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Development of a high power coherent quantum cascade laser array mounted in extended-cavity system

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[2] III-V lab, GIE Alcatel – Thales – CEA LETI

Outline

- Motivations

- Technical challenges
- Array QCL emitters performances
- Preliminary results in extended cavity

- Conclusion & perspectives

Introduction

High power technology

High power extended-cavity QCL for spectroscopic applications

- photo-acoustic,
- saturated molecular absorption
- …

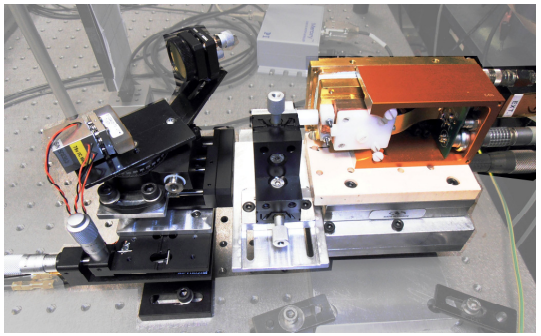
Single-mode

Tunable

Wide-spectral range

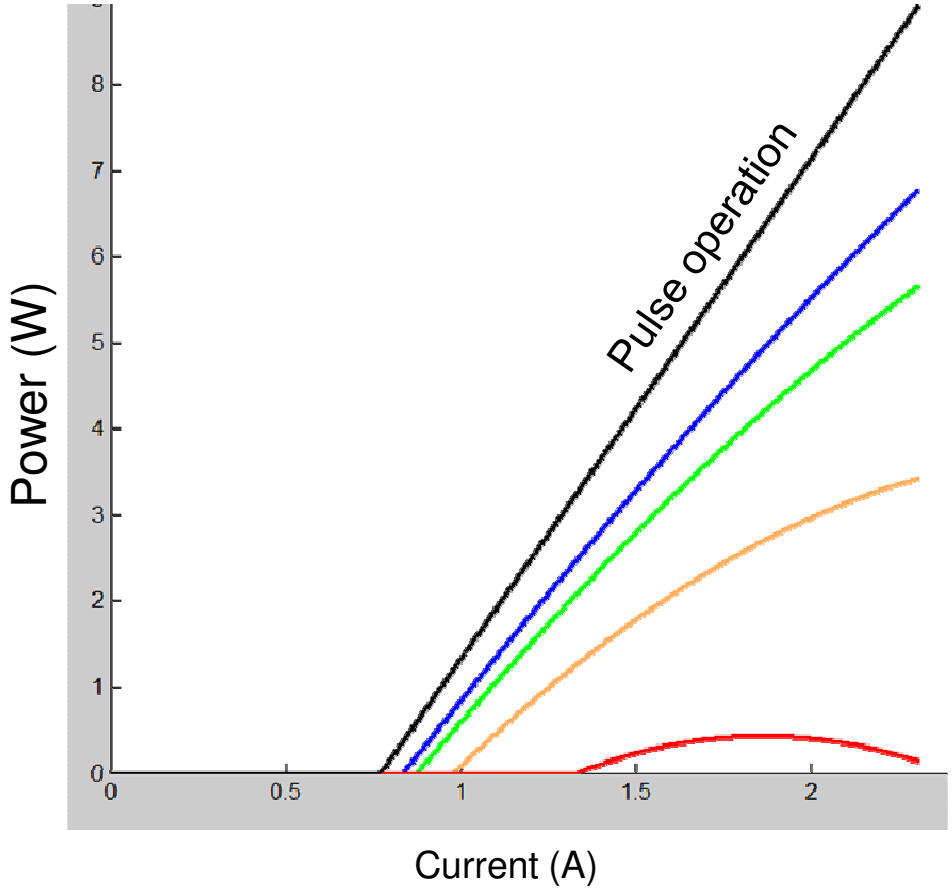
Room temperature

EC-QCL



Context

Power vs current



Slope ↘

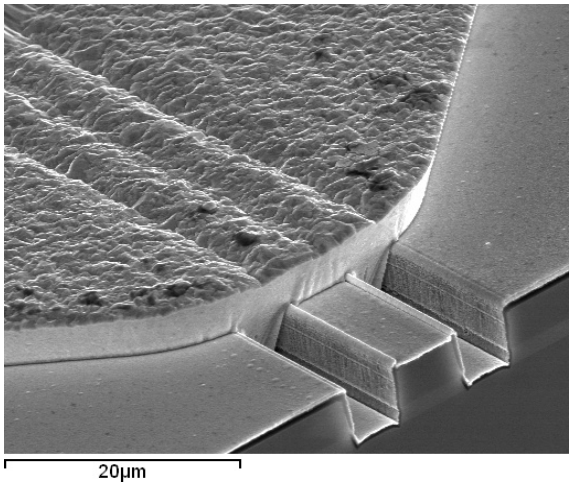
Threshold current ↗

QCL Optical performances limited by thermal resistance

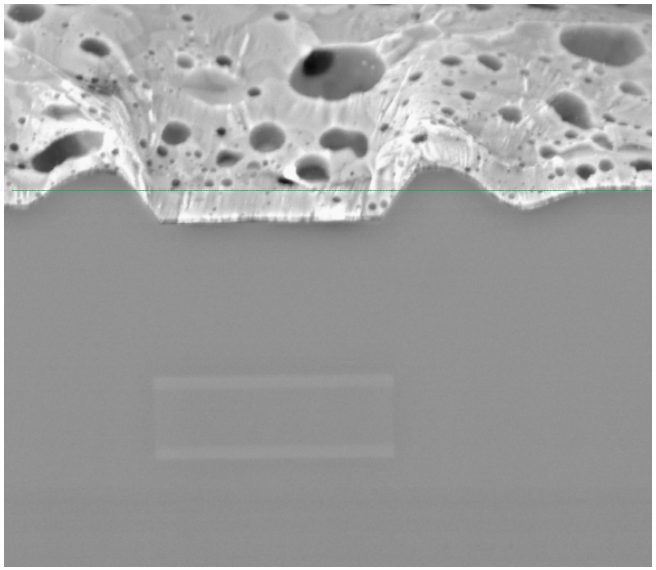
Context

Increase heat extraction

Double trench process



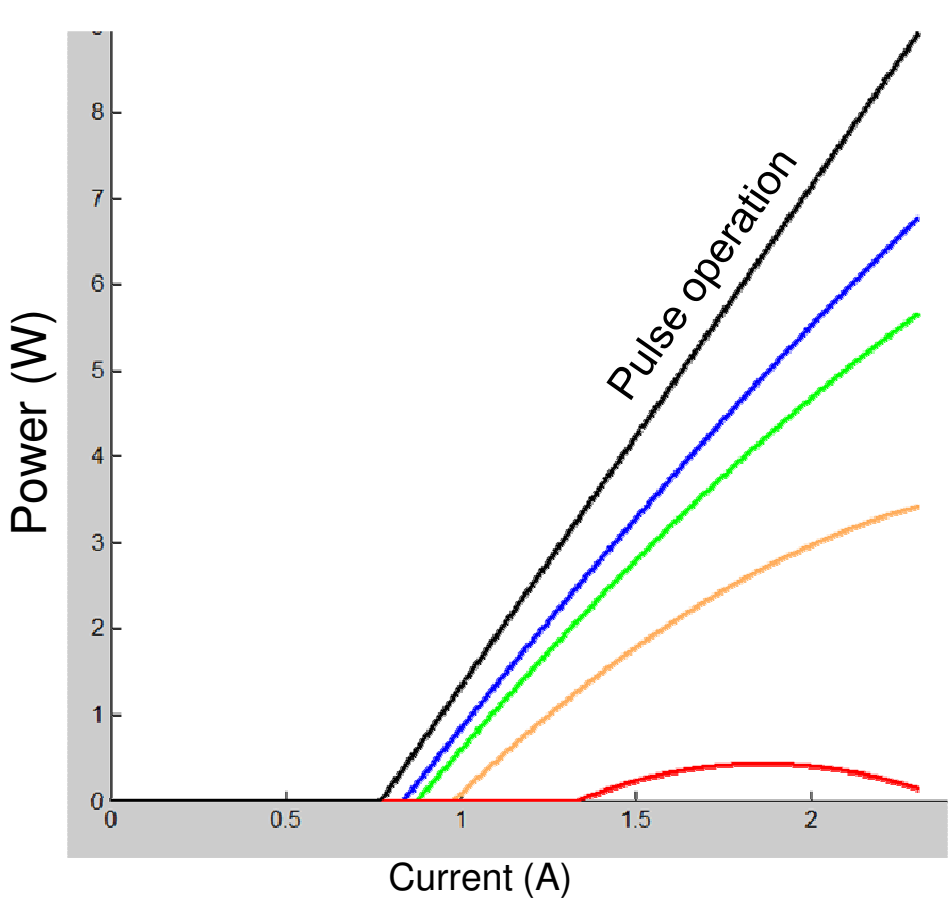
Buried process



R_{th}= 10 °K/W

R_{th}= 4 °K/W

Context



No warming

Rth =3,5 K/W

Rth =4 K/W

Rth = 5 K/W

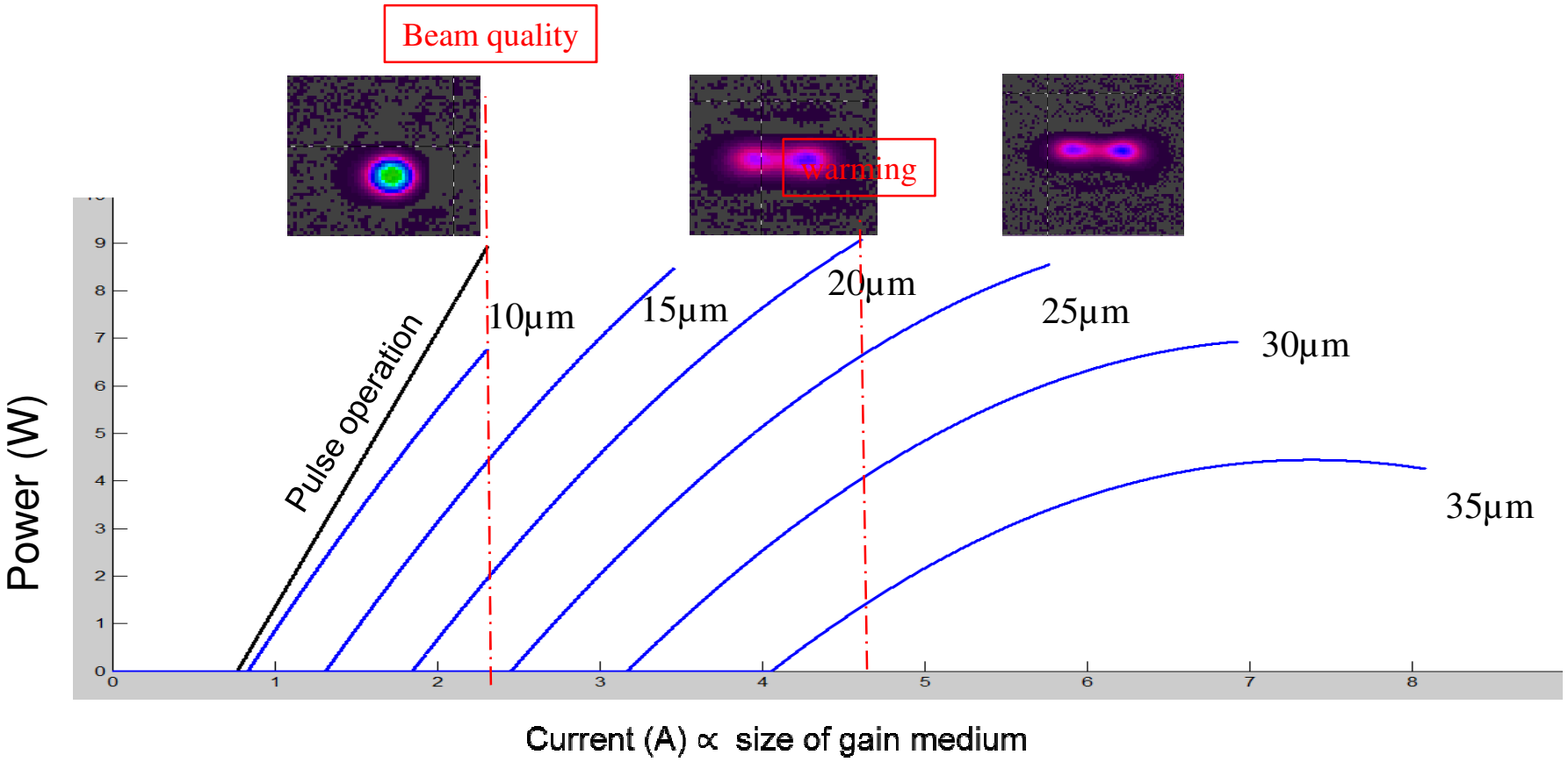
Rth = 8 K/W

Optical performances : not limited by thermal resistance but by injection current

Context

Increase current

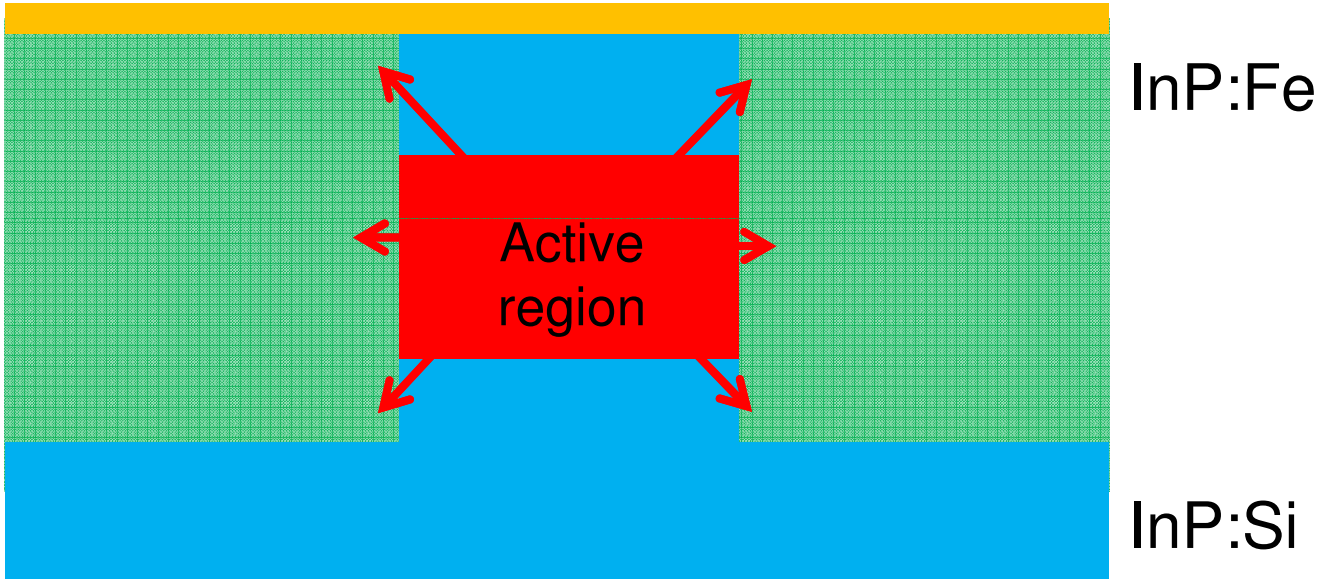
performances limited by active region size



One solution :

buried + micro-structured QCL

µ-structure increase thermal surface exchange

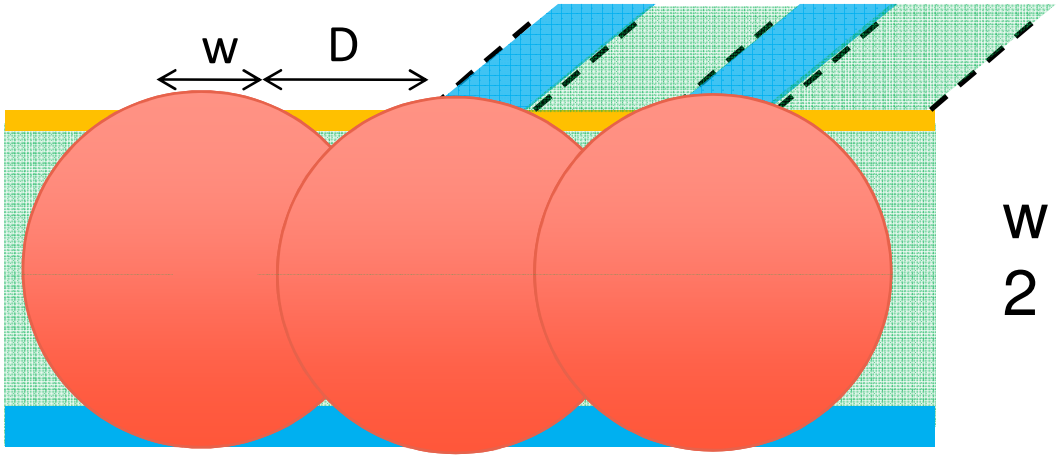


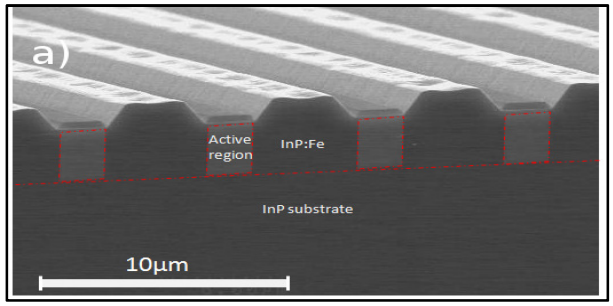
Thermal dissipation enhancement

One solution :

buried + micro-structured QCL

μ-structure pitch: Λ=w+D





w ~ 2μm

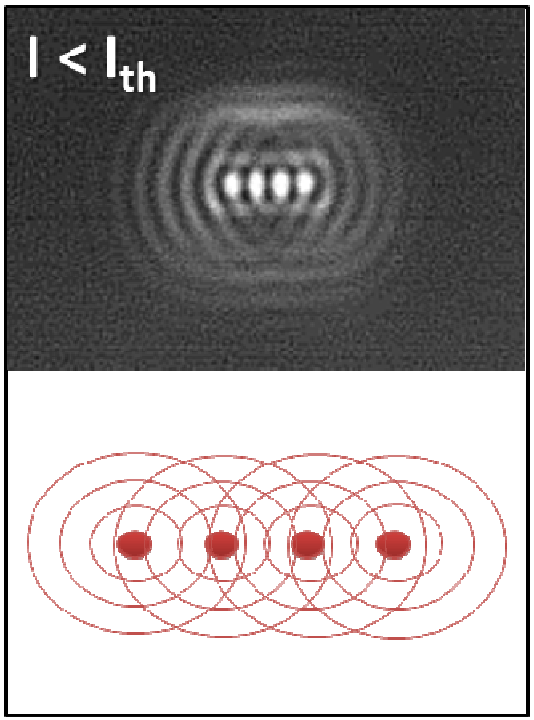
2 μm<D <8μm @ 8.2μm

*Λ < 3*λ/2 for dual-lobe operation (anti-symetric supermode)*

Evanescent coupling

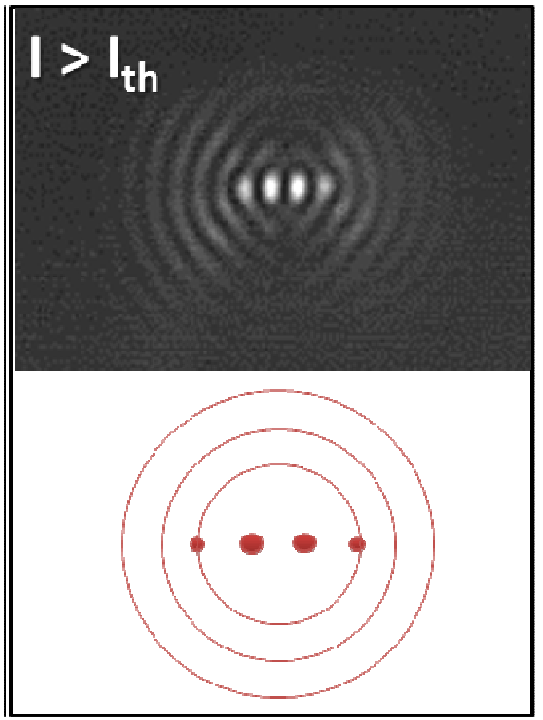
µ-stipes QCL
Near field

Below threshold



Spontaneous emission

Above threshold



Stimulated emission

G.M. de Naurois et al, Optics Letters, Vol. 37, No.3 (2012)

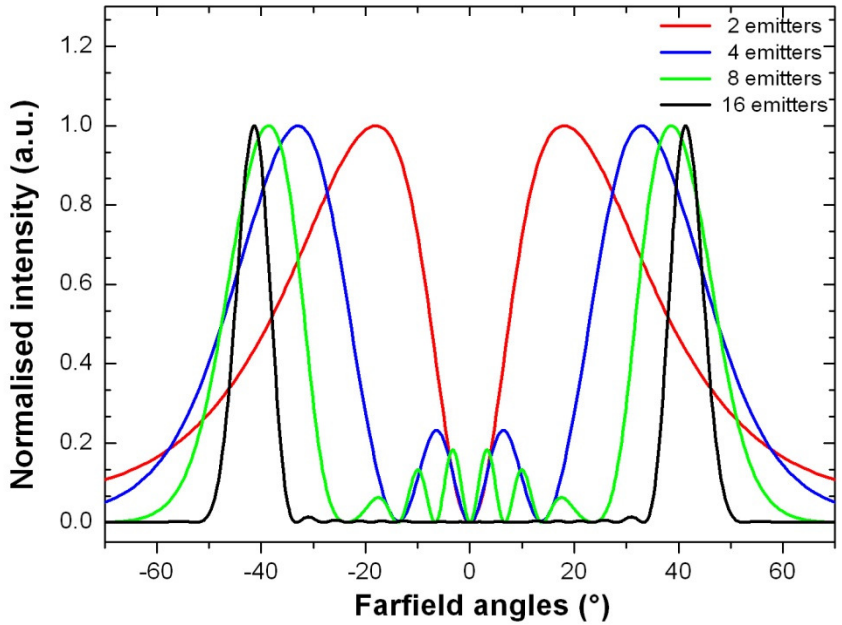
µ-stripes QCL

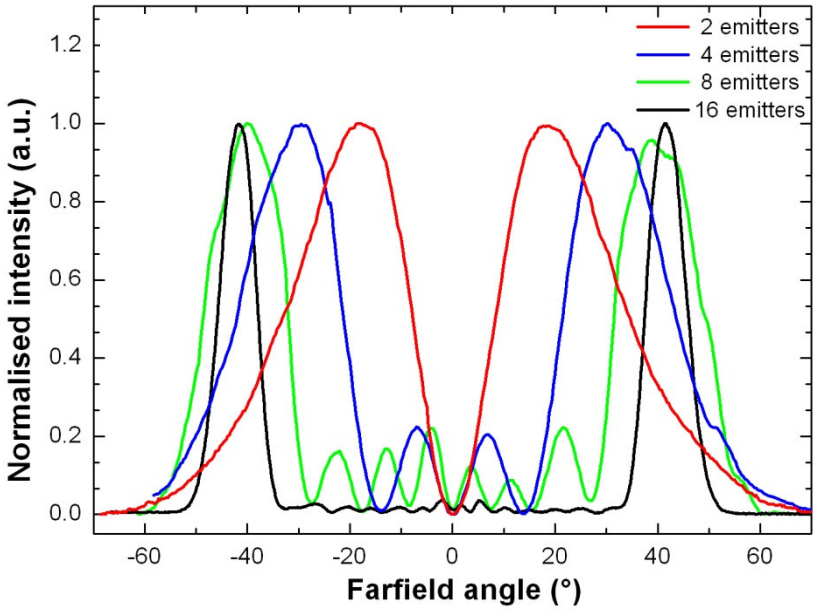
Far field : dual lobes emission

Simulation

Measurement

2µm width, 6µm pitch



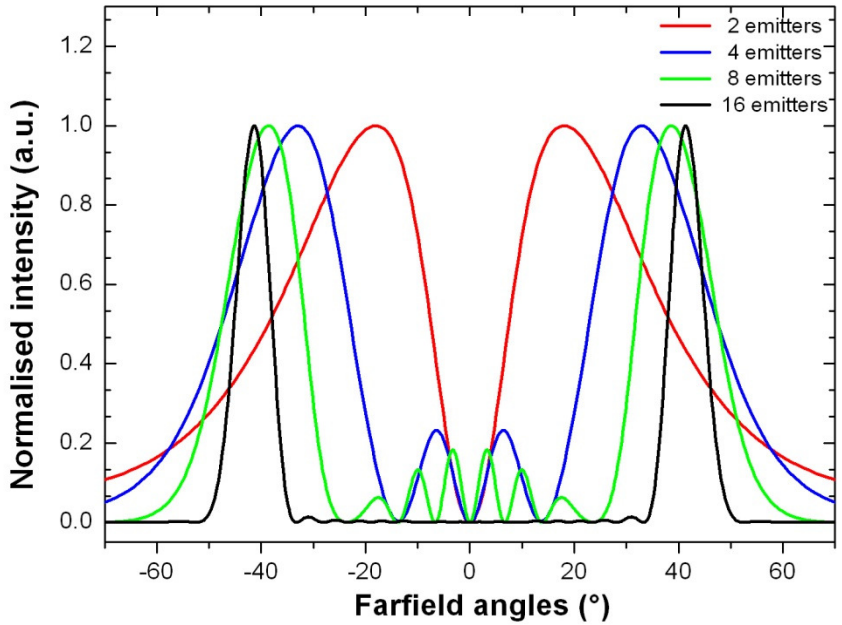


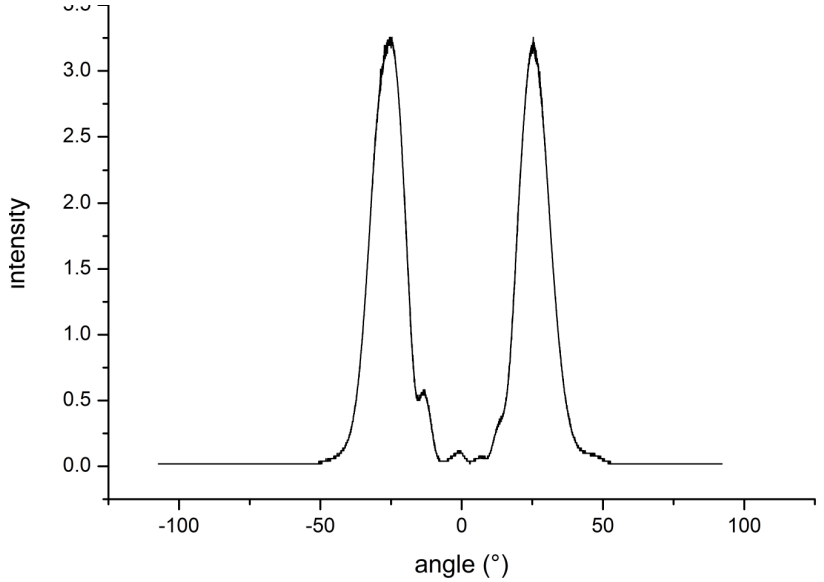
µ-stripes QCL
Far field

Simulation

Measurement

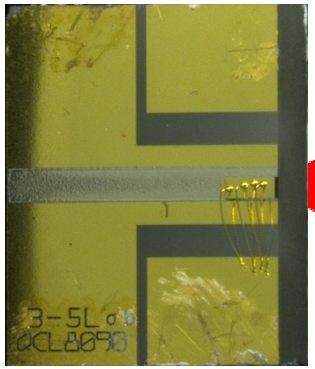
2µm width, 6µm pitch



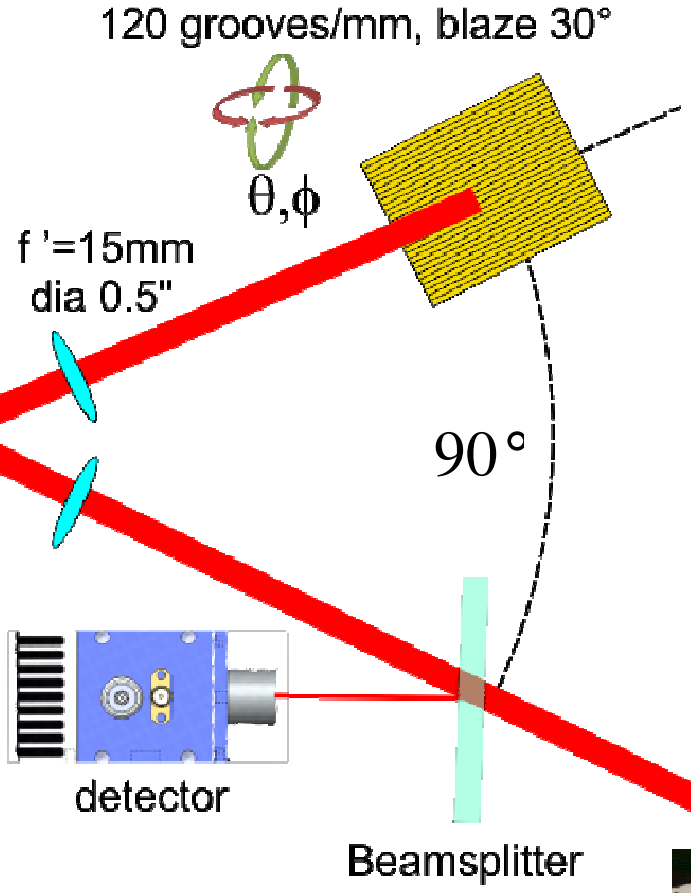


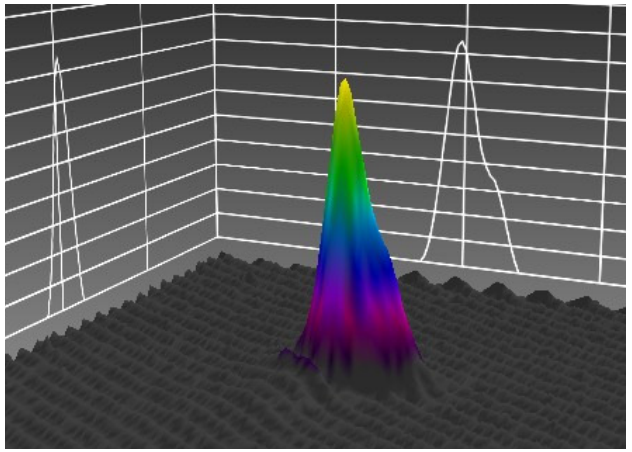
4 emitters in extended cavity

µ-stripes EC-QCL
Experimental setup



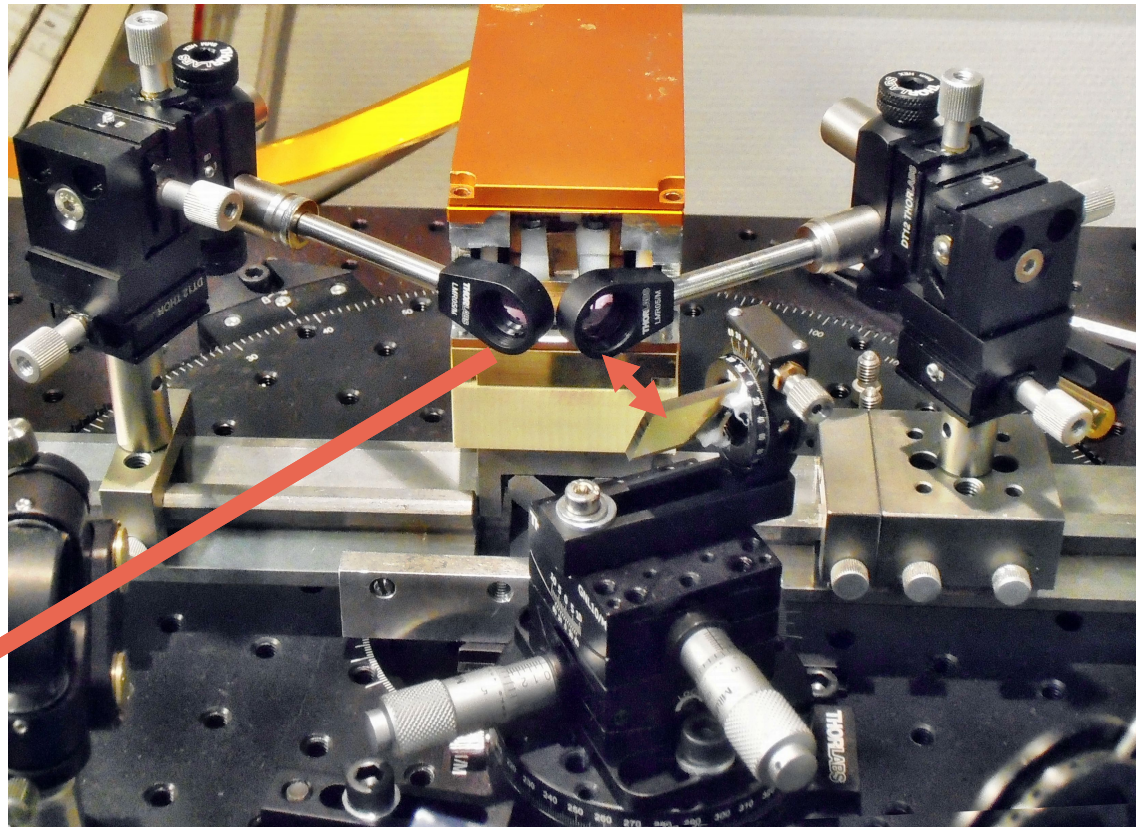
HR coated –
uncoated (R=30%)





FTIR
interferometer

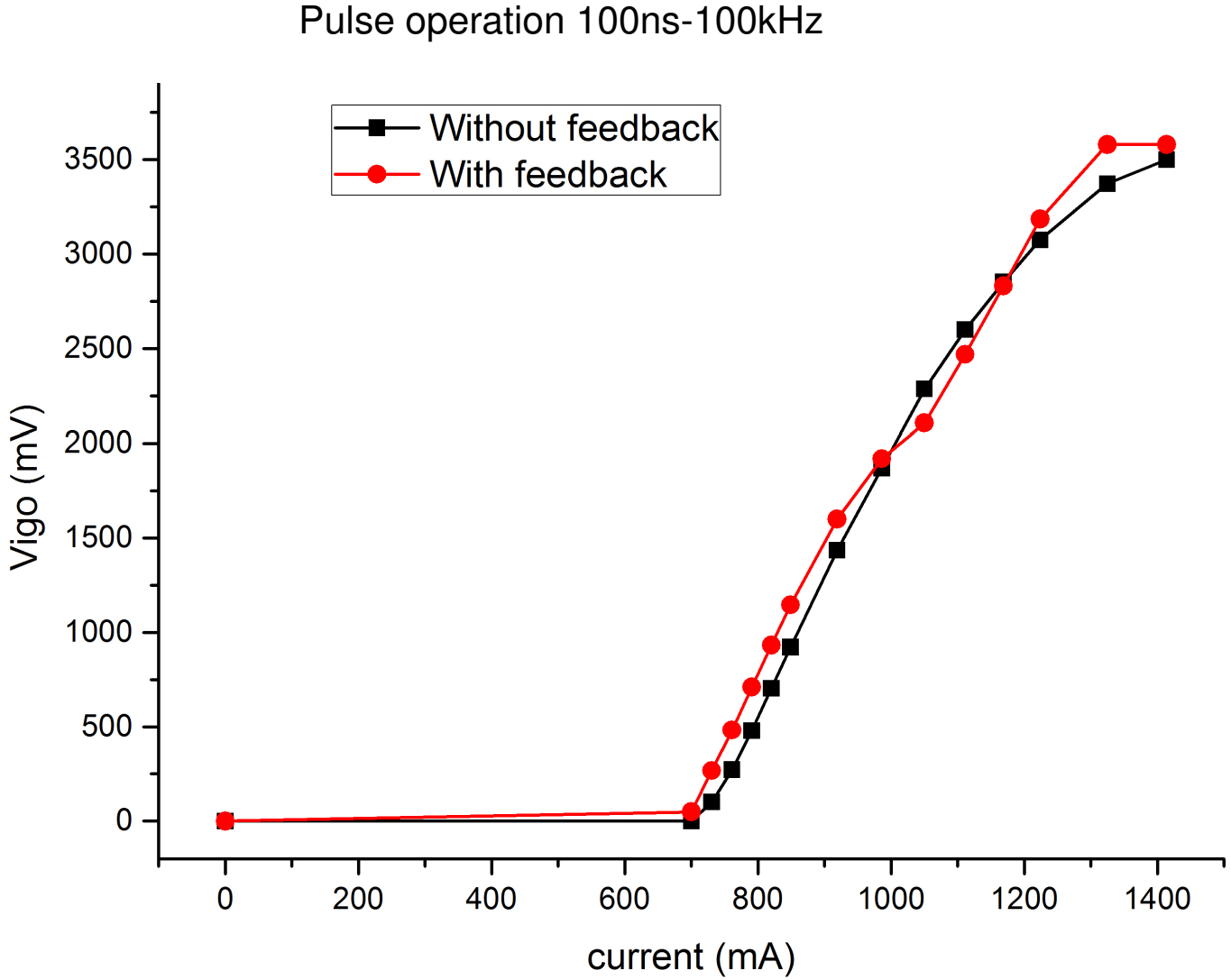
µ-stripes EC-QCL
Experimental setup



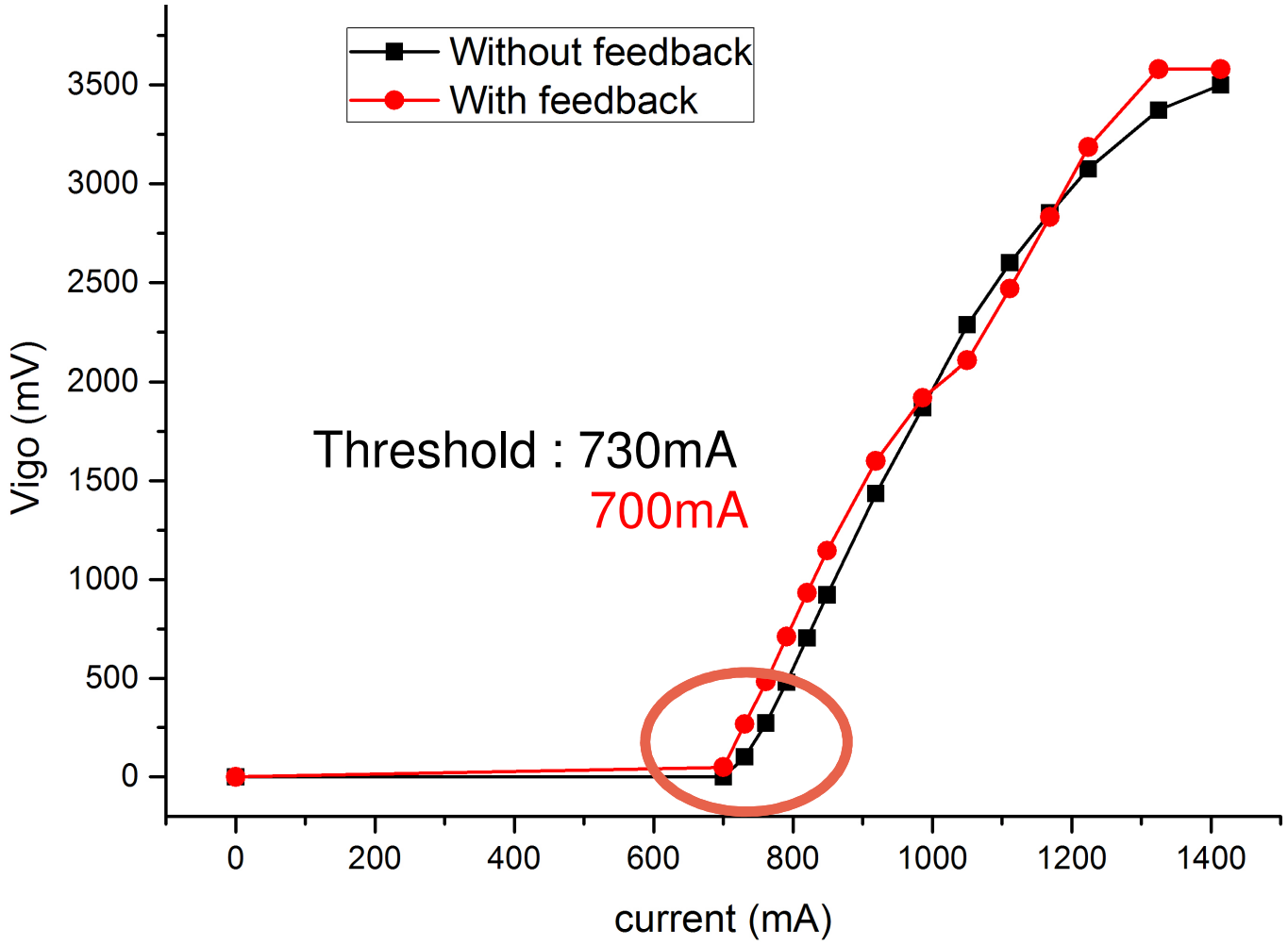
Output beam

µ-stripes EC-QCL

P(I)

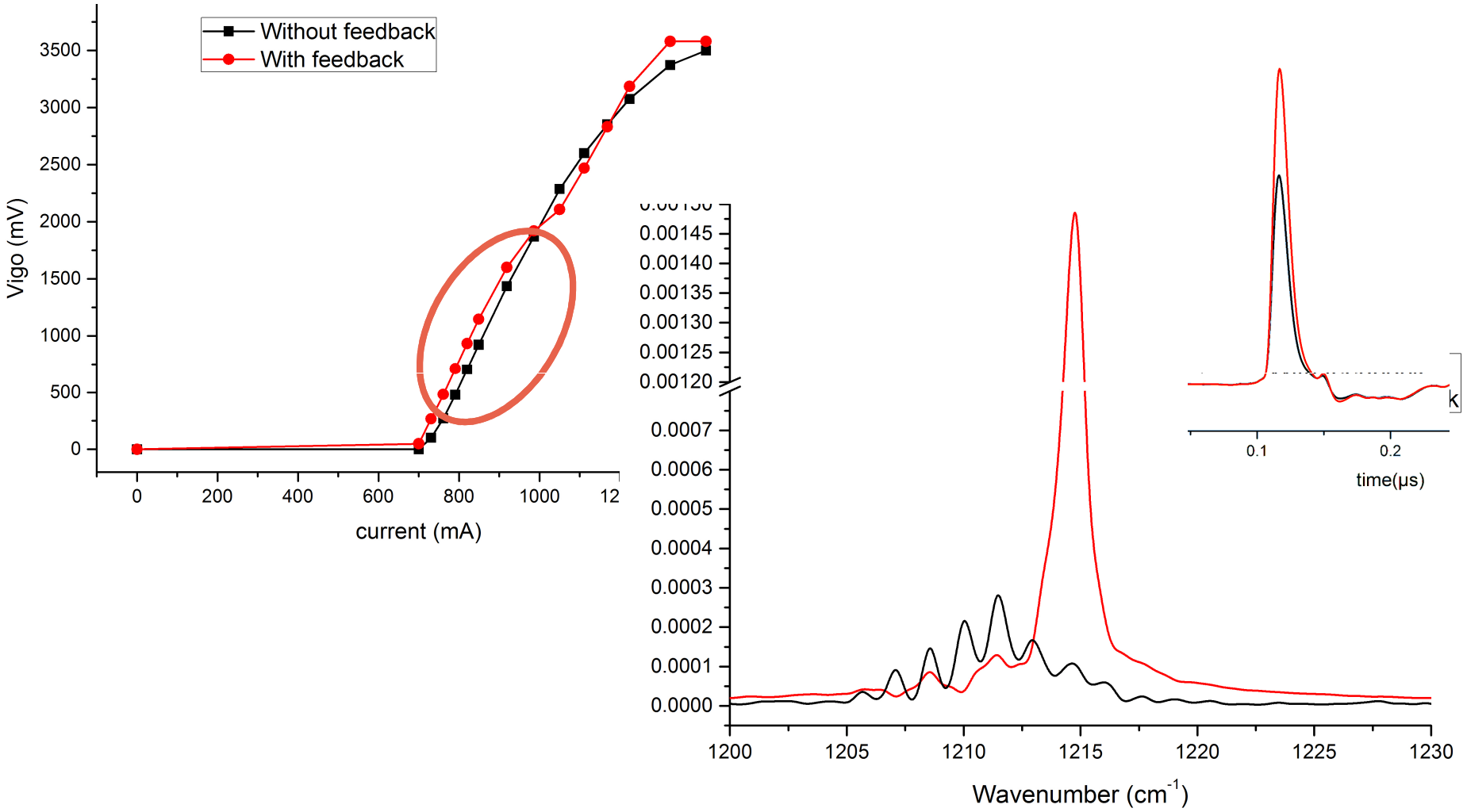


µ-stripes EC-QCL
Threshold



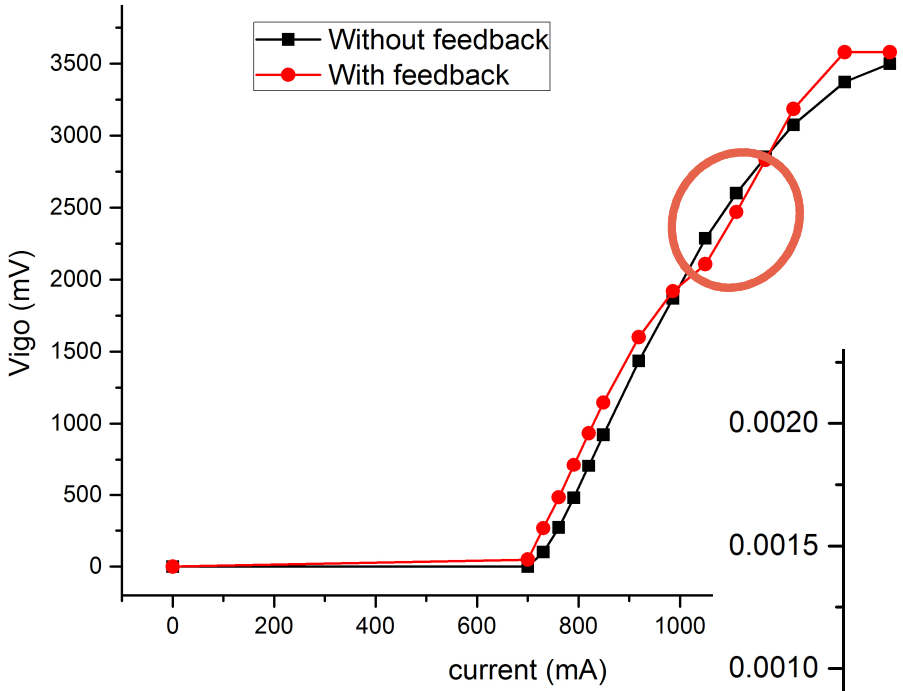
µ-stripes EC-QCL

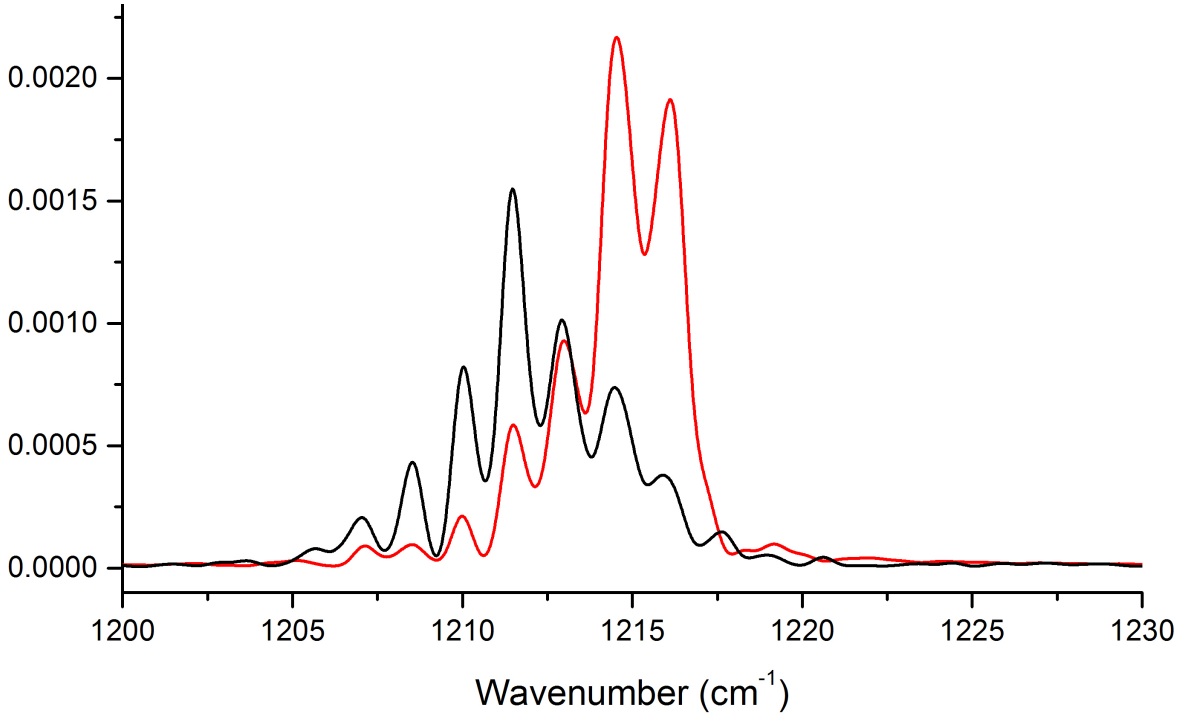
P(I)



µ-stripes EC-QCL

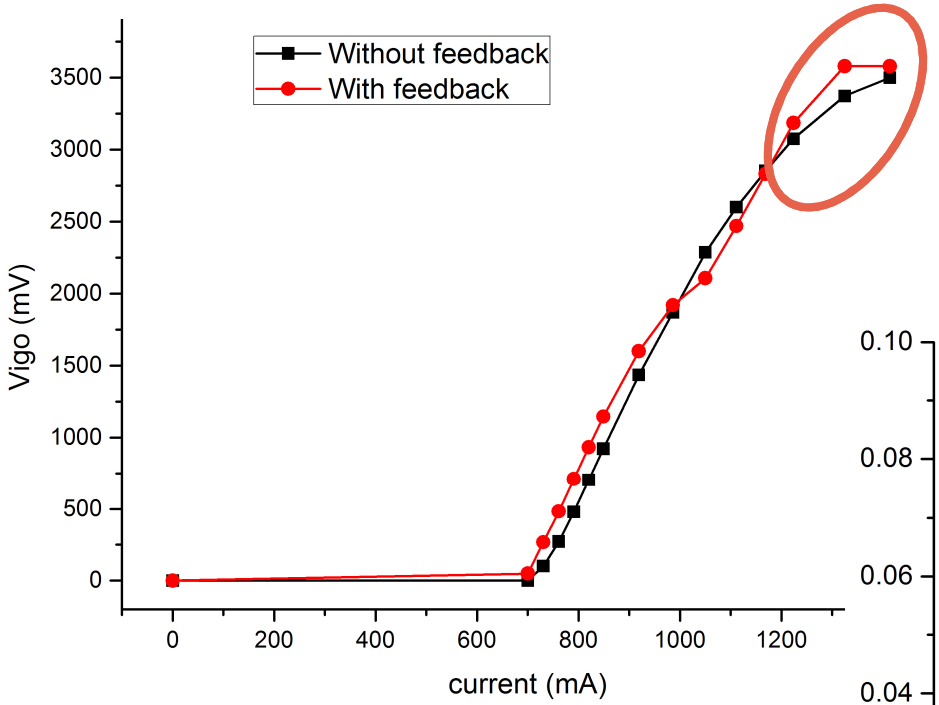
P(I)

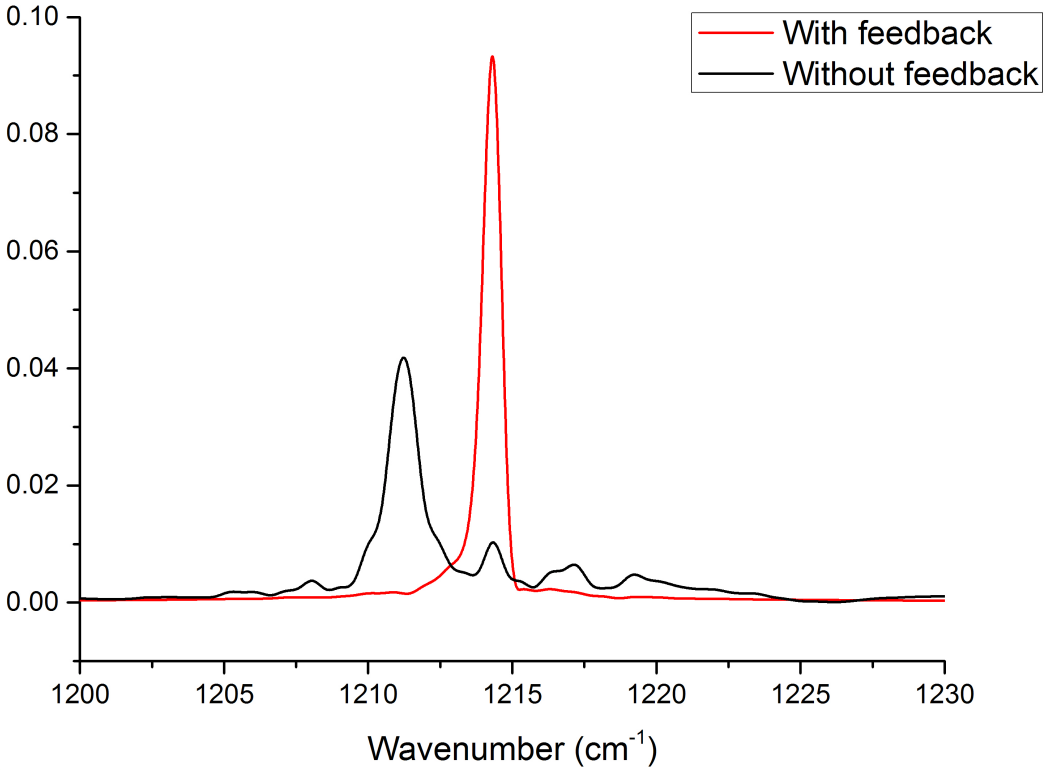




µ-stripes EC-QCL

P(I)





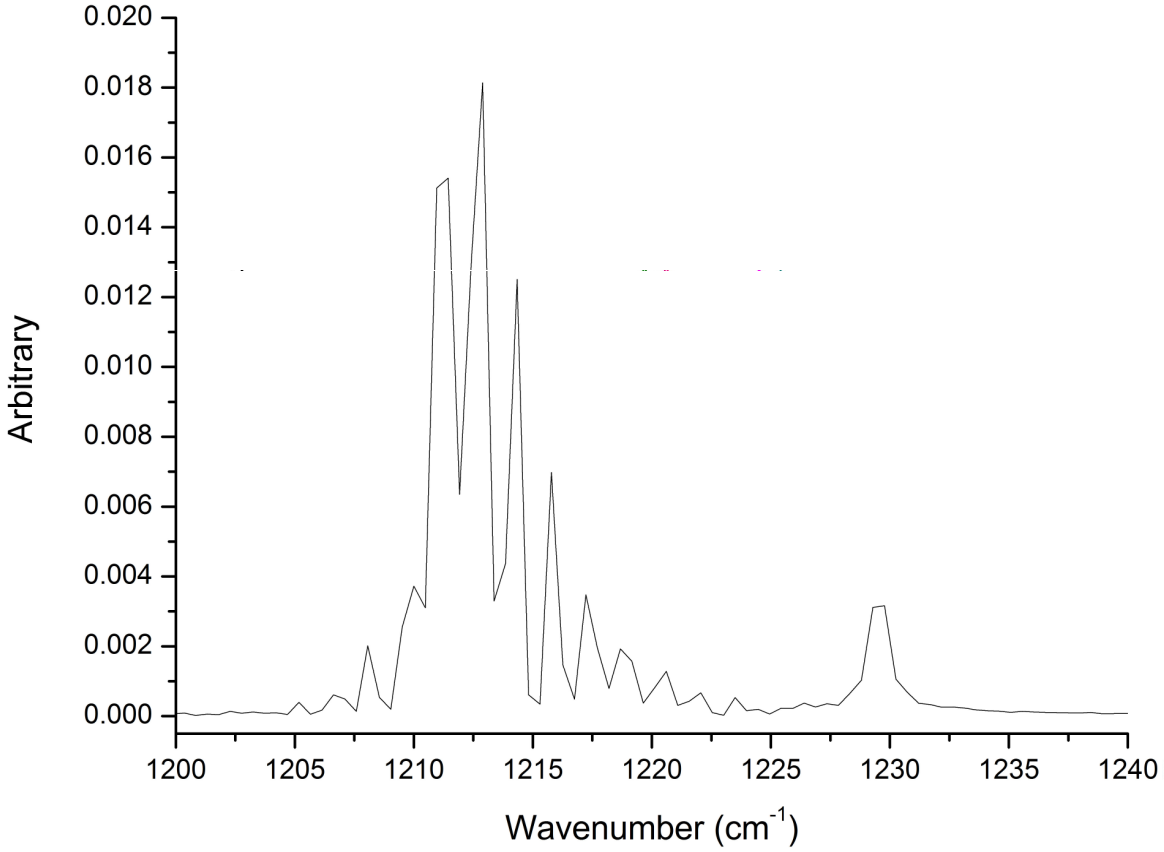
µ-stripes EC-QCL

Spectral range

Mono-mode operation : 19.5 cm^{-1}

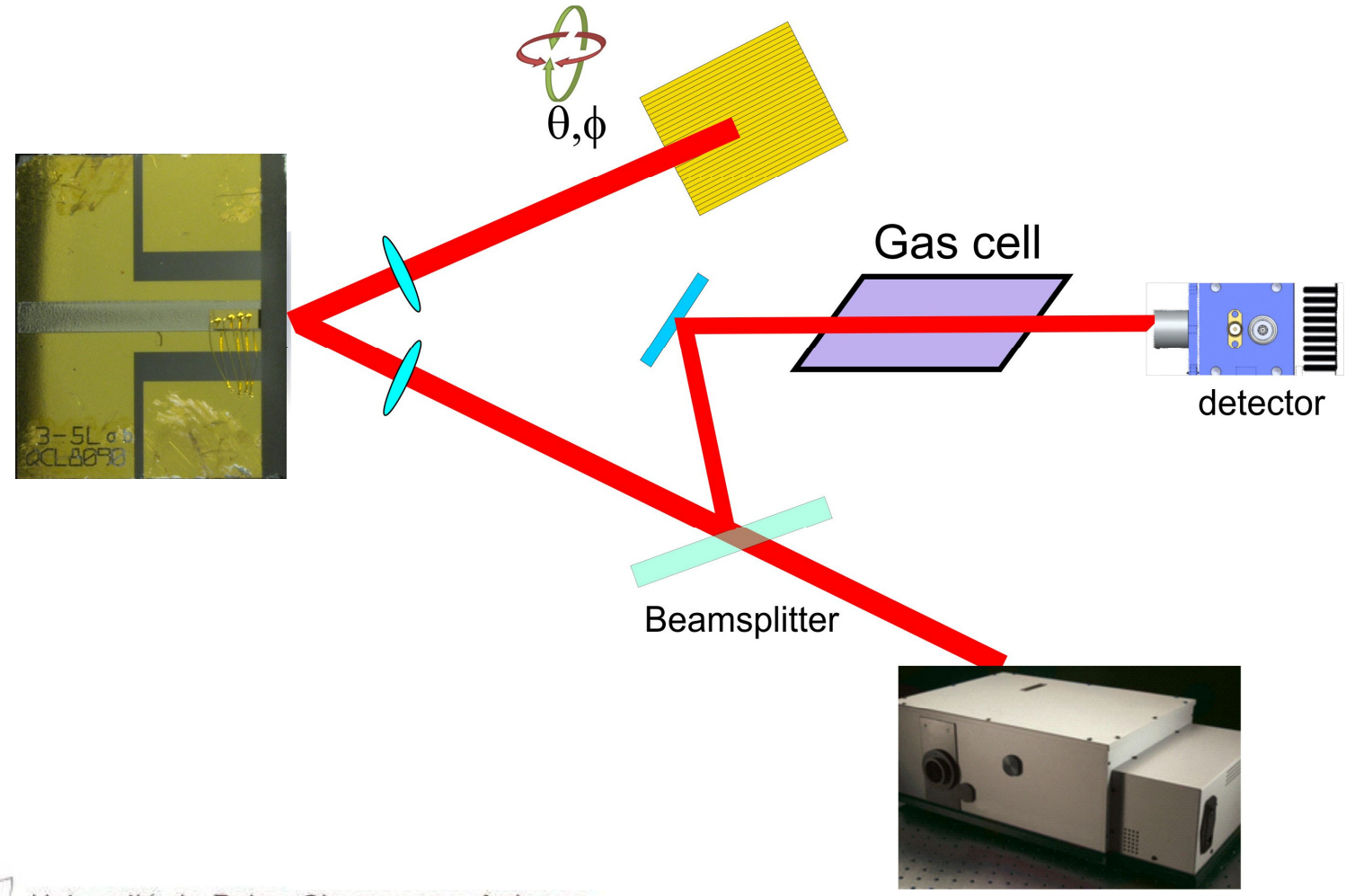
multimode : 30 cm^{-1}

Δ : 1.45 cm^{-1}



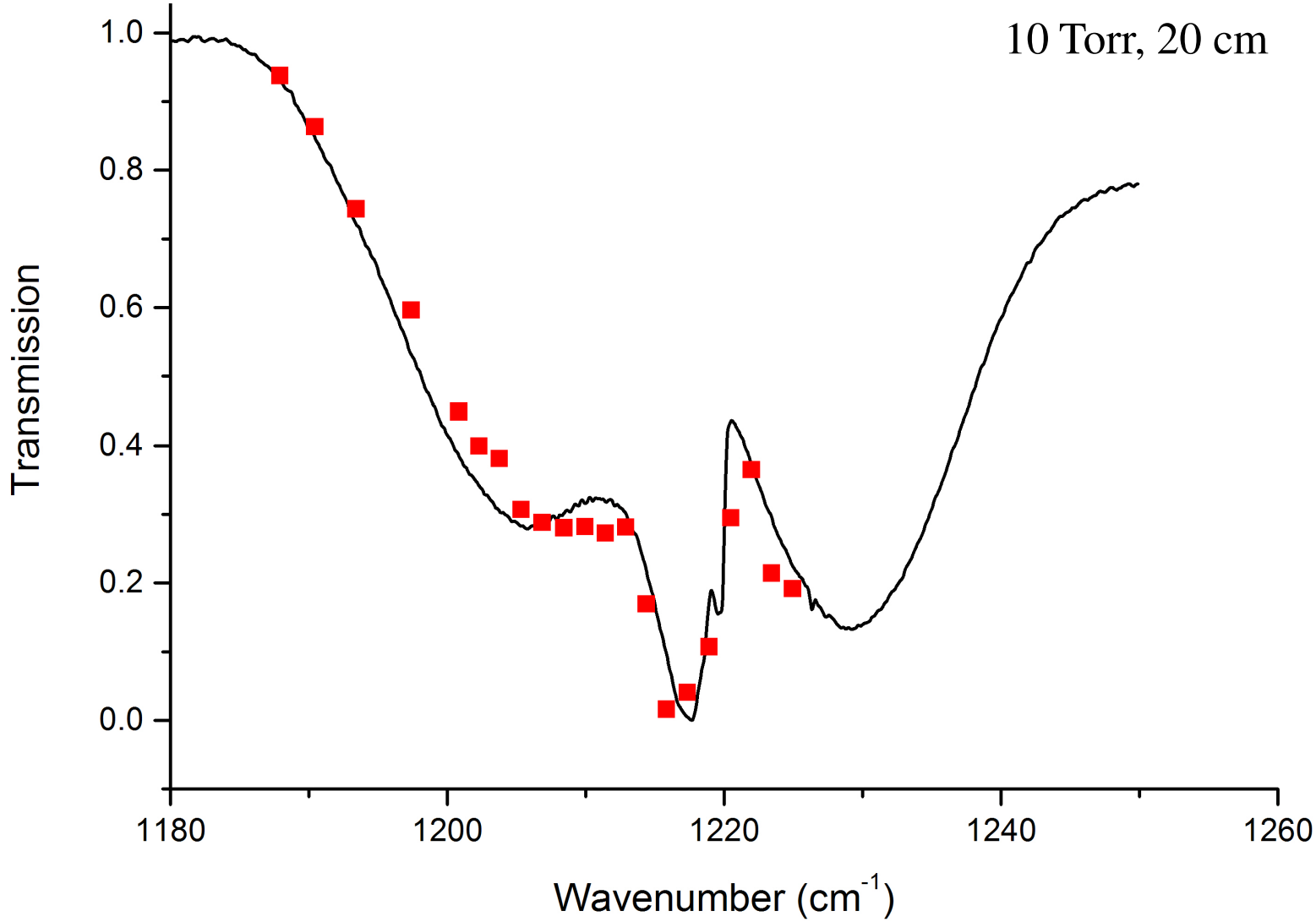
µ-stripes EC-QCL

Gas analysis : setup



µ-stripes EC-QCL

Gas analysis : Acetone

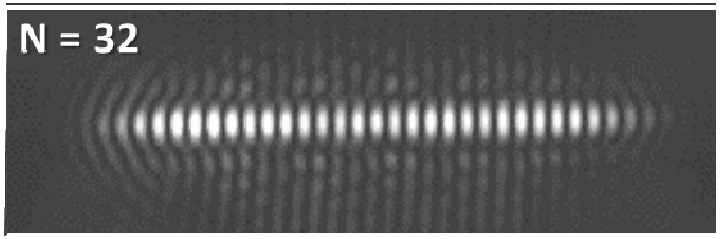


Conclusion / Perspectives

Preliminary results of EC-µstripe QCL array

Perspectives :

- Increase optical feedback to increase tunable spectral range
- 32 emitter array EC-QCL
- CW operation
- …

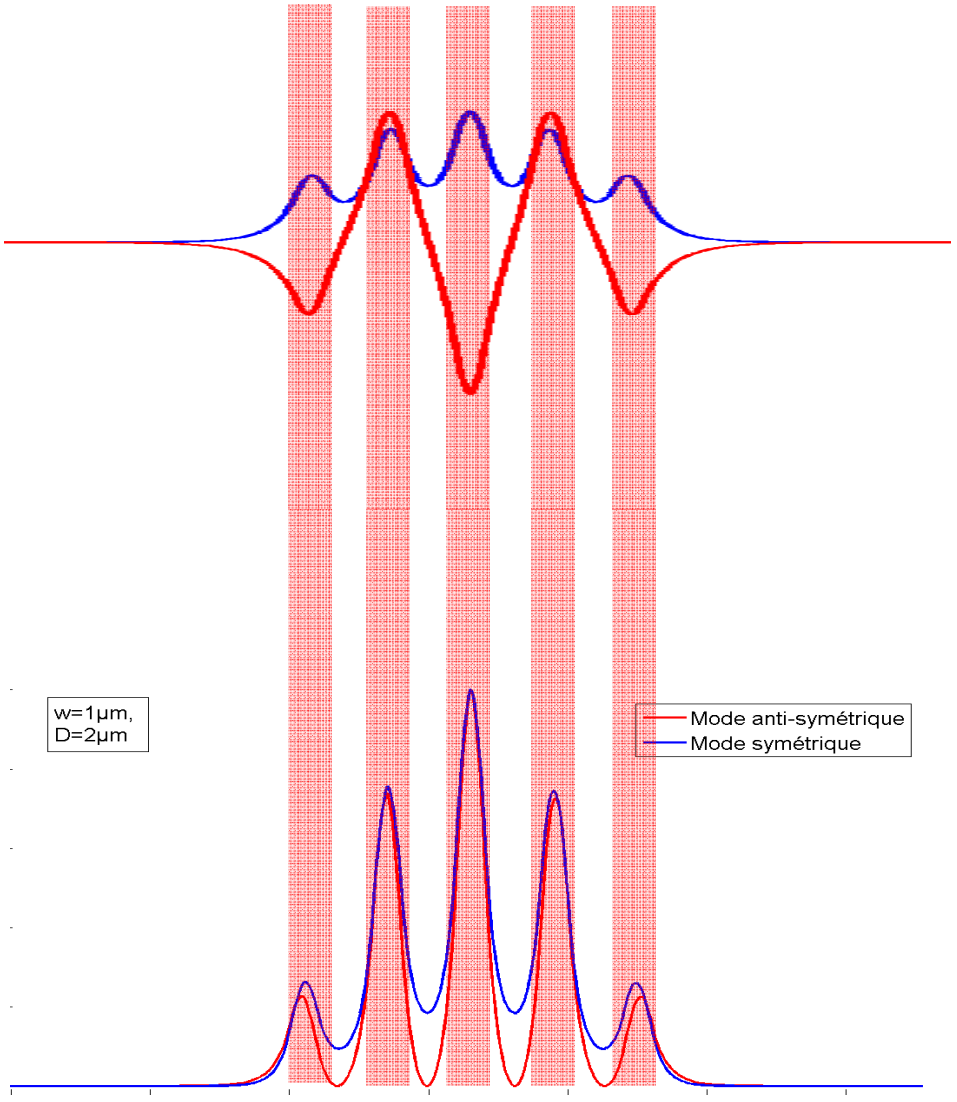


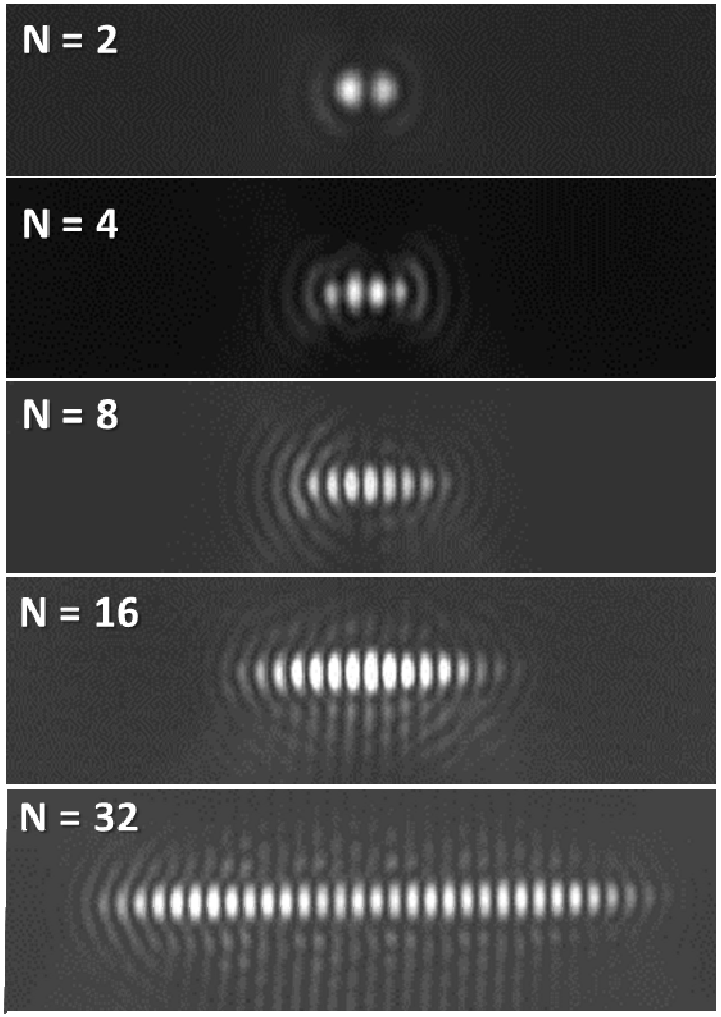
Application : photoacoustic spectrometer

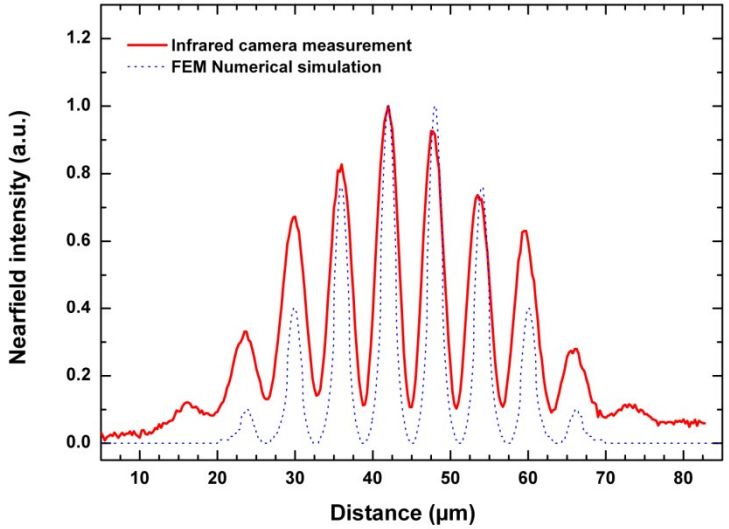
…

Acknowledgement : French Research Agency

Electric Field & µ-stripe




N = 2
N = 4
N = 8
N = 16
N = 32


Infrared camera measurement
FEM Numerical simulation
Nearfield intensity (a.u.)
Distance (μm)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
10
20
30
40
50
60
70
80

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