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

In accordance with a first aspect of the embodiment, there is provided a testing system including a probe changing assembly for coupling and decoupling a probe of a mechanical testing instrument configured for mechanical testing at

micron or less scale, the probe changing assembly comprising: a probe magazine housing a plurality of probes, the probes are configured for mechanical testing at micron scale or less; at least one probe change unit configured to: grasp one of the plurality of probes housed in the probe magazine, couple one of the plurality of probes with a probe receptacle of a mechanical testing instrument, and decouple one of the plurality of probes from the probe receptacle of the mechanical testing instrument; and an actuator coupled with the at least one probe change unit, and the actuator is configured to move and align the at least one probe change unit with the probe magazine and the probe receptacle of the mechanical testing instrument.

In accordance with a second aspect of the embodiment, there is provided a probe change unit for changing instruments probes used in mechanical testing at micron scale or less, the probe change unit comprising: a motor; a drive shaft coupled with the motor; a spindle coupled with the drive shaft; a rotary clutch assembly coupled with the spindle; a probe changing tool coupled with the spindle, wherein the rotary clutch is configured to provide locking rotary engagement between the probe changing tool and the spindle in a probe decoupling rotational direction and selective slipping engagement between the probe changing tool and the spindle in a probe installing rotational direction, and selective slipping engagement includes: engagement of the spindle with the probe changing tool and transmission of rotation from the spindle to the probe changing tool for probe installation, and sliding of the spindle along the probe changing tool after probe installation; and wherein the probe changing tool is sized and shaped to non-rotatably couple with an instrument probe configured for mechanical testing at micron scale or less.

In accordance with a third aspect of the embodiment, there is provided a method for installing an instrument probe with a mechanical testing instrument configured for performing mechanical testing at micron scale or less, the method comprising: aligning an instrument probe coupled with a probe change unit with a probe receptacle of the mechanical testing instrument; moving one or more of the instrument probe or the probe receptacle into engagement with the other of the probe receptacle or the instrument probe; coupling the instrument probe with the probe receptacle, coupling including rotating the instrument probe in probe installing rotational direction with a probe changing tool of the probe change

unit, and the probe changing tool is coupled with a spindle with a rotary clutch providing slipping engagement between the probe changing tool and the spindle, slipping engagement including: engagement of the spindle with the probe changing tool and transmission of rotation from the spindle to the probe changing tool for probe installation, and sliding of the spindle along the probe changing tool after probe installation; and disengaging the instrument probe from the probe change unit.

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.