Multiaxis Assemblies

Multiaxis systems are traditionally built by connecting together a series of single-axis mechanisms. As the number of axes involved increases, the designs grow in complexity and become cumbersome. Furthermore, the overall performance of the system will be inferior to that of any of its individual components because stacking drives reduces stiffness and can introduce positioning errors. Consequently, for many specialized high-precision applications, it is desirable to use integrated multiaxis systems which are designed specifically to provide high resolution and stability in all degrees of motion.

For everyday, general-purpose uses in the laboratory, one can create and build a wide variety of complex assemblies using the standard positioning building blocks offered in various opto-mechanical catalogs: the key considerations are compatibility and modularity. For example, when choosing parts from different suppliers, it is important that the parts be cross compatible. Often it is not possible to bolt and connect a stage from one manufacturer to a stage from another manufacturer. Even in the case of a sole supplier, not all the stages are necessarily compatible with each other. This can be quickly determned by comparing mounting hole patterns.

Figure 8.10 shows an example of how a number of standard positioners can be used to create a relatively complex system for addressing a specific application. Because of the modularity and compatibility of the individual positioning building blocks used in this system, the experimentalist in the laboratory can easily disassemble and then reassemble the components to create a new configuration.

For complex, multiaxis positioning, integrated parallel-flexure stages that incorporate three or more degrees of freedom into a single compact unit provide significantly improved performance over stacked stage assemblies (see figure 8.11). The starting point for the conceptual design is the observation that a rigid body naturally has six degrees of freedom. Each actuator should subtract one degree of freedom from the body, so that with six actuators the body becomes fully constrained. This contrasts with serial designs which use a stack of single-degree-of-freedom mechanisms.

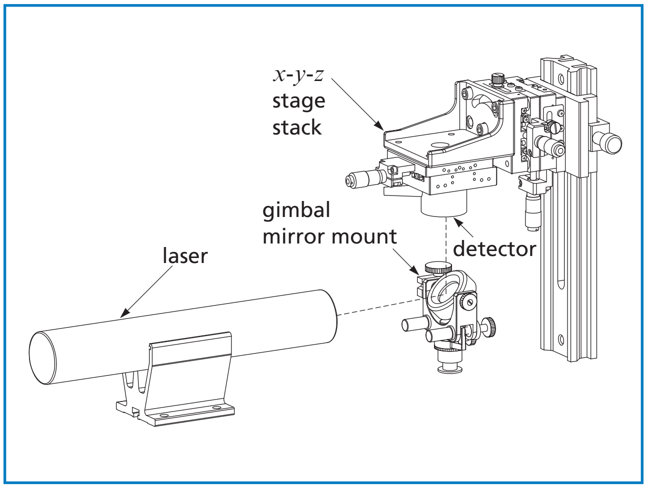

Figure 8.10 **Multiaxis stacked assembly used in a laser measurement application**

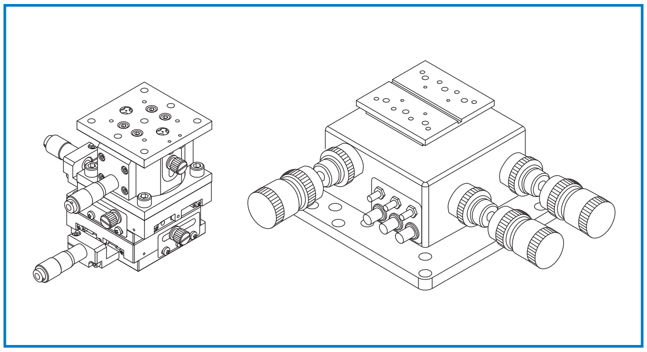

Figure 8.11 **Comparison of stacked and integrated positioning stages**

The beauty of the parallel flexure approach is its simplicity. Designers and users of nanometric positioning equipment know that, to transmit motion accurately, it is preferable to have as few moving parts acting in series as possible. Microscopic friction can occur at each interface between parts. Since such friction tends to be unpredictable and uncontrollable, it is the sworn enemy of the designer. Parallel flexure stages have very few moving parts and can transmit motion very precisely.

Parallel flexures, like serial flexures, have arcuate motion. These secondary motions do not occur in the main axis of motion. As a stage is moved to either side of its central position, transverse arcuate displacements on the order of tens of microns occur. If several axes are moved at once, the combined effect can be greater. Although these arcuate displacements are sometimes of concern, they rarely hinder aligning fibers or other optical components since optical beams rarely propagate colinearly with the axes of any stage to better than the scale of the arcuate motion. However, if arcuate motion is a defining parameter of a particular alignment or positioning application, software and a closed-loop autoalignment system can compensate for its effects.