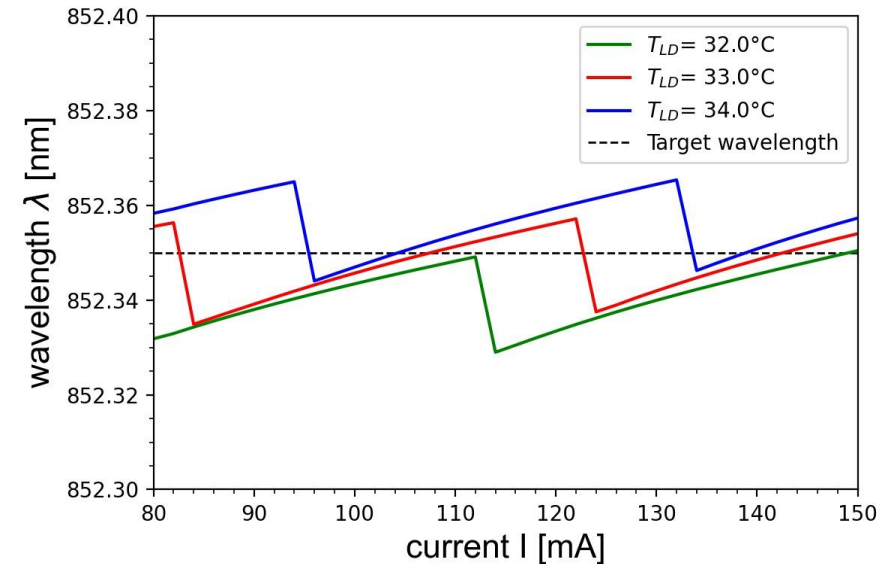
Small linewidth (<100 kHz) & collimated output beam & optical power > 80 mW



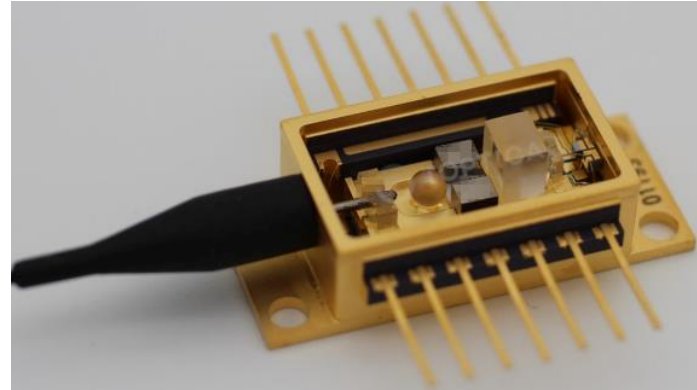
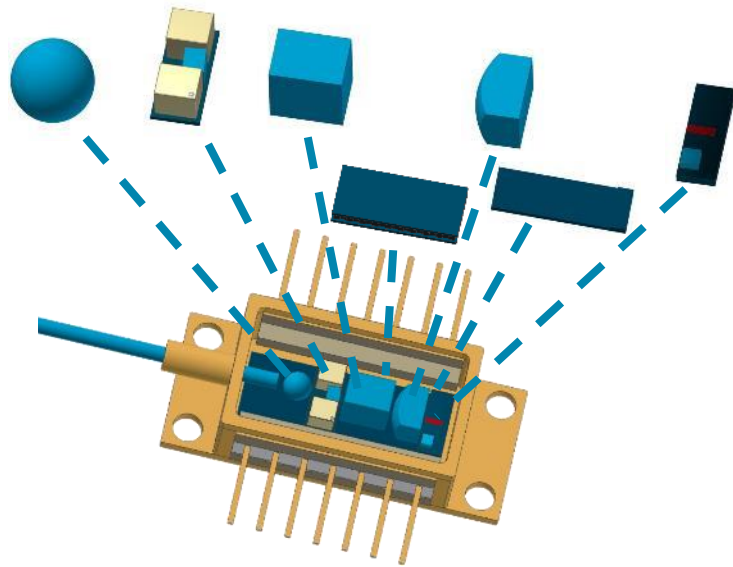
Output power > 80 mW



Single frequency
operation at target
wavelength

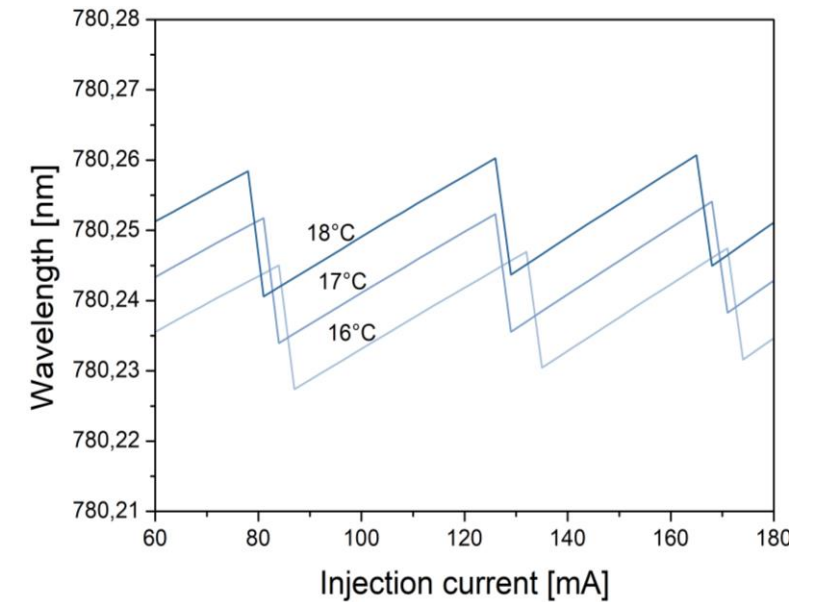
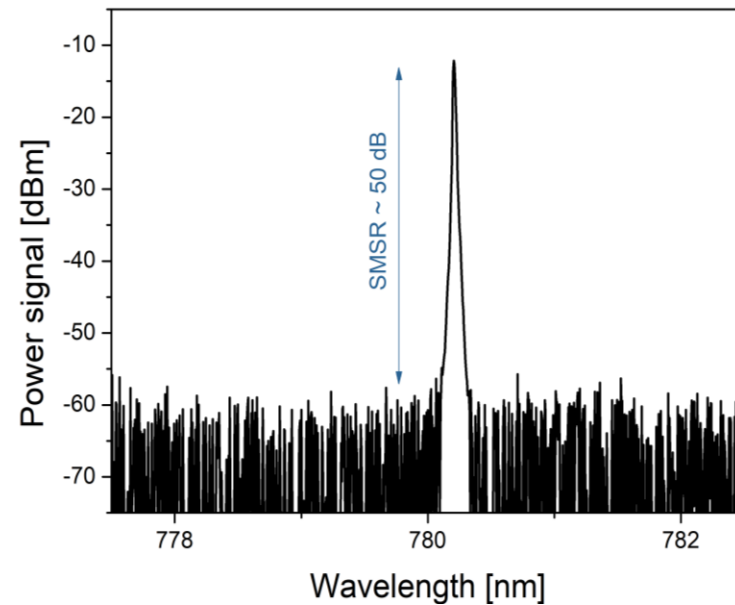
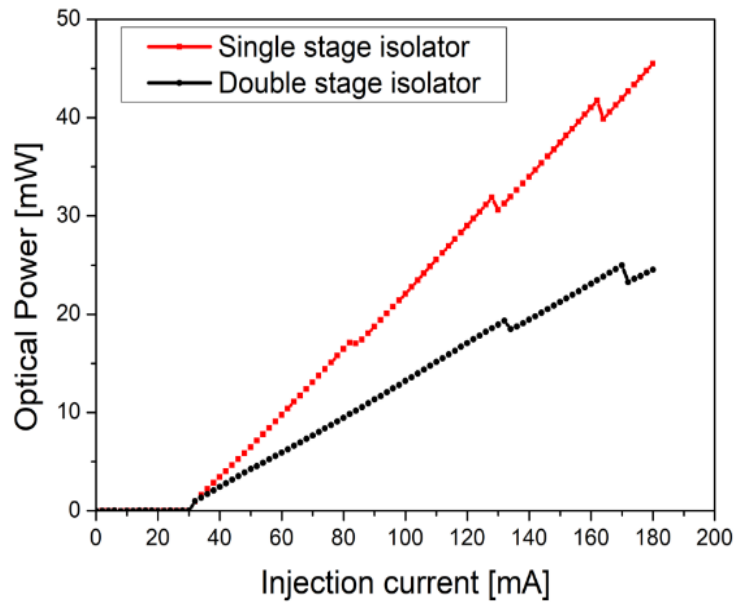


miniECL: ECDL in a 14-pin butterfly with PM fiber coupling at 780.24 nm

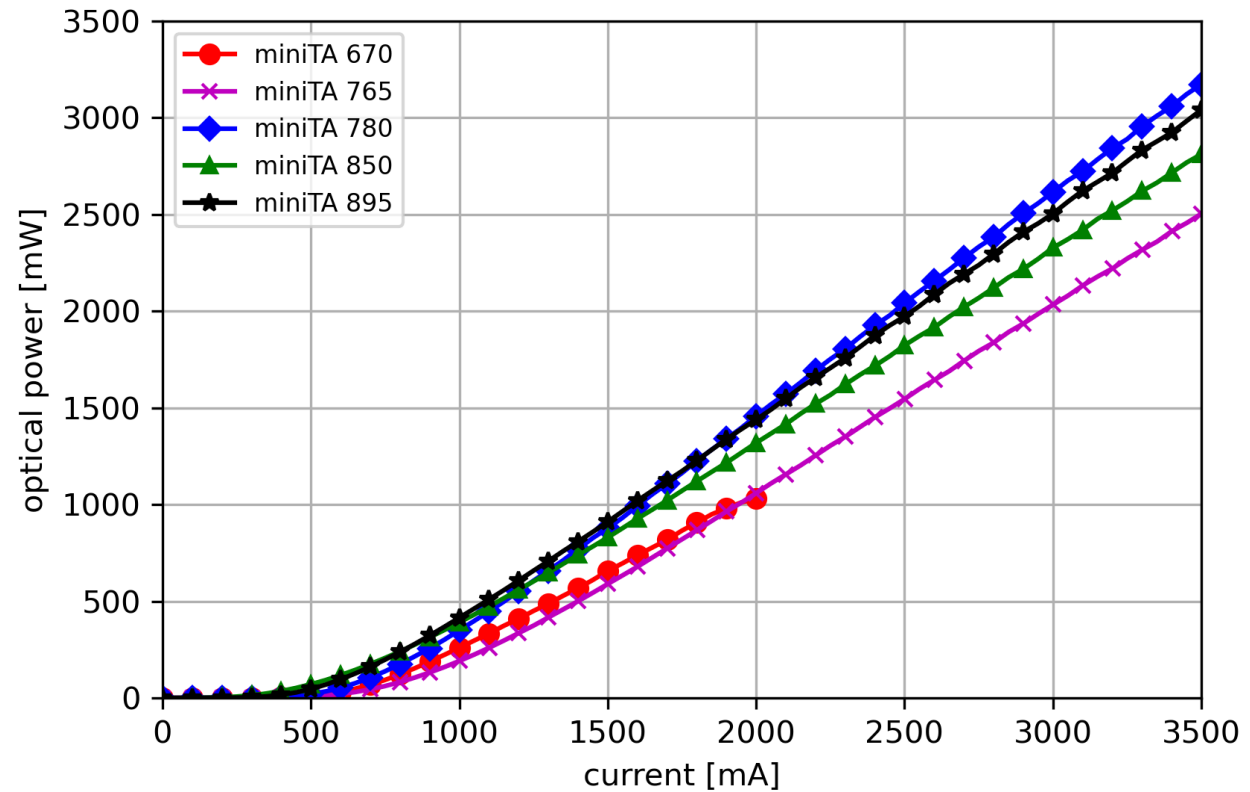
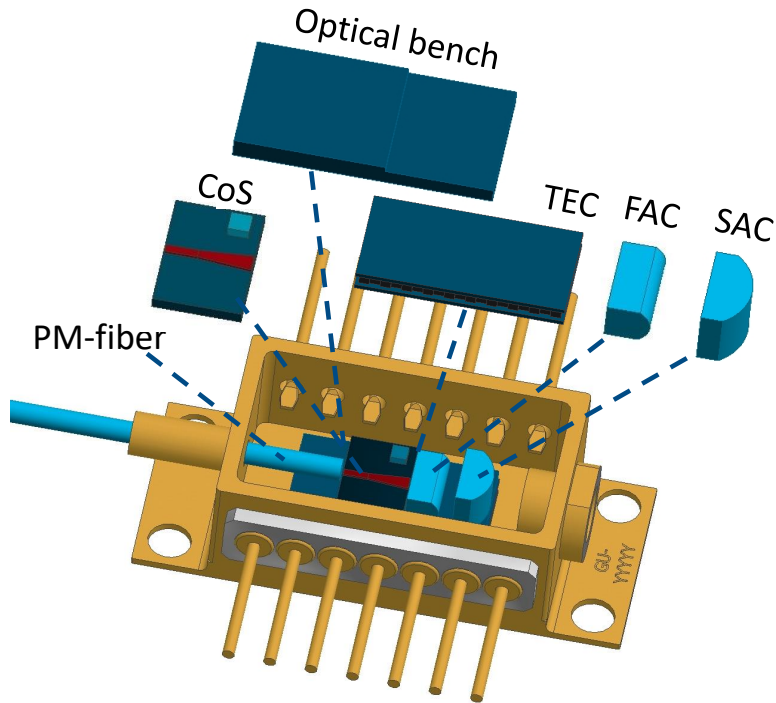


miniECL with:

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

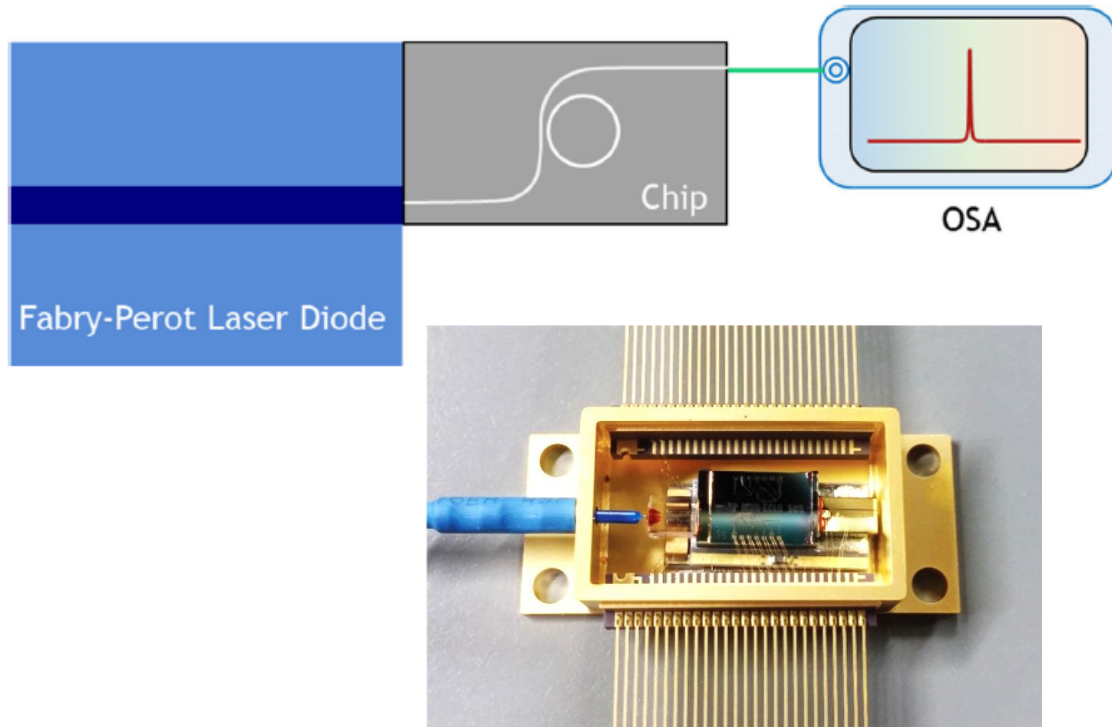


miniTA: fiber coupled tapered amplifier with collimated output beam



Output power > 3 W

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



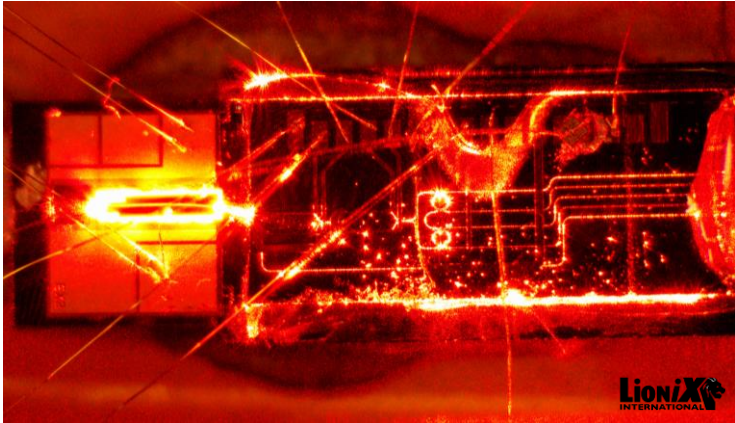
Challenges in the VIS / NIR:

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

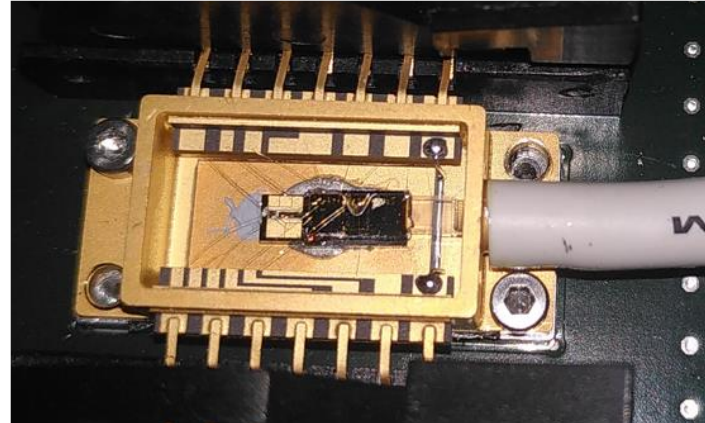
Advantages:

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

Chip-integrated lasers: 640 nm Demonstrator



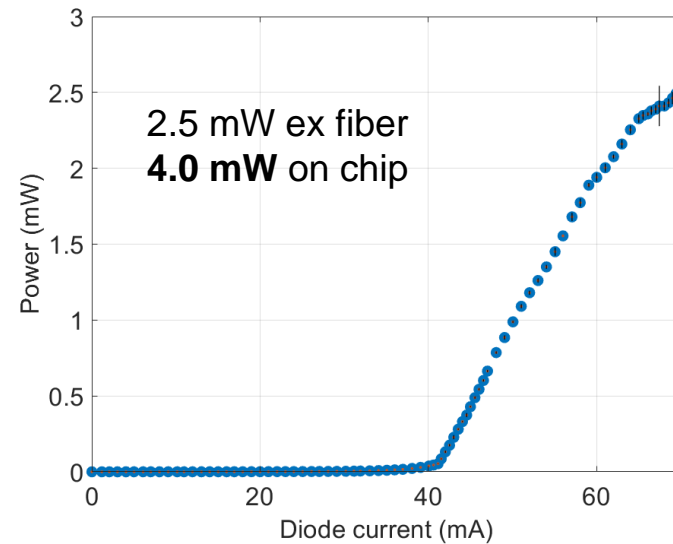
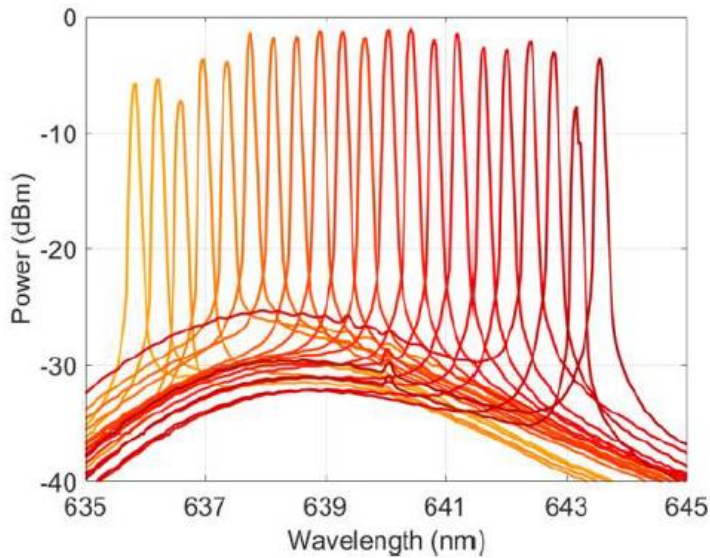
Lisa Winkler et al., Proc. SPIE, Vol. 12424 (2023)
Lisa Winkler et al., CLEO Europe 2023



design goals:

- > 1 nm frequency tuning
- < 100 kHz linewidth

thermal tuning via resistive heaters

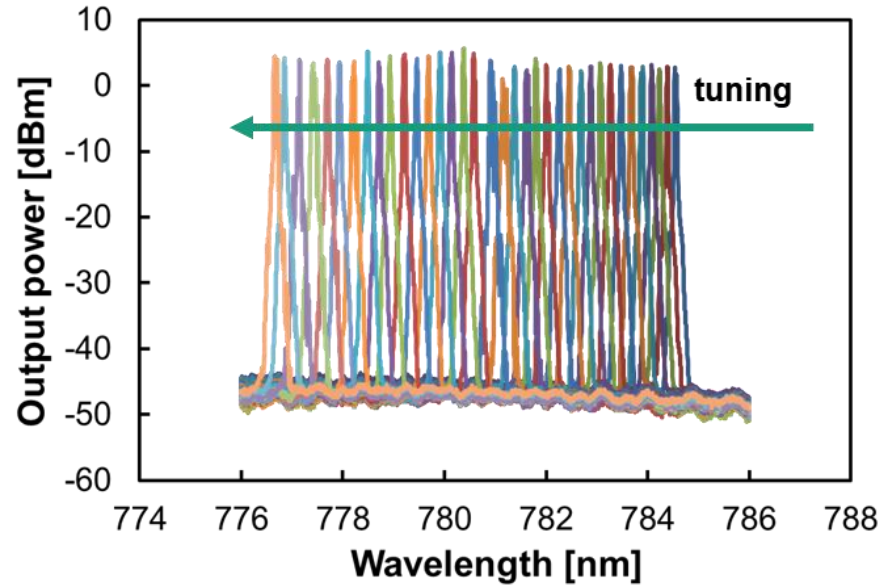
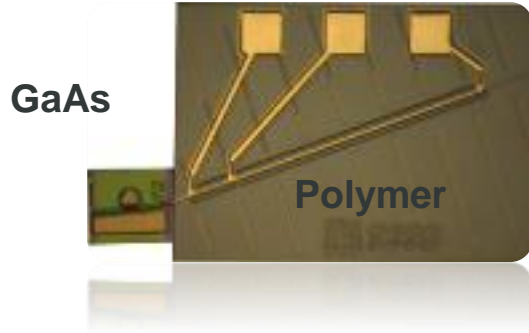


intrinsic linewidth ~ 10 kHz

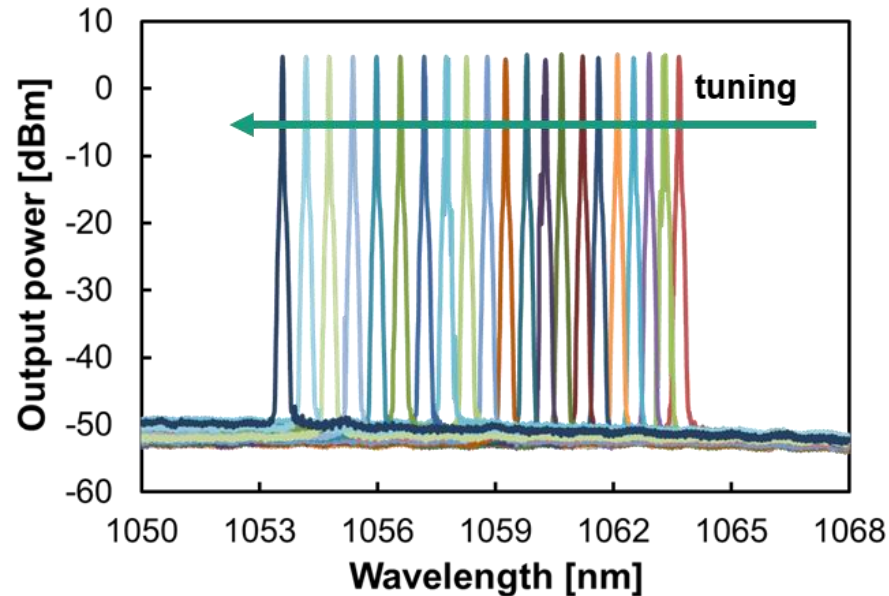
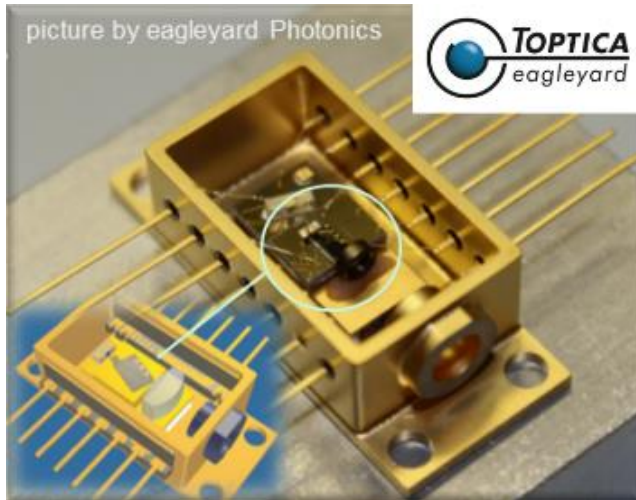
Tunable laser at 780 nm and 1064 nm with GaAs gain chip



PolyPhotonics Berlin
Great in Optics – Small in Size



9 nm continuous tuning around
780 nm and 1064 nm

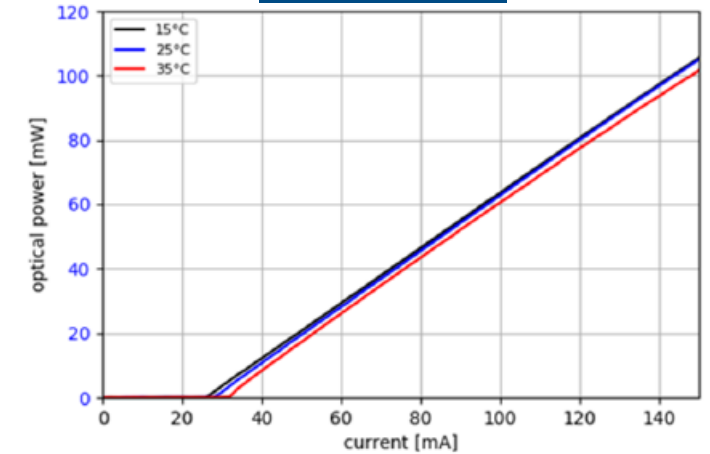


Alternative packaging techniques investigated with Fraunhofer IZM

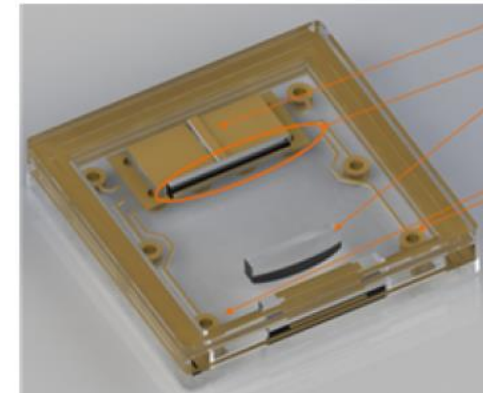
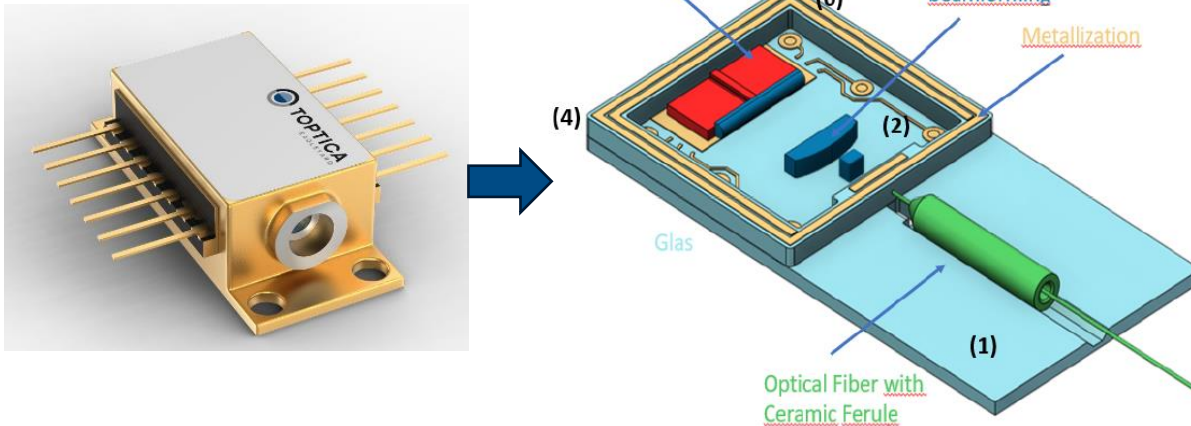
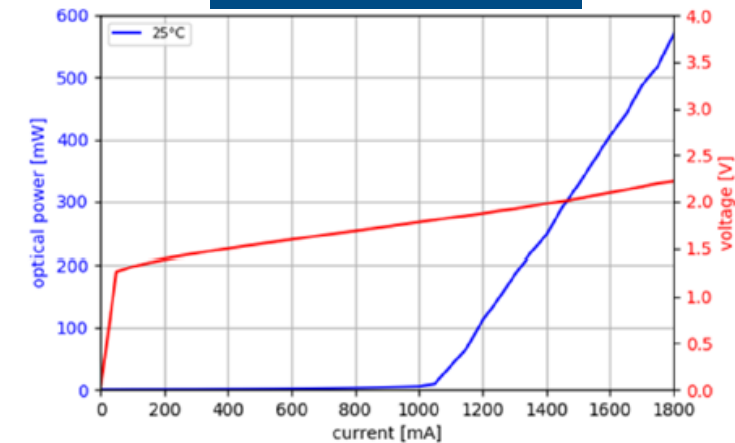
Microelectronic packaging approaches using glass substrates. Goal:

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

DFB-Laser

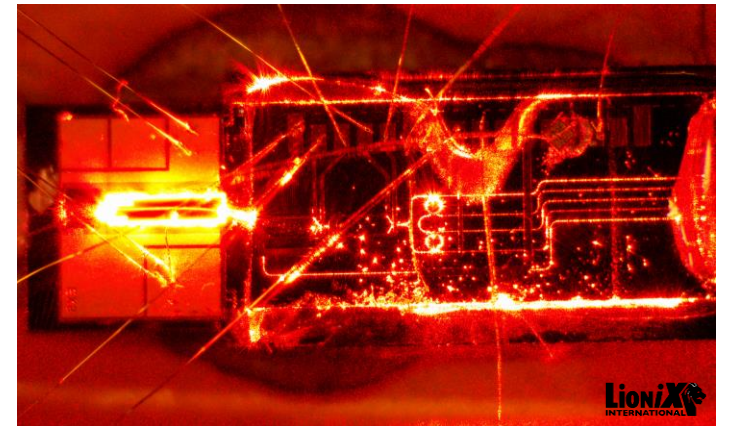
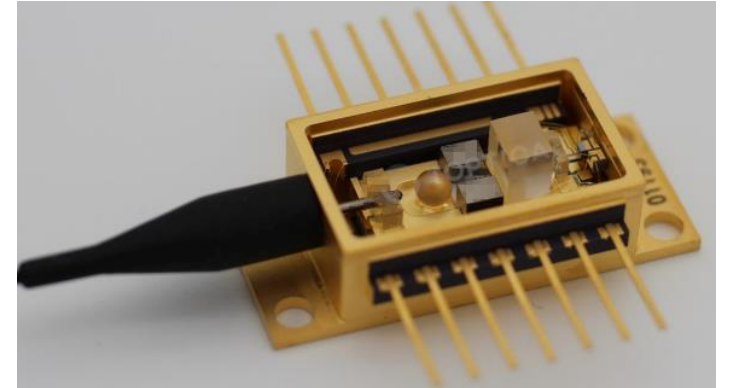


Tapered Amplifier



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!

THINKING BEYOND

UNIQUE LASER DIODES TO EMPOWER YOUR VISION

COLLABORATION ACROSS THE WORLD TO UNVEIL THE MYSTERIES OF THE UNIVERSE!

WORLD OF OUR CUSTOMERS SHARED VALUES & VISIONS EAGLEYARD'S WORLD

TO ACHIEVE SUCCESS

CONTINUE LISTENING TO CUSTOMERS!

DETECTOR IN HEAD FOR PROSTHETIC LIMBS FOR PEOPLE WITH DISABILITIES

LASER DIODES & OPTICAL SYSTEMS NICELY PACKAGED IN GLASS HOUSING

TUNABLE LASERS FOR OPTICAL COHERENCE TOMOGRAPHY

IMPLEMENTATION OF MICROTECHNOLOGIES

SAVING LIVES WITH LASERS

YOU WILL NEVER SEE THE INVISIBLE SO CLEARLY!

LASER DOPPLER VELOCIMETER HIGHEST PRECISION HIGHEST RELIABILITY

LASER USER IN

BRIGHT LIGHT SOURCES FOR ALL!

REMOTE SENSING OF OCEAN

BRING LASER & OPTICAL FIBER'S TOGETHER FOR RAMAN SPECTROSCOPY

USING LASERS TO NAVIGATE AROUND THE WORLD!

INCREASE AWARENESS OF THE IMPACT OF SEMICONDUCTOR PRODUCTS REGARDS TO SUSTAINABILITY

QUANTUM TECHNOLOGY NEEDS HELP TO BRING THE WORLD TOGETHER

PRECISE MEASUREMENT OF DISTANCE

NO MORE MERCURY!

PRODUCTS TO HELP & SUPPORT PEOPLE WITH EXOSKELETONS USING HUMAN BRAIN INTERFACE SOLUTIONS

BY REDUCING POWER CONSUMPTION IN DATA CENTRE

PRESERVE THE ECOSYSTEM

MORE MEDICAL STANDARDIZED PROTOCOLS FOR BIOPHOTONICS

CLEANING THE WATER FROM MICROPLASTICS

ZOOM IN ZOOM OUT DEVICE FOR THE HUMAN EYE - TO SEE MICRO & MACRO-SCOPIC WORLD BETTER!

LIVE ILLUSTRATION: JENNYLEONARDART.COM

WITH OUR CLIENTS WE GO BEYOND TOGETHER TO REACH THE UNREACHABLE

WE SHAPE THE FUTURE WITH OUR UNIQUE LASER DIODES

20+ YEARS OF EXPERIENCE

HIGH INTEGRATION GAME CHANGING MINIDATURIZATION

MULTIMODE LASER DIODES

TAPERED AMPLIFIERS

SINGLE MODE LASER DIODES

SINGLE FREQUENCY LASER DIODES

GAIN CHIPS

WORLD WIDE SALES

MUTUAL TRUST & TRANSPARENCY

DESIGNED SPECIFICALLY FOR CLIENTS' NEEDS

TECHNICAL SKILLS

RESEARCH

MARKET READY PRODUCTS

HIGHEST DEGREE OF PROFESSIONALISM

HERMETICALLY SEALED PACKAGE

EVALUATION BOARD

CLOSE CONSULTING CUSTOMIZATIONS & ADAPTIONS TO SPECIFIC REQUIREMENTS

EASE OF USE

PLUG & PLAY

NEW WAVELENGTHS