APPLICATION NOTE ***ES 9901***

ALIGNMENT OF FIBRE ARRAYS TO WAVEGUIDES

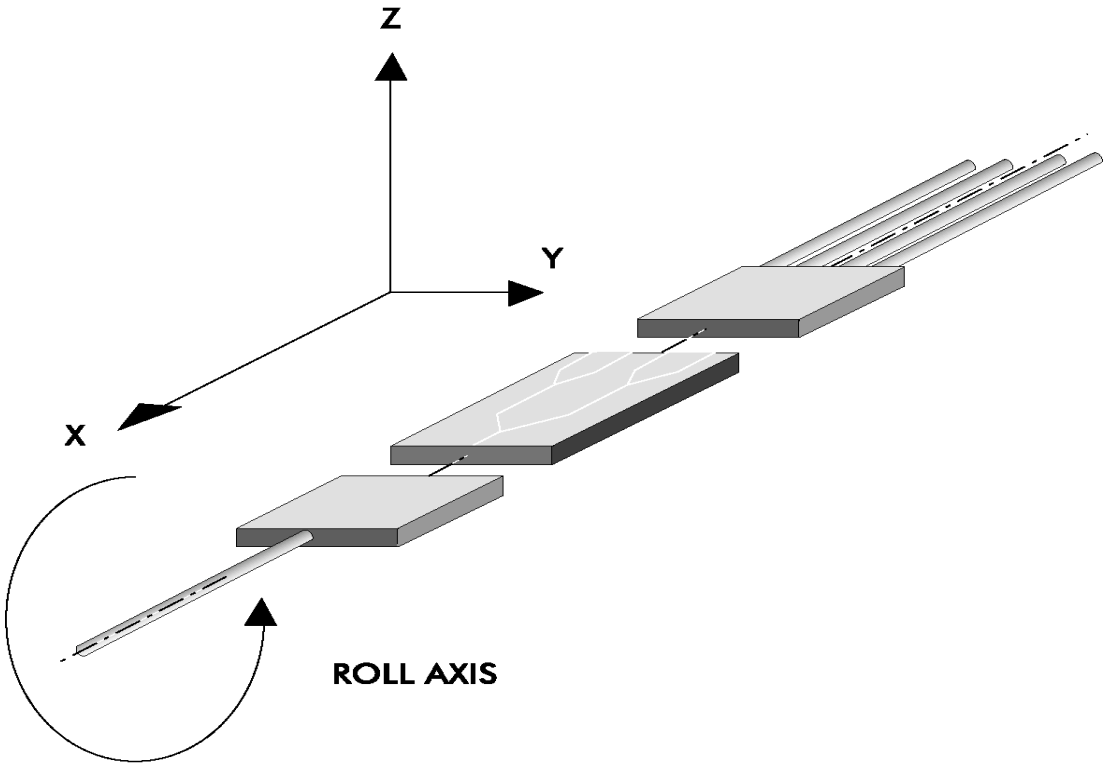
Introduction

The Elliot / Martock range of positioners has been developed to solve a wide range of alignment tasks, particularly those involving single mode fibres and waveguide geometries. The usefulness of the range is extended by the DALI E-2400 Device Alignment Instrument which allows the linear axes to be automated over the range of travel of the attached piezo adjusters.

Specific systems such as the MDE 881 Waveguide Manipulator have been developed in collaboration with industry professionals to offer a versatile platform for a wide range of fibre-waveguide alignment tasks. For some applications however, it is more appropriate to build up the alignment system using a combination of stages and axes.

Application Geometry

The application considered here involves aligning fibre arrays to the input and output of a multi-port waveguide device such as a passive splitter:



Obviously both the input and output fibre arrays need XYZ linear travel to align them to the central device, but in this configuration rotation axes also need to be considered. Pitch and yaw are both required to set the end face of the fibre array parallel to the end facet of the waveguide substrate. Roll is also useful and can be used actively as part of the alignment process.

Two strategies are commonly used for active alignment of this type of component.

Integration Method:

An optical signal is injected into each of the input fibres simultaneously. All of the output ends of the output fibres are gathered together and directed into an integration sphere.

The alignment is done on both the input and output starting as an XYZ alignment while the total integrated output is measured. Once a maximum value has been reached the rotation axes can be adjusted to peak the signal further.

Roll Method

This technique is more controlled than the Integration Method and involves the following steps:

Fibre arrays are mounted so that one of the fibres is on the roll axis of the positioning stage.

Light is injected into one input fibre only - this should be the fibre on the roll axis.

An alignment is done in XYZ of this input fibre and the corresponding output fibre.

Once the output power in this fibre pair has been optimized, a second optical signal is injected into a fibre pair on the other side of the array.

Using the roll axis this second pair are aligned while the original pair are held in linear alignment on the roll axis. The DALi aligner is an ideal choice for this application as it can actively hold Pair 1 in alignment while the second pair are rolled into place.

This technique relies on the fact that the waveguides themselves and the fibre arrays are fabricated in a manner which gives them similar tolerances on the spacing.

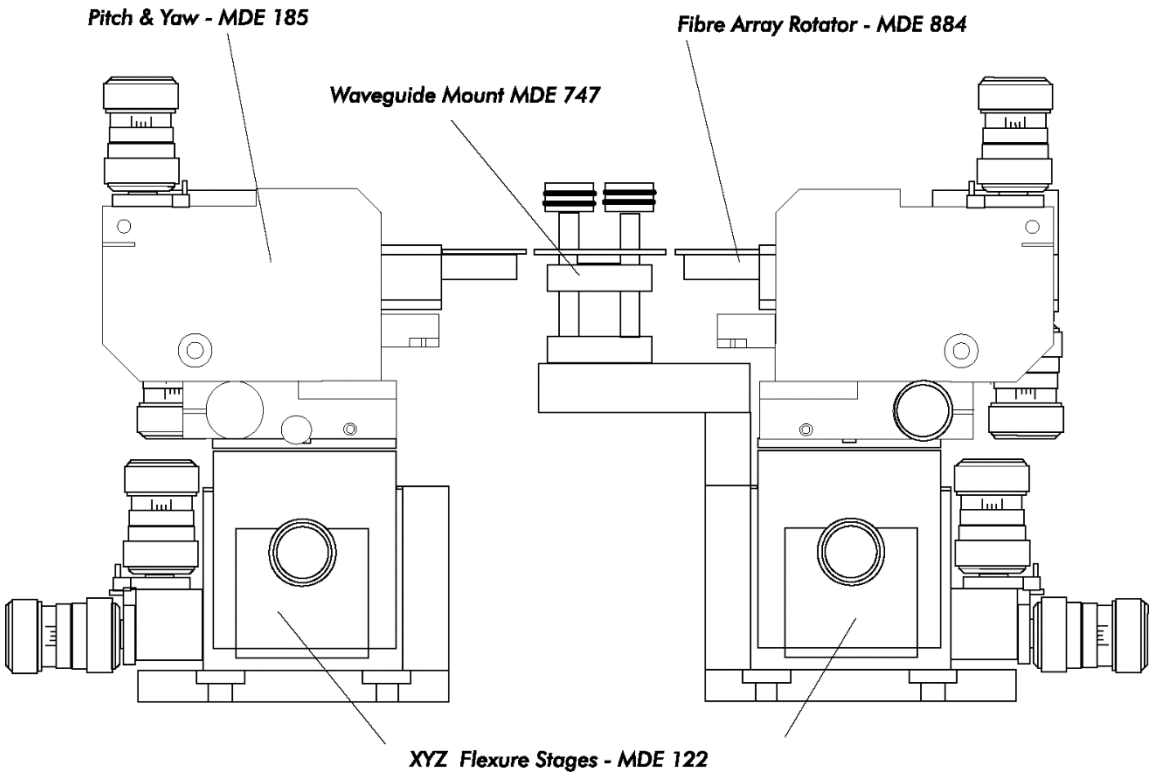
To work with either one of these techniques 6 axes of positioning are required on both the input and output fibres.

The waveguide itself should not require any movements unless the substrate is deformed and cannot sit flat on its mount or the device is being aligned in a package, in which case the chip may be bedded down on epoxy and therefore not sitting flat. The waveguide can be mounted on either a rigid bracket or a waveguide mount with adjustment.

If several devices are to be tested on a wafer then the middle stage can also be fitted with a long travel Y stage to traverse the wafer past the fibre arrays and bring each device into alignment.

Recommended Positioners for this Alignment

The following positioners from the Elliot / Martock range are recommended for this application. The schematic diagram below shows the base system configured for alignment to waveguides less than 30mm in length.



MDE 122

XYZ travel of 2mm is provided on the input and output fibre using the MDE 122 flexure stage. Using our patented flexure construction this stage is rugged, has excellent repeatability, is immune to dust & dirt ingress, and does not require lubrication.

Any of our adjusters with a 12mm barrel can be fitted into this stage. The base level system for this application uses the patented MDE 216 adjusters. These have 300µm of fine drive with 20nm resolution and a locking coarse drive.

If "hands-off" operation is required on the linear axes then the MDE 218 piezo adjusters are recommended instead of the MDE 216 adjusters. These have 25µm travel with 10nm resolution. A flexure stage fitted with 3 x piezo adjusters is known as an MDE 123.

As the adjusters are all user replaceable then it is feasible to start with manual adjusters and swap them out for piezo at a later date.

Left and right handed versions of the MDE 122 are available by appending LH and RH to the part number. This allows the alignment system to be configured with all adjusters facing the user.

MDE 185

Pitch and Yaw motions are provided by the MDE 185 which clamps on top of the flexure stage using a dovetail plate.

This positioner is unique in that both rotation axes are centred on a common point 26mm in front of the top plate of the stage. If the fibre array is held so that the front face coincides with this point then the rotations will both be centred correctly.

The stage includes a mechanical indicator to assist setting the tip of the fibre array at the rotation centre.

The basic MDE 185 uses MDE 216 high precision mechanical adjusters. Piezo adjusters can be fitted if required but the useful range of remote adjustment is less than 2 arc minutes.

MDE 884

The ribbon arrays are held in MDE 884 ribbon-rotators which add +/- 4° of roll adjustment to the stage. This positioner is also designed so that the end of the fibre array can be placed at the common rotation point.

This positioner allows the roll alignment as described above.

When this stage is ordered a channel is cut along the length of the aluminium tip specific to the dimensions of the customer's fibre array, which helps locate the array on the optical axis.

The combination of MDE 122, MDE 185, and MDE 884 places the fibre array on an optical axis of 125mm.

Waveguide Mount

Several options are available for mounting the waveguide.

MDE 741 is a simple flat platform designed to place the substrate at the optical axis height.

MDE 742 is the same but the substrate is held down using a vacuum.

MDE 743 uses a mechanical clamp to hold the substrate down.

These are all available in 3 standard lengths - 10mm, 14mm and 30mm.

If the substrate actually requires some adjustment then MDE 747 is recommended. This holder is a kinematic mount with height, roll, and pitch adjustment plus a sliding plate to locate the device parallel to the optical axis.

Whichever version is chosen, it can be screwed down onto an MDE 147 plate.

If the waveguide is shorter than 30mm then this MDE 147 can be mounted on the front fixed pillar on one of the flexure stages using an MDE 190 riser block to get the optical axis height correct.

For longer waveguides the MDE 147 should be mounted on an MDE 189 L-bracket with the MDE 190 riser block. This creates a free standing fixed mount which can be placed anywhere between the flexure stages.

Applications where more control of the actual waveguide can be built up using the MDE 883-25 as the central platform. This is the free-standing version of the central platform of the MDE 881 waveguide manipulator and includes all 3 rotation axes, height adjust and the ability to move the waveguide 25mm drive by a digital micrometer. This can read to 1μm and so is useful for stepping between adjacent guides.

Automatic Alignment Using Dali4

For hands-off adjustment of the linear axes MDE 218 piezo adjusters can be fitted to the flexure XYZ stage. These have 25μm of useful range and can be driven "manually" using the E1100 piezo controller or by the DAli E-2400 for automated operation.

DAli combined with our E1100, 3 channel piezo driver allows automatic alignment and a USB interface for connection to a PC. Software drivers are available for National Instruments LabVIEW ™ and LabWindows CVI ™ control languages.

An optical detector is required to couple the optical signal into the unit. DAli is designed to work with most detectors and power meters.

In an automatic alignment DAli has 3 main operating stages:

SEARCH	Fibre is scanned vertically and horizontally in 2 axes mapping out a square area 25μm x 25μm to find some signal. Once a signal greater than threshold is located the unit switches to:
TRACK	Fibre is now continuously dithered in an elliptical pattern. The gradients of the optical signal are measured using an algorithm known as a "Conical Scan". DAli interprets these signals and adjusts the piezos accordingly to track the optical signal peak.
HOLD	Once a signal is tracking it is usual to switch into a Hold mode where the fibre stops scanning and is held onto the signal peak. At this point a measurement can be made or the latter stages of an epoxy cure can take place.

For an alignment in and out of a waveguide 2 x DAli's can be used together off the same optical signal. These are set with the dither signals running at different frequencies so that each stage can be driven separately.

In the particular application of aligning fibre arrays to a waveguide DAli is used for the following :

Acquire and align the first fibre pair (on roll axis).

Leave tracking this pair while light is injected through the opposite pair and the roll movement is made to align them. This actively fixes the roll axis pair in place while the outer pair are being manipulated.

Alternatively Dali 4 can be used in the Integration Method to align and optimize the integrated signals.

Equipment List

Manual System

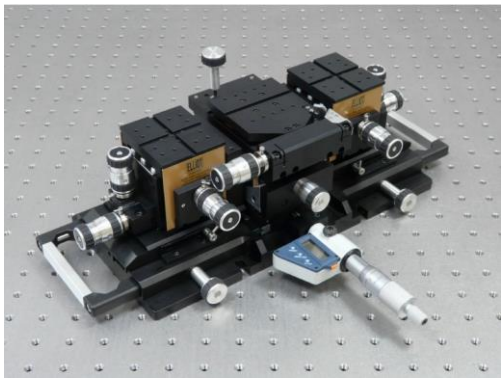
MDE 122 LH
MDE 122 RH
MDE 185 x 2
MDE 884 x 2
MDE 147
MDE 189
MDE 190
Choice of waveguide mount

Automated System

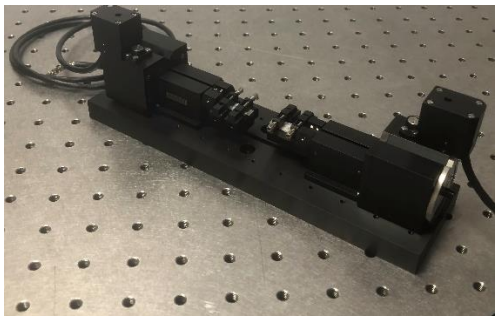
MDE 123 LH
MDE 123 RH
MDE 185 x 2
MDE 884 x 2
MDE 147
MDE 189
MDE 190
E1100
DAli
Choice of waveguide mount

Full system options include :

Dali 4- Automated fibre/ device alignment system



MDE881- workstation for 6 axis manipulation



MDE235/ E22891 Dual fibre rotation system for PM fibre applications