High Power Pump Laser Diodes for 2 µm Fiber Laser

Laser Enterprise Overview

Zurich facility

At a glance

- Rich heritage of innovation for over 30 years
- State-of-the-art semiconductor laser technology and manufacturing infrastructure
- 180 employees

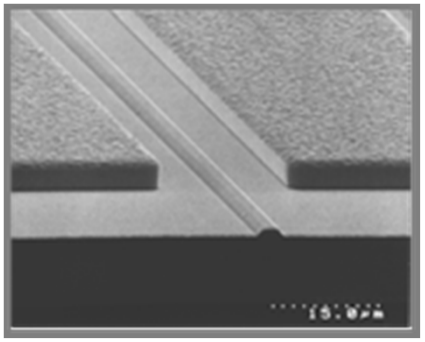
Global Presence

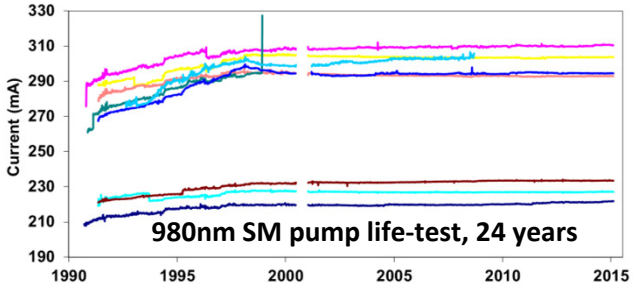
- World Class Semiconductor GaAs Laser Fab in Zurich
- Backend Manufacturing in Asia

Laser Diode Portfolio

- High Power Lasers
- High Volume Components – VCSELs and Edge-Emitters
- 980nm single-mode pump lasers

Laser Enterprise: Differentiating Technologies





Epitaxy

- Optimized advanced AlGaAs material system
- High control and repeatable growth utilizing MBE and MOVPE
- Quick turn around testing for instant performance validation

Die-attach technology

- AuSn hard solder die bonding for long life operation
- Expansion matched assembly and material composition
- High precision, high volume die-bonding equipment

Advanced Packaging

- Proprietary Spatial and Polarization beam conditioning
- Robust housing and package design
- Optimized Fiber Pigtail Assemblies

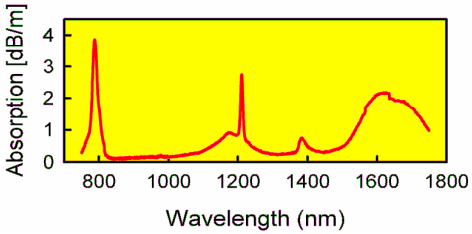
Outstanding Reliability

- Proprietary E2 Facet Passivation for long life operation
- Proven reliability with rigorous life-testing
- Sophisticated test equipment and statistical modeling

Outline

- Motivation
- Fabry-Pérot chip development
- Wavelength stabilization
- Fiber coupled results
- Summary and Outlook

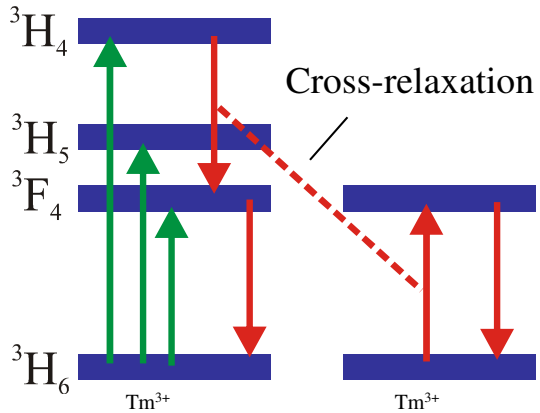
Pump Wavelength for Tm-doped Silica Fibers

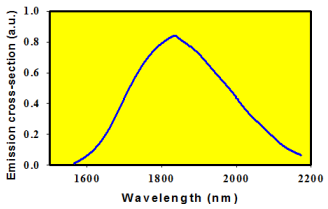


$\lambda_p \approx$ ~780 – 810 nm

$\lambda_p \approx$ ~1200 nm

$\lambda_p \approx$ ~1550 – 1750 nm

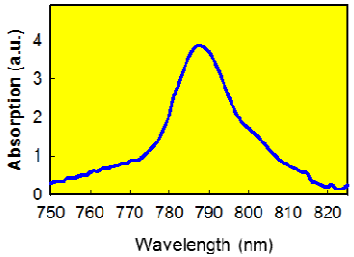




$\lambda_L \approx$ ~ 2 µm

Main pump bands:

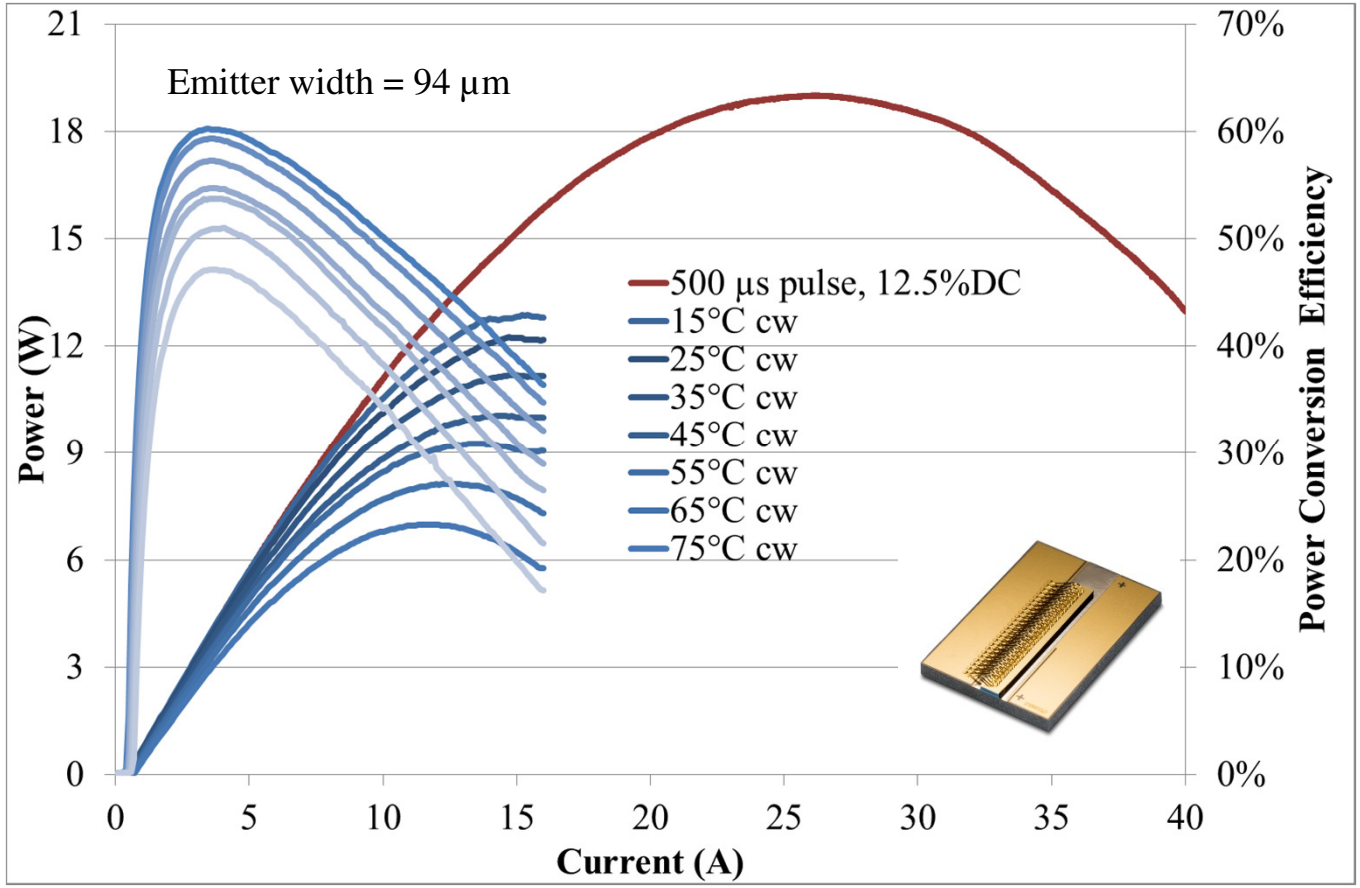
- λ_p ~ 790 nm
- Bandwidth ~ 20 nm
- Core absorption coefficient ~ 280 dB/m for ~1 wt% Tm



- λ_p ~ 1630 nm
- Bandwidth ~ 200 nm
- Core absorption coefficient at 1565 nm is ~ 100 dB/m for ~1 wt% Tm

Courtesy of A. Clarkson, ORC, University Southampton

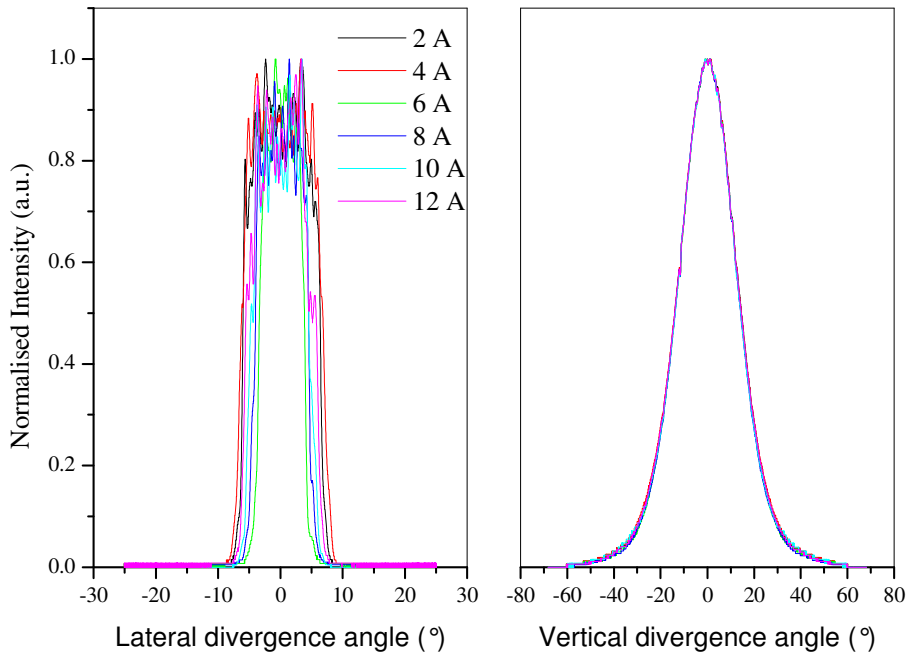
Single emitter performance

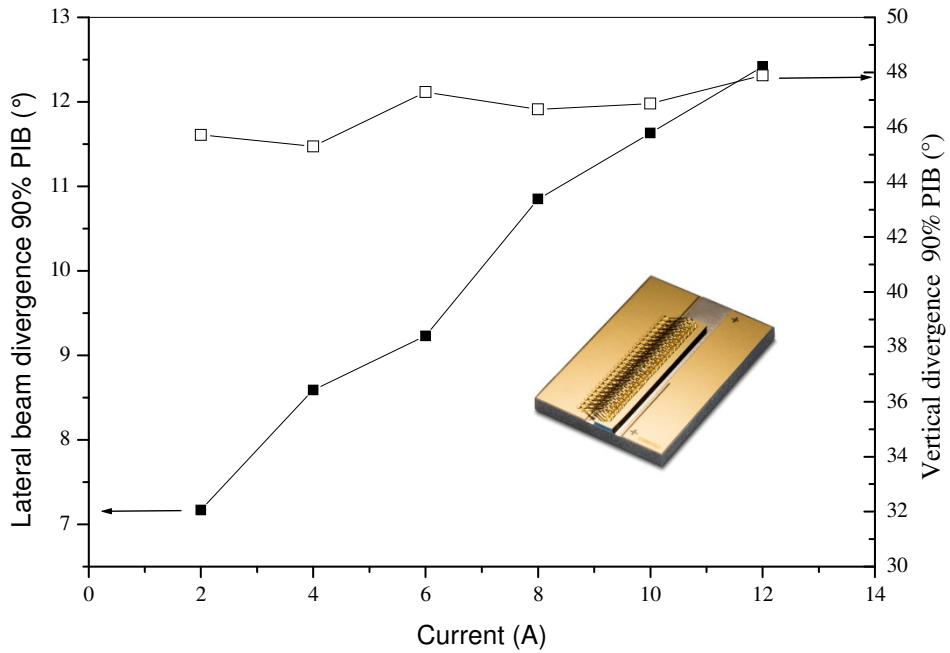


- **60% Wall plug efficiency**
- **Up to 19 W qcw ex-facet power**

Single emitter performance

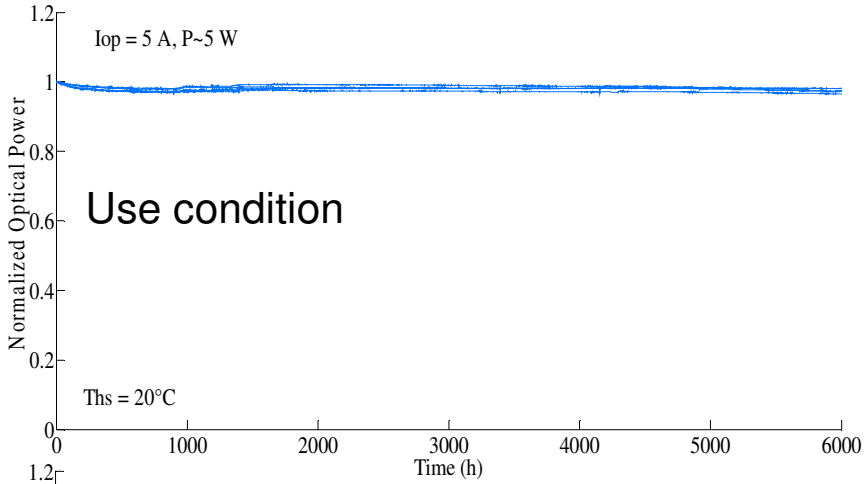
Emitter width = 94 µm, Ths = 25°C

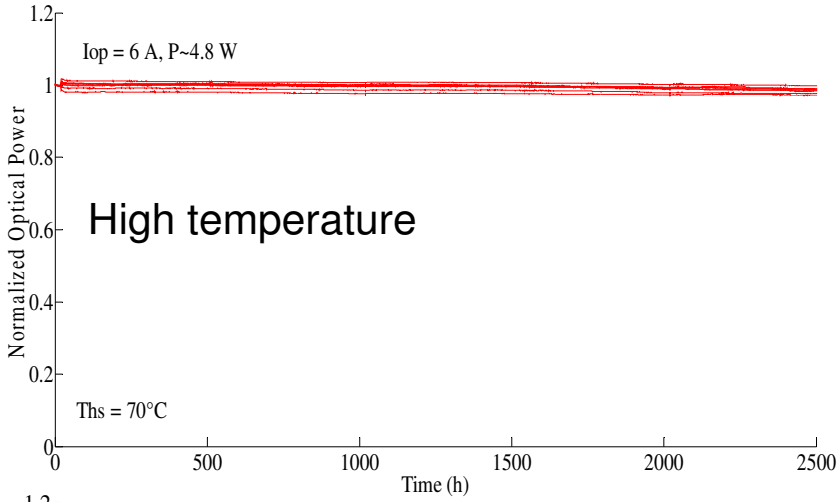


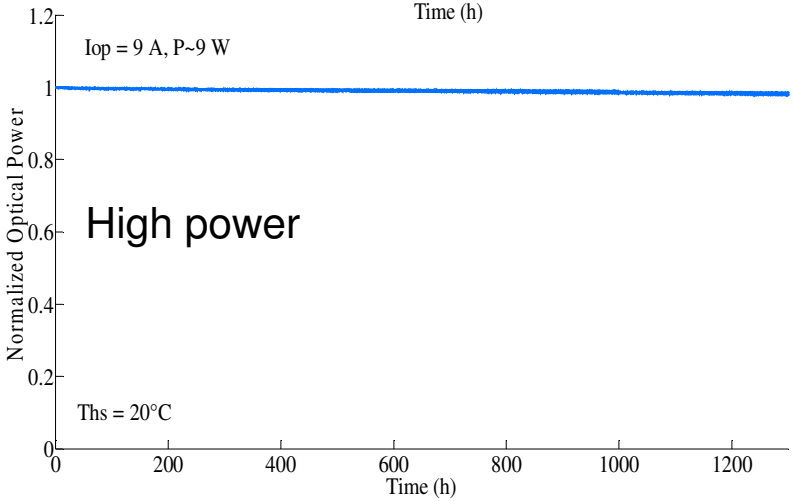


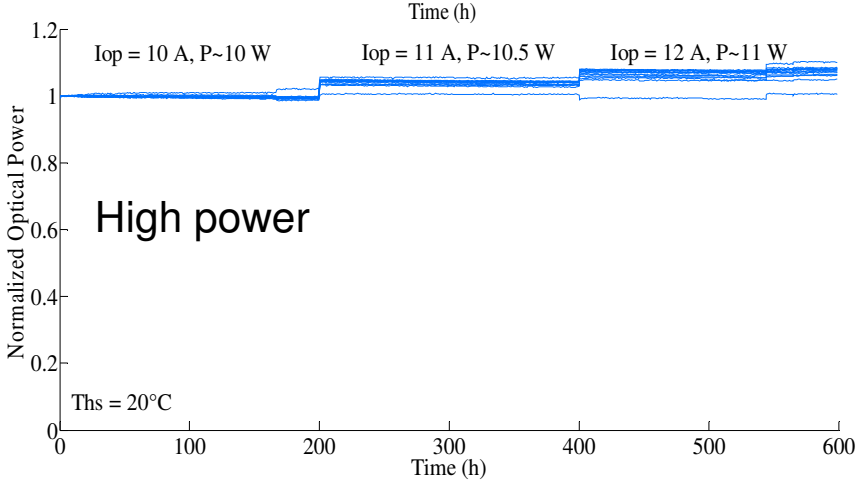
- **Beam divergence optimized for efficient fiber coupling**

Robustness of devices



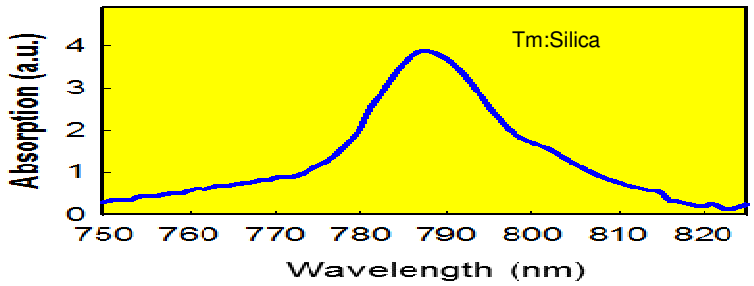


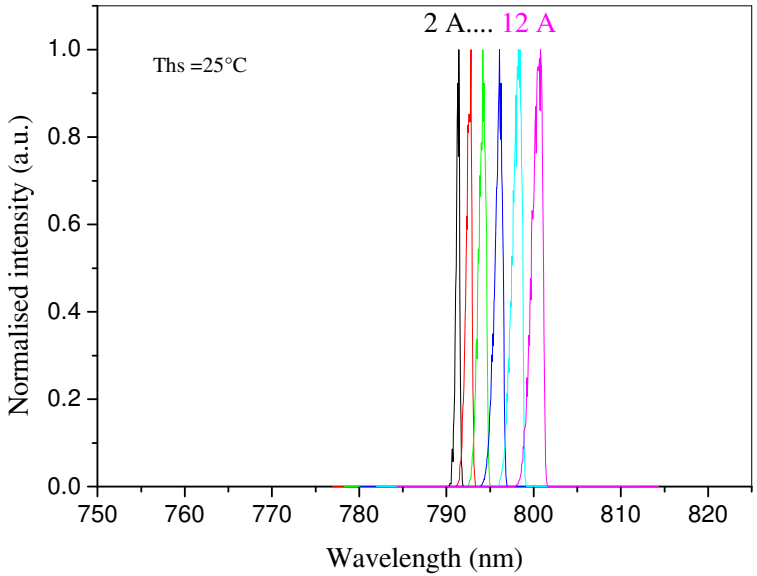




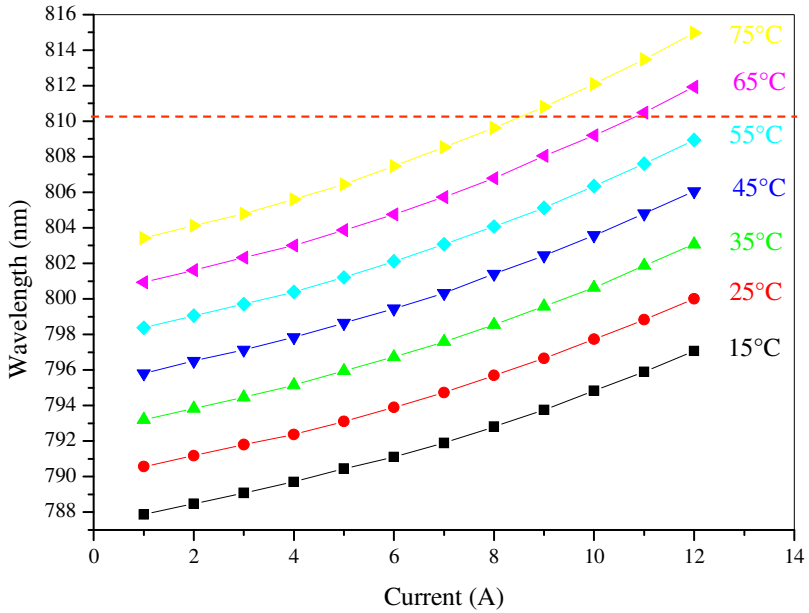
- Up to 6000h life test data available

Spectral Behavior





$\Delta\lambda/\Delta I$ ~0.65-0.75 nm/A
$\Delta\lambda/\Delta T$~ 0.28 nm/K

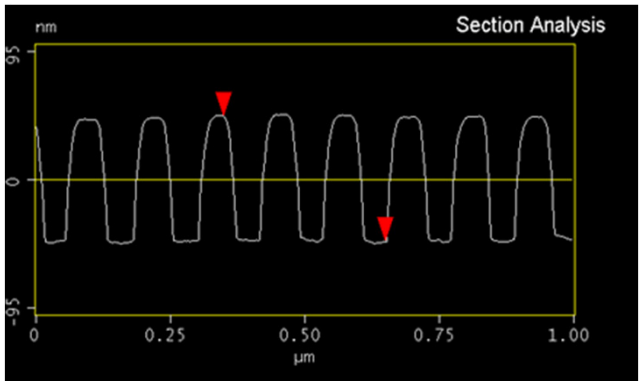


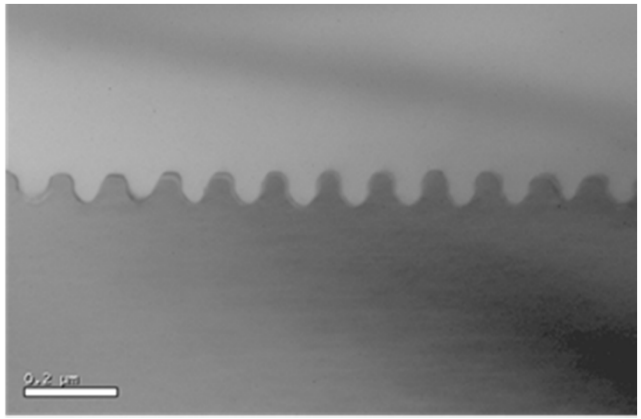
- Spectral properties suitable for Tm fiber laser pumping

Integrated Wavelength Stabilization

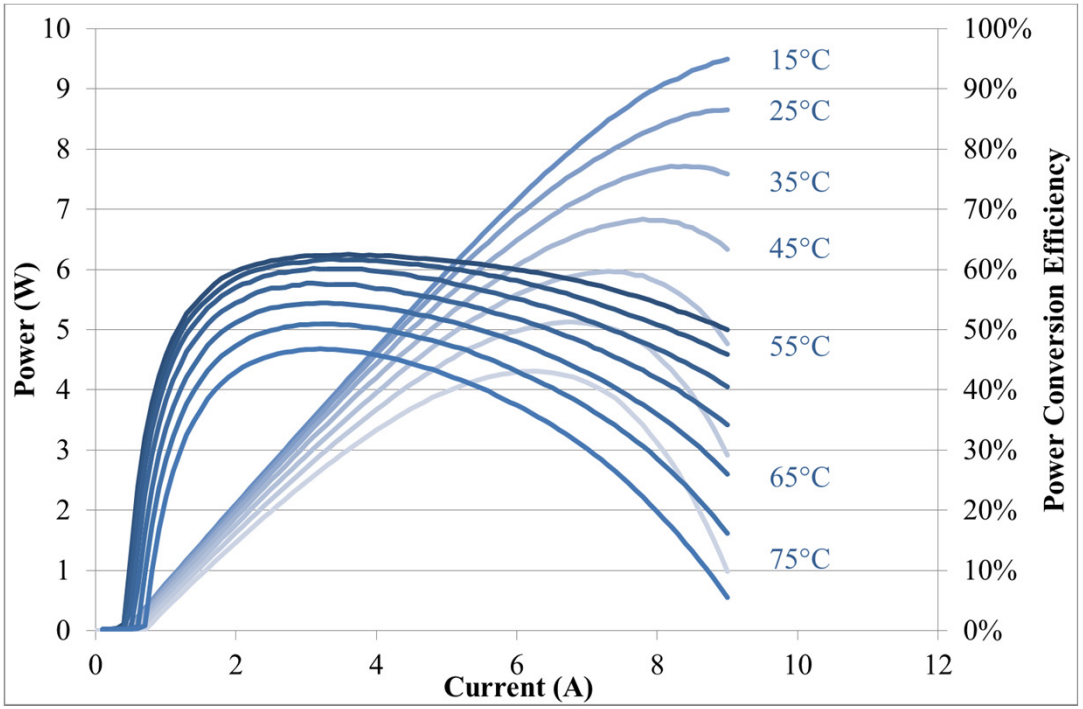
Realisation of DFB gratings:

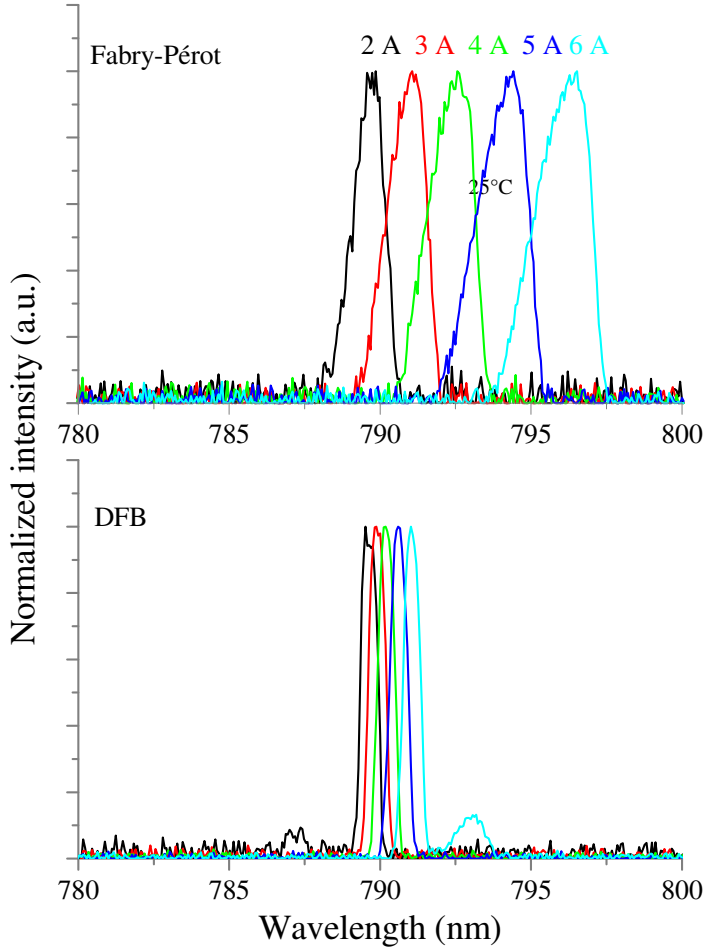
- **2 step growth**
- **Al free layer in p-waveguide**
- **Definition of first order grating**
  - **E-beam**
  - **Reactive Ion Etching**
- **Epitaxial overgrowth**
- **Processing as standard ridge wave guide laser**
- **AR/HR coating**





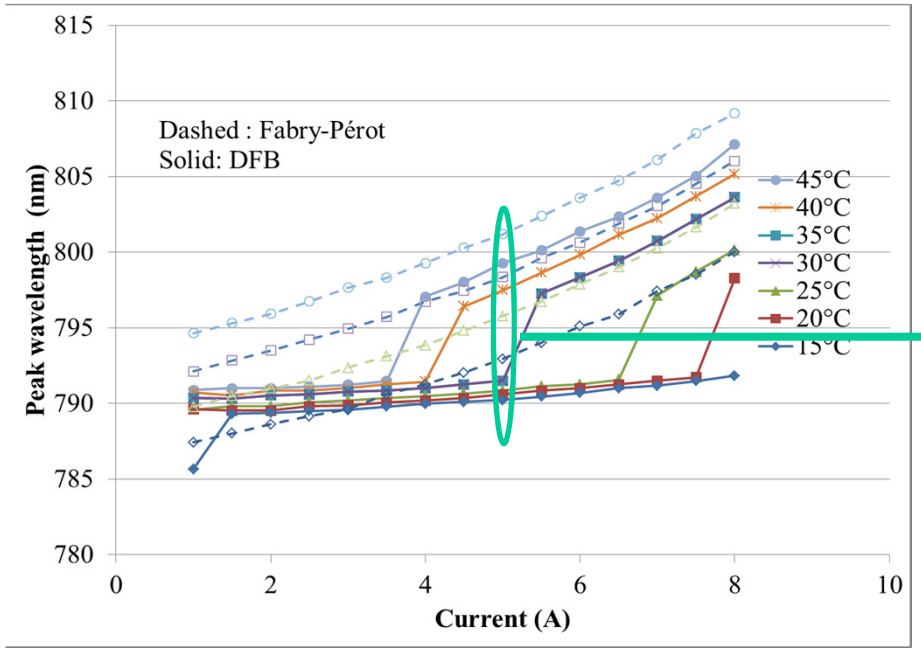
DFB laser performance

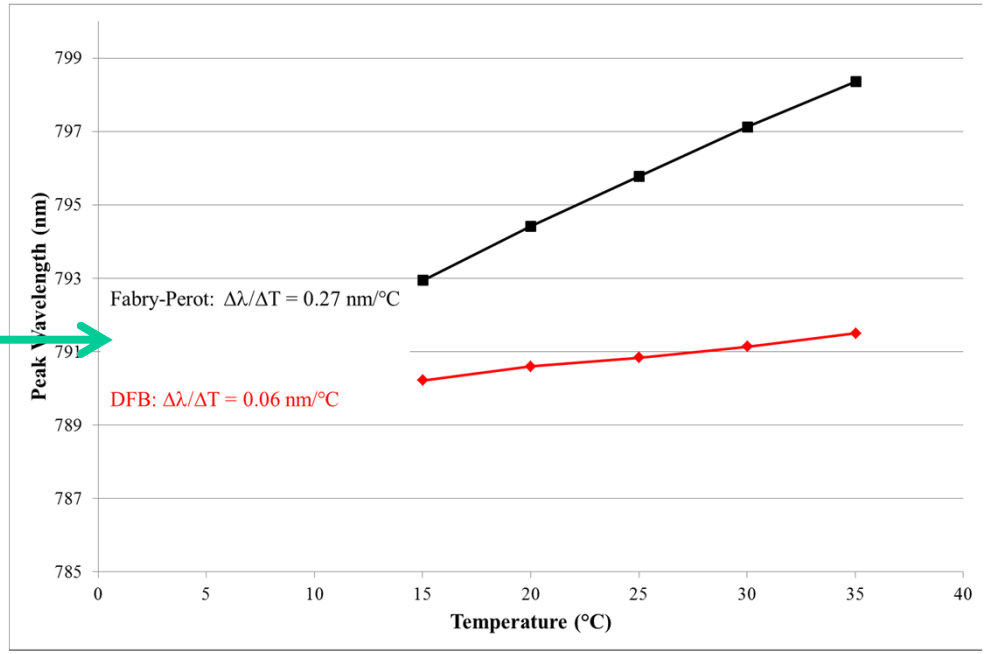




- **> 60% Power Conversion Efficiency**

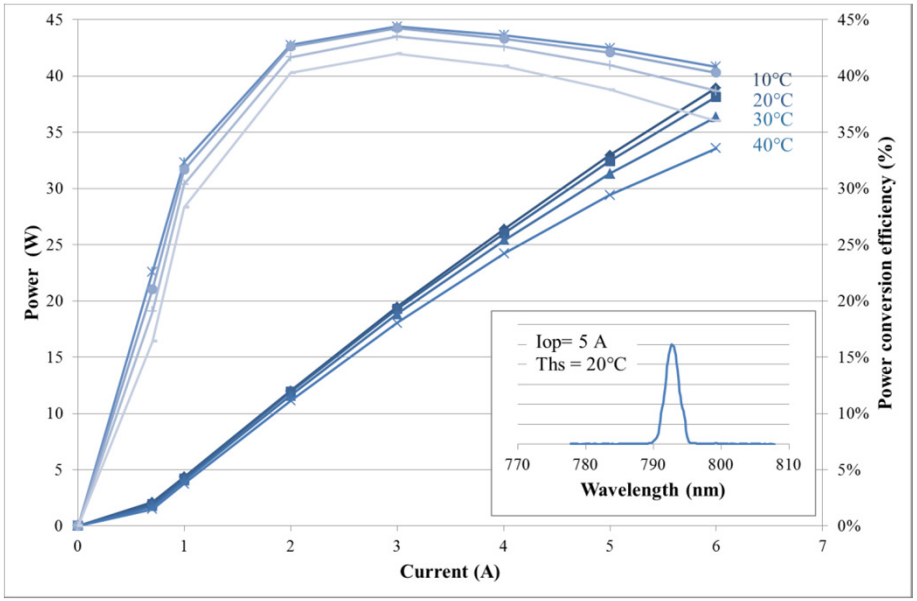
Locking range

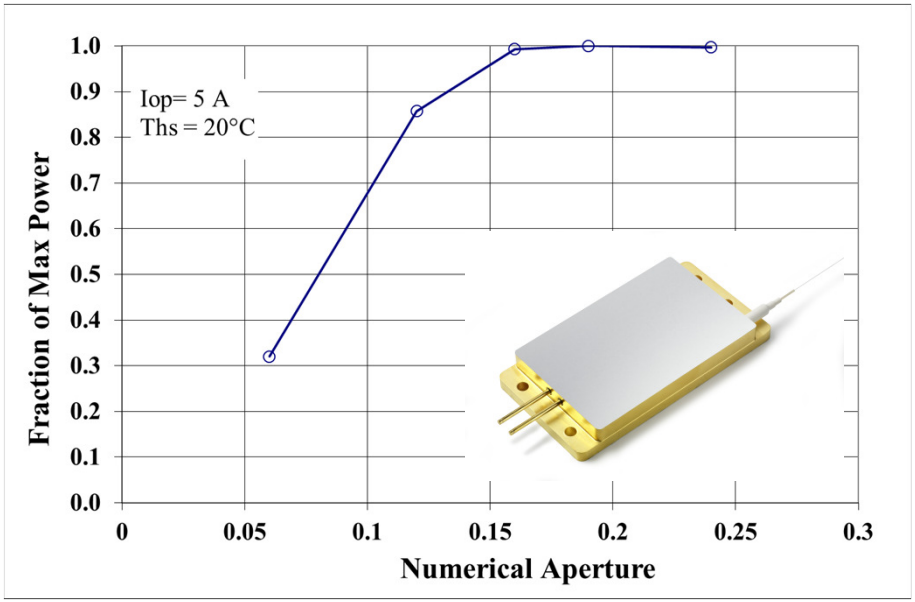




- **Locking over 1-5 A current range with margin for temperature variation**
- **Reduced wavelength shift with temperature for DFB**

79x Multi-Emitter Platform for 2 µm fiber laser pumping





> 38 W ex-fiber light output power

Summary and Outlook

Chip development at 79x nm

- **> 60% power conversion efficiency**
- **>12.5 W cw ex-facet power**
- **Up to 19 W qcw ex-facet power**
- **Up to 6000h life test data**
- **Wavelength stabilization realized with integrated DFB grating**

Fiber coupling

- **79x nm: > 38 W into 105 μm fiber with 0.15 NA**

Further activities:

- **Integration of wavelength stabilized DFB laser diodes in multi-emitter platform**

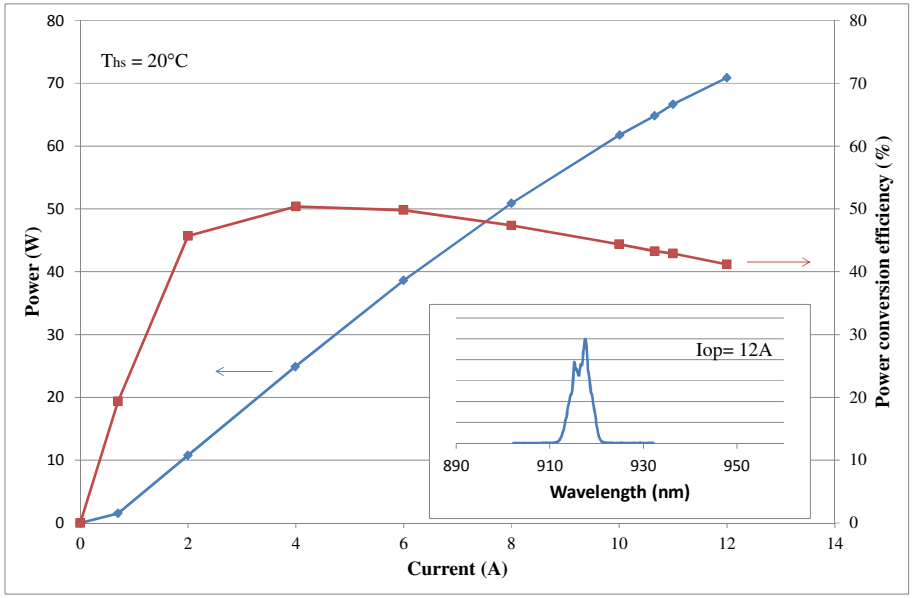
ACKNOWLEDGEMENTS

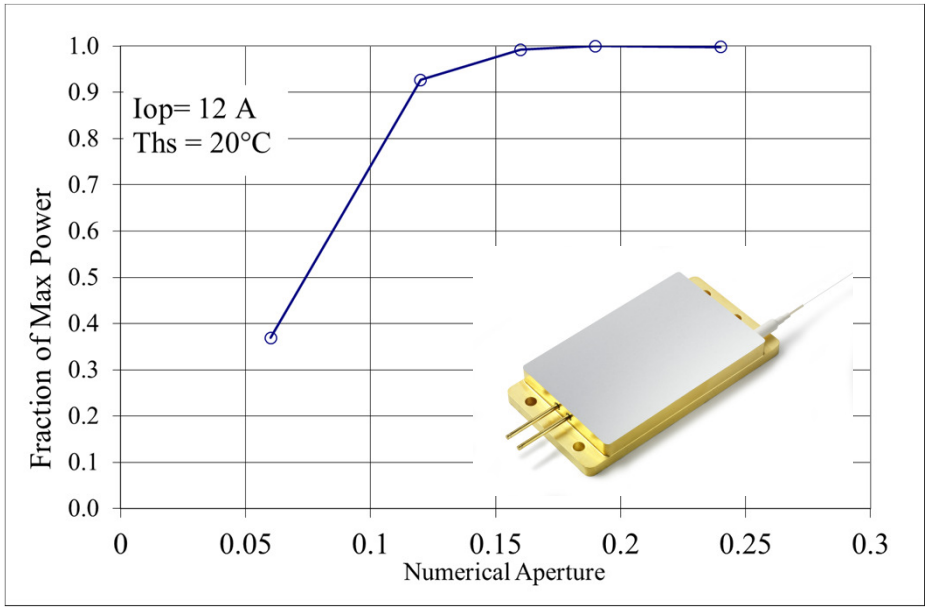
- **ISLA is supported by the European Commission's 7th Framework Program under contract 287732**

- **The authors would like to thank Mark Kearley, Chris Button, James Waddup, Ian Davies and their teams at Oclaro for their valuable support**

Thank you!

9xx Multi-Emitter Platform for 1 µm fiber laser pumping





70 W ex-fiber light output power in 105 µm fiber
50% power conversion efficiency
>95 % power in 0.13 NA