nanoindentation is less than 10 mN, with a typical displacement range being smaller than 10 μm, and with a noise level typically being better than 1 nm rms. The force and displacement data are used to determine a sample's mechanical properties, and to determine if the properties are within acceptable performance limits for a particular product or application.

In some examples a probe with a well-known shape is pressed into a material in a predetermined manner and removed therefrom while continuously measuring the probe position and applied probe/sample contact force. Nanomechanical characterization employs one or more actuators and sensors to perform one or more of control or measurement of the applied force that the probe exerts on the material and the relative displacement of the probe during the test. Sensors and actuators are applied along a single axis, in one example, as is the case with standard instrumented depth sensing indentation, or in two to three dimensional space for tribological measurements. Probe-based nanomechanical testing techniques are used for the determination of mechanical properties such as hardness, modulus, fracture toughness and tribological characteristics such as scratch/mar resistance, friction coefficient measurement and interfacial adhesion assessment.

Critical technological advances in nanomechanical test instruments have been mandated by the ability to control processes and structures to nanometer length scales and have required the development of higher sensitivity force and displacement actuators/sensors. Due to combined advances in actuator/sensor and control electronics technologies, nanomechanical testing systems can control and measure forces to within several nano-Newtons (nN) and control and measure displacements within several Angstroms (Å). These developments have permitted quantitative nanomechanical characterization of ultra- small volumes of material, including thin films used in the semiconductor and data storage industries; nano-composite polymers, ceramics, metals,; and nanostructures including nanoparticles, nanowires, nanopillars, and nanotubes.

SUMMARY

According to a first aspect, there is provided a testing system including a multiple degree of freedom stage for aligning a sample with an instrument configured for mechanical testing at micron or less scale, the testing system comprising: a instrument column including a column base and an instrument arm extending from the column base; an instrument coupled with the instrument arm; a multiple degree of freedom sample stage assembly including: a sample stage, and a stage actuator assembly including at least one translational actuator and a rotational actuator, and the stage actuator assembly is configured to selectively align substantially all locations between the instrument and the sample stage with the instrument through actuation of the at least one of the translational actuator and the rotational actuator.

According to a second aspect, there is provided a method for selectively aligning and testing one or more testing locations with an instrument, the method comprising: coupling a sample on a sample stage of a testing system, the sample includes one or more testing locations spaced apart on the sample, wherein the testing system includes: an instrument configured for one or more of testing or observation of the sample, and the sample stage; aligning a testing location of the one or more testing locations with the instrument, aligning the testing location includes: rotating the sample stage and the testing location toward alignment with a working region of the instrument, translating the sample stage and the testing location toward alignment with the working region of the testing instrument, and wherein the sample stage is rotated and translated within a sample stage footprint bounded by outermost perimeter surfaces of the sample stage relative to the instrument in a plurality of orientations configured to selectively align the instrument with substantially the entire surface area of the sample stage; and testing the testing location of the one or more testing locations with the instrument.

According to a third aspect, there is provided a method for initializing a testing system comprising: positioning a sample coupled with a sample stage in alignment with an instrument, wherein the sample stage is configured for translational and rotational movement relative to a base; deformably marking the sample with marks at at least first, second and third marking locations with the instrument; rotating the sample a specified angle measure between each marking of the sample at the first, second and third marking locations, wherein the sample stage and the sample are translationally static relative to the base; and determining the center of rotation of the sample stage from a circle having a perimeter coincident with at least the markings at the first, second and third marking locations, the center of rotation coincident to a center of the circle.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, which are not necessarily drawn to scale, like numerals may describe similar components in different views. Like numerals having different letter suffixes may represent different instances of similar components.