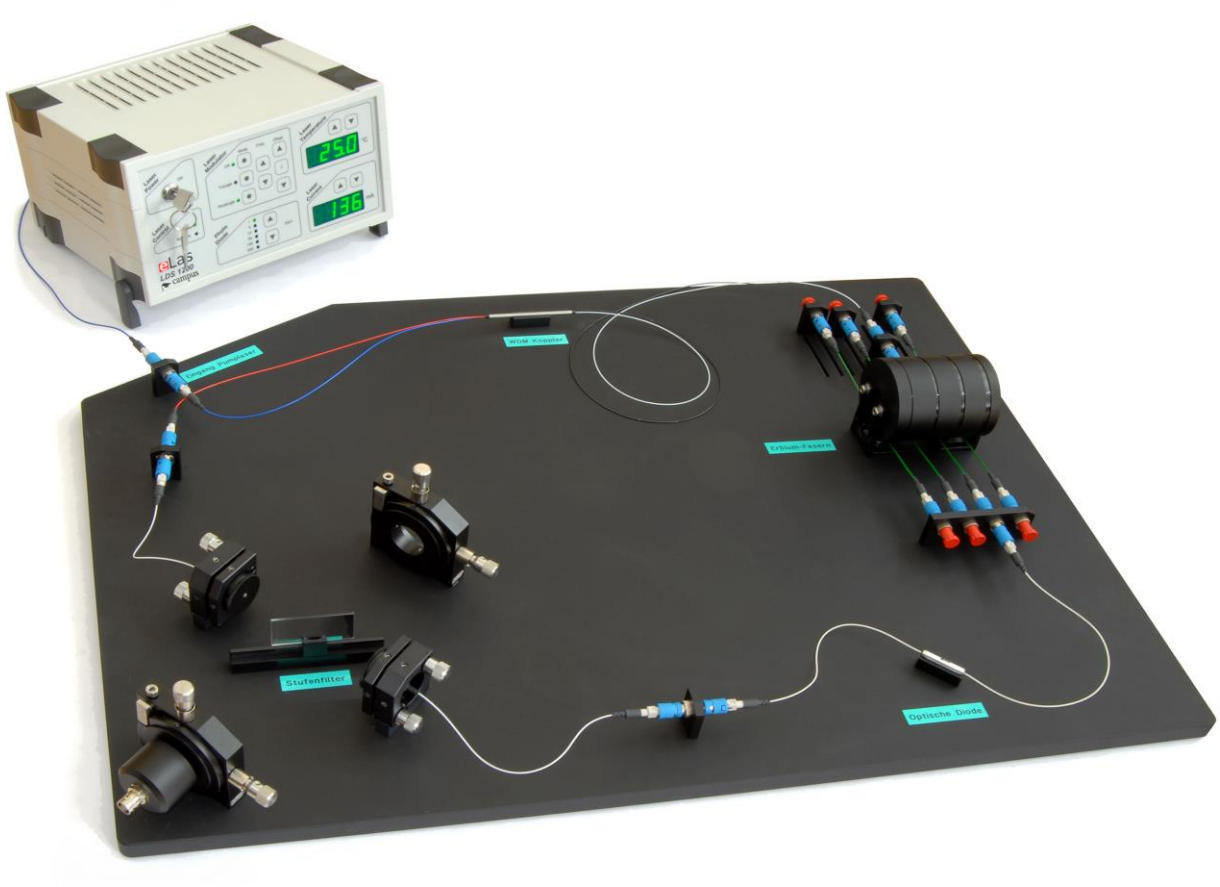
Fiber Ring Laser (CA-1240)

Extension EDFA (CA-1241)



This fiber laser set offers a multitude of experimental performances. As a start-up measurement the characterization of the 980 nm pump laser concerning the diode current or the beam profile is recommended. The characteristic laser parameters slope efficiency and laser threshold are measured. Coupling the pump light in the erbium fibers, absorption and fluorescence properties can be investigated.

By use of a resonator mirror a linear erbium fiber laser is realized. Closing the resonator for a ring the fiber ring laser is built. Both types can be investigated with respect to several parameters, for example the active fiber length (four different lengths of erbium fibers are provided), the amount of losses (variable in 11 steps), the pump power, and so on. The ring laser can be operated bi-directional. An optical diode allows an unidirectional operation in or against the pumping direction as well. The pump diode controller contains an internal modulator for rectangular and triangular pump current modulation which enables investigations of static as well as dynamic laser processes. Measured signals are amplified by an integrated photo diode amplifier and can be displayed on an oscilloscope (optionally available at eLas).

If a laser source of 1,55 µm is available (optionally offered by eLas: CA-1241 EDFA) the interaction of this laser light with the erbium fibers can be studied. By simultaneously pumping of the fibers at 980 nm an erbium doped fiber amplifier (EDFA) is realized and can be investigated. Several EDFA measurements concerning the fiber length, pump laser power, signal laser power, pump direction etc. are possible.

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Educational Objectives of Investigation

- Absorption/emission of the gain medium
- Optical pumping and absorption saturation
- Fluorescence lifetime
- Laser threshold
- Slope efficiency
- Laser spiking
- Introduction of losses
- Dynamic laser behavior
- With extension: erbium doped fiber
- Erbium doped fiber amplifier (EDFA)

Ordering Information

For ordering the Fiber Ring Laser experimental kit (CA-1240)

use ordering number: 490091240

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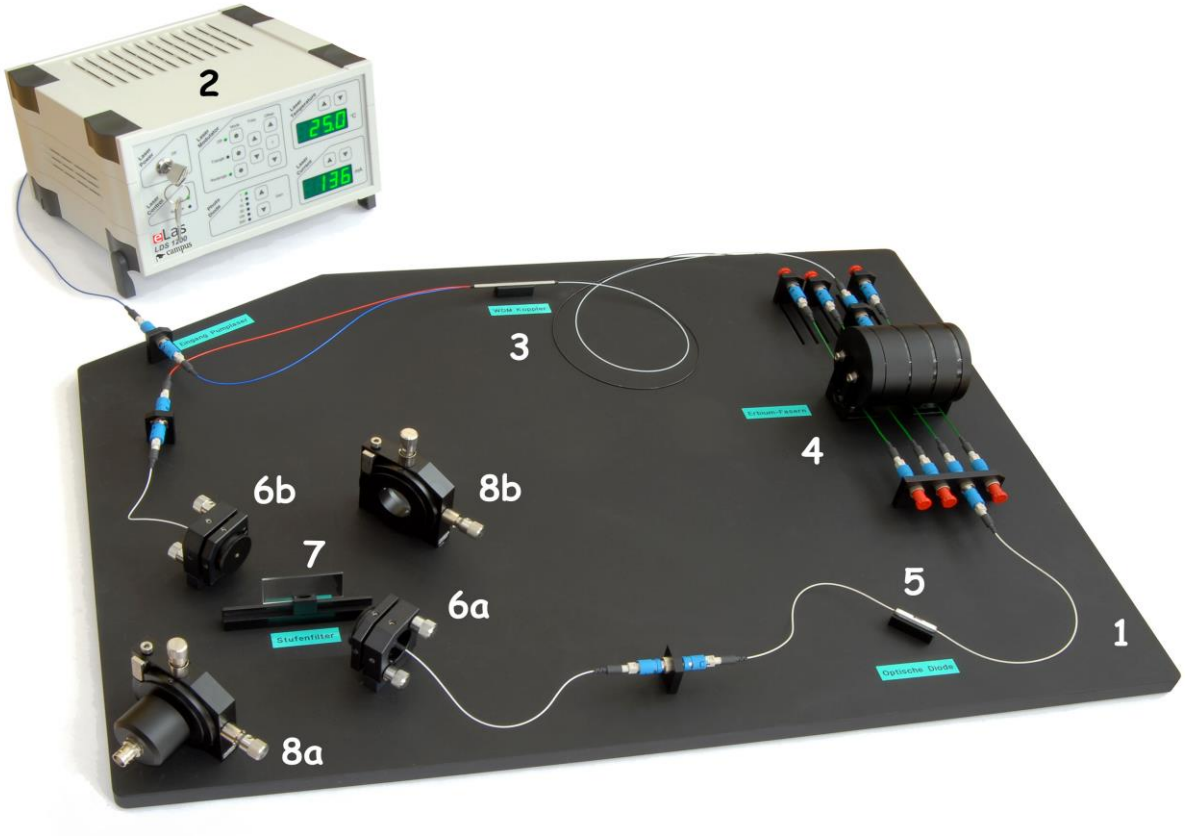
Setup and Components



1 Base plate 700 x 500 mm

2 Fiber coupled laser diode 980 nm / 100 mW, integrated in Laser diode controller LDS 1200 with integrated photo amplifier, current modulator and temperature control

3 Wavelength division multiplexer 980/1550 nm

4 Fiber drum with four erbium fibers (1 – 4 m)

5 Optical diode for 1550 nm

6 Pair of fiber collimators in θ,φ adjustment holders for free-beam line

7 Step density filter with 11 steps on slide

8 Pair of Si-PIN and InGaAs photo detectors in XY adjustment holders

9 Plane mirror in mount (not shown)

10 Set of single mode patch cables (not shown)

11 Infrared detector card 800 – 1600 nm (not shown)

12 Set for optics cleaning (not shown)

13 User manual (not shown)

The extension CA-1241 EDFA contains

1 Fiber coupled laser diode 1550 nm / 1 mW

2 Laser diode controller LDS 1200 with integrated photo amplifier, current modulator and temperature control

3 Set of cables and fiber equipment

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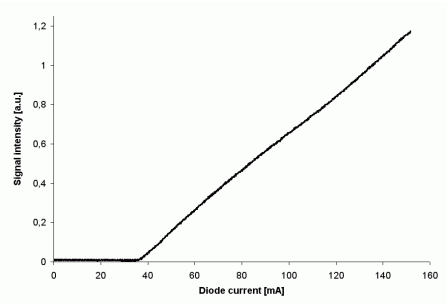
Measurements and Handling

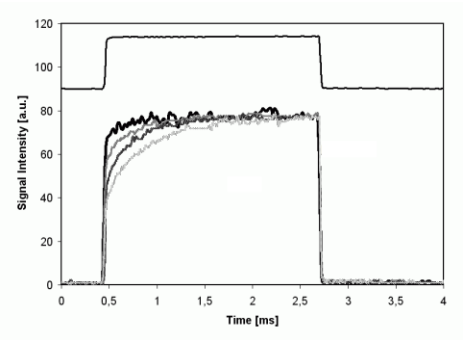
Some of the possible measurements are presented in the following list.

- **Pump laser diode output power versus current**



The output power of the pump diode laser at 980 nm is measured as a function of the diode current. For this purpose the ramp modulation mode of the LDS 1200 diode controller is used. The laser threshold and the slope efficiency are derived from this measurement.

- **Absorption of pump laser light**

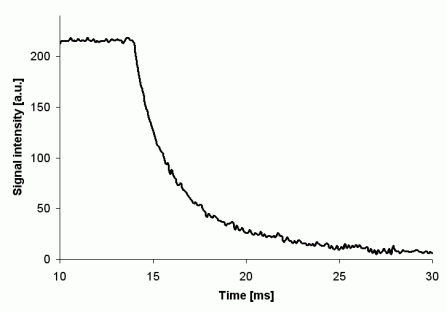


The transmission of the pump light through Erbium fibers is detected. When rectangular modulation of the diode current is applied, the absorption of the pump light (980 nm) by the Erbium ions of the fibers can be seen as a function of time and of the fiber length. Reaching a plateau in the transmission signal indicates saturation of the absorbing centers.

Upper curve: pump diode current as a function of time

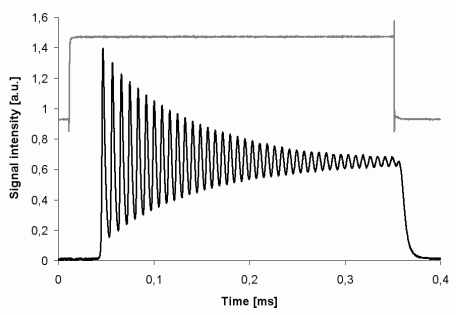
Lower curve: measured pump power through the 1 - 4m (up to down) erbium fibers as a function of time.

- **Fluorescence at 1550 nm**



As an active medium the Erbium centers in the fiber show fluorescence. This fluorescence is observed when pumping the fibers at 980 nm and can be investigated as a function of the pump diode current and as a function of the fiber length. From the fluorescence decay curves the fluorescence lifetime of the excited state of the Erbium ions can be measured.

- **Fiber laser oscillation**



When the fiber laser is in resonance and the pump diode current is rectangular modulated one can observe the start-up oscillation of the laser emission. Signal amplitude, damping strength, or signal onset can be measured. The influence of changing the pump power, switching to another Erbium fiber length (for lengths are provided) or varying the output coupling ratio (11 steps are possible), on these parameters is investigated.

Upper curve: pump diode current

Lower curve: Erbium laser signal.

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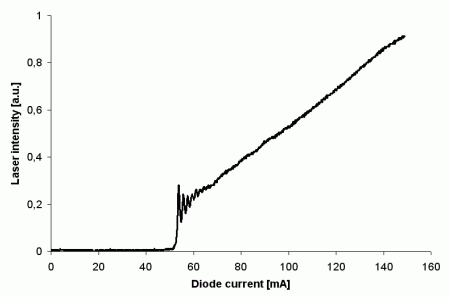
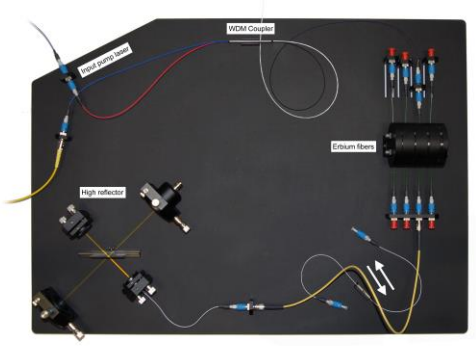
- **Fiber laser activity**



The output power of the fiber laser at 1550 nm can be measured as a function of the diode current. Using the ramp modulation together with the offset function of the LDS 1200 for tuning the pump diode current, the laser emission can also be measured directly as a function of the pump diode power. The laser threshold and the slope efficiency are derived from this measurement. Also here, changing of the active fiber length, or of the output coupling ratio provides a variety of measuring options.

- **Linear versus ring laser operation / optical diode**



Closing all fiber connectors, the laser forms a ring resonator. An optical diode forces the laser to operate in clockwise (cw) or counterclockwise (ccw) direction, respectively. Simultaneous emission in cw and ccw direction is achieved by bypassing the optical diode.

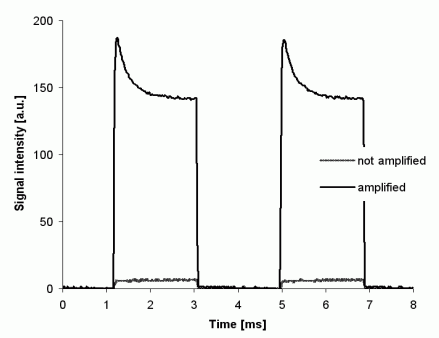
If the laser ring is interrupted and the provided resonator mirror is used for signal feedback, the laser can be operated in linear configuration. Here again, the already mentioned variations of the active fiber length, the output coupling ratio or the pump power may be examined.

Extension for Fiber Laser: CA-1241 EDFA

Once more the characteristic laser threshold and slope efficiency for the fiber coupled laser diode (1550 nm) of this extension kit can be measured (see first example above).

Further tests with this extension kit are shown in the following sections:

- **Signal amplification (1)**

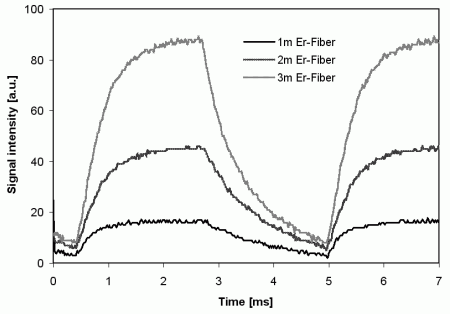


Continuously pumping of the Erbium fibers at 980 nm and inserting a seeding signal at 1550 nm shows the physics behind Erbium doped fiber amplifiers: a weak input signal is gained by a huge factor, depending on the active fiber length and excitation. The signal gain at 1550 nm is investigated as a function of the fiber length, the pump power or the signal power.

Upper curve: amplified signal through 3 m erbium fiber

Lower curve: signal at 1550 nm without pumping.

- **Signal amplification (2)**



While the measurements of the previous example where performed with modulated signal and continuous pumping, this example shows the effect of modulated pumping with continuous signal. Clearly to see are the fluorescence decay of the signal and the influence of different fiber lengths on the signal intensity.

The flexibility of the experimental setup allows EDFA tests with signal and pump light in the same direction or in opposite directions in the active fiber. Further, amplification can be investigated with or without the optical diode inserted.

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