# @Flex: CW Fiber-Coupled Diode Laser
with enhanced brightness

monocrom
*Crafting ideas into light*

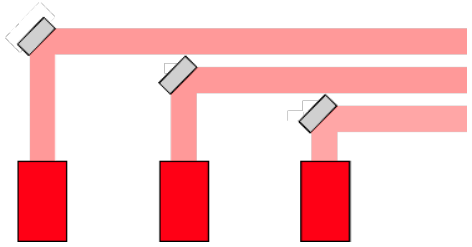
Joan Montiel-Ponsoda
j.montiel@monocrom.com

# Contents

- Beam combining techniques
- Rectified polarization coupling
- Packaging of laser diode bars
- Products review
- What’s next

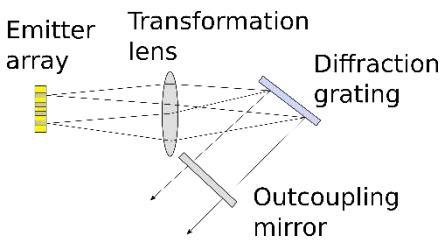
# Beam combining techniques

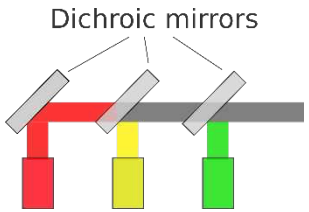
## Side-by-side beam combining



- ✓ Thermal drift robustness
- ✓ Spectral width maintenance
- ✓ Cascadable concept
- ✗ Brightness increase

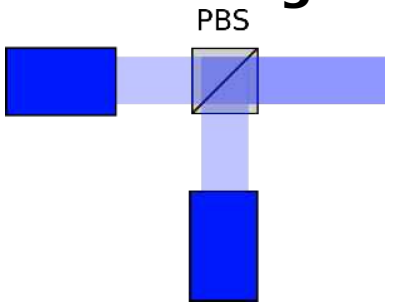
## Spectral-beam combining




- ✗ Thermal drift robustness
- ✗ Spectral width maintenance
- ✓ Cascadable concept
- ✓ Brightness increase

## Polarization beam combining

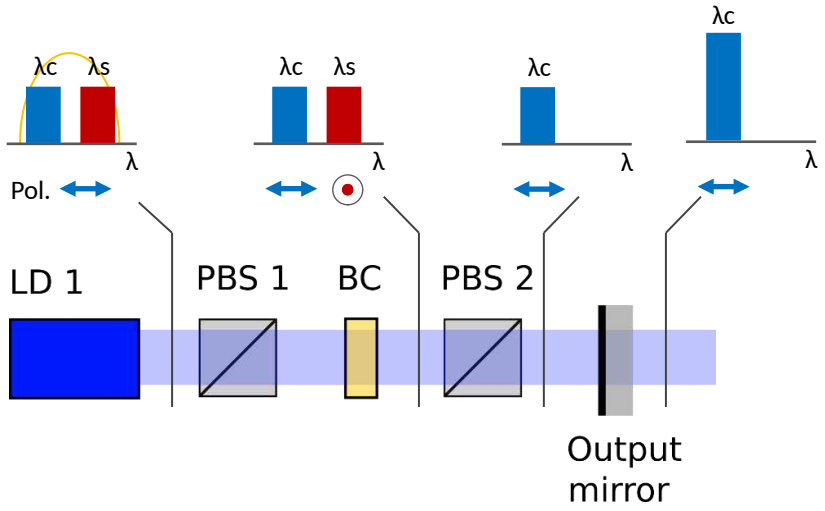


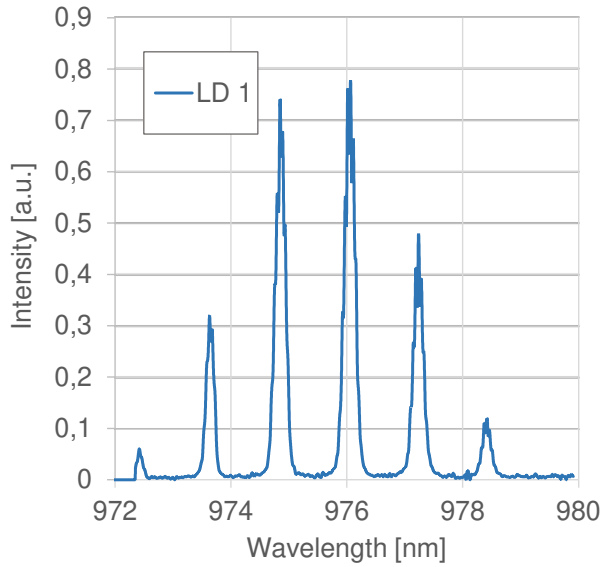

- ✓ Thermal drift robustness
- ✓ Spectral width maintenance
- ✗ Cascadable concept
- ✓ Brightness increase


Joan Montiel-Ponsoda
j.montiel@monocrom.com

# Rectified polarization coupling

- Lyot filter optical reinjection
- BC is oriented at 45º
- Phase delay depends on wavelength (BC is dispersive)
- BC acts as a HWP for a set of wavelengths and phase neutral for another
- It is modular: allows using



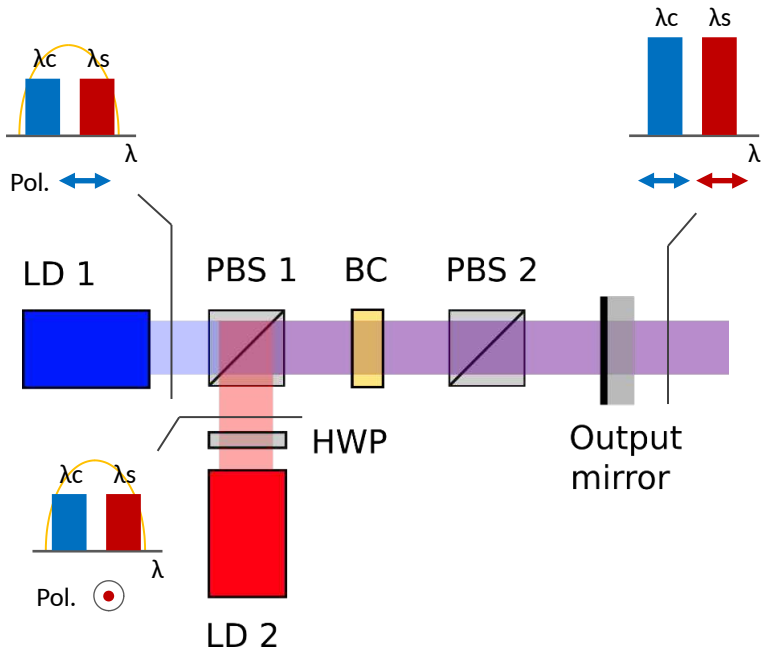



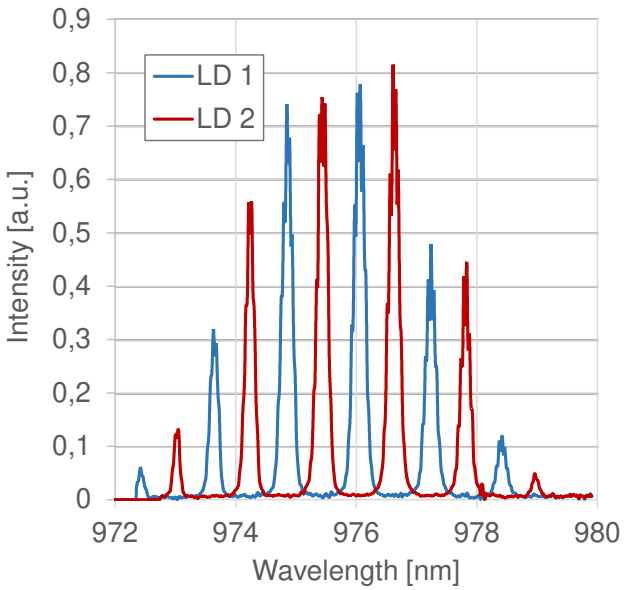


Joan Montiel-Ponsoda
j.montiel@monocrom.com

# Rectified polarization coupling

- Second laser diode with same properties
- The result is a combined beam with higher brightness and linear polarization
- It is cascadable
- Spectral width similar to one single laser diode
- Power loss due to coatings and unpolarized



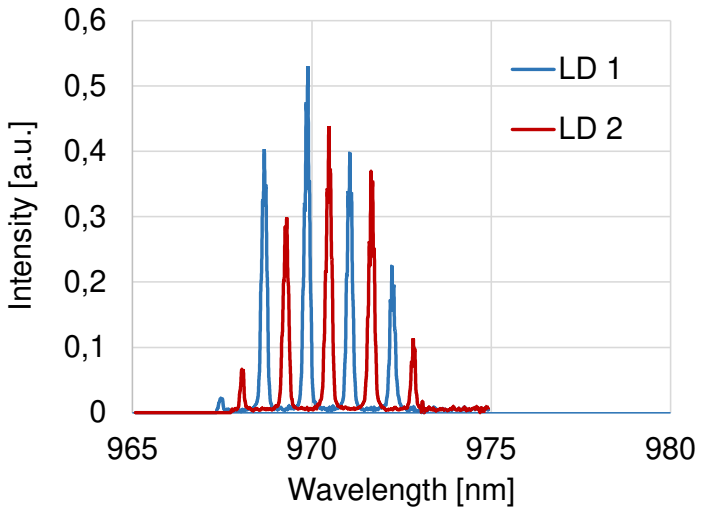





Joan Montiel-Ponsoda
j.montiel@monocrom.com

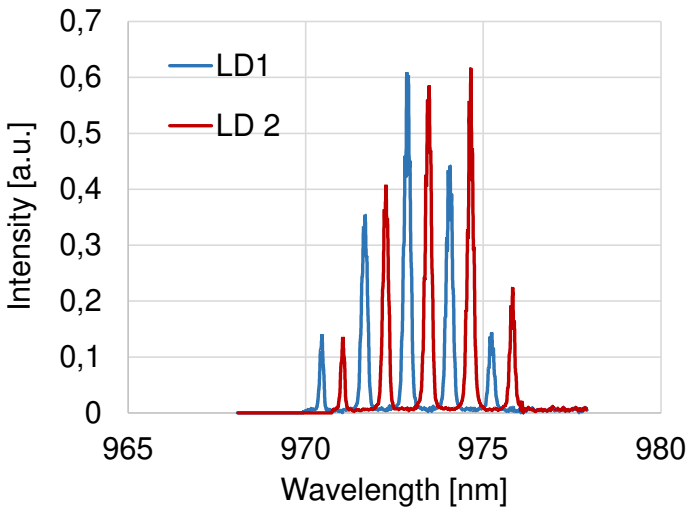
# Insensitive to thermal drift

Coupl. Eff: 76%



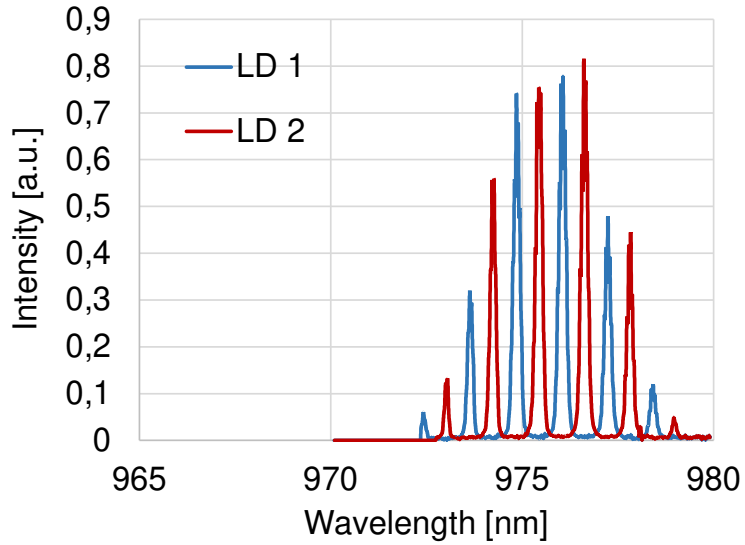

100 A

75%




150 A

75%




200 A


Joan Montiel-Ponsoda
j.montiel@monocrom.com

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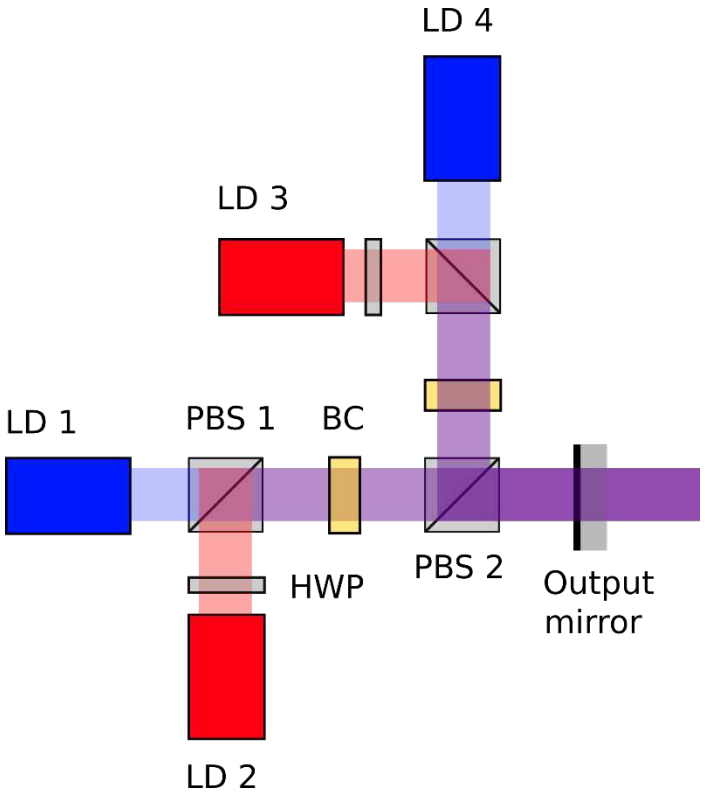
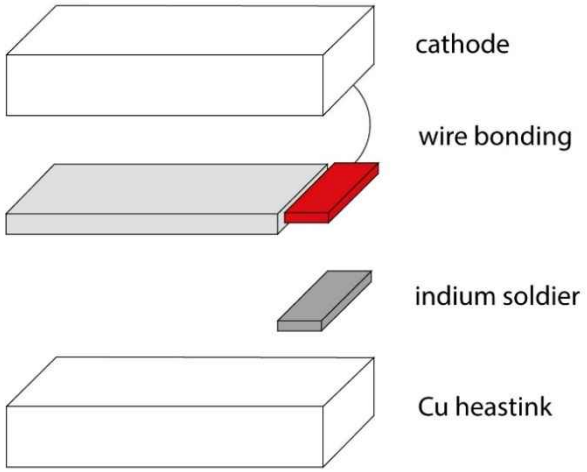
# Beam combining of $2^n$ diode lasers



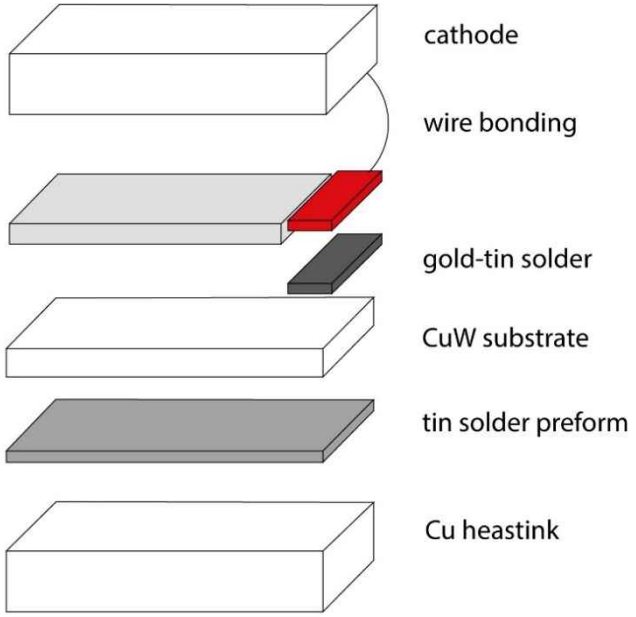

We achieved beam combining of 4 laser diodes with 75% coupling efficiency


Joan Montiel-Ponsoda
j.montiel@monocrom.com

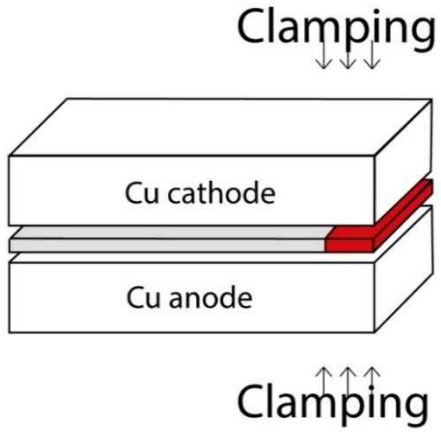
# Packaging of high power diode laser bars

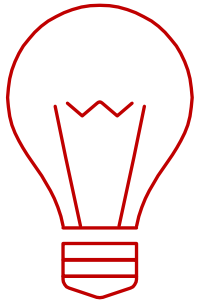



Soft soldering

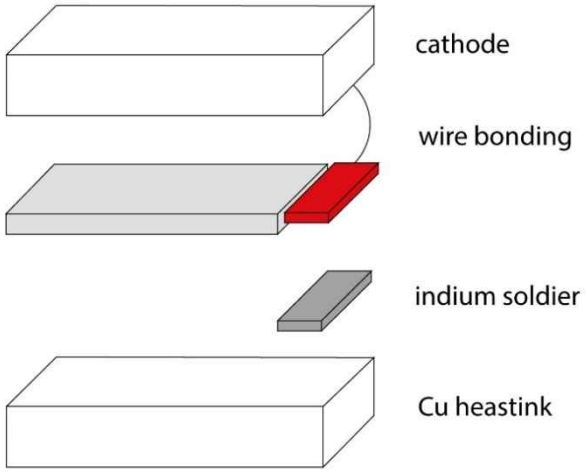



Hard-soldering

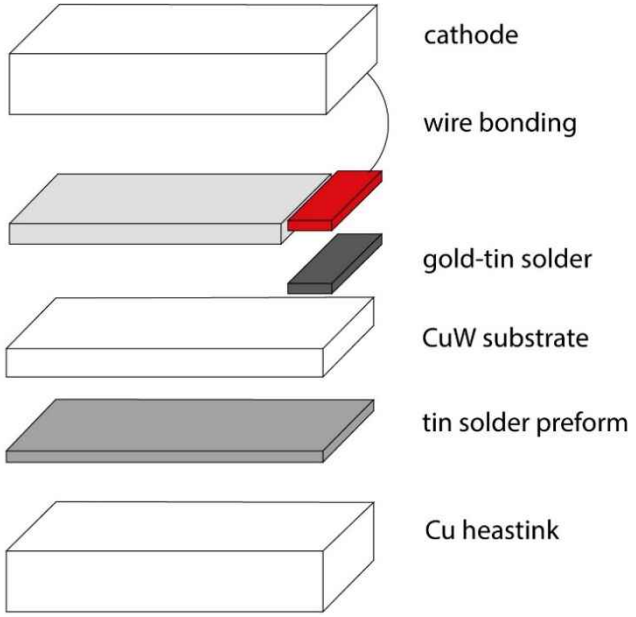


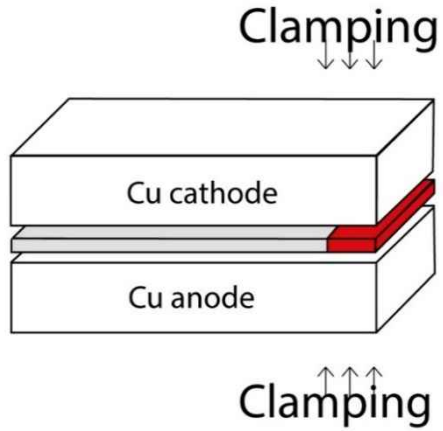
# Packaging of high power diode laser bars



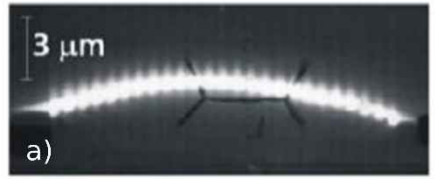

Soft soldering




Hard-soldering

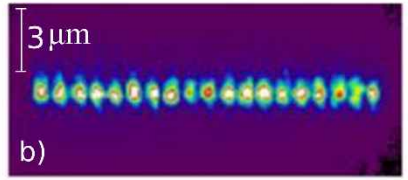



Soldered




typical 1 µm

Clamping™




under 0,1 µm


Joan Montiel-Ponsoda
j.montiel@monocrom.com

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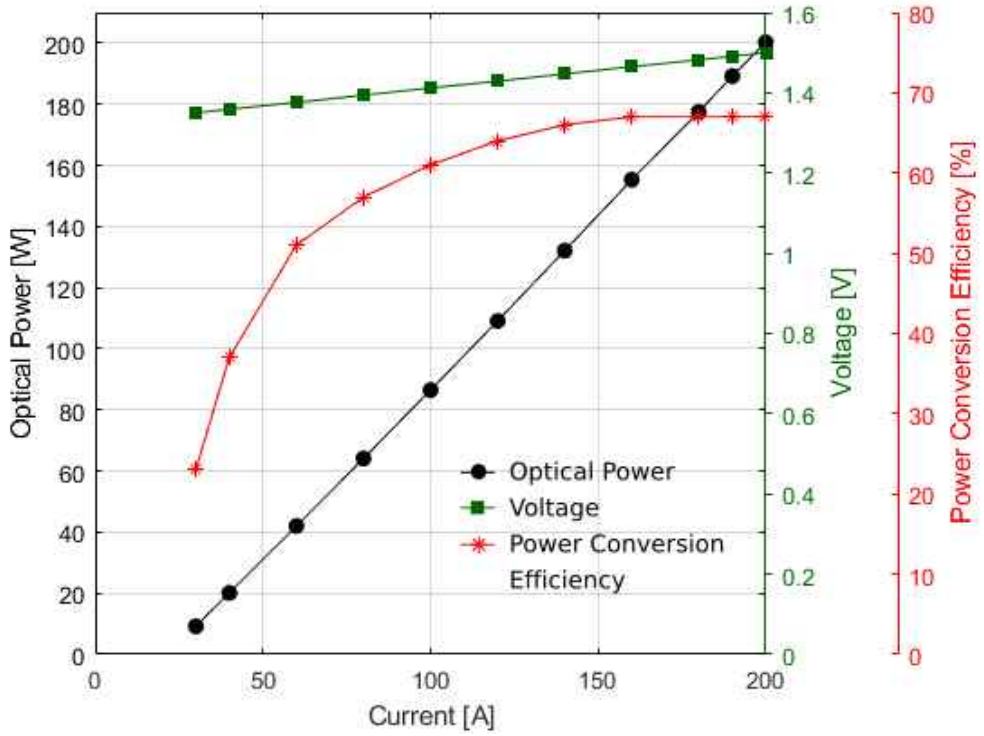
# Packaging of high power diode laser bars

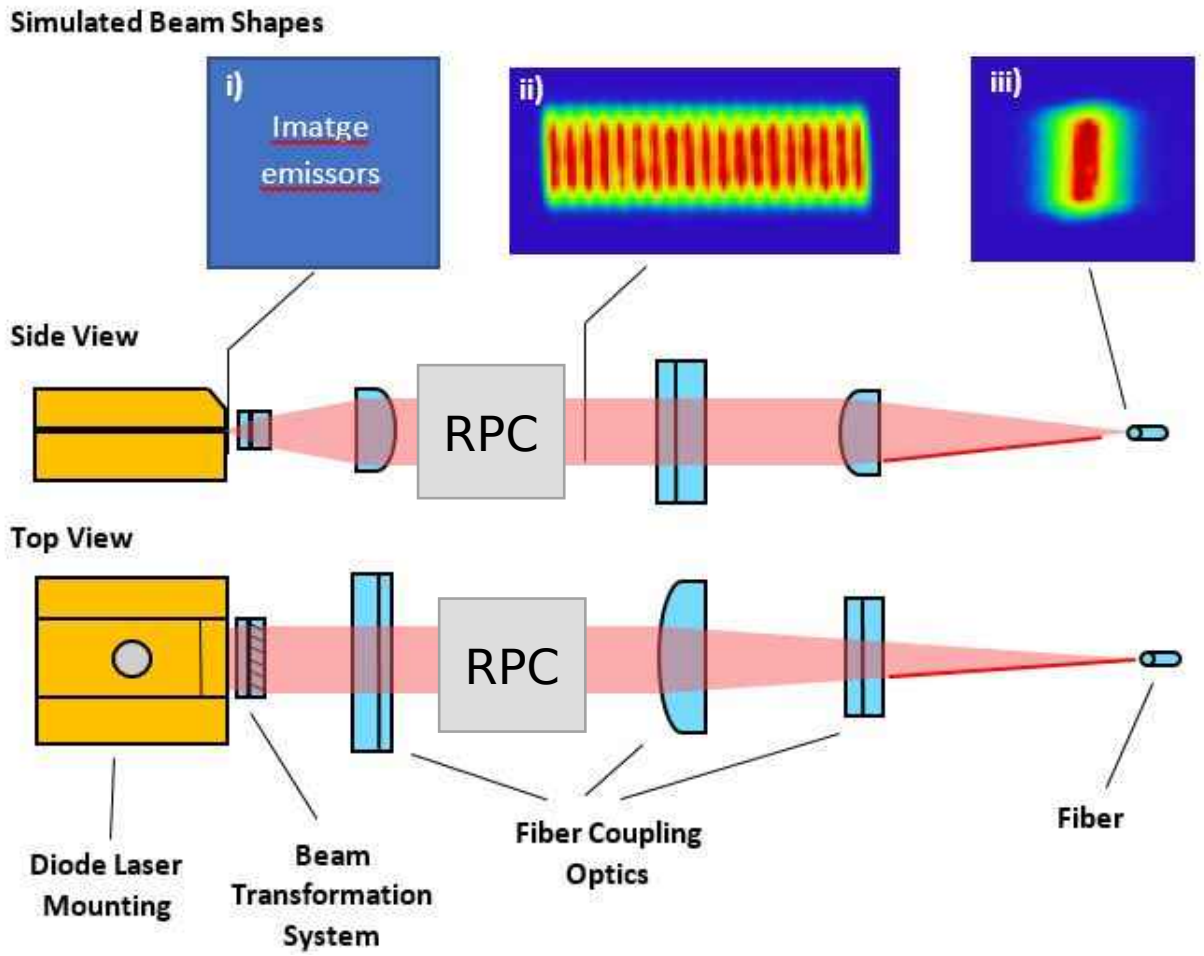
- 200 W commercial laser bars
- Resonator length of 4 mm
- Cooling from both sides
- Small thermal resistance <0,3 K/W
- Power conversion efficiency of 67%





Joan Montiel-Ponsoda
j.montiel@monocrom.com

# @Flex Fiber-Coupled Direct Diode Laser – Optical design

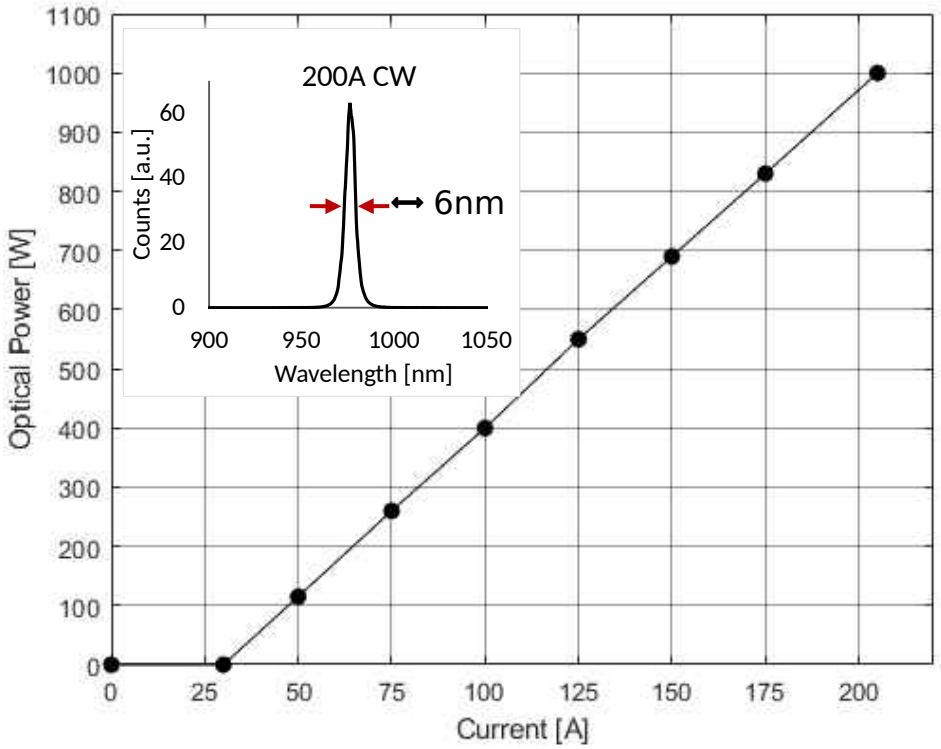




Joan Montiel-Ponsoda
j.montiel@monocrom.com

# @Flex: 1kW single wavelength

- Output power at single wavelength: 1kW (CW)
- Optical fiber core diameter 400 µm
- Single wavelength
- High E-O efficiency (coupling eff. 64%)
- Temperature drifting do not affect optical efficiency






Joan Montiel-Ponsoda
j.montiel@monocrom.com

# Monocrom @Flex Datasheet

***Monocrom @FLEX Direct Diode*** I TECH Specifications

| Laser Parameters[1,2,3,4] | @FLEX-2 | @FLEX-4 | @FLEX-6 | @FLEX-10 |
|---|---|---|---|---|
| Wavelength[5] [nm] | 976 | | | |
| Linewidth[6] [nm] | < 5 | | 5-7 | |
| Optical power (unpolarized) [W] | | 400 | 600 | 1000 |
| Optical power (linearly polarized) [W] | 200 | 320 | 500 | 800 |
| Coupling efficiency of unpol. light to 600 / 400 µm fiber | > 90% / > 85% | | | |
| Repetition rate[7] | CW – 10 kHz | | | |
| Pulse width[7] | < 50 µs - CW | | | |
| Power stability | < 1% @ 8 h | | | |
| Pulse to pulse stability | < 1% rms | | | |
| **Optics** | | | | |
| Operating voltage[8] [V] | < 2 | < 4 | < 8 | < 16 |
| Threshold current [A] | < 25 | | | |
| Operating current [A] | < 270 | | | |
| Divergence without fiber[9] [mrad] | 10 (FA) / 15 (SA) | | | |
| Beam size without fiber [mm × mm] | 12 × 6 | | | |
| Fiber connector type[10] | HP-SMA-905 / D80 / QBH | | | |
| Beam quality BPP[11] @ 400 µm [mm mrad] | 44 | | | |
| Beam quality BPP[11] @ 600 µm [mm mrad] | 68 | | | |
| Pointing stability @ fixed power [µrad] | ± 50 | | | |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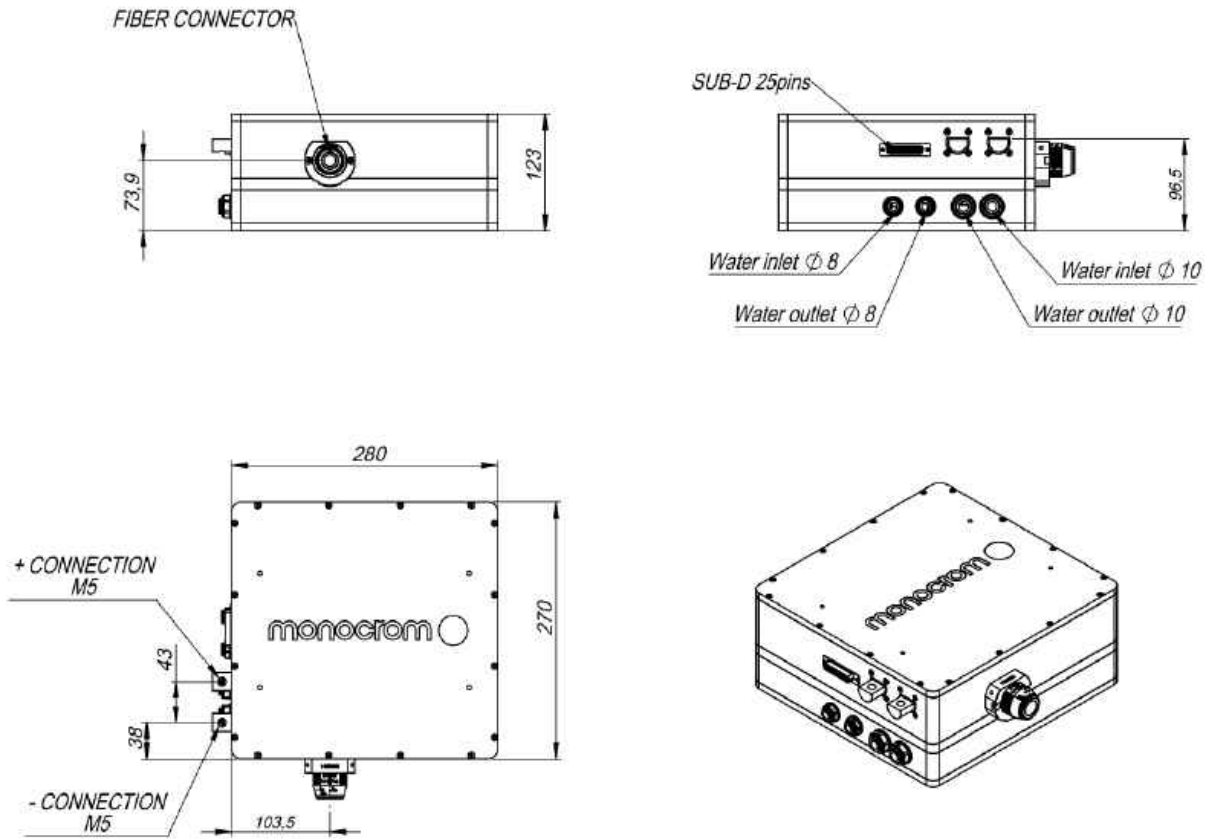
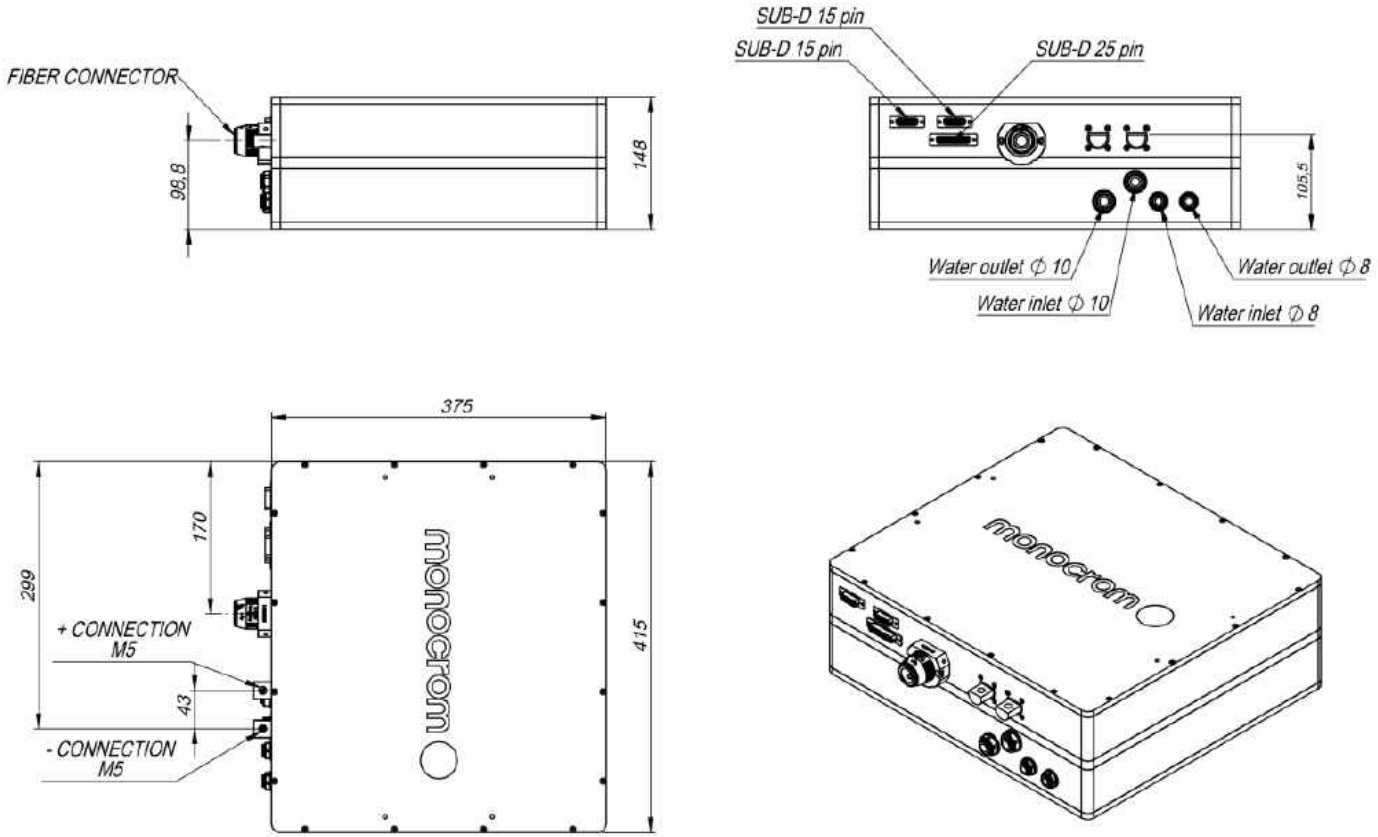
# Monocrom @Flex Outline

Monocrom @FLEX Direct Diode - @FLEX-6



# Monocrom @Flex Outline

## Monocrom @FLEX Direct Diode - @FLEX-10



# Multi-kilowatt platform

- Multi-kilowatt platform based on spectral beam combining.
  - Wavelength peaks: 880, 915, 940, 976, 1060 nm.
  - Output power: up to 5 kW.
- 6-10 kW output power in a 400 um fiber expected before the end of 2022
  - Spatial beam combining (efficient filling of the fiber core diameter and NA)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# Thanks!

***Any questions?***

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