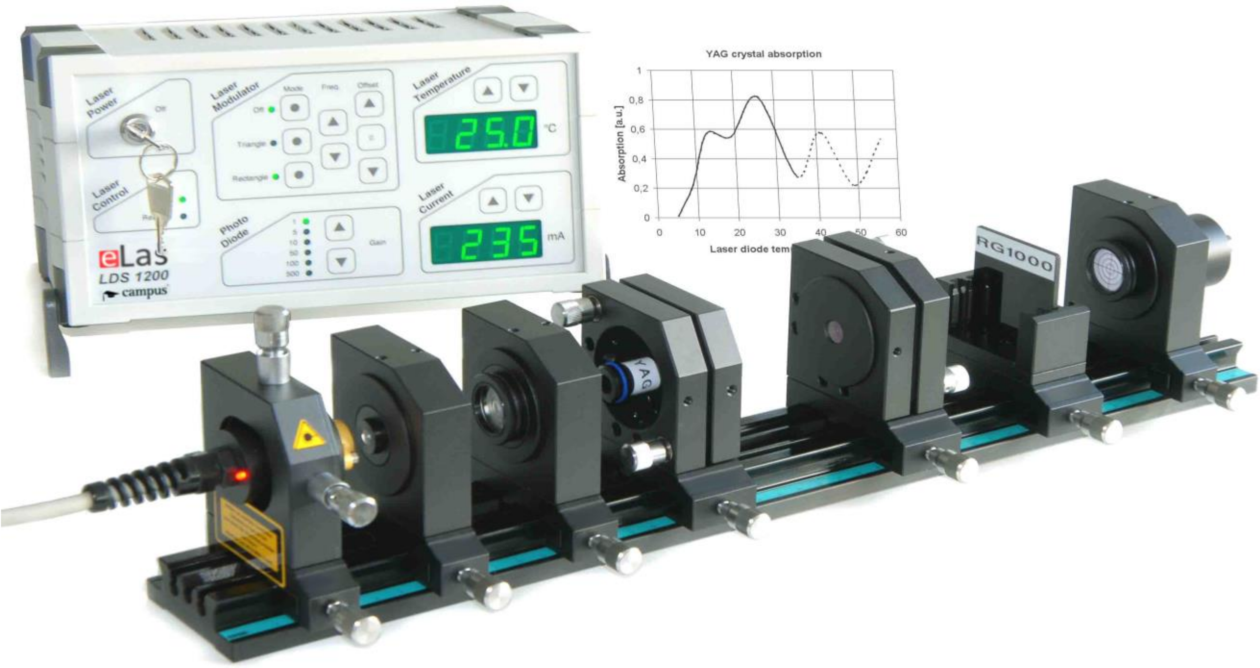
Diode Pumped Nd:YAG Laser (CA-1230)



The diode-pumped solid-state laser CA-1230 is a versatile laser source designed for training and educations, but can also be used in research applications. The system with all its extension options (CA-1231 through CA-1234) is the most flexible DPSS system on the market. With its seven operating modes it offers a variety of opportunities for experimentation in the field of diode and DPSS lasers and nonlinear optics.

Educational Objectives of Investigation

- Properties of Laser Diodes
- Optical Pumping by Diode Laser
- Spectral Properties of Active Medium
- Fluorescence Decay and Lifetime of Excited State
- Output Power Optimization by Resonator Alignment
- Transversal Resonator Mode Properties (TEM_{00} and higher)
- Stability Criterion of Laser Operation and Cavity Optimization
- Laser Spiking, Threshold and Slope Efficiency
- Second Harmonic Generation by Frequency Up-Conversion
- Short Pulse Generation by Active and Passive Q-Switching
- Characterization of Pulse Generation: Threshold, Pulse Shape, Duration and Energy
- Inter- versus Intra Cavity Second Harmonic Generation in cw- and Pulsed Mode
- Output Power with varying the Output Coupling
- Minimum Laser Threshold Investigation
- Comparison of Nd:YAG and $Nd:YVO_4$ as Active Media

Modes of Operation

Mounted on an optical rail all components can be installed and exchanged in short time. Therefore a change between the following seven modes of operation is quick and straightforward:

- Diode laser @808nm
- DPSS laser @1064nm in cw operation
- DPSS laser @1064nm in actively q-switched operation
- DPSS laser @1064nm in passively q-switched operation
- intra cavity frequency doubled cw DPSS laser @532nm
- intra cavity frequency doubled q-switched DPSS laser @532nm
- extra cavity frequency doubled q-switched DPSS laser @532nm

The kit uses a 450 mW laser diode with integrated TE-cooler and thermistor to control the laser temperature. All components to set up a complete laser diode pumped Nd:YAG laser with its required optics like crystal, mirrors, lenses and collimators are included. All optical elements including frequency doubling and q-switch crystal are mounted in special opto-mechanics for quick installation and alignment. The provided versatile electronics controller comprises the laser diode temperature and injection current control, a build in function generator to modulate the laser diode current and a photo diode amplifier converting the light signals for the measurements to be done.

Ordering Information

This ordering information gives an overview of ordering numbers of the laser kit and its extensions. All modules of the kits can be ordered separately, if required.

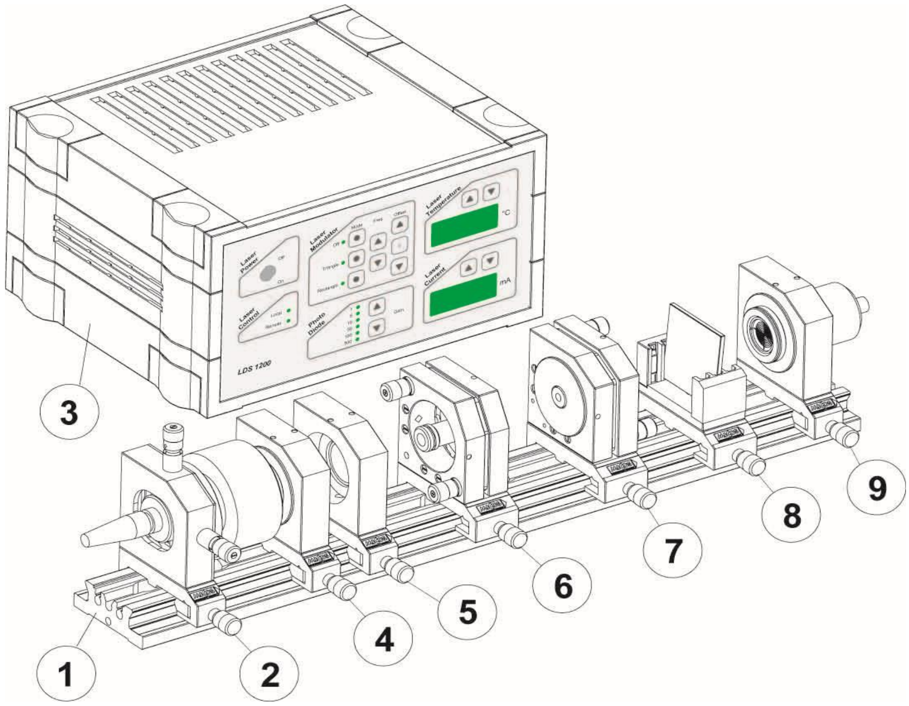
For ordering the Diode Pumped Nd:YAG laser kit (CA-1230)

use ordering number: 490091230

Available options for extensions:

- components to upgrade the kit to 'Optical Frequency Doubling' (CA-1231)
  use ordering number 490091231
- components to upgrade the kit to 'Short pulse generation by Active Q-switching' (CA-1232)
  use ordering number 490091232
- components to upgrade the kit to 'Short pulse generation by Passive Q-switching' (CA-1233)
  use ordering number 490091233
- components to upgrade the kit with the Mirror Extension Set (CA-1234)
  use ordering number 490091234

Setup and Components of the basic kit



The Diode Pumped Nd:YAG laser kit includes:

1 Flat rail 500 mm with scale

2 Laser diode 450 mW with thermo-electric cooling in X-Y adjustment holder on carrier

3 Microprocessor controlled laser diode supply LDS 1200 with thermo-electric controller, integrated current modulation and photo diode signal amplifier

4 Pump diode beam shaping optics in holder on carrier

5 Pump diode beam focusing optics in holder on carrier

6 Nd:YAG crystal with mount in adjustment holder on carrier, Nd:YVO_4 crystal optionally available

7 Laser output mirror (R = 98%) with mount in adjustment holder on carrier

8 Filter holder for three filter plates on carrier with filter RG1000

9 Si-PIN photo detector, spectral range 400 nm - 1100 nm in holder on carrier with adjustment target

10 Set of three BNC cables (not shown)

11 Infrared converter card 800 - 1600 nm (not shown)

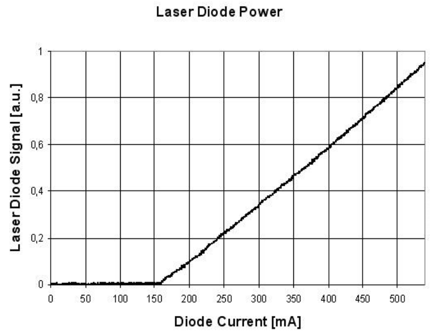
12 Optics cleaning kit

13 Comprehensive user manual (not shown)

Measurements and Handling

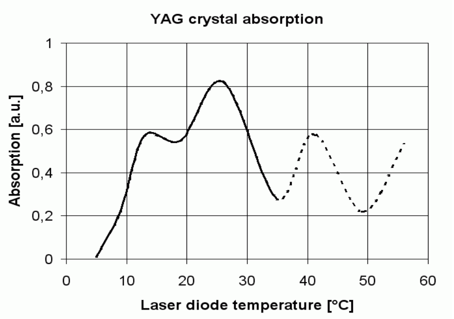
Some of the possible measurements are presented in the following list:

- **Laser diode output power versus current**



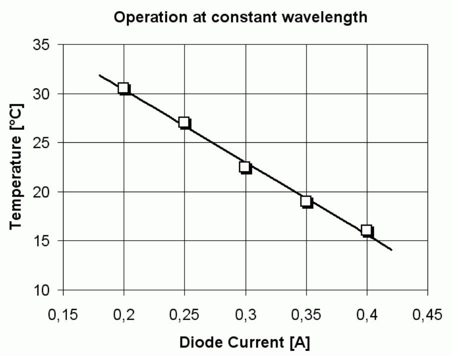
The relative output power of the laser diode used for optical pumping can be measured in dependence on the injection current. Parameters like laser threshold and slope efficiency are evaluated.

- **Absorption/fluorescence spectrum of Nd:YAG**



The absorption spectrum of the Nd:YAG crystal in dependence of the temperature of the laser diode is measured. Using the known absorption lines of Nd:YAG the transmitted intensity or the fluorescence intensity of the crystal is measured. By varying the laser diode temperature its emission wavelength is scanned.

- **Wavelength dependence of injection current**



Increasing of wavelength proportional to raising power is characteristic for laser diodes. To compensate this behavior it is necessary to vary its temperature. Operation at a constant wavelength is realized by working at an absorption minimum (i.e. maximum transmission) and optimization of the temperature and current for maximum transmission.

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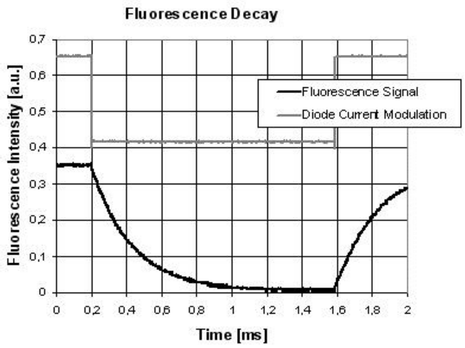
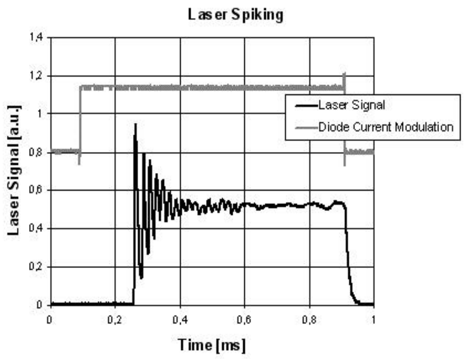
- **Measurement of life time of fluorescent light**



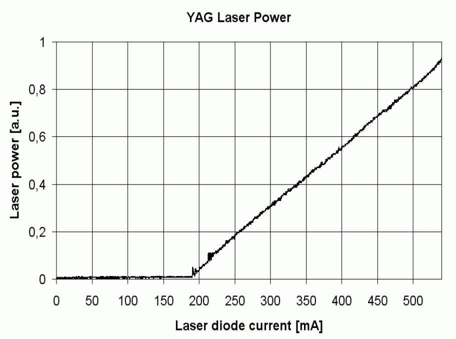
The $^4F_{3/2}$ level is the starting level for the emission at 1064 nm. The life time of the fluorescence of the Nd:YAG crystal pumped by the laser diode is detected. The current of the diode is TTL modulated and the decay curve of the fluorescence is measured.

- **Demonstration of laser spiking**



Laser spiking as a result of switching on of the laser is demonstrated. Working close to the laser threshold and in a rectangular modulation mode the effect of spiking and its damping is clearly observable.

- **Output power of Nd:YAG laser versus pump power**



Using the triangular modulation mode of the pump diode current, the Nd:YAG laser power can be presented as a function of the pump diode power. Parameters like laser threshold and laser slope efficiency are determined. Varying the length of the laser resonator, these parameters can be evaluated with respect to the resonator's stability range.

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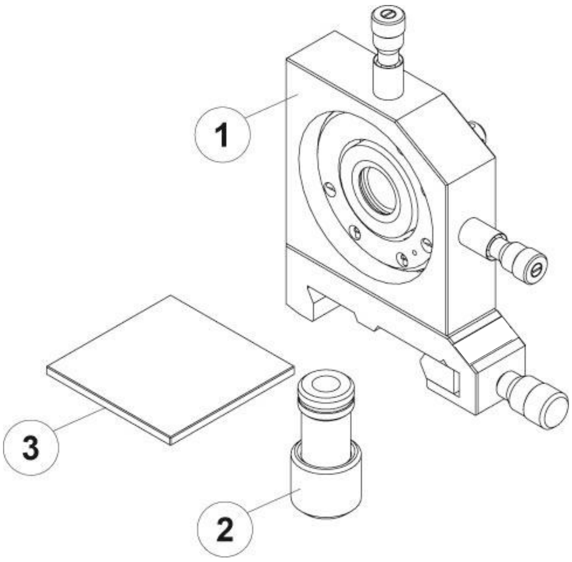
CA-1231 Nd:YAG Laser
Frequency Doubling Extension

A KTP crystal converts the Nd:YAG emission intra-cavity to green light. For green emission above 5 mW an output coupler mirror highly transmissive at 532 nm is provided. Using an IR-absorbing filter the quadratic response of the SHG process is measured. Transverse cavity modes of the Nd:YAG laser are visualized by SHG impressively.

Educational Objectives of Investigation

- Nonlinear Optics Effect: Second Harmonic Generation by Frequency Up-Conversion
- Transversal Resonator Mode Properties (TEM_{00} and higher)
- Power Function of SHG Radiation
- Inter- versus Intra Cavity Second Harmonic Generation in cw-Mode
- With active- or passive q-switch: Inter- versus Intra Cavity Second Harmonic Generation in Pulsed Mode
- Minimum SHG Threshold Investigation

Components of the Frequency Doubling Extension



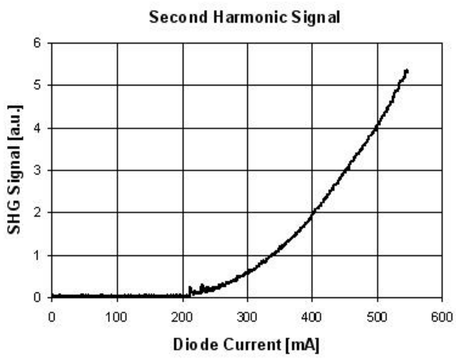
1 KTP frequency doubling crystal, AR/AR @1064 nm and @532 nm in 5-axes adjustment holder on carrier

2 Laser mirror (HR @1064 nm, HT @532 nm) in mount

3 Optical filter BG 39 for IR light suppression and green light transmission

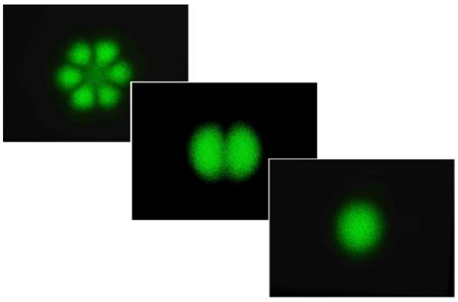
Measurements and Handling

- **Second harmonic generation signal**



As an example of measurements the second harmonic signal as a function of the pump diode current is shown. The non-linear (quadratic) behavior of the up-converted light can clearly be seen.

- **Mode pattern visualized by SHG**



By second harmonic generation transversal mode structures can be visualized. Besides the TEM_{00} fundamental mode, modes of higher order can be adjusted and determined.

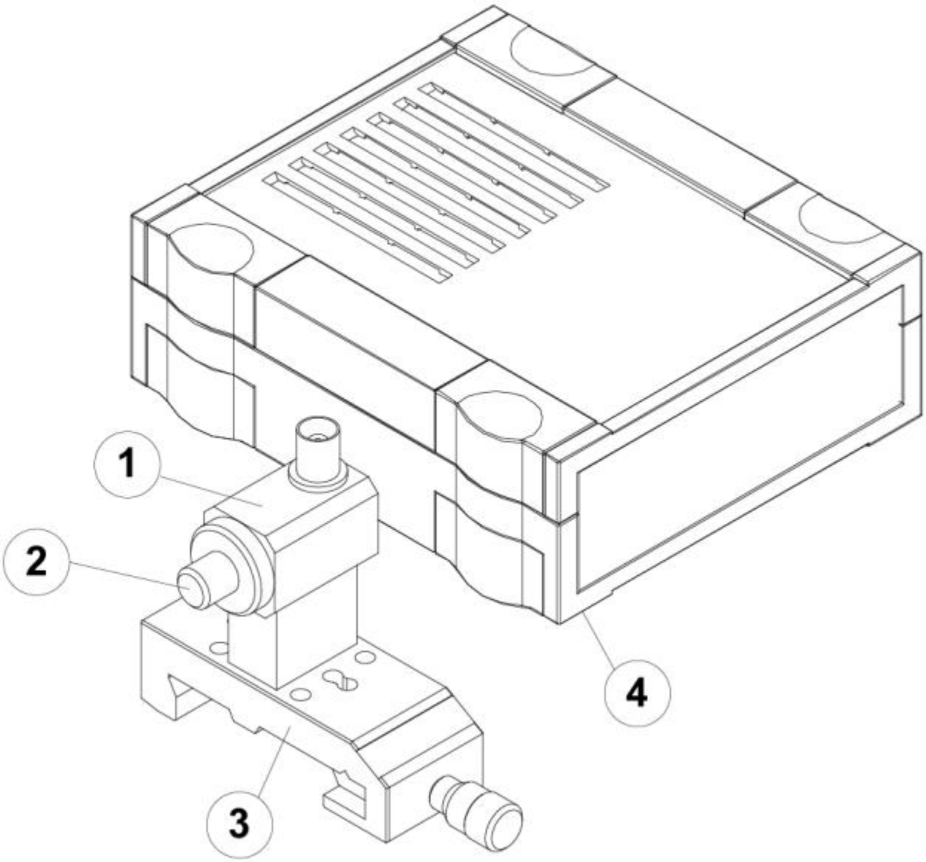
CA-1232 Nd:YAG Laser
Active Q-Switch Extension

A $LiNbO_3$ Pockels cell changes the polarization state of the Nd:YAG emission. A Brewster plate introduces losses and laser operation is suppressed. When switching the cell, the losses are minimized and a laser pulse builds up. Periodical switching leads to pulsed laser operation and a q-switched pulse train is observed. Switching voltage and frequency are adjusted by a controller. In combination with CA-1231 intra- and extra-cavity SHG can be shown.

Educational Objectives of Investigation

- Nonlinear Optics Effect: Active Q-Switching of Nd:YAG laser
- Electro-Optical Modulator Application
- Short Pulse Generation by Active Q-Switching
- Characterization of Pulse Generation: Threshold, Pulse Shape, Duration and Energy
- With Frequency Doubling Extension: Inter- versus Intra Cavity Second Harmonic Generation in cw- and Pulsed Mode

Components



1 LiNbO$_3$ Pockels Cell

2 Brewster Window adjustable

3 Carrier for Pockels Cell

4 High Voltage Pulse driver electronics

5 Optical density filter NG 9 (not shown)

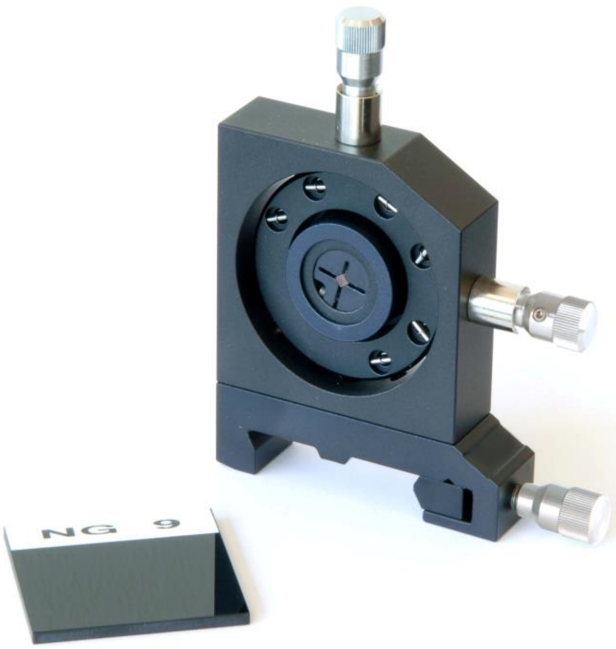
Measurements and Handling

Active Q-Switching control

Electro-optical modulator

Q-Switching behavior of Nd:YAG laser

CA-1233 Nd:YAG Laser
Option Passive Q-Switch

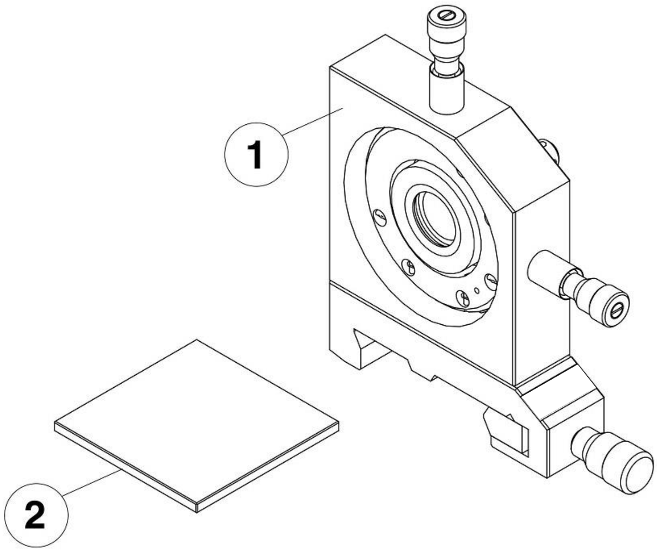


A Cr:YAG crystal acts as a saturable absorber within the resonator. A train of needle like pulses is observed. The pulse frequency is influenced by the pump power and the cavity alignment. When oscillating at more than one transversal mode two or more pulse trains appear. A neutral density filter in the setup avoids saturation of the photo detector. In combination with CA-1231 intra- and extra-cavity SHG can be shown.

Educational Objectives of Investigation

- Nonlinear Optics Effect: Passive Q-Switching of Nd:YAG laser
- Saturable Absorber Application
- Short Pulse Generation by Passive Q-Switching
- Characterization of Pulse Generation: Threshold, Pulse Shape, Duration and Energy
- With Frequency Doubling Extension: Inter- versus Intra Cavity Second Harmonic Generation in cw- and Pulsed Mode

Components



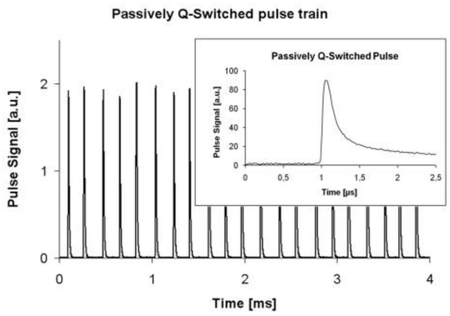
1 Cr^{4+}:YAG saturable absorber crystal, AR/AR coated @1064 nm in 5-axes adjustment holder on carrier

2 Optical density filter NG 9

3 BNC T-piece with 50 Ω shunt (not shown)

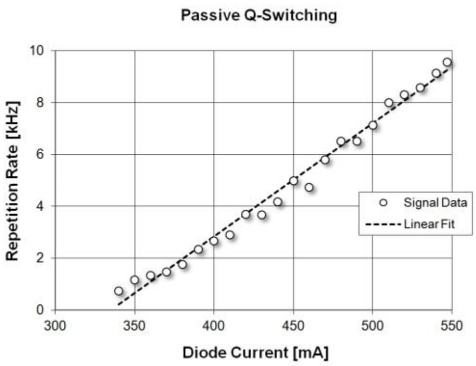
Measurements and Handling

- **Passively q-switched pulses**



Using the saturable absorber crystal in its 5-axes adjustment holder, passive q-switching is achieved and pulse trains as shown aside are generated. Zooming in a single pulse (insert) its rise and fall time as well as its pulse width of less than 200 ns can be determined.

- **Repetition rate of pulse trains**



The pulse repetition rate of the passively switched signal can be measured as a function of the pump diode current. As a result one gets a nicely linear behavior.

CA-1234 Nd:YAG Laser

Option Mirror Extension Set

A set of four laser mirrors with reflectivities between 80% and 99% at 1064 nm are provided in this set. The mirrors allow the performance of measurements for which the reflectivity of the mirrors is important. The influence of the reflectivity on the laser threshold and on the slope efficiency is shown. The maximum laser power as a function of the reflectivity is measured. The laser thresholds for different mirrors are plotted and extrapolated for a minimum threshold value.

Educational Objectives of Investigation

- Output Power and Laser Losses with varying the Output Coupling
- Minimum Laser Threshold with Different Laser Mirror Transmissions
- Slope Efficiency with Different Laser Mirror Transmissions
- With Active or Passive Q-Switch: Threshold, Pulse Shape, Duration and Energy of Laser Pulses

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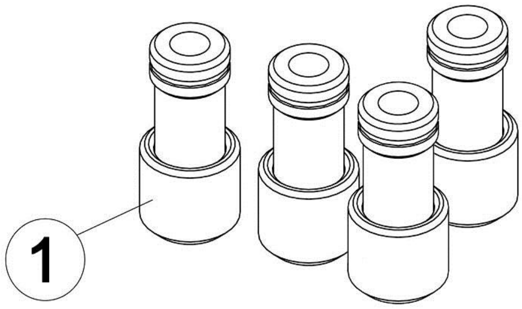
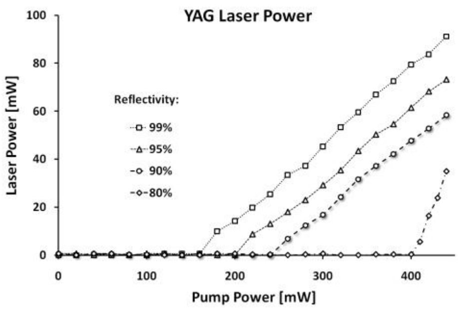
Components



1 Set of four laser mirrors with Reflectivity 80%, 90%, 95%, and 99% in mirror mounts

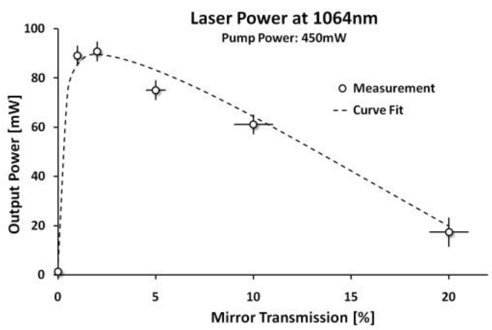
Measurements and Handling

- **YAG threshold and slope efficiency**



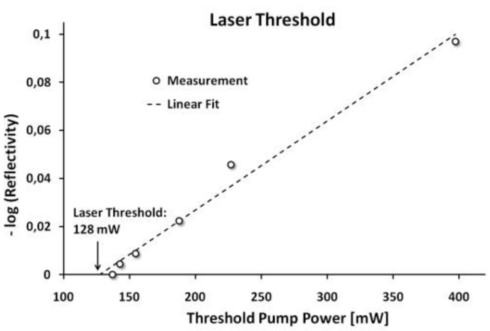
The output power of the Nd:YAG laser can be measured in dependence on the pump power of the laser diode. Parameters like laser threshold and slope efficiency are evaluated for each of the four mirrors.

- **Mirror transmission influence**



The Nd:YAG laser power at a fixed pump power is measured. Plotted as a function of the mirror transmission, one gets the dependence of the power from the reflection value. Using the output coupler mirror (R = 98%) and the frequency doubling mirror (R = 99,9%), the theoretical curve can be fitted to the measured values.

- **Extrapolated YAG laser threshold**



Plotting the negative logarithm of the mirrors' reflectivity against the laser threshold values, a linear fit can be performed. The intersection of the fitted curve with the x axis indicates the minimum laser threshold theoretically achieved with a resonator built by mirrors of 100% reflectivity.

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