attocube WITTENSTEIN Group

Beam Steering with Customized Positioners

xzθr-Application with attocube's Nanopositioners

Thomas Ch. Hirschmann, Gregor Schindler, Isabel Greisberger, and Mark Braun
attocube systems AG, Eglfinger Weg 2, 85540 Haar, Germany

Introduction

One of the key challenges for the semiconductor industry is achieving the highest levels of precision for positioning applications. Industry requirements include accurate wafer positioning, as well as ultra-precise adjustability of the laser beam path. Therefore, the optical components including polarization filters, lenses, and mirrors, must be controlled very precisely with 6 degrees of freedom (DOF). For example, in deep ultraviolet (DUV) wafer inspection tools, a large number of nanometer (nm) adjustable linear positioners and micro radian (µrad) adjustable goniometers and rotators are required to enable sufficiently accurate defect inspection. In addition to these nm- and µrad-scale accuracy and repeatability requirements, these positioners must meet challenging requirements such as high stiffness with high resonance frequencies. attocube offers a large variety of positioners for ultra-precise beam steering applications in ambient conditions, as well as extreme environments such as ultra-high vacuum (UHV).

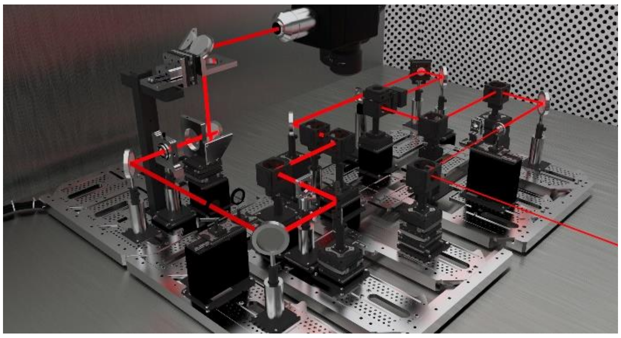

Figure 1: A schematic laser beam adjustment setup with multiple optical components, as for example lenses and filters mounted on attocube positioners, is shown.

Figure 1 highlights a possible beam steering application in which attocube positioners are utilized to place multiple optical filters and lenses which align and shape the laser beam.

attocube manufactures a variety of standard positioners that meet the needs of most customer applications, but some unique applications require customized positioners or testing in order to satisfy the setup and measurement requirements. attocube designs and manufactures an assortment of customized positioners to meet these needs. Customizations can range from specific testing of a single positioner to qualification of a stack of combined positioners in order to learn about the sample location and optical component behaviors. attocube's test measurement setups include ambient conditions as well as UHV chambers. attocube can also provide

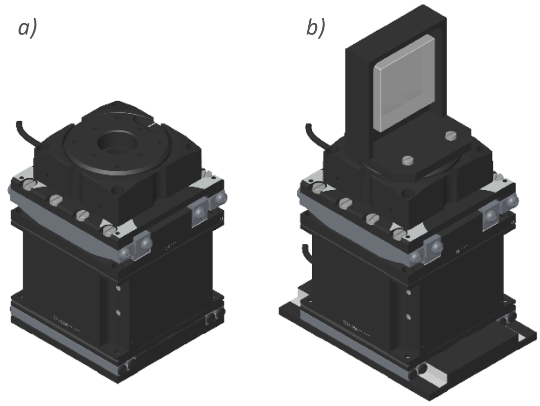

Figure 2: On the left, a standard positioner stack is shown. On the right, the customized equivalent for the requested customer application is shown.

services including loan kits, in-house and remote product trainings, and on-site installation support.

This Application Note details the measurement results of one such customized test setup with an xzθr-stack. The positioners in the stack included two translational stages (ECSx and ECSz), one goniometer (ECGt), and a rotator (ECR). Figure 2 shows the standard xzθr-stack on the left. On the right, the customized stack included a modified ECSx positioner with a larger base, providing higher stiffness and meeting additional customer requirements. A customer-supplied mirror was mounted to the top of the rotator.

In conjunction with the customer, our Application Development Team also made test measurements on the customized xzθr-stack in order to determine the positioners settling time after 3 µm and 80 nm movements. The following section provides a summary of the measurement setup and the results of this unique customer-specific investigation.

Setup

The goal of the test measurements was to characterize the settling time for different motion events of the customized 4 DOF positioning stack, displayed in Figure 2b. The stack included individual attocube positioners for translation in x- and z-axis, as well as for the rotation around the y- and z-axis. A detailed list of the positioners is included in Table 1.

Table 1: Positioning xzΘr-stack configuration from bottom to top.

Positioner Type and Model		Description
x	ECSx-T5050-B5070 /Al/NUM/RT/Cust	Customized linear positioner stage with a 50 mm long moving top table and a 70 mm long affixed base table
z	ECSz5050/Al/NUM/RT	Standard z-positioner
θ	ECGt5050/Al/NUM/RT	Standard goniometer
R	ECR4040/Al/NUM/RT	Standard rotator

Beam Steering with Customized Positioners

xzθr-Application with attocube's Nanopositioners

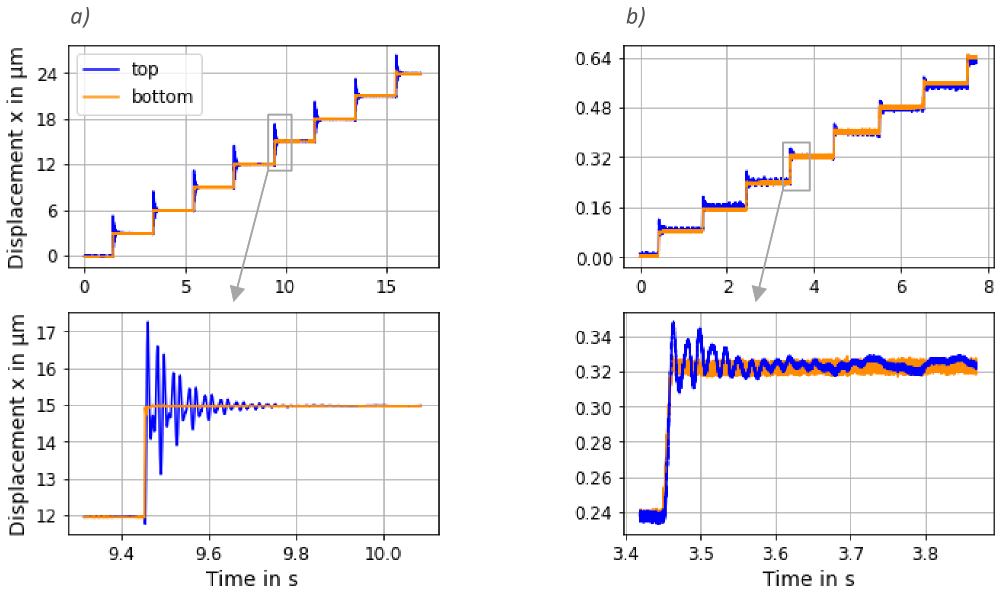

Figure 3: Interferometric measured displacement data of the bottom mirror (orange curves; ECSx-T5050-B5070) and the top mirror (blue curves; customer mirror holder) with a) 3 µm and b) 80 nm movements. The zoom-in graphs highlight the settling times.

The customer-provided mirror holder with a high-quality mirror was mounted on top of the xzθr-stack, adding an additional weight of around 300 grams. Another mirror was attached to the moving top table of the base ECSx-T5050-B5070 positioner. Then we used an attocube IDS3010 interferometer, in combination with two stationary sensor heads (D4/F17/RT), to simultaneously track the displacements of these two mirrors. The IDS3010 allows displacement and vibration detection with picometer resolution, nanometer accuracy, and MHz real-time data outputs. For these test measurements, the IDS was set to a sampling rate of 50 kHz.

Measurement Results

The customer defined settling time for both mirrors as the necessary waiting period after an 80 nm movement until a position stability of less than ± 10 nm oscillation. Respectively, the criteria was set to ± 20 nm for a 3 µm move. Figure 3 depicts the displacement data of the bottom mirror and top mirror after a) 3 µm and b) 80 nm move of the ECSx-T5050-B5070 positioner. Differences of the position settling mechanisms of both mirrors was observed, with expected significantly smaller oscillations at the stack base. Also, the larger settling time for larger moves is due to the working principle of the xzθr-stack. The 3 µm and 80 nm movements were achieved with the closed loop mode. For the 80 nm moves the controller adjusts the constant DC voltage (fine positioning) that was applied to the piezo drive. For the 3 µm movements the positioner performs steps according to the slip-stick principle (coarse positioning), with significant voltage changes of up to 45 volts and afterwards using the fine positioning to approach the target position. These higher excitations corresponded with higher oscillations. The analysis of several movements resulted in an average settling time of 0.39 s for the 3 µm and 0.05 s for the 80 nm movements, which was significantly below the customer's requirement.

Moreover, we analyzed resonance frequencies, jitter characteristics, power-off behaviors, pitch-yaw-roll properties, and lateral runouts of other requested individual positioners and positioner stacks. These results are important for each individual application.

Conclusion

The test measurement focused on the average settling time of the customer's setup, aiming for the optimization of positioning routines. This Application Note highlights five main messages:

1) Our positioners have several advantages for beam steering applications, such as precise 6 DOF positioning for ambient and extreme environmental conditions.
2) Standard positioners can be customized to customer needs.
3) attocube offers various services such as, for example, test measurements.
4) The measurement results showed that the positioner's moving table reaches the settled state within a few tens of milliseconds. Importantly, the settled state at the actual point of interest, *i.e.* the sample location on top of the customer's requested stack, takes on average 0.39 s for 3 µm movements and 0.05 s for 80 nm, respectively.
5) The IDS3010 interferometer provided detailed measurement results that helped to pre-test the stack configuration for the customer application.