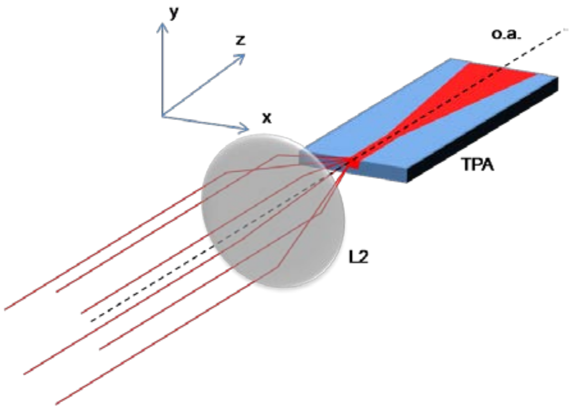
Alignment of a DFB MOPA System with DFB TPA Configuration



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1 Introduction

This application note deals with the setup and alignment procedure of a master oscillator power amplifier (MOPA) system. The master oscillator, also called a seed laser, is a distributed feedback laser (DFB) and the amplifier is a tapered amplifier (TPA). Both lasers are included in our portfolio which can be found on our homepage.

To our knowledge the best alignment procedure for a MOPA configuration is based on a standard method using a pair of mirrors and irises. However, sophisticated alignment methods are required during the adjustment of the TPA to the focused seeding beam of the DFB. In this application note we describe both the basic alignment procedure and the tricky procedure of aligning the TPA to the seeding beam.

If you already have a collimated free-beam seeding laser, skip Section 3.1. If you are familiar with the basic alignment procedure using a pair of mirrors and irises, continue with section 3.4, where the alignment of the TPA to the seeding beam is described. The last chapter describes the method for determining the optimum seeding power.

2 Setup

Figure 1 shows a schematic view of the MOPA system. The DFB beam is collimated with lens L1, guided via two mirrors DM1 and DM2, and finally focused with lens L2 to the TPA. An optical isolator is placed between L1 and DM1 in order to avoid disturbing back-reflections between the DFB and the TPA.

For collimation of the amplified laser beam, a pair of lenses, L3 and CL, enable the intrinsic astigmatism of the TPA to be corrected. The two irises are not shown in the figure.

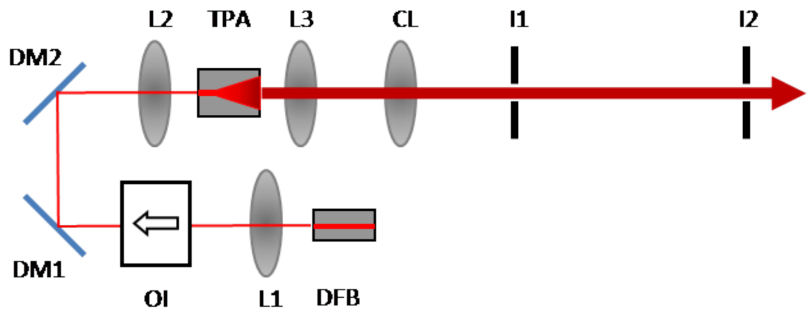

Figure 1: Setup of a seeded TPA

Abbreviation	name	recommended values	degree of freedom*
DFB	distributed feedback laser	see eagleyard portfolio	-
L1	aspheric lens	*f* = 8 mm, *NA* = 0.5	*xyz* translation
OI	optical isolator	> 50 dB	-
DM1, DM2	broadband dielectric mirror	*R* > 99 %	two-axis tilting
L2	aspheric lens	*f* = 8 mm, *NA* = 0.5	*xy* high-precision translation
L2'	aspheric lens	*f* = distance between L2' and second iris	
TPA	tapered amplifier	see eagleyard portfolio	*xyz* translation
L3	fast-axis collimating lens	*f* = 11 mm, *NA* = 0.3	*xyz* translation
CL	slow-axis collimating cylindrical lens	*f* = 300 mm	*xyz* translation
I1, I2	irises with variable aperture		

*The *z* axis points in the direction of beam propagation, the *x* axis is parallel to the optical table and perpendicular to the *z* axis.

All optics must have antireflection coating. The direction of polarization of the DFB must correspond to the direction of polarization of the TPA as specified in our data sheets.

3 Alignment

3.1 Seed-laser

We achieve the best results by seeding the TPA with our own laser, due to the nearly identical dimensions of their active regions. Hence, a 1:1 magnification is sufficient for an efficient coupling.

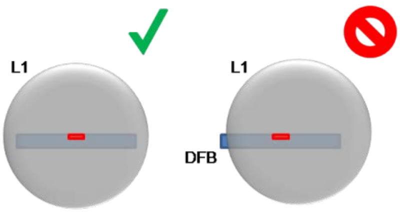

Figure 2: Alignment of the collimating lens in front of the seed-laser.

For high coupling efficiency, precise imaging of the active region on the front facet of the DFB to the active region on the rear facet of the TPA is required. When an aspheric lens is used, the main optical aberrations stem from the misalignment between the active region of the DFB and the lens L1, as depicted in Figure 2. It is therefore crucial to place L1 directly in front of the active region of the DFB.

In order to achieve straight propagation of the beam, the threaded holes of the optical table can be used as a reference, as shown in Figure 3. For this purpose, the seed-laser should be mounted on a steady mount, its position being predetermined by the geometry of the mount.

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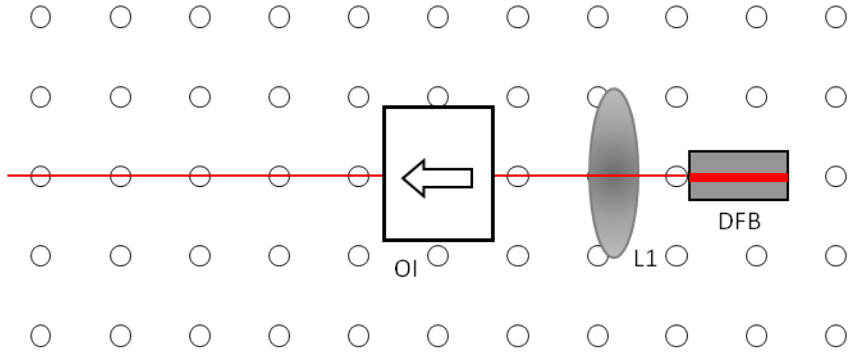

Figure 3: Propagation of the seeding beam along the threaded holes of the optical table

A defined propagation of the beam as described above can be accomplished by placing L1 in front of the DFB at the distance of its focal length (8 mm), then adjusting L1 in directions *x* and *y*. Collimate the beam by moving L1 in a *z* direction. The size of the beam directly beyond L1 must be the same as it is about three meters away from it.

3.2 Optical axis

The core idea, vital to the alignment procedure, is the combined adjustment of the collimated DFB beam, focusing lens L2 and the TPA on an optical axis. The optical axis is set by two irises that should be placed at a distance of about 1 m to each other along the threaded holes of the optical table at exactly the same height.

After the DFB beam has been collimated as outlined in Section 3.1, place the optical isolator inside the course of the beam directly after the collimating lens L1. Place the mirrors at an angle of 45° as in Figure 1. The distance between mirrors should be about 20 cm.

Depending on the application, put the first iris either between the second mirror DM2 and the focusing lens L2 or behind the place where the TPA will be located. Make sure to leave enough space behind the irises for a detector.

Turn on the DFB laser and set the optical power to 10 mW. Set the aperture of the second iris to 3 mm and proceed as follows to align the collimated beam to the optical axis:

1. Diminish the aperture of the first iris to about 3 mm.
2. Place the detector behind the first iris.
3. Tilt the first mirror to direct the DFB beam into the first iris. Adjust to maximum power.
4. Open the first iris and place the detector behind the second iris.
5. Tilt the second mirror to direct the DFB beam into the second iris. Adjust to maximum power.
6. Continue with step 1 until the DFB beam matches the optical axis.

For rough adjustment use a laser viewing card instead of a photo detector.

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3.3 Focusing lens

Users should place the focusing lens L2 at the optical axis on a lens mount with *xy* translation which allows the lenses to be exchanged. The position of the mount after lens exchange must be maintained (e.g. an *xy* translator with a tube system can be used for this purpose).

At first, mount lens L2' with a focal length that corresponds approximately the distance between L2 and the second iris. Turn on the seed laser and change the *x* and *y* positions of L2', thus adjusting the center of the divergent beam to the second iris. Then exchange L2' for L2.

3.4 Tapered Amplifier

Place the TPA at a distance slightly greater than the focal length of L2.

We recommend that users start the adjustment by disconnecting the current cable from the TPA-driver and connecting it to an ammeter, thus using the TPA as a photo detector. Operate the ammeter with a sensitivity in the nano ampere range. Turn on the cooling of the TPA to prevent later thermal expansion during regular operation of the TPA.

Move the TPA in the *x* and *y* directions (see Figure 4), trying to get a current signal on the ammeter. Maximize it by moving the TPA in the *x* and *y* directions. Repeat the following two-step alignment until a photocurrent I_{ph} of more than 1.5 mA is reached.

1. Move the TPA along the *z* axis in toward L2 while monitoring the ammeter. When the TPA-current starts to decline, stop the motion.
2. Maximize I_{ph} by moving the TPA in the *x* and *y* directions.

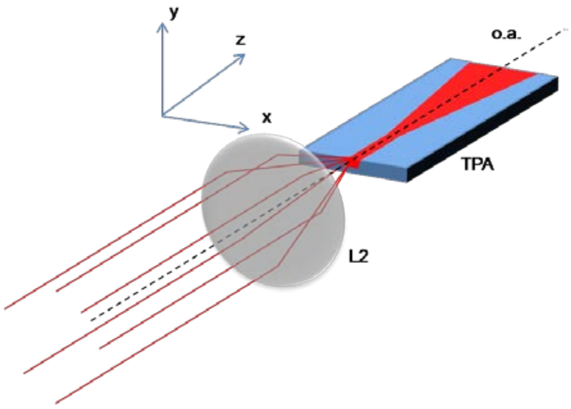

Figure 4: Alignment of the focused DFB-beam to the TPA. OA = optical axis.

Although a high TPA photocurrent can be reached this way indicating a high coupling efficiency, it is likely that the seeding power is not directly coupled into the ridge section of the TPA. Figure 5 shows measured values of I_{ph} while the position of the TPA is being moved in an *x* direction.

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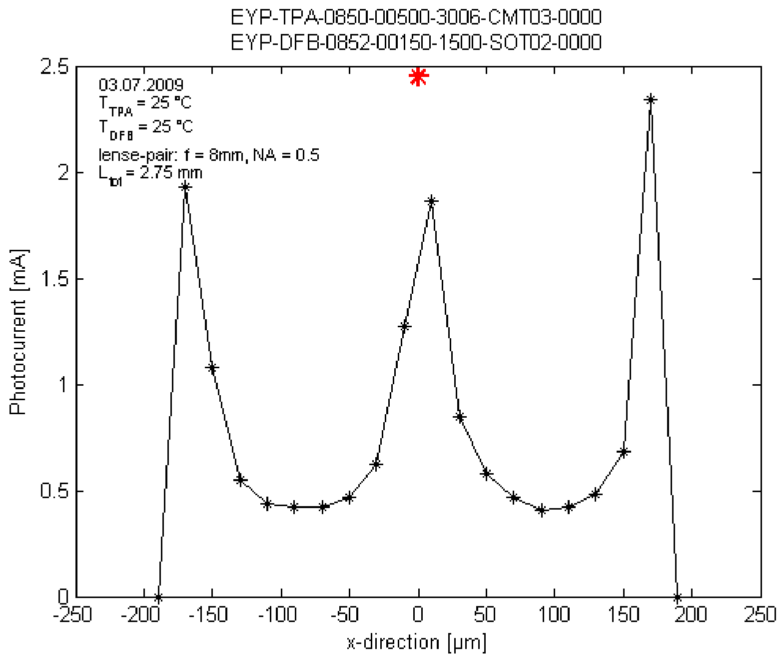

Figure 5: Photocurrent against x-direction.

The data shown in Figure 5 was obtained by moving the TPA in 20 µm steps in the *x* direction. After every step the current was maximized by changing the *y* position of the TPA. The maximum photocurrent was reached after final alignment at *x* = 0 µm (red star). The distance between the right and the left peak may vary between 350 µm and 550 µm depending on the type of TPA being used.

Proper alignment is only achieved at the central peak. Repeat the following alignment steps until the photocurrent remains at less than 20 µA after adjustment in the *y* direction:

1. Move the TPA in the *x* direction until I_{ph} declines to about 20 µA.
2. Maximize I_{ph} by moving the TPA in the *y* direction.

Note the *x* value and repeat the alignment in the opposite *x* direction. Obtaining the second *x* value that way, calculate the optimum *x* position of the TPA by dividing the difference between the obtained values by two.

$$x_{\mathrm{optimum}} = \frac{x_{\mathrm{right}} - x_{\mathrm{left}}}{2}$$

Move the TPA to $x_{optimum}$ and proceed with the final photocurrent adjustment analogous to the two steps shown at the beginning of this chapter. Depending on the type of TPA being used, a maximum photocurrent of 2...5 mA should be reached at a seeding power of 10 mW.

Connect the TPA back to the power supply and set the TPA current to 700 mA. Place a FAC lens and a photo detector in front of the TPA for power adjustment. Turn on the TPA driver and use the *xyz* axes for power adjustment. The next step is to increase the current by 500 mA and readjust the *xyz* axes of power adjustment. This procedure should be repeated until the desired power has been reached.

Then increase the TPA current to the desired value and conduct the final power adjustment using the *xyz* axes of the TPA mount.

4 Seed power and saturation

Since the alignment process of seeded TPA is relatively sophisticated and time consuming, and the characteristics vary with different types of TPAs, we measure only random TPA-samples for their saturation characteristics.

Figure 6 shows the TPA-power against seed-power in the range of 0...50 mW.

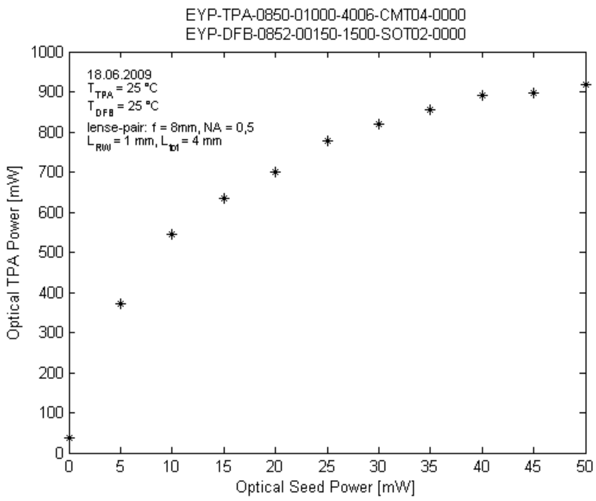

Figure 6: TPA power against seed power:

The operational current of the TPA was set to 2.5 A.

For high operational efficiency and lifetime considerations we recommend measurement of the saturation characteristic in the range of 0...50 mW. Saturation is reached when the slope stops to change significantly - in the example above at about 45 mW.

5 Abbreviations

DFB	distributed feedback laser
TPA	tapered amplifier
MOPA	master oscillator power amplifier
FAC	fast axis collimation

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