POSITIONING STAGE

This application claims the benefit of U.S. provisional application No. 60/140,066, filed Jun. 21, 1999 and No. 60/180,966, filed Feb. 8, 2000.

TECHNICAL FIELD

The present invention relates to positioners for positioning objects, and more particularly to a deformable positioning stage.

BACKGROUND ART

Assembly of optic-electronic devices requires precision alignment of optical fibers with lasers or sensors and then bonding. A worker looking through a microscope at the end of a fiber conventionally executes this precision alignment and bonding process.

The alignment and bonding process can take as little as five minutes. However, if there is a misalignment of the fiber ends, this process can take as long as forty-five minutes to an hour. Misalignment often occurs because the fibers are subject to other than pure linear movement during the alignment process. Accordingly, a need exists for an improved alignment process which will reduce, if not eliminate, misalignment of a fiber end.

It is likely that in the next ten years the use of opto-electronic devices will spread to automobiles and every phone and computer manufactured in the United States, resulting in an estimated volume of 25 million units produced per year. Conventional assembly of opto-electronic devices can, as discussed above, require substantial worker time and therefore be quite costly. Accordingly, a need exists for a way to assemble opto-electronic devices which would require less worker effort and hence reduce the cost of assembly.

In other fields, delicate precision micrometer, sub-micrometer and nanometer assembly or positioning is also required. Such fields include medicine, biotechnology and electronic manufacturing. For example, individual atoms, molecules or nano-particles may be combined or separated to build materials and devices exhibiting desirable properties. Positioning devices currently available do not provide the precision and range of motion required in these and other technological fields. Accordingly, an improved technique is required for performing precision movement, often referred to as fine movement, at each of the micrometer, sub-micrometer and nanometer levels.

A planar biaxial micropositioning stage, which includes a deformable structure micro-positioning stage and which utilizes two nested cantilever flexure mechanisms facilitating movement of the stage in each of the X and Y axes has been proposed for use in precision manufacturing. A force can be applied to the proposed structure by an actuator to move the stage along the intended axis of movement. The actuator placement in this positioner is perpendicular to the axis of movement of the stage. However, the resulting movement in each of the X and Y directions is not purely linear. Rather, the proposed structure introduces a yaw which is unacceptable for precision manufacturing applications. This yaw is often referred to as a rotational cross talk error.

Known prior art positioning devices cannot eliminate rotational cross talk unless additional actuators are included in the device to apply counterbalancing rotation and thereby ensure pure linear movement. These actuators add undesirable complexity and costs to the devices. Additionally, complex control algorithms must be developed and used to operate multiple actuators in concert to compensate for the cross talk.

In the proposed micro-positioning stage discussed above, as well as other proposed stages, the rotational cross talk error is inherent in the design. That is, applying a force intended to move a stage in one direction necessarily produces an unintended rotation. Accordingly, a need exists for a micro-positioner which does not impart rotational cross talk error into intended linear movement.

Control of conventional micro-positioners is performed through the use of feedback loops. At least one sensor is required to measure movement of a stage. Conventional deformable structure micro-positioners use sensors which are typically located at a position which results in inaccurate measurement of the true stage displacement. This inaccuracy due to sensor placement is commonly referred to as Abbe effect. Accordingly, a positioner is required which provides more accurate sensing.

Conventional deformable structure micro-positioners require that the actuator used to impart a force upon a movable stage be attached to the movable stage with an epoxy compound, or some other adhesive. These attachments impart a loss of force into the system. For example, when a force is applied to an epoxy connection between the actuator and the moving stage, the epoxy compresses, resulting in up to a 60 percent loss in applied force. Hence, an improved technique is required to attach an actuator to a movable stage to reduce the loss of force.

Using an epoxy or screws for the coupling, it is also difficult to obtain a pure parallel alignment of the actuator and the moving stage. Unparallel alignment results in a loss of force in the system. Furthermore, misalignment between the components may produce damaging stresses on the actuator. Accordingly, an improved coupling is required to achieve a parallel attachment between the coupling and an actuator.

Epoxy couplings are also subject to maintenance difficulties and durability limits. To remove an actuator from a deformable structure micro-positioner with epoxy couplings, the epoxy coupling must be cut using a machine tool. The two surfaces exposed by the cutting must be cleaned before they are reattached. This cutting and cleaning process may damage both the actuator and the deformable structure micro-positioner. Accordingly, a need exists for an improved technique of attaching and removing an actuator from a micro-positioner which eliminates the potentially damaging cutting and cleaning process.

Conventional deformable structure micro-positioners can be subjected to forces which may damage the individual components of a positioner. These forces may include inadvertent contact with the movable stage portion of the positioner or over-actuation of a drive used to move the movable stage. Accordingly, a need exists for a deformable structure micro-positioner which can better withstand damaging forces.

Deformable structure micro-positioners with one and two-degrees of freedom are well known. Six-degree of freedom positioners in the macro-scale are common. One type of six-degree of freedom positioner is often referred to as a Stewart platform. One familiar use of Stewart platforms is in aircraft simulators. However, a practical adaptation of macro-scale Stewart platforms to the micro-scale using a deformable structure platform has not been previously achieved.