

Towards a high-power femtosecond MIXSEL

ETH

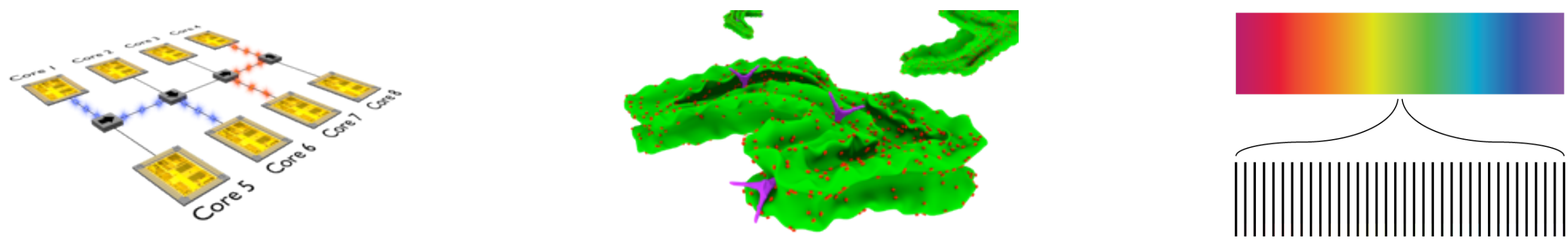
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M. Mangold, V.J. Wittwer, O.D. Sieber, M. Hoffmann, B.W. Tilma,
M. Golling, T. Südmeyer, U. Keller

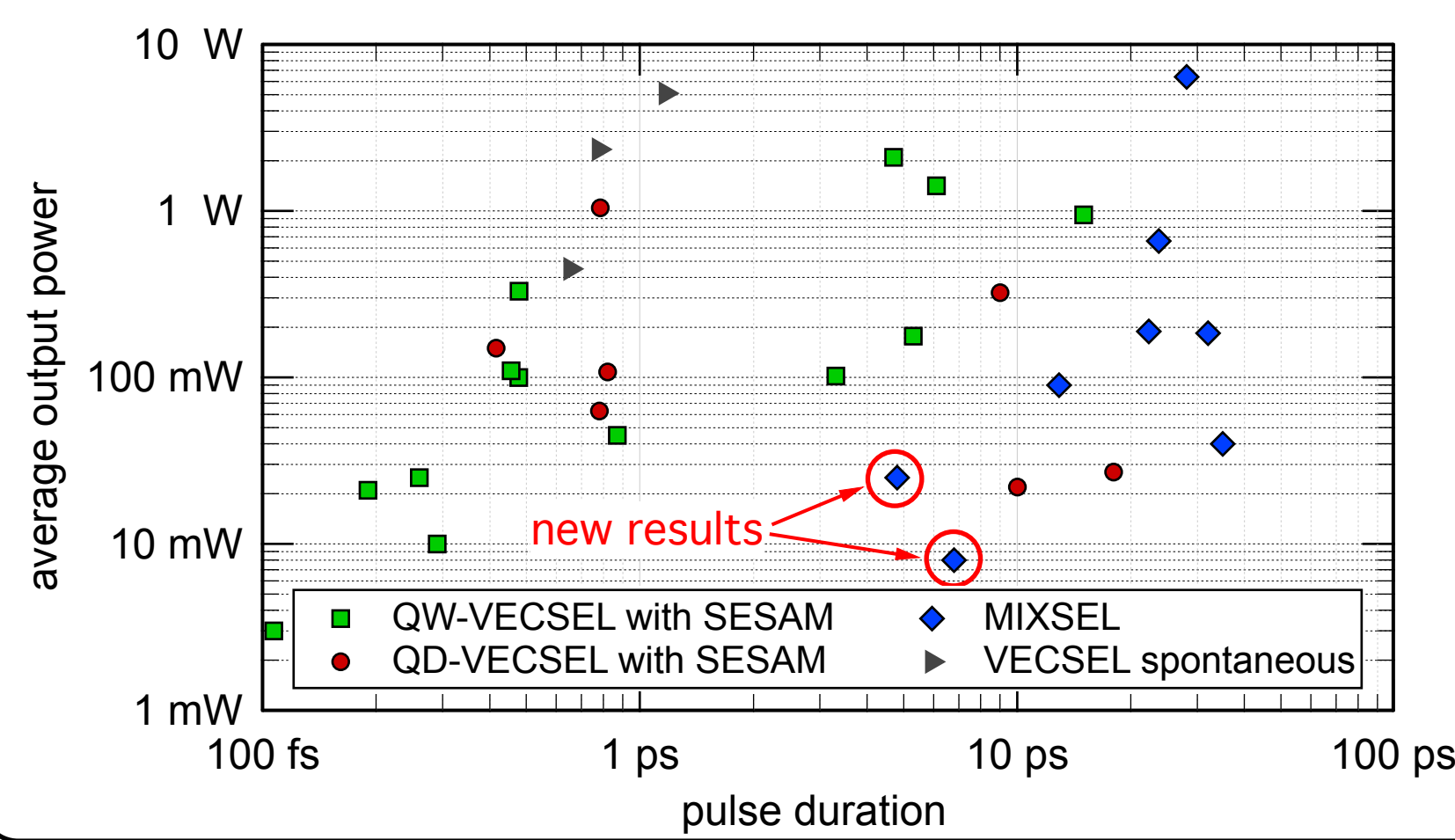
ETH Zurich, Institute for Quantum Electronics, Ultrafast Laser Physics

Motivation

Applications of SESAM-modelocked Vertical Cavity Surface Emitting Lasers (VECSELs) and Modelocked Integrated eXternal-cavity Surface Emitting Lasers (MIXSELS)



need for femtosecond pulses with high average output power



first Watt-level femtosecond VECSEL [1]

784-fs-pulses with >1 W output power in a 5.4 GHz V-cavity

femtosecond VECSEL with tunable repetition rate [2]

625-fs-pulses with 169 mW output power in a cavity tunable from 6.5 - 11.3 GHz

next step: femtosecond MIXSEL

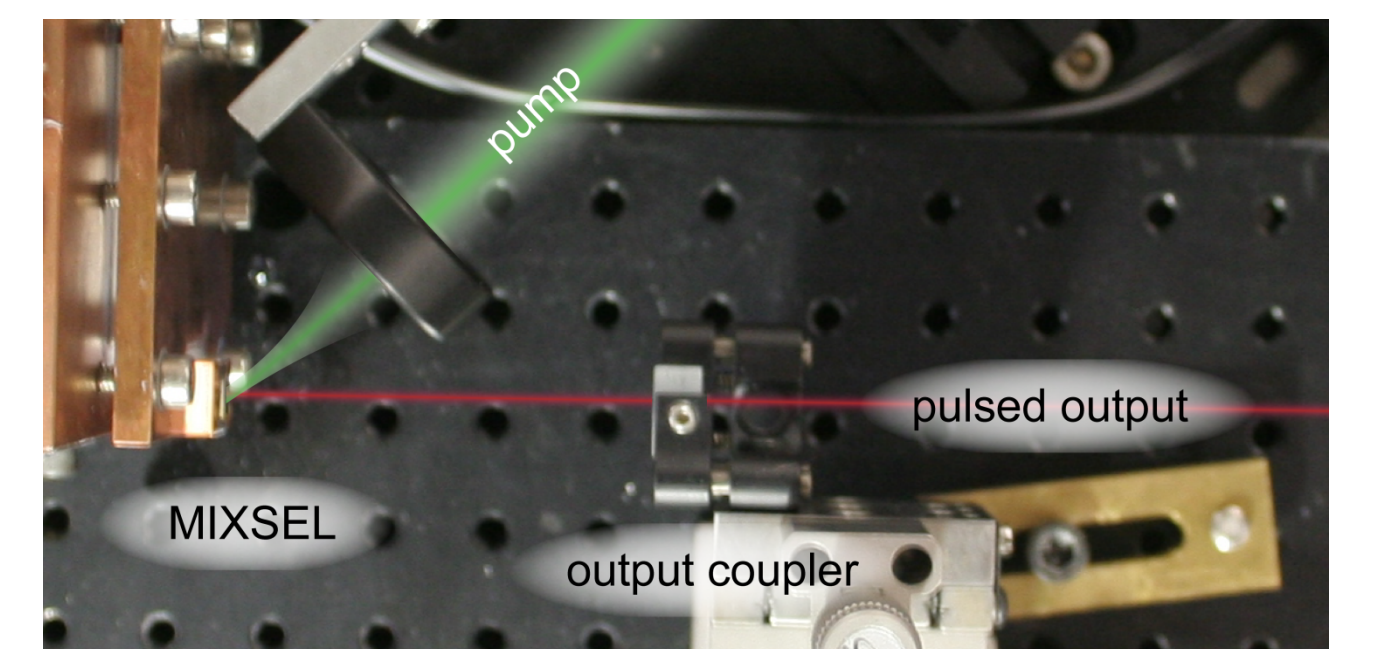
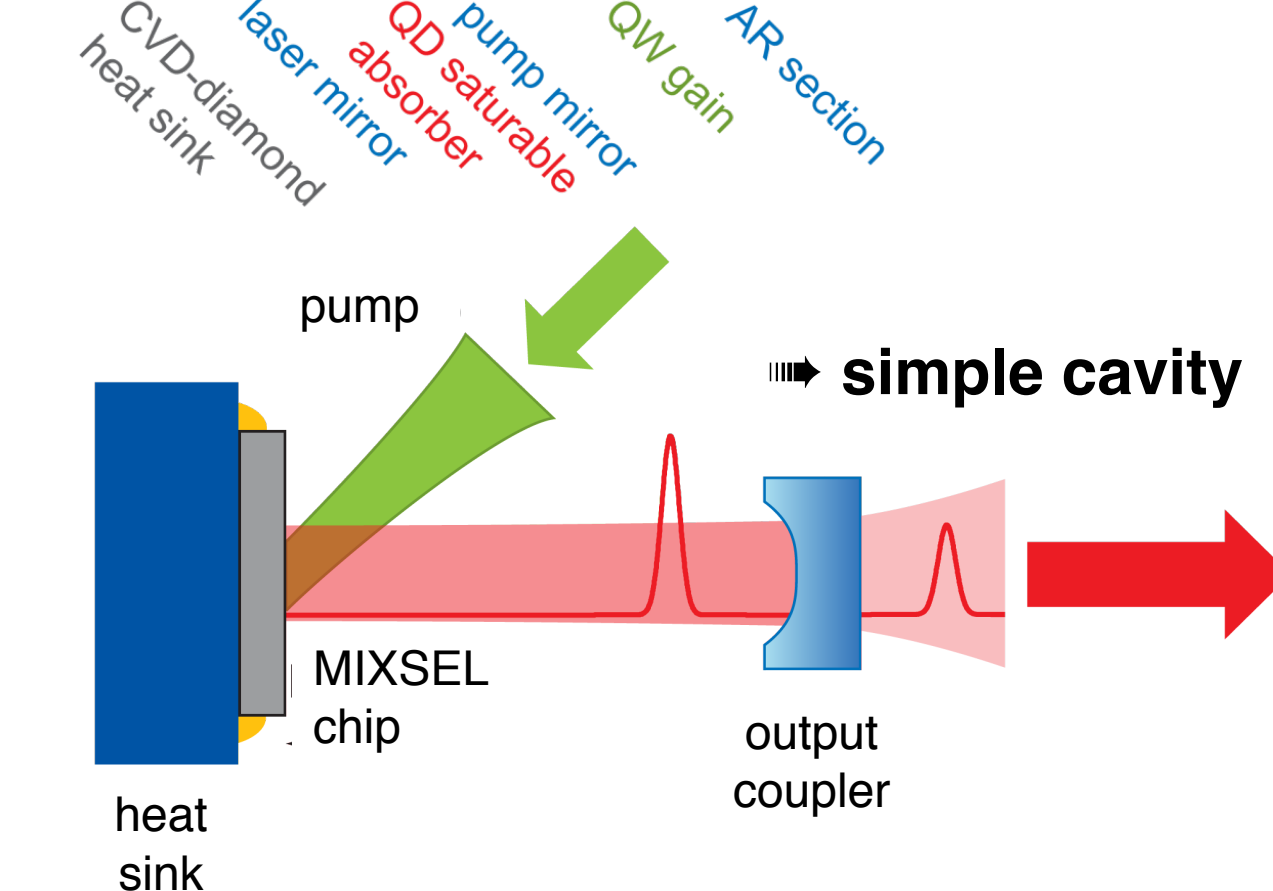
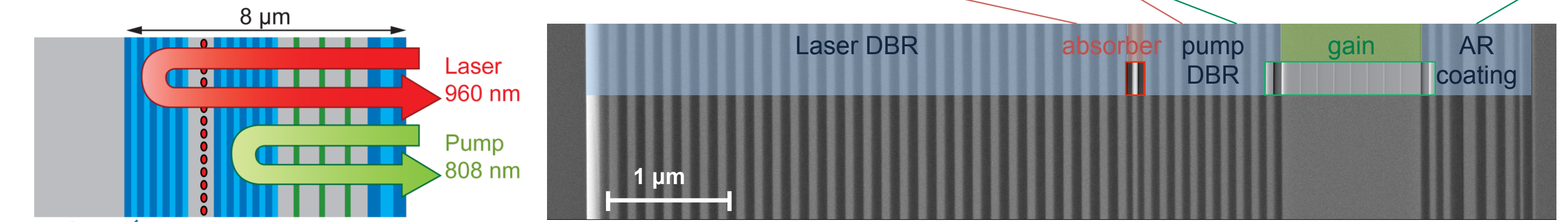
[1] M. Hoffmann et al., Optics Express (2011) vol. 19, 8108-8116
[2] O. D. Sieber et al., Opt Express (2011) vol. 19, pp. 23538-23543

High Power MIXSEL

integration concept

- semiconductor based
- integrated QD absorber
- power scalable
- potential for monolithic design

Modelocked Integrated eXternal-cavity Surface Emitting Laser

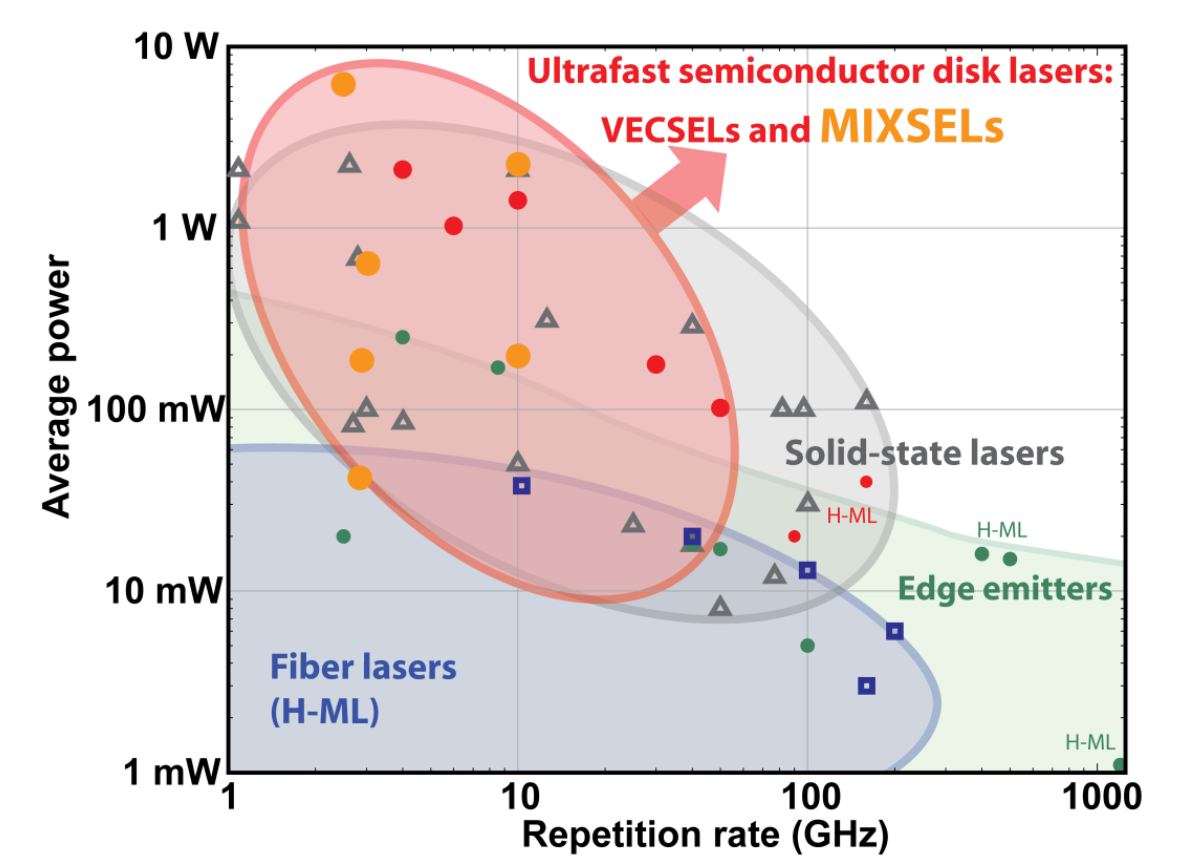


modelocking results

highest output power of a modelocked semiconductor laser [4]

pulse duration	output power	repetition rate	peak power
28.1 ps	6.4 W	2.5 GHz	80 W
16.9 ps	2.4 W	10 GHz	41 W

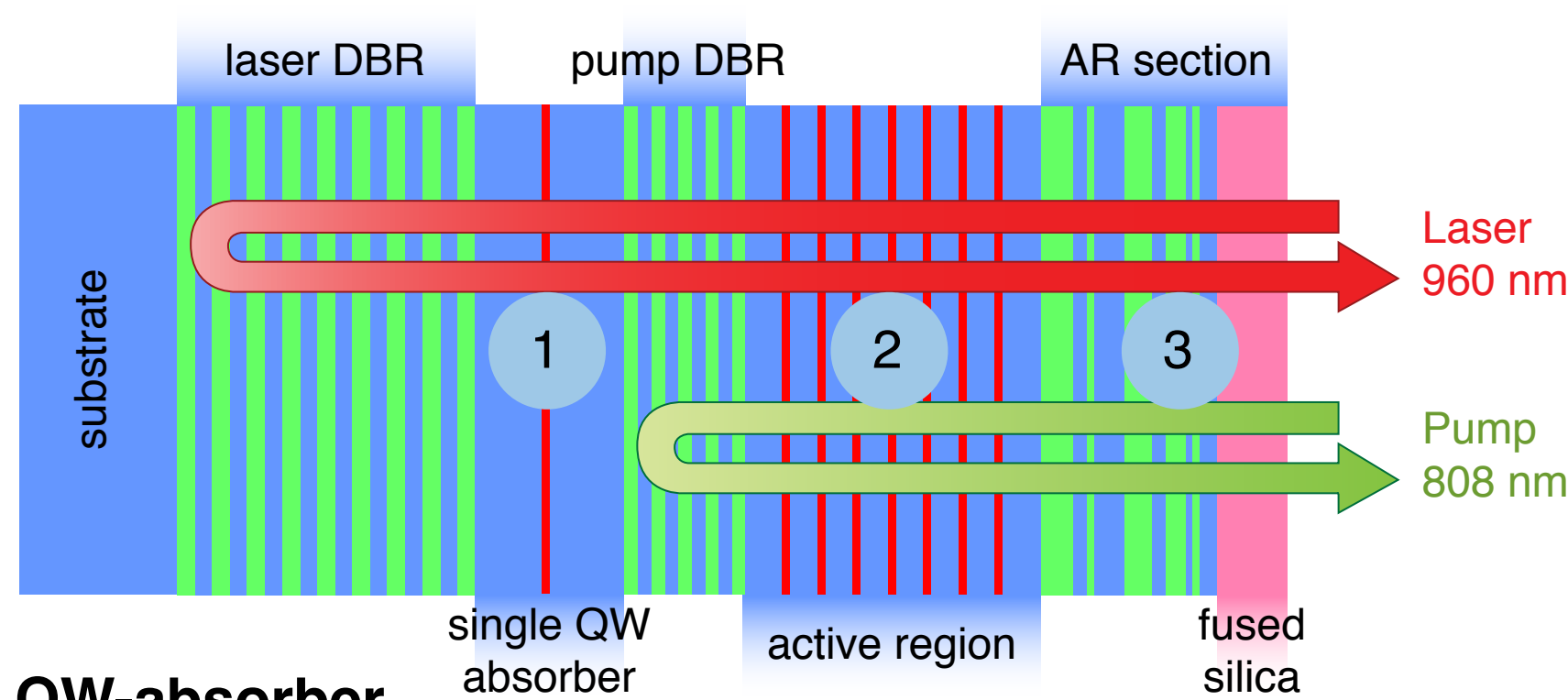
highest output power of any modelocked 10 GHz semiconductor laser



[4] B. Rudin, V. J. Wittwer, D. J. H. C. Maas, M. Hoffmann, O. D. Sieber, Y. Barbarin, M. Golling, T. Südmeyer, and U. Keller, Opt. Express (2010) vol. 18 (26) pp. 27582-27588

MIXSEL with fast absorber

structure

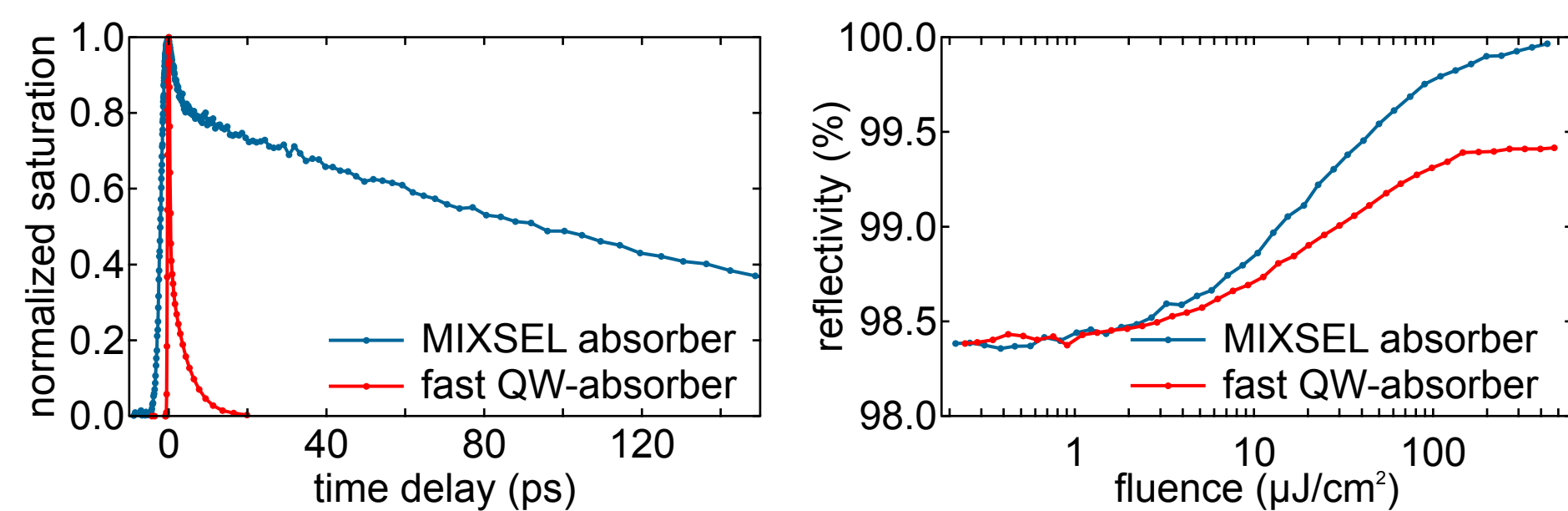


QW-absorber MIXSEL

- single quantum-well absorber fast absorber with low saturation fluence
shorter pulses possible
- quantum-well active region
- low dispersion AR coating semiconductor / fused silica
 $\pm 100 \text{ fs}^2$ over broad wavelength range

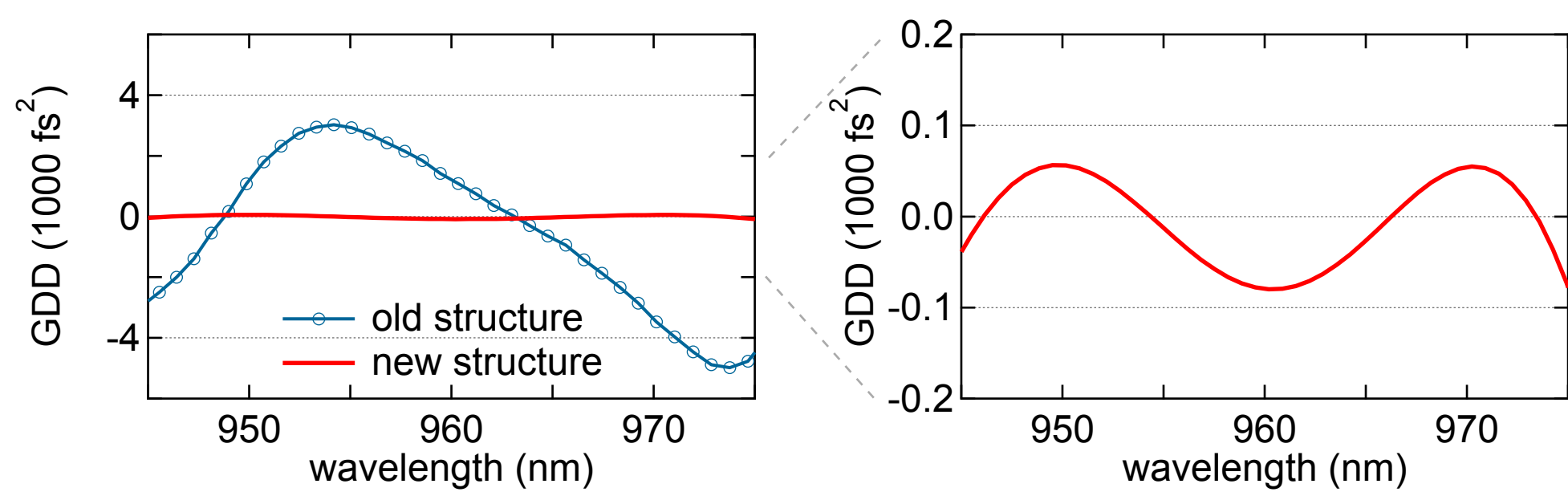
absorber characterization

- 10 times faster absorber recovery
- comparable low saturation fluences



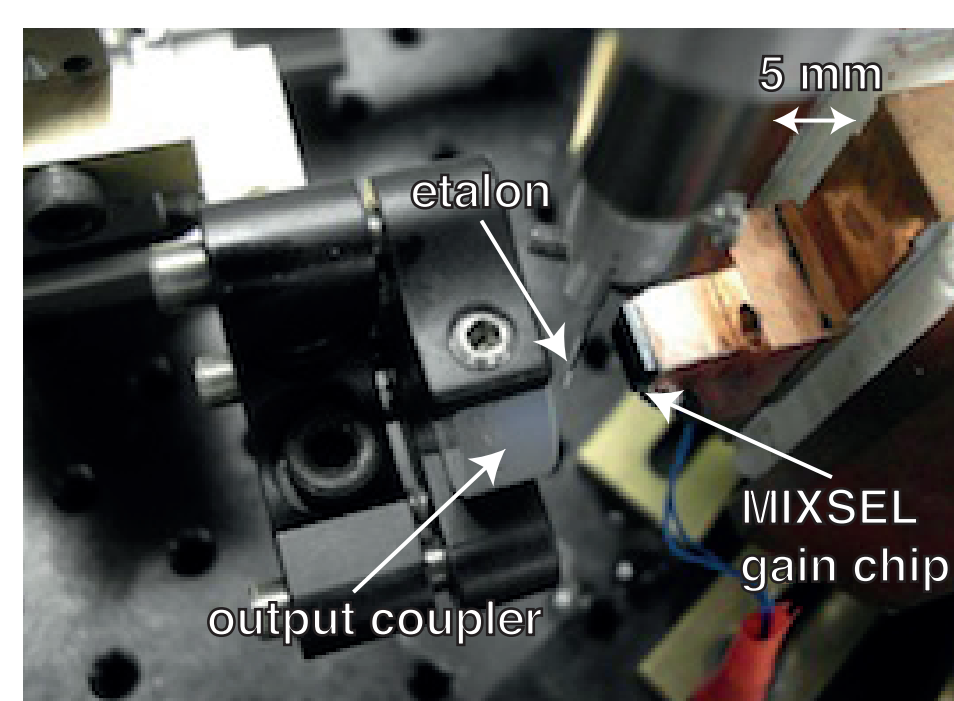
coating for low group-delay dispersion

- flat group delay dispersion around lasing wavelength
- essential for the generation of femtosecond pulses



modelocking results

4.8 ps	25 mW	2.9 GHz
pulse duration	output power	repetition rate
6.8 ps	8 mW	20.8 GHz

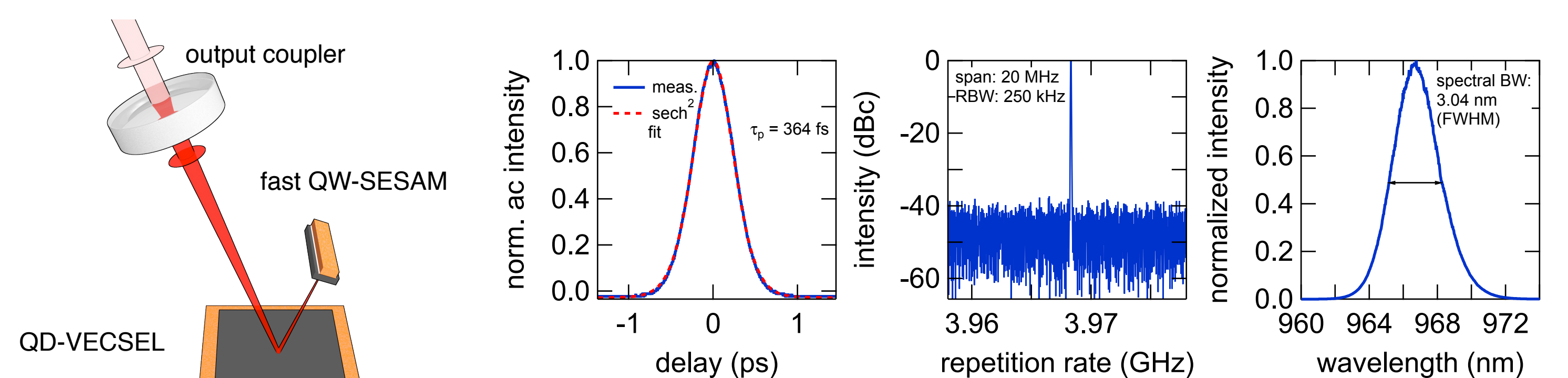


3 times shorter pulse duration than with slow QD-absorber [3]

highest repetition rate of any MIXSEL

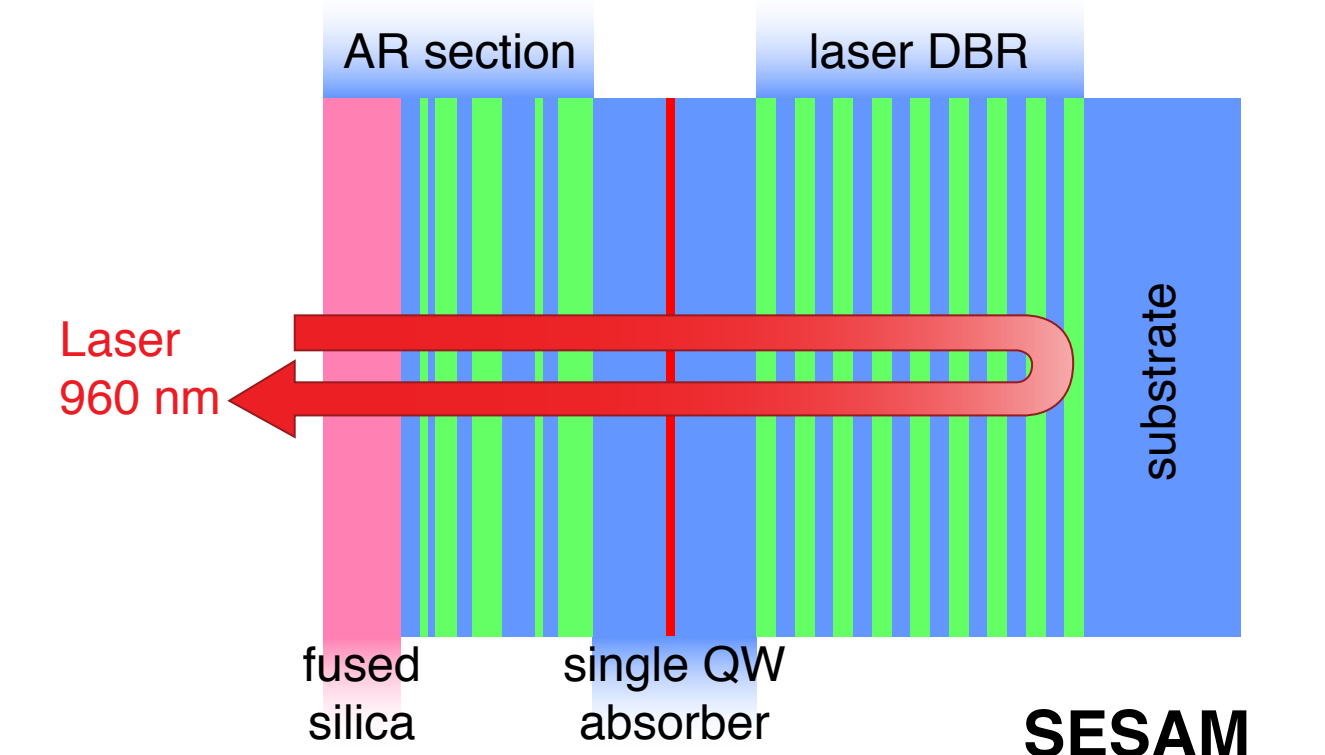
[3] V. J. Wittwer, O. D. Sieber, M. Mangold, M. Hoffmann, C. J. Saraceno, M. Golling, B. W. Tilma, T. Südmeyer, U. Keller, "MIXSEL with a Quantum Well Saturable Absorber: Shorter Pulse Durations and Higher Repetition Rates", CLEO US 2012, San Diego

fast absorber for femtosecond operation



pulse duration	output power	repetition rate
364 fs	70 mW	4 GHz

- same absorber as in QW-MIXSEL
- low-GDD AR section on VECSEL and SESAM
- fast absorber with capability of femtosecond operation

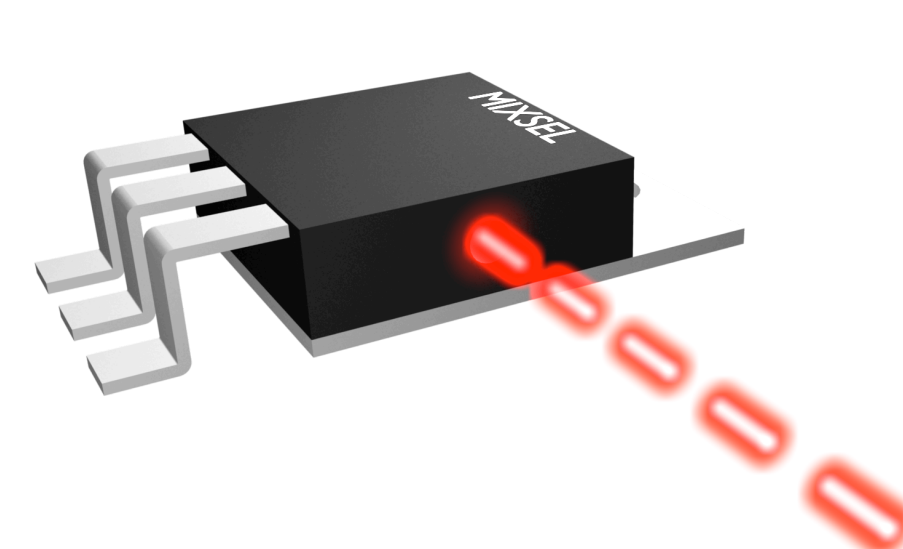


Outlook

faster absorber and optimized group-delay dispersion for shorter pulse duration

novel high-power MIXSEL on diamond

femtosecond MIXSEL



pulse duration	output power	repetition rate	peak power
200 fs	1 W	1 GHz	4.4 kW

compact, low cost laser with high peak power for frequency comb generation

our work is supported by:

