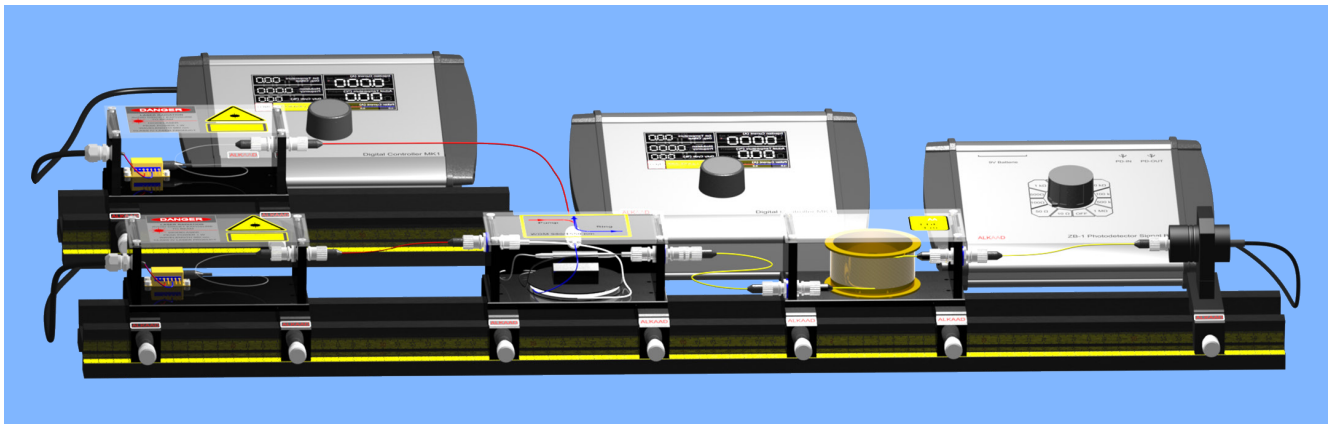
LT-0300 Erbium doped Fibre Amplifier (EDFA)



Keywords

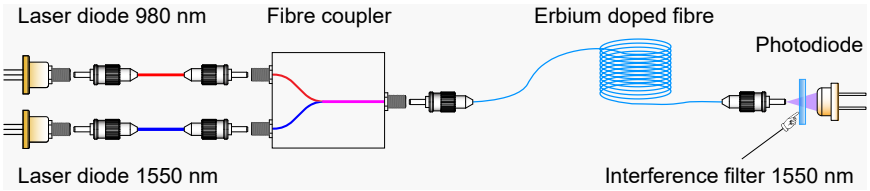
Optical Amplifier
Coupling light to fibre
Lifetime of Excited State
Optical Pumping
Signal Amplification
Fibre Laser Spiking
Erbium doped optical Amplifier
Fibre Laser

Introduction

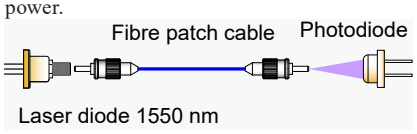
The success of the optical communication would not have been perfect without the invention of optical amplifier. A lot of effort has been invested in reducing the losses in optical fibres. However the residual losses limiting a maximum distance of around 80 km for a single mode fibre before the signal becomes to weak for detection. In principle the weak light could be amplified by an electronic amplifier and fed again into the fibre. However, this foils the extraordinary high bandwidth of optical fibre and a pure optically working amplifier is required. The concept of optical amplification is part of each laser and optical amplification is a well established technology. The genius underlying concept is the combination with an optical fibre and amplifier in one piece which has been realized in the erbium doped fibre amplifier (EDFA). The EDFA consists of an optical fibre which is doped with a defined concentration of Erbium atoms. By means of a coupler the light of a pump source is fed into the fibre exciting the erbium atoms which are acting now as amplifier. The pump wavelength is typically 980 nm and the amplification takes place around 1500 nm, the same range as the optical communication signal. Due to the coherence of the amplification process the amplified stream of photons are indistinguishable with respect to the incoming ones. What a great idea!

This experiment is designed to avoid time consuming adjustments procedures to launch the light of two diode laser into the amplifying EDFA fibre. As fibre coupled system each component can viewed to enhance the understanding of the EDFA concept. It starts with the pump laser diode emitting a wavelength of 980 nm. The pump radiation is coupled via a single mode fibre beam Y coupler into the Erbium doped fibre (EDF). The EDF has a length of about 16 metre and is coiled up on a drum. As signal source a laser diode emitting at 1550 nm is used. Its radiation passes the same fibre coupler is also launched into the EDF. At the output end of the EDFA an InGaAs detector is used for the detection of the 980 nm radiation as well as for the detection of the 1550 nm radiation respectively. A variety of measurements are carried out like the characterization of the two diode lasers. The injection current of each laser can be set independently by two controllers. In a next experiment the 980 nm radiation is coupled into the EDF and the created fluorescence is detected and monitored on an oscilloscope. The controller allows the modulated operation of the diode laser in such a way that the fluorescence decay the excited erbium atoms are displayed and the life time determined. By a further increase of the power of the pump diode laser the EDFA turns into a fibre laser which dynamic behaviour like distinctive spiking. Finally the 1550 nm radiation is fed into the EDFA and the gain is measured as function of the pump power.

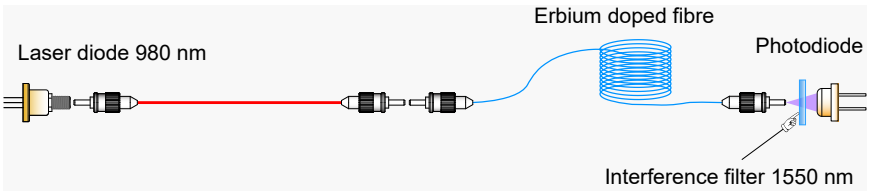
How it works



The experiment uses two laser diodes, one emits a wavelength of 980 nm with a power of 300 mW and serves as pump source. The other emits a wavelength of 1550 nm with lower power around 5 mW and serves as signal source. Both diode laser are fibre coupled and are connected via single mode patch cables to the fibre coupler. The pump as well as the signal wave enter the Erbium doped fibre and the signals leaving the fibre are detected by a InGaAs photodetector. In order to detect only the 1550 nm radiation a laser line or interference filter is placed in front of the photodetector. Each diode laser has its own controller to set the individual injection current for the measurement of the EDFA as function of the pump and the signal power.



In such case, the laser diode is directly coupled to the photodiode by means of fibre patch cable and the photocurrent is converted by means of the provided junction box into a linear voltage.



This setup uses only the pump diode laser to characterize the Erbium doped fibre in terms of measuring the lifetime of the excited state and even to perform some fibre laser experiments. For this purpose the 980 nm laser diode is directly coupled to the Erbium doped fibre. A photodiode monitors the output of the EDFA fibre. It will be a mixture of not absorbed pump power of 980 nm and the created fluorescence of 1550 nm. Of special interest is the 1550 nm radiation and therefore a line filter is placed in front of the photodiode.

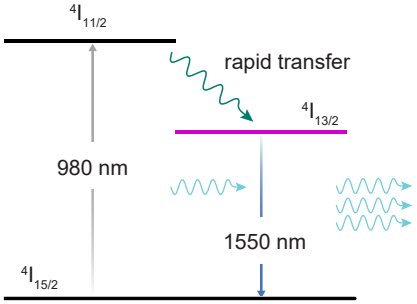
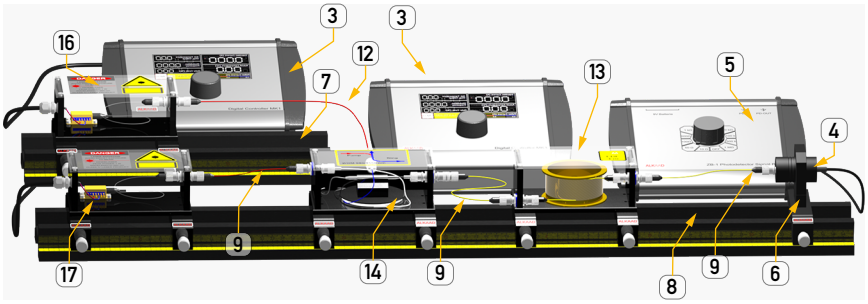


Fig. 3.10: EDFA amplification process

Description of the components



The amplifying medium is a 16 m long Erbium doped fibre which is coiled up on a drum (13) and terminated with single mode ST fibre panel jacks. The pump laser source (17) consists of a 980 nm laser diode in a so called butterfly housing which also contains a Peltier element to control the temperature of the laser chip. The radiation is available at a single mode ST fibre panel jack. By means of single mode fibre patch cables (12 and 9) both laser sources are connected to the wavelength division multiplexer (14, WDM). The combined radiation enters via a single mode patch cable the Erbium doped fibre (13). The output of the fibre is connected via a patch cable to the photodetector (4) which is connected to the junction box (5) where the detected photocurrent is converted into a voltage and can be displayed on an oscilloscope. Each laser diode has its own controller (3) which maintains the set values for the injection current and temperature.

Measurements

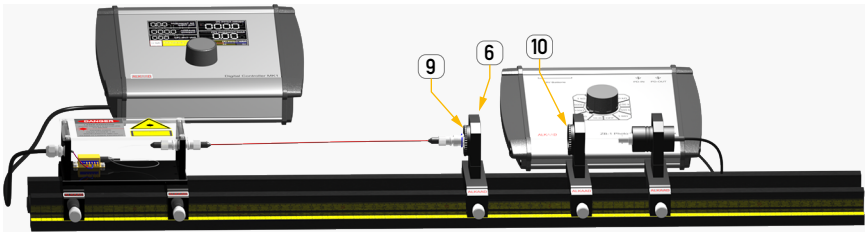
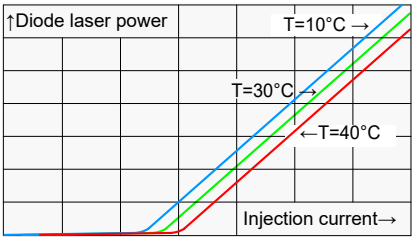


Fig. 3.11: Setup to characterize the individual diode laser modules



Pump laser power versus injection current and temperature

In first experiments the characteristics of the diode laser modules are measured. These are mainly the output power versus the injection current with the temperatures as parameter.

Laser operation and Gain Measurements

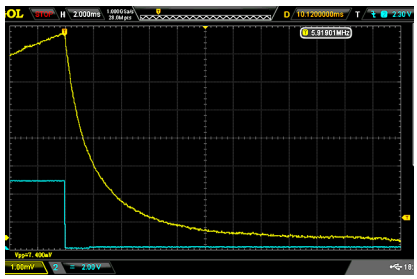


Fig. 3.12: Lifetime of the excited state

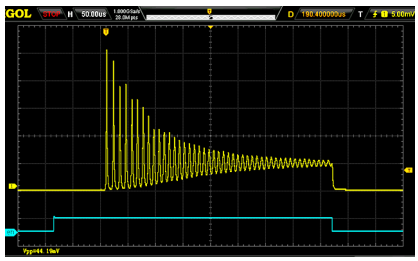


Fig. 3.13: Spiking of the Erbium laser

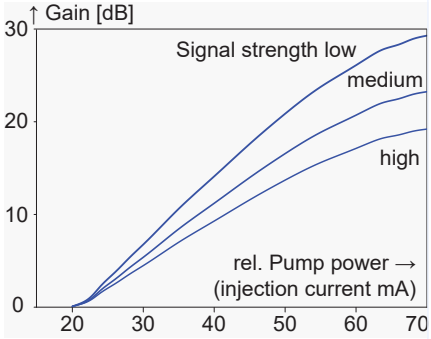


Fig. 3.14: Gain versus pump power and signal strength, small signal and large signal amplification, gain saturation

For the measurement for the lifetime of the excited state (Fig. 3.12) and the fibre laser operation (Fig. 3.13) only the pump laser (17) is connected to the Erbium doped fibre. The full setup is chosen to measure the gain of the EDFA.

The gain is measured as a function of the pump power with the for signal strength of the 1550 nm radiation as parameter. If the pump power exceeds a certain value, the EDFA start to work as laser and falsifies the gain measurement.

LT-0300 Erbium doped Fibre Amplifier EDFA consisting of:

Item	*Code*	*Qty.*	*Description*	*Details page*
1	CA-0060	1	Infrared display card 0.8 -1.4 µm	127 (10)
2	CA-0450	3	BNC connection cable 1 m	130 (28)
3	DC-0040	2	Diode laser controller MK1	121 (4)
4	DC-0164	1	InGaAs Photodetector ST with connection leads	123 (18)
5	DC-0380	1	Photodetector Junction Box ZB1	125 (30)
6	MM-0020	3	Mounting plate C25 on carrier MG20	93 (1)
7	MP-0130	1	Optical Bench MG-65, 300 mm	93 (7)
8	MP-0150	1	Optical Bench MG-65, 500 mm	93 (8)
9	OC-0430	1	Fibre jacket in C25 mount	100 (21)
10	OC-0760	1	Laser line filter 1550 nm in C25 mount	102 (42)
11	OC-2010	3	ST/ST SM Fibre patch cable, length 0.25 m	107 (81)
12	OC-2020	1	ST/ST SM Fibre patch cable, length 1 m	107 (82)
13	OC-2230	1	Erbium doped fibre unit, ST terminated, length 16 m	108 (91)
14	OC-2300	1	SM-WDM coupler 980/1550 nm unit ST terminated	108 (91)
15	OM-0540	1	Diode laser module 980 nm, ST fibre connector	113 (23)
16	OM-0550	1	Diode laser module 1550 nm, ST fibre connector	113 (24)
17	UM-LT03	1	Manual EDFA	
	Required Option (order separately)			
18	CA-0200	1	Oscilloscope 100 MHz digital, two channel	128 (19)

Highlights

Advanced and top level ★★★ experiments

Outstanding features for an all fibre coupled Erbium doped fibre amplifier

Intended institutions and users:
- Physics Laboratory
- Telecommunication
- Engineering department
- Electronic department
- Biophotonics department
- Chemistry department