

## Data sheet microchip MC-1064-90ps

microchip for pulsed laser emission at a wavelength  $\lambda = 1064 \text{ nm}$

MC – Microchip

MC-1064-90ps - microchip with 1064 nm laser emission and 90 ps pulse duration

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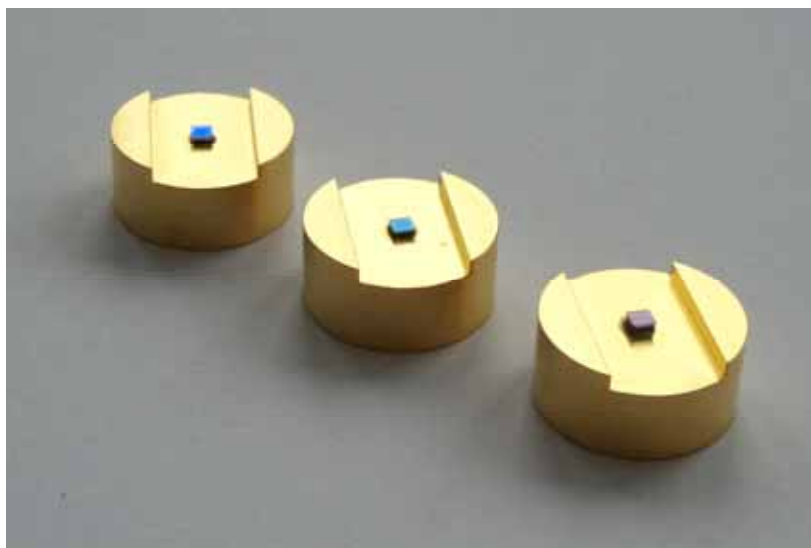
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### 1. Microchip description and applications

The Microchip (MC) consists of a saturable absorber mirror bonded with a Nd:YVO<sub>4</sub> laser crystal. The MC can be used to generate pulsed laser radiation at 1064 nm wavelength if pumped with a pump diode at 808 nm. Possible application areas of this laser radiation are:

- micromachining
- light detection and ranging (LIDAR)
- precision measurements
- frequency conversion

The main advantage of a laser build with this microchip is the pump power dependent repetition rate with fixed pulse duration and pulse energy. By simply increasing the pump power at 808 nm the repetition rate - and consequently the average output power - will be increased proportionally starting from the laser threshold.

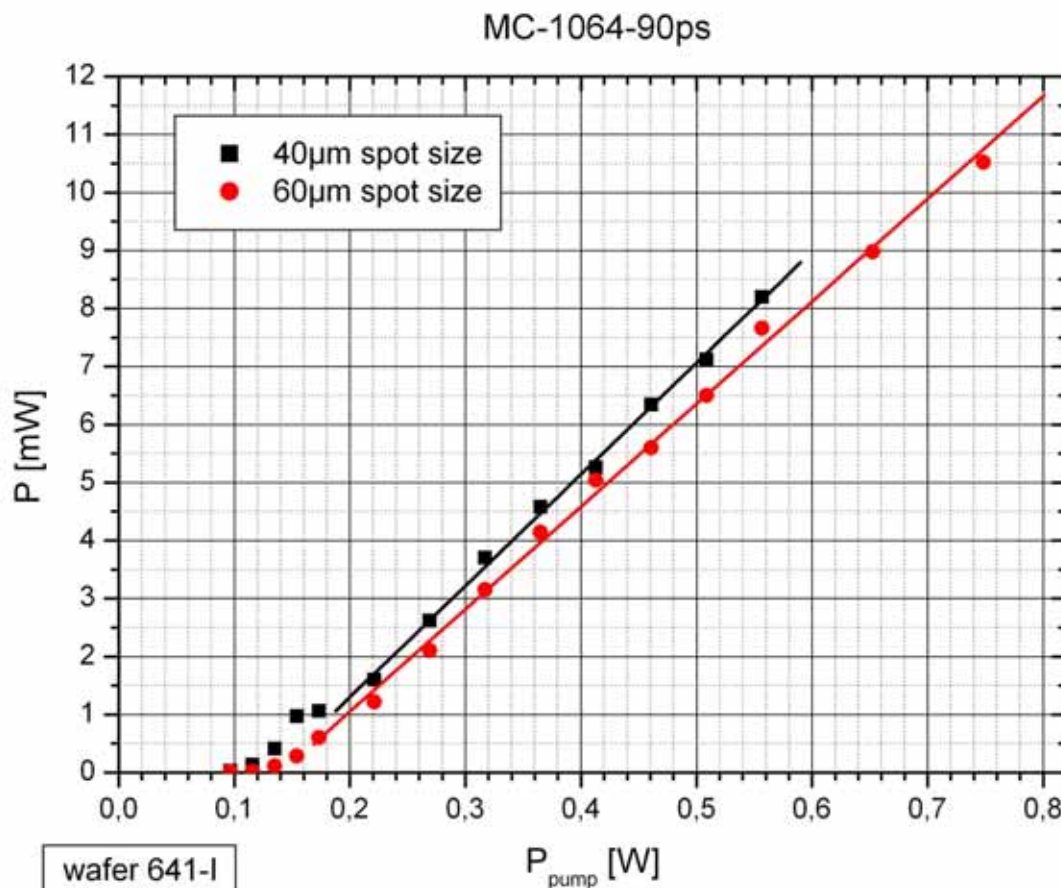


## 2. Microchip parameters

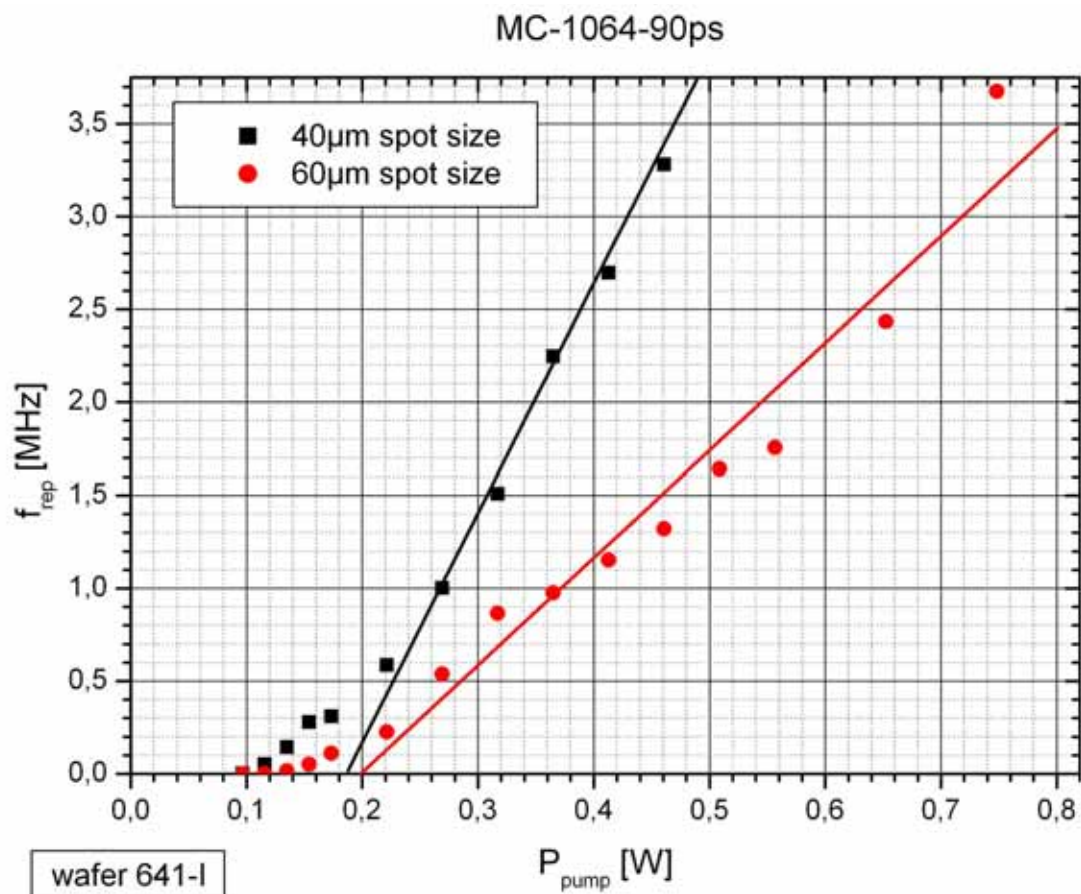
|                           |                                                                                  |
|---------------------------|----------------------------------------------------------------------------------|
| Laser emission wavelength | $\lambda = 1064 \text{ nm}$                                                      |
| Pump wavelength           | $\lambda = 808 \text{ nm}$                                                       |
| Pulse duration            | $t_P \sim 90 \text{ ps}$                                                         |
| Pulse energy              | $E_P \sim 4 \text{ nJ}$ at $60 \mu\text{m}$ pump spot diameter                   |
| Repetition rate           | $f_R \sim 100 \text{ kHz} - 3 \text{ MHz}$ , dependent on the pump power density |
| Average output power      | $P_{AV} \sim 0.2 - 10 \text{ mW}$ , dependent on the pump power                  |
| Polarization              | linear, perpendicular to the groove in the heat sink                             |
| Pump power density        | $5 \text{ kW/cm}^2$ (threshold) - $55 \text{ kW/cm}^2$ (maximum)                 |
| Beam quality              | $M^2 = 1.05$ at $60 \mu\text{m}$ pump spot diameter                              |
| Copper heat sink          | $12.7 \text{ mm}$ diameter, $6 \text{ mm}$ thick                                 |
|                           | microchip is mounted on the centre in a $1 \text{ mm}$ deep groove               |

The average output power  $P$  and the repetition frequency  $f_R$  are a function of the optical pump power. These dependencies are nearly linear above the laser threshold. The jitter of the repetition frequency decreases with increasing pump power to about 2 %, whereas the pulse energy  $E_P$  remains constant.

### Dependency of the average output power $P$ on the pump power at $808 \text{ nm}$

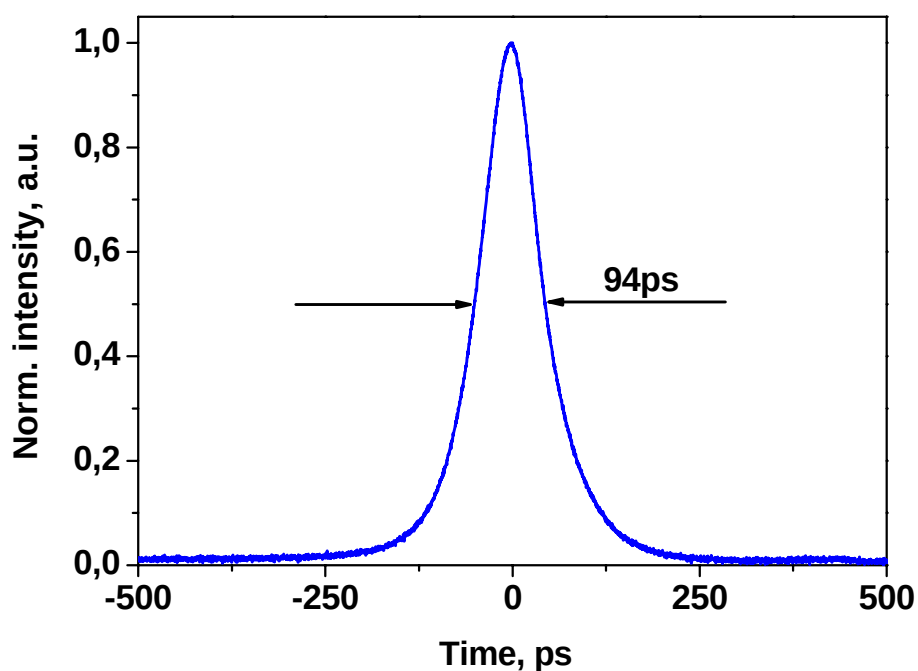


### Dependency of the repetition rate $f_{\text{rep}}$ on the pump power at 808 nm



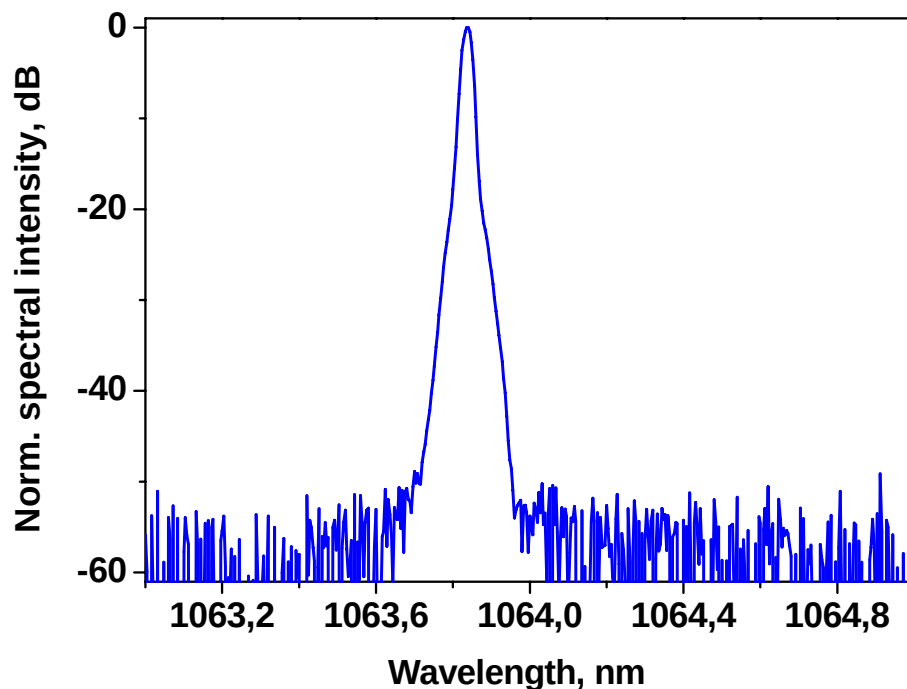
### Pulse duration $t_p$

measured by Reinhold Lehneis, Institute of Applied Physics, University of Jena, Germany

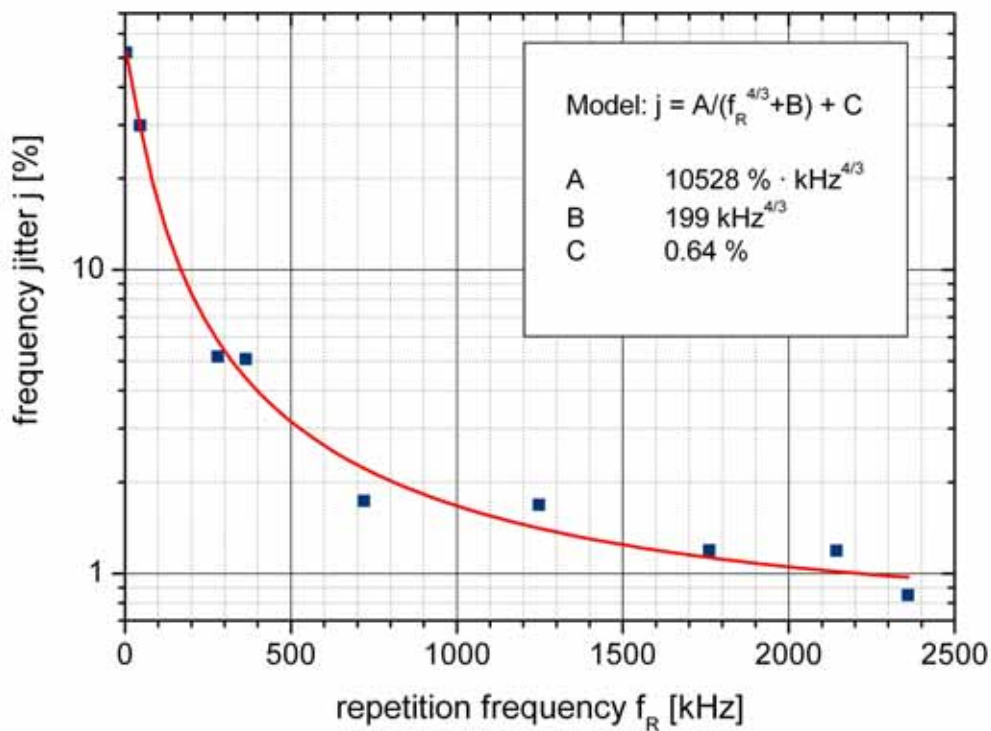


### Pulse spectrum

measured by Reinhold Lehneis, Institute of Applied Physics, University of Jena, Germany

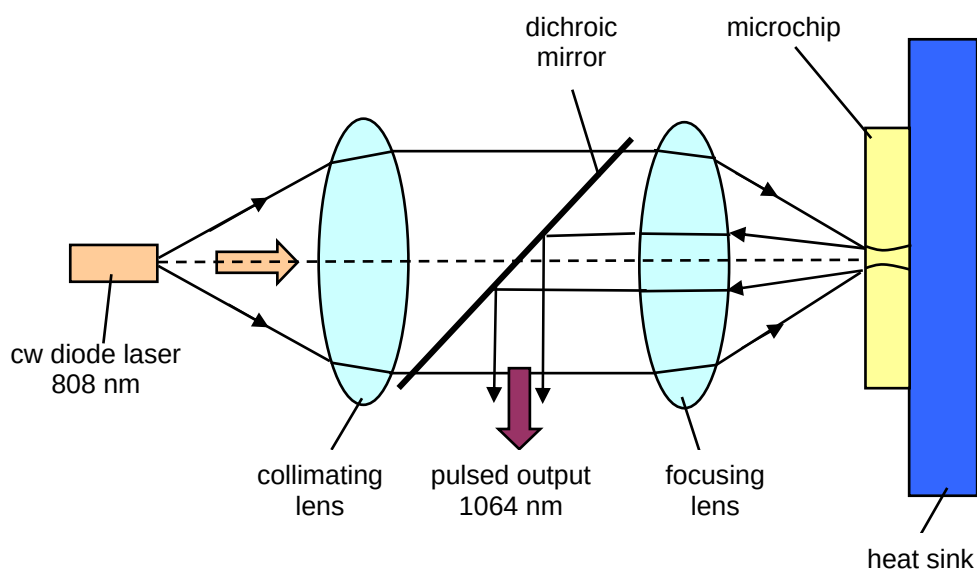


### Dependency of the relative frequency jitter on the repetition rate $f_R$



### 3. Microchip laser setup

The microchip consists of a saturable absorber mirror (SAM) and a Nd:YVO<sub>4</sub> laser crystal. Because the SAM is not transparent, the laser setup must be in reflection mode. For optical pumping a multi-mode laser diode with about 1 W cw output power at 808 nm wavelength is appropriate. The proposed laser setup using two lenses and a dichroic mirror is shown below.

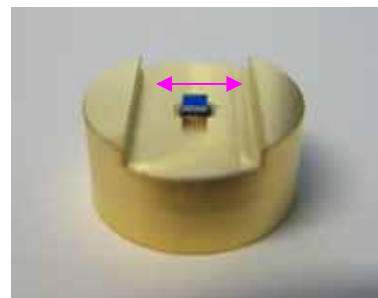


The dichroic mirror has a high reflectance for the laser output at 1064 nm wavelength and a high transmittance for the 808 nm pump light.

The laser output is collimated and nearly diffraction limited, if the pump spot diameter in the laser crystal of the microchip is small enough. Typical pump spot diameter values are between 40  $\mu\text{m}$  and 80  $\mu\text{m}$ .



The arrow shows the polarization direction of the emitted light (parallel to c-axis)



#### 4. Theoretical considerations about pulse duration, repetition rate and pulse energy

The pulse energy of a microchip laser can be estimated by<sup>[1]</sup>

$$E_p \approx F_{sat,L} \cdot A \cdot \Delta R \cdot \frac{T}{T + A_{ns}} \quad , \quad (1)$$

where  $F_{sat,L}$  is the saturation fluence of the laser material,  $A$  is the pump spot diameter,  $\Delta R$  is the modulation depth of the SAM,  $T$  is the output loss and  $A_{ns}$  denotes intrinsic losses.

The repetition rate  $f_R$  is given by<sup>[1]</sup>

$$f_R = \frac{P_{AV}}{E_p} = \frac{\eta_s \cdot (P_p - P_{p,th})}{E_p} \quad , \quad (2)$$

here  $P_{AV}$  is the average power,  $P_p$  is the pump power,  $P_{p,th}$  is the pump power threshold and  $\eta_s$  is the slope efficiency (  $\sim 0.5$  ).

The pulse duration can be stated<sup>[1]</sup> by formula (3) as follows

$$t_p \approx \frac{3.52 \cdot T_R}{\Delta R} \quad \text{with} \quad T_R = \frac{2 \cdot n_c \cdot d_c}{c} \quad (3)$$

$T_R$  is the resonator round trip time which comprises the refractive index  $n_c$  and the thickness  $d_c$  of the laser crystal. For a deeper theoretical review please see [2].

[1] Appl. Phys. B 97 (2009) p.317-320, A. Steinmetz et. al., "2 MHz repetition rate, 200 ps pulse duration from a monolithic, passively Q-switched microchip laser"

[2] J. Opt. Soc. Am. B Vol. 16 (1999) p.376-388, G. J. Spühler et. al., "Experimentally confirmed design guidelines for passively Q-switched microchip lasers using semiconductor saturable absorbers"