'Latest News' submission

# Tapered Quantum Cascade Lasers

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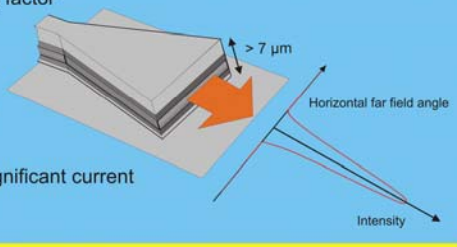
## Motivation

Mid-infrared light sources are suitable for various applications, e.g. optical free space communication, medical imaging and gas sensing

High beam divergence is limiting factor for coupling efficiency

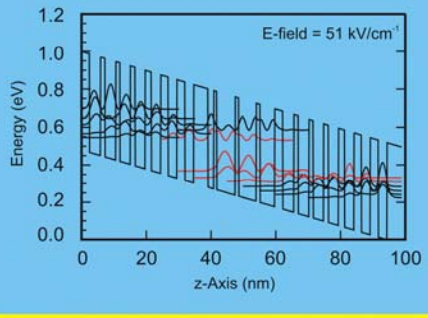
Tapered laser sections provide small horizontal far field FWHM-angles and high output powers

Index guided devices prevent significant current spreading




## MBE-Growth

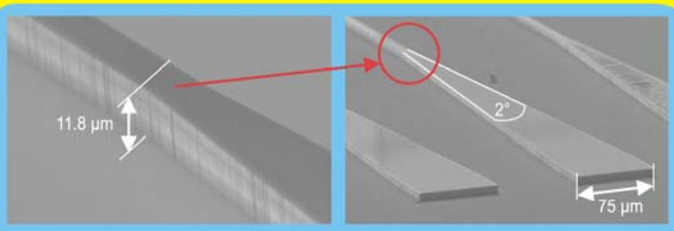
Laser structure is grown by a gas-source MBE-system (lattice matched InAlAs/InGaAs)




Based on 2-LO-Phonon design (Liu et al., Phot. Tech. Letters, **18** (2006))

35 cascades and waveguide add up to a total layer thickness of 6.7 µm

## Sample- / Device-Processing

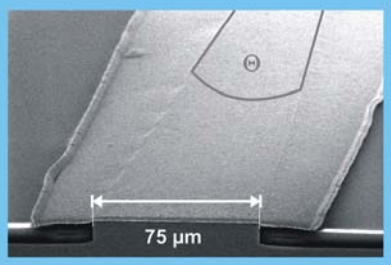



Tapered laser sections are defined by optical lithography

Patterned into the structure by inductively coupled plasma etching with an etch depth of ~12 µm

Variations on the sample:
RWG-section: 0.5 mm - 1.5 mm long / 8 µm - 20 µm wide
Tapered-section: 1 mm - 2 mm long
Taper-angle Θ: 1.2° - 2.6°
→ Output facets: 50 µm - 100 µm

Structure is planarized with a polymer and the top gold contact is evaporated on the thinned sample

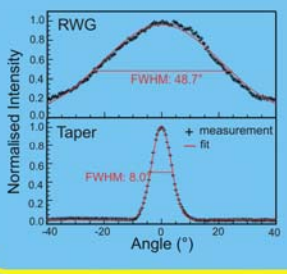



Front facets are coated with AR coatings, back facets with HR coatings

## Horizontal Far Field Characteristics

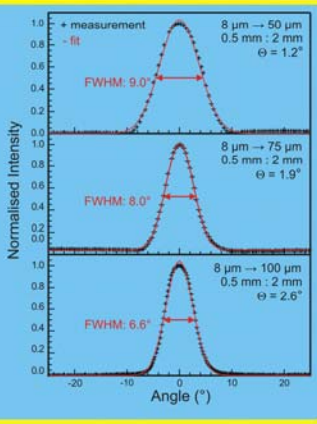
Horizontal far field intensity scans were measured in pulsed operation at room temperature
(pulse width: 300 ns, repetition rate 1 kHz)

Submitted to APL by L. Nähle et al.

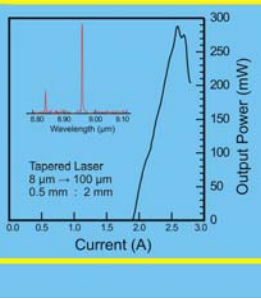



Comparison of the horizontal far field intensity scan of a tapered device with a regular 12 µm RWG device (processed on the same sample) shows improved FWHM-angle of the tapered device

An increased taper angle yields a narrower FWHM-angle due to an increased output facet



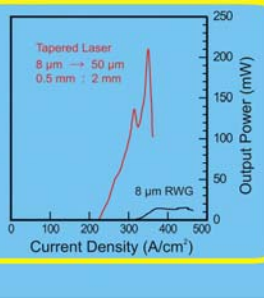

## Basic Characterization




Electro-optical output characteristics of a taper device (100 µm output facet) at room temperature show higher output powers than comparable RWGs (~ 300 mW)

Emission wavelength ~ 8.9 µm

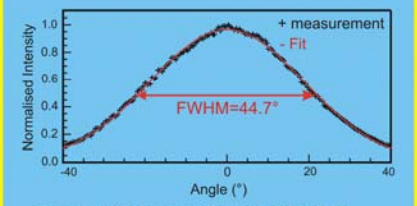
Decrease in threshold current density for the tapered device can be observed




## Summary / Outlook

Tapered QCLs have been fabricated. In addition to improved room temperature performance with output powers up to ~ 300 mW a decreased horizontal far field FWHM-angle of 6.6° could be obtained.

Vertical far field intensity scan:




The relatively broad vertical far field can be improved by applying tapered laser concept to large optical cavity structure.

## Acknowledgement

Thanks to A.Wolf for technical assistance during device processing. The financial support of the state government of Bavaria is gratefully acknowledged.