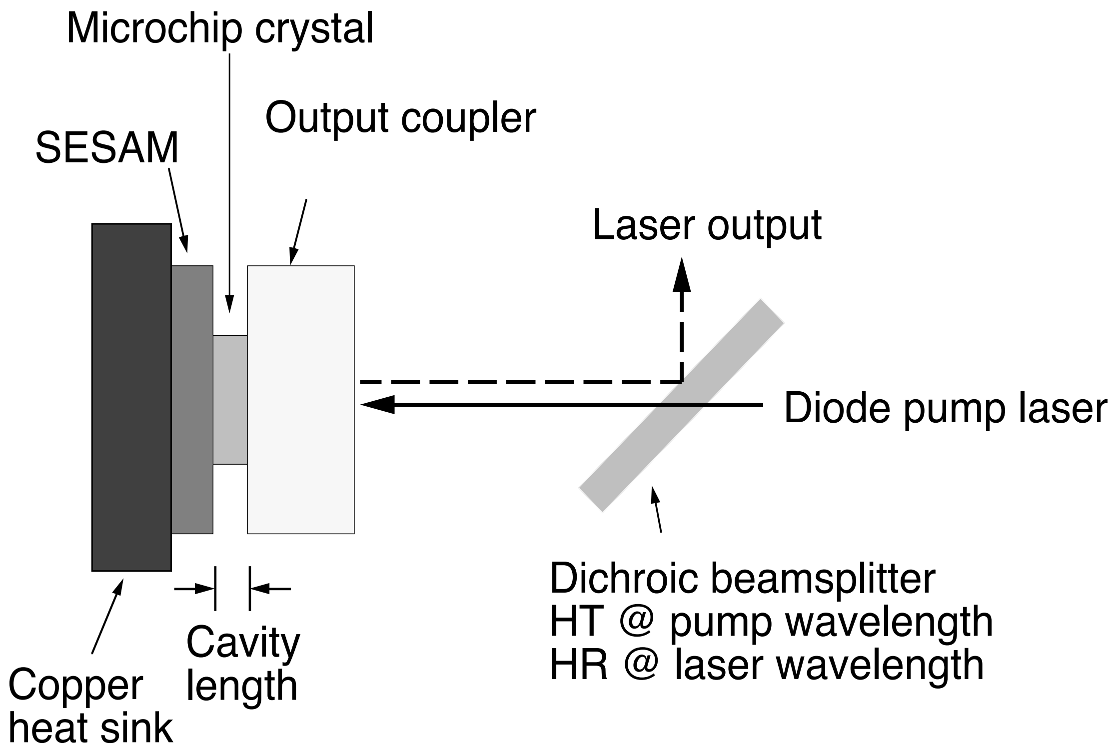
Overview

SESAM Q-switched microchip lasers

Ursula Keller

Department of Physics, Institute for Quantum Electronics,
ETH Zurich, Switzerland

Passively Q-switched Microchip Laser



Flat/flat resonator

Cavity stabilization by

- Thermal lensing
- Thermal expansion
- Gain guiding

- Compact and simple all-solid-state laser
- Short cavity: Single longitudinal mode
  Short Q-switched pulses
- High pulse energies possible
- Good beam quality

SESAM + Nd:LSB microchip laser

SESAM
+ Nd:LSB
1996

Milestone:
“first SESAM Q-switched microchip laser”

Passively Q-switched 180-ps $Nd:LaSc_3(BO_3)_4$ microchip laser

B. Braun, F. X. Kärtner, and U. Keller

Ultrafast Laser Physics, Institute of Quantum Electronics, Swiss Federal Institute of Technology, ETH Hönggerberg–HPT, CH-8093 Zürich, Switzerland

J.-P. Meyn* and G. Huber

Institute of Laser-Physics, University of Hamburg, Jungiusstrasse 9–11, D-20355 Hamburg, Germany

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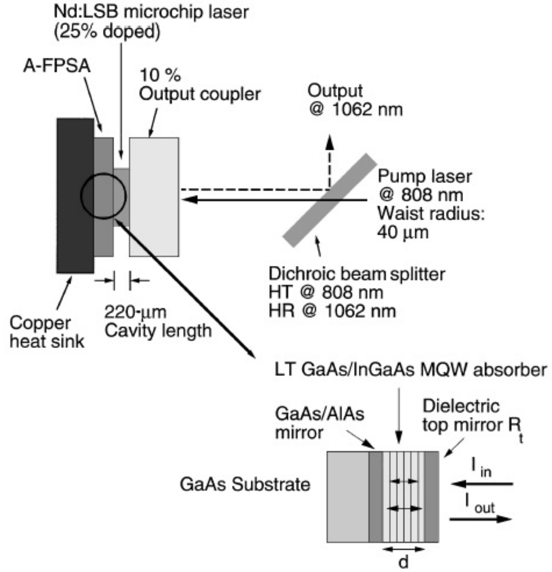
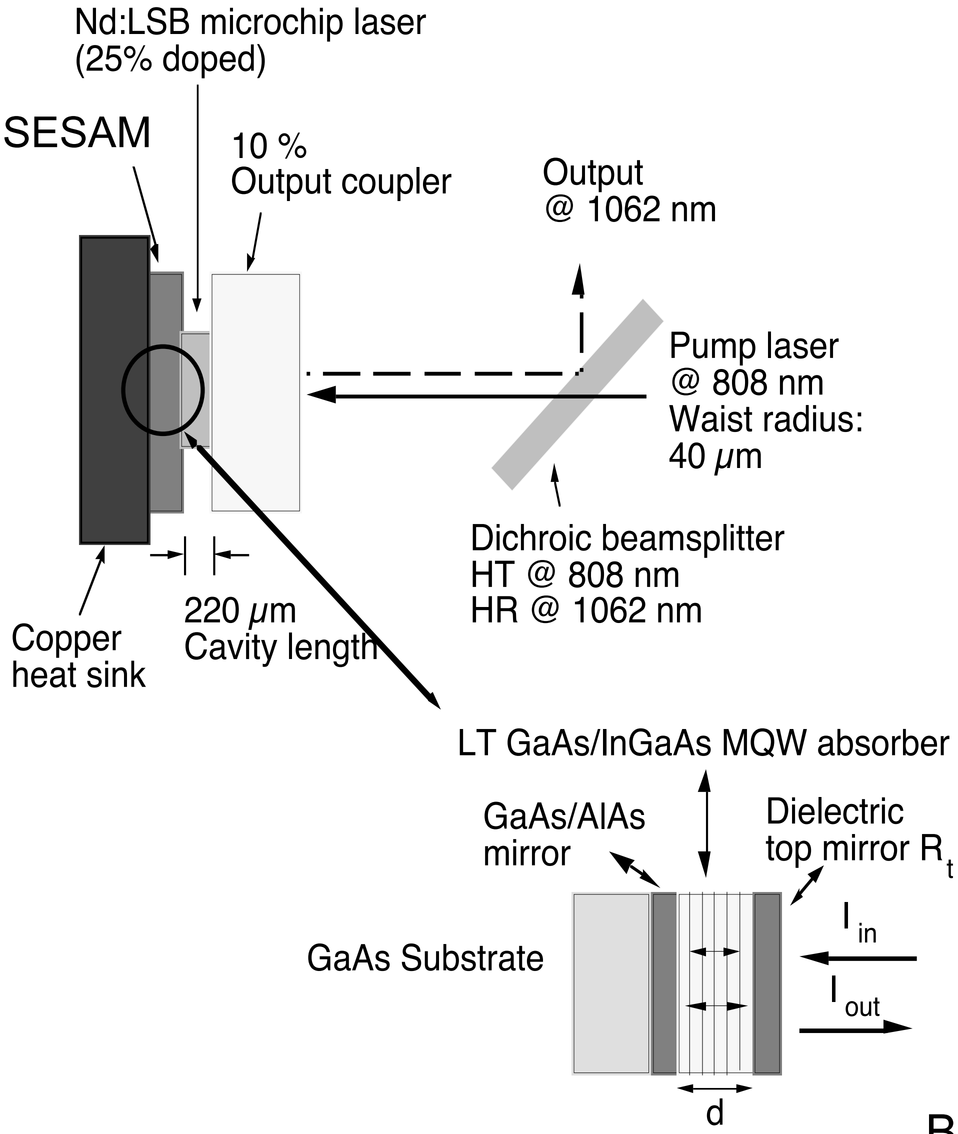
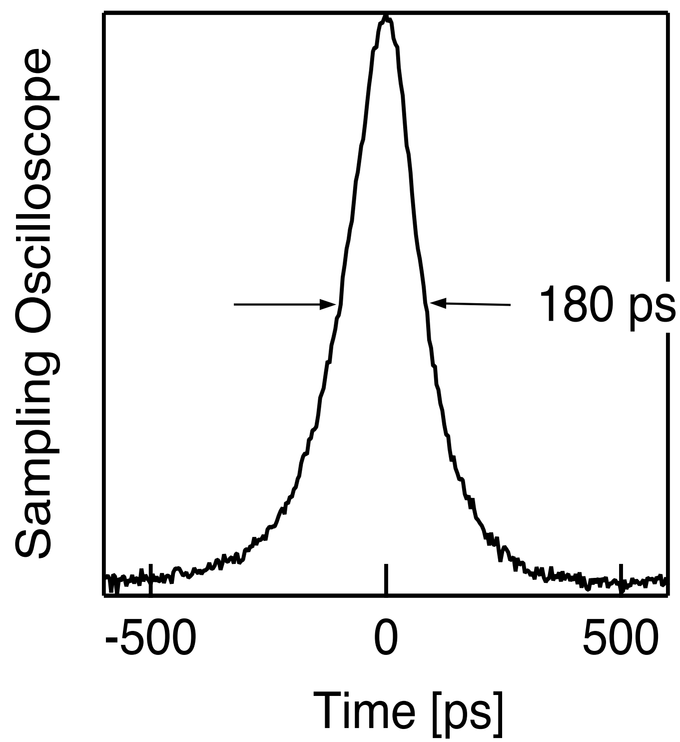
We passively Q switched a $Nd:LaSc_3(BO_3)_4$ microchip laser with an antiresonant Fabry–Perot saturable absorber (A-FPSA) and achieved single-frequency, 180-ps pulses with 0.1 μJ of pulse energy at a repetition rate of 110 kHz. Because of the compactness and scaling possibilities offered by the A-FPSA, the pulse width can be varied from 180 ps to 30 ns and the repetition rate from 50 kHz to 7 MHz.



Passively Q-switched microchip laser





B. Braun et al., *Opt. Lett.* **21**, 405, 1996

SESAM Q-switched Yb:YAG microchip laser

Q-switched microchip laser

again in 2001 with Yb:YAG

Appl. Phys. B 72, 285–287 (2001) / Digital Object Identifier (DOI) 10.1007/s003400100507

Applied Physics B
Lasers and Optics

A passively Q-switched Yb:YAG microchip laser

G.J. Spühler[1], **R. Paschotta**[1,*], **M.P. Kullberg**[1], **M. Graf**[1], **M. Moser**[2], **E. Mix**[3], **G. Huber**[3], **C. Harder**[4], **U. Keller**[1]

[1] Ultrafast Laser Physics, Institute of Quantum Electronics, Swiss Federal Institute of Technology, ETH Hönggerberg–HPT, 8093 Zürich, Switzerland
[2] Centre Suisse d'Electronique et de Microtechnique-Zürich, Badenerstrasse 569, 8048 Zürich, Switzerland
[3] Institut für Laser-Physik, Universität Hamburg, Jungiusstr. 9–11, 20355 Hamburg, Germany
[4] JDS Uniphase AG, Binzstrasse 17, 8045 Zürich, Switzerland

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Abstract. We present a diode-pumped passively Q-switched Yb:YAG microchip laser, using a semiconductor saturable absorber mirror. We obtained pulses with 1.1-µJ energy, 530-ps duration, 1.9-kW peak power, and a repetition rate of 12 kHz. The laser is oscillating in a single longitudinal mode.

PACS: 42.55.Xi; 42.60.Gd

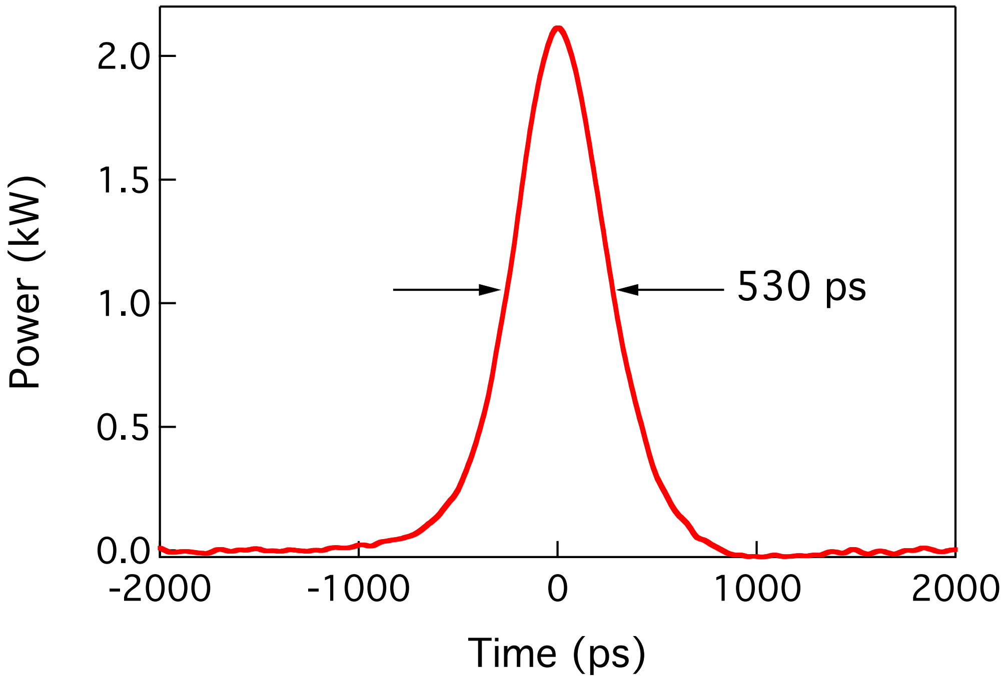
1 Materials and experimental procedure

As a gain medium, Yb:YAG is particularly interesting for several reasons. Figure 1 shows the measured emission and absorption cross-sections. We used small splinters of the gain medium surrounded by index matching fluid in order to avoid undesired effects such as reabsorption and radiation trapping [12]. In order to obtain the emission cross-section, the measured fluorescence spectrum was multiplied by λ^5 and an absolute scaling was done using the measured fluorescence

Passively Q-switched Yb:YAG microchip laser

Spühler et al., *Appl. Phys. B* **72**, 285-287 (2001)

25 GHz sampling oscilloscope trace



$$P_{\text{pump}} = 485 \text{ mW}$$

$$E_{\text{p}} = 1.1\ \mu\text{J}$$
$$F_{\text{p}} \approx 100 \text{ mJ/cm}^2$$
$$\tau_p = 530 \text{ ps}$$
$$P_{\text{peak}} = 2.1 \text{ kW}$$
$$P_{\text{avg}} = 13.2 \text{ mW}$$
$$f_{\text{rep}} = 12 \text{ kHz}$$

$\Rightarrow$ Single longitudinal mode

SESAM $\Delta R \approx 1.6\%$ ($R_{\text{top}} = 75\%$)

shorter pulses with larger ΔR (smaller R_{top})

- but larger $\Delta R \Rightarrow$ higher E_{p} $\Rightarrow$ damage of the SESAM
- $R_{\text{top}} = 0\%$: damage threshold ≈ 30 mJ/cm^2
- $R_{\text{top}} = 75\%$: damage threshold ≈ 200 mJ/cm^2

Design Guidelines

Short pulses

- Short cavity T_R
- Large modulation depth ΔR
- Large emission cross section σ_L

$$\tau_p \approx \frac{3.5 T_R}{\Delta R}$$

Nd:YVO_4: small absorption length,high gain

Shortest Q-switched pulses from solid-state laser

Large pulse energy

- Small emission cross section σ_L
- Large modulation depth ΔR
- Large mode area A

Yb:YAG, Er:Yb:glass

$$E_p \approx \frac{h\nu_L}{\sigma_L} A \, \Delta R \, \eta_{out}$$

Repetition rate

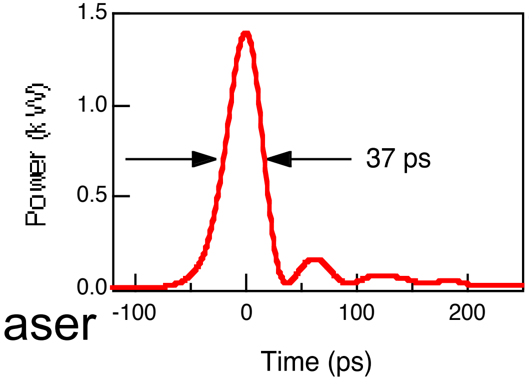
- Adjustable by pump power

$$f_{rep} \approx \frac{g_0}{2 \Delta R \tau_L}$$

Overview and design guidelines: *JOSA B* **16**, 376-388 (1999)

Results

45-GHz sampling oscilloscope trace



185 μm Nd:YVO_4

f_{rep} = 160 kHz

E_p = 53 nJ

$\Delta R \approx$ 13 %

τ_p = 37 ps

Spühler et al., *JOSA B* **16**, 376-388 (1999)

200 μm Yb:YAG*	0.5 mm Er:Yb:glass**
1.03 μm	1.535 μm
f_{rep} = 12 kHz	f_{rep} = 1.4 kHz
E_p = 1.1 μJ	E_p = 11.2 μJ
τ_p = 530 ps	τ_p = 840 ps

*Spühler et al., *Appl. Phys. B* **72**, 285-287 (2001)

R. Häring et al., *JOSA B* **18, 1805-1812 (2001)

Different crystals and SESAMs

Varying pump power

f_{rep} = 320 Hz - 7.8 MHz