Application Note: Motion & Sensing 21

Fiber Alignment with Micrometer Precision

Multi-Axis Positioning using a 5 Degree of Freedom attocube Positioner Stack

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Introduction

The expansion of telecom networks and the ubiquity of consumer electronics is pushing the photonics industry to further miniaturization. For optical data transmission fibers need to be attached to a wide variety of optical, photonic, and electronic modules. The precise alignment in all Degrees of Freedom (DOF) is the only method to ensure high and reliable light transmission between the ever more complex components. Therefore, highest precision in multi-axis movements, which is directly related to the system's noise level, repeatability, and stability (over time), is required for the assembly of photonic devices. Suitable positioning solutions can be created by stacking attocube's modular EC* series positioners to create highly precise multi-axis solutions. Since the EC* series positioners can be driven in coarse as well as fine positioning modes, the fiber can be quickly moved to the desired position on a mm level and then be adjusted on a nanometer level with the highest precision. Another advantage of piezo driven positioners is their long-term stability, enabling a specific position to be held for an extended period. The positioners make it possible to reliably align two micro-sized fiber cores to each other. Such an application example using EC* series positioners is shown in Figure 1.

Figure 1: An application example is shown: an x- and y-positioner stacked with a goniometer (movement around z-axis) and a tilted rotator are used to align two fiber ends such that the light is coupled.

We conducted the following measurement to demonstrate the possibilities of a multi-axis stack for fiber alignment, leading to this Application Note.

Setup

Figure 2 shows a comparable application setup to make the measurements. The setup consists of a 5 DOF – stack including xyzθr-positioners (ECSx5050/NUM/RT, ECSz5050/NUM/RT, ECGt5050/NUM/RT, ECR5050hs/NUM/RT), along with a fiber optic cable secured to the adapter plate which is mounted to the top of the rotator. One end of this fiber cable is connected to the detector. The second fiber cable, which is connected to the signal source, is secured to another adapter plate, which is mounted to the top of a separate fixture.

The IDS3010 laser, with a wavelength of 1530 nm, was utilized as the light source and it generated the initial optical signal. We used a Thorlabs optical power meter for the detector.

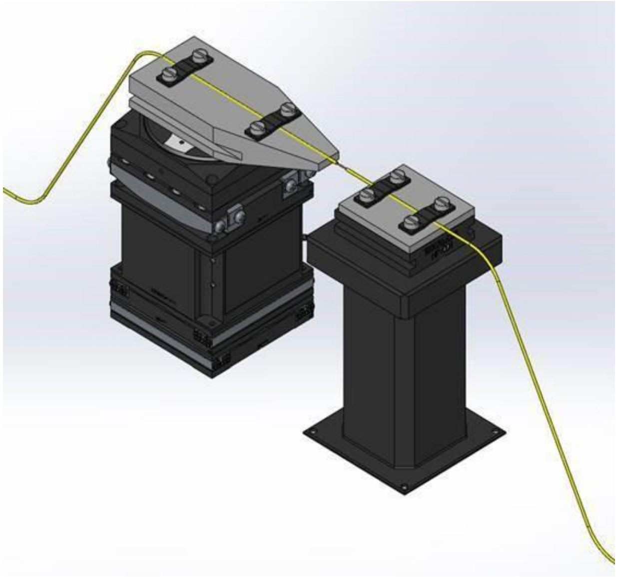

Figure 2 Measurement Setup: A 5 DOF stack including xyzθr-positioners was used to scan the intensity of the coupled signal. The detector measured the intensity over a range of displacements and then the intensities were plotted as a function of the displacements.

Alignment and Execution

The goniometer and rotator positioners were used to align the two fiber ends to be parallel to each other, as shown in Figure 2. We then used the x positioner to adjust the distance between the fiber ends. The starting distance was defined as $x = 0$, which corresponds to a distance of a few µm between the fibers. Next, we used the y and z positioners to roughly align both fiber ends to the same height and horizontal position.

A scan of the x-, y-, and z-positions lead to the optimal coupling efficiency. The intensity was recorded during a scan over the y-z plane. The total range covered by y and z was 30 µm in each direction. The resolution of the scan was set to 2 µm, since the diameter of the fiber core was 9 µm. Of course, the resolution

can also be set to as low as a few nanometers. The entire y-z scan was repeated after each of two 100 µm x direction steps, separating the fibers, showing the decrease in overall signal.

Measurement Results

After the scan was finished, it was visualized and evaluated by displaying the intensity of each 2 µm pixel over the entire scan range, Figure 3. The results show the effective fiber coupling in the middle (bright spot), with a size that is approximately half of the diameter of the fiber core ≈ 9 µm. The fiber coupling reduces further with increasing distance from the center and with increasing distance between the fiber ends. The resolution could be improved down to a few nanometers with the EC* series positioners from attocube. As shown, the 5 DOF stack is perfectly suited for fine scanning over an specific area and finding the position of transmission for the fiber coupling.

Conclusion

The 5 DOF stack proved to be a suitable tool for fiber alignment applications. Another goniometer can be added to provide a 6 degrees of freedom (6 DOF) stack, allowing for a scan over all possible necessary axes in case of the alignment of microstructures. With movements as small as a few nanometers, attocube's EC* stages are perfectly suited for fiber alignment or the alignment of microstructures. Furthermore, even higher precision can be achieved by utilizing attocubes's IDS3010 interferometer as a closed loop sensor (read more in our AppNote Interferometric Closed Loop Piezo Positioning).

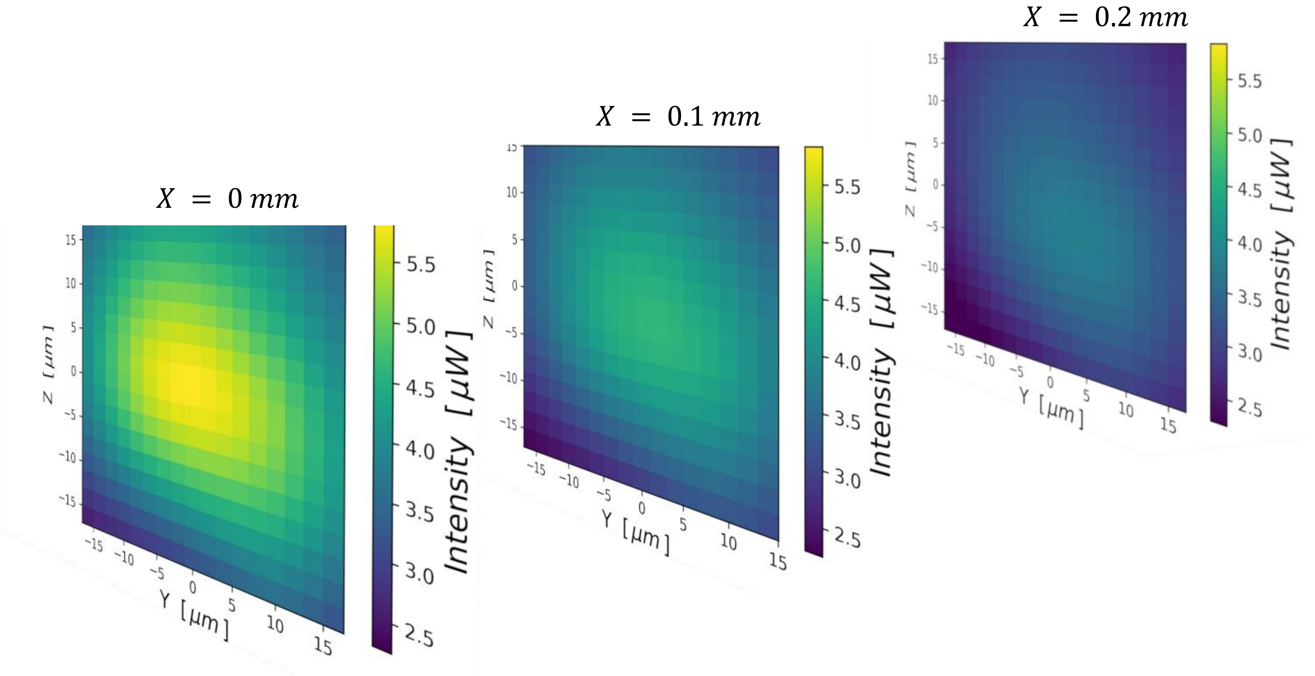

Figure 3: The measurement results are visualized and evaluated by displaying the intensity of each 2 µm pixel over the entire scan range. The results show the effective fiber coupling in the middle (bright spot), with a size of approximately half of the diameter of the fiber core ≈ 9 µm.