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 OF INVENTION

The present disclosure provides a method for automatically examining an instrument probe coupled with a mechanical testing instrument configured to performing mechanical testing at micron scale or less, the method comprising:

determining if an instrument probe use threshold is achieved, the instrument probe is coupled with a transducer, and the transducer is configured to move the instrument probe, measure an instrument probe indentation depth and measure force applied to the instrument probe through the transducer, and determining if the instrument probe use threshold is achieved includes one or more of:

counting a number of transducer operations, and

determining if the number of transducer operations is greater than a transducer operation count threshold, or

measuring one or more of the instrument probe indentation depth, force applied to the instrument probe through the transducer or a sample mechanical parameter of a sample, and

determining the instrument probe use threshold is met if one or more of the instrument probe indentation depth, force applied to the instrument or the sample mechanical parameter is outside of one or more of a specified indentation depth threshold range, a specified force threshold range or a specified sample mechanical parameter threshold range of the sample; and

conducting a probe check operation once the instrument probe use threshold is achieved, the probe check operation includes:

aligning the instrument probe with a diagnostic sample,

indenting the instrument probe into the diagnostic sample,

measuring one or more of the indentation depth, indentation force or a sample mechanical parameter with the transducer, and

determining the instrument probe requires one of calibration or replacement if one or more of the measured indentation depth, the measured indentation force or the sample mechanical parameter are outside of an indentation threshold range, an indentation force threshold range or a sample mechanical parameter threshold range of the diagnostic sample, respectively.

The present disclosure also provides a method for automatically examining a transducer response of a mechanical testing instrument configured to perform mechanical testing at micron scale or less, the method comprising:

determining if a transducer operation threshold is achieved, the transducer is coupled with an instrument probe, and the transducer is configured

to move the instrument probe, measure the instrument probe movement and measure the force applied to the instrument probe through the transducer, and determining if the transducer operation threshold is achieved includes one or more of:

counting the number of transducer operations, and

determining if the number of transducer operations are greater than a transducer operation count threshold, or

determining that the transducer operation threshold is achieved if the transducer measures a force or displacement outside of a normal operating force or displacement range, respectively; and

conducting a space indentation operation with the transducer once the transducer operation threshold is achieved, the space indentation operation includes:

moving the instrument probe into a position where the instrument probe will not engage a surface during the space indentation,

applying a specified voltage to the transducer,

measuring the movement of the instrument probe caused by the application of the specified voltage, and

determining the transducer requires one or more of calibration or service if the movement is outside of a specified movement threshold for the specified voltage.

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.