ABRASIVE PLATEN WAFER SURFACE OPTICAL MONITORING SYSTEM

Applicant: Wayne O. Duescher, Roseville, MN (US)
Inventor: Wayne O. Duescher, Roseville, MN (US)
Appl. No.: 13/665,759
Filed: Oct. 31, 2012

Publication Classification

Int. Cl. B24B 49/12 (2006.01)
U.S. Cl. 2
CPC B24B 49/12 (2013.01)
USPC 451/6

ABSTRACT

Flat-surfaced workpieces such as semiconductor wafers are held in flat-surfaced abrading contact with the abrasive surface of a flexible raised-island disk that is attached to a flat-surfaced rotating platen. There are recessed areas between the abrasive-coated raised islands where light can transmitted through the transparent backings. Platen is constructed with open passageways that extend radially from the outer periphery of the platen to the area that is under the abraded wafer. Stationary light sources are directed radially to the platen edge where they enter the open passageways to impinge on mirrors that direct the light to contact the surface of the wafer. The light beams reflected from the wafer surface are directed with mirrors back to a stationary light-receiver positioned at the outer periphery of the platen. The light-receiver device allows abraded condition of the flat surface of the wafer to be monitored during the abrasive lapping or polishing procedure.
Fig. 2A

Prior Art

Fig. 2B

Prior Art
ABRASIVE PLATEN WAFER SURFACE OPTICAL MONITORING SYSTEM

BACKGROUND OF THE INVENTION

[0001] Field of the Invention

The present invention relates to the field of abrasive treatment of surfaces such as grinding, polishing, and lapping. In particular, the present invention relates to actively monitoring the surface of semiconductor wafer workpieces as they are being lapped or polished by abrasive material.

[0002] Background of the Art

Chemical mechanical planarization (CMP) polishing is often used to remove surface irregularities remaining on the surfaces of the wafers. This is done periodically after the many steps of the deposition of the etching steps that take place on the surface of a wafer during the manufacturing of semiconductor integrated circuits.

[0003] Lapping or polishing of the wafers can be performed using flexible disks that have an annular band of abrasive-coated raised islands that are attached to transparent backings. These raised-island disks are attached to flat-surfaced platens that rotate where rotating wafers are held in flat-surfaced contact with the platen abrasive. There are recessed areas between the abrasive-coated raised islands where light or radiation energy can transmitted through the abrasive disk transparent backings.

[0004] Optical observations of the abraded surface of a wafer are commonly used in wafer polishing systems. It is desirable to determine the process-condition of the wafer surface planarity or to determine when an underlying layer has been exposed during the polishing procedure as a wafer is being polished. This optical monitoring system can be used to determine the state of completion of the wafer polishing process, control the localized wafer abrading pressures, control the wafer abrading speeds and to terminate the wafer polishing procedure.

[0005] Conventional optical wafer-surface optical monitoring systems provide a near-vertical optical path to the wafer surface through window openings that extend through the thickness of the flat surface of the abrading platen. The abrasive article that covers the flat surface of the rotating platen also has transparent windows or open apertures to allow the passage of light or radiation beams from a stationary light or radiation source. The light is projected through the platen window and through the transparent abrasive article window to impinge upon a localized abraded surface of the moving wafer. These light beams are reflected off the surface of the wafer, back through the window openings of both the abrasive article and the platen to impinge on a light receiver device. The signal from the light-receiver device is used to determine the condition of that localized portion of the wafer that the light impinges on. As the wafer rotates, the surface condition of selected or random “spots” on an annular ring of the wafer can be determined by the stationary optical monitoring system.

[0006] The disadvantages of the conventional optical wafer-surface optical monitoring systems are related to the location of the stationary light source and receiver devices as these active electronic devices are typically positioned within the body of the rotatable platen spindle system. Communication of these rotating electronic light sources and receiver devices that are attached to the rotating platen with the stationary polishing machine control system is done with the use of electronic slip-rings that are attached to the rotating platen spindle shaft. The slip-rings provide electrical power to the rotating electronic light sources and receiver devices and the electrical output of the receiver sensor device is also sent to the stationary wafer polishing machine control system via the slip rings.

[0007] There are disadvantages with another embodiment of the conventional optical wafer-surface optical monitoring systems that have stationary electronic light sources and receiver devices that project and receive light beams vertically through open holes in the horizontal platen thickness. Providing through-holes through the thickness of the platen horizontal abrading plate is only practical when the platen abrading plate cantilevers or extends out a substantial distance radially from the rotating-platen axial bearing components. Free line-of-sight paths are required to obtain straight-line vertical access for light beams as they are projected against and reflected from the bottom exposed surfaces of the rotating wafers as they are abraded. Platens that are supported by small-diameter roller bearings located at the rotation axis of the platen can provide access for these light beams.

[0008] However, these roller-bearing platen platens that provide the required precision-flatness of the platen abrading surface typically cannot be operated at the desired high rotation speeds required for high-speed flat lapping. Instead, it is often necessary that air bearing spindles are used to provide both the required platen flatness and the high rotation speeds for high-speed flat lapping or polishing. These air bearing spindles are bulky with large diameters to successfully support the rotating platens on a pressurized film of air. The air bearings are located at the outer periphery of the air bearing spindles. Because of the internal location of the spindle air bearing surfaces, and due to construction considerations of the air bearings, it is not practical to provide straight-line light-beam passages vertically through the body of the air bearing spindle having a rotating platen with a horizontal abrading surface. Wafers typically are in flat-surfaced contact with the outer annular band of the platens. However, the desired locations of light-beam surface measurements on the wafers are positioned a substantial distance from the platen outer periphery and from the spindle body outer periphery.

[0009] The present optical wafer surface monitor system described here offers a technology that eliminates the use of electrically-active light sources and light receivers that are mounted on or within the rotating abrading platen bodies which require the use of rotary electrical slip rings to power the light sources and receivers and to communicate the output of the receivers with the stationary polishing machine process control system. Also, this system eliminates the use of light-beam access holes that penetrate the thickness of the rotating platen and holes that penetrate the thickness of the CMP polishing pads or abrasive disks or abrasive webs.

[0010] To overcome the inherent difficulties of the commonly used wafer surface monitoring systems, light beams are projected from and received by remote stationary devices that do not physically contact the rotating platen. Instead, light or radiation source beams are directed by reflective mirrors from non-contacting stationary sources that are adjacent to the horizontal platen outer periphery edge to impinge on the wafer surface. The mirrors direct the light from a horizontal direction to a near-vertical direction to contact the abraded surface of the wafer. Then the light or radiation beams reflected from the wafer surfaces are directed with mirrors back to non-contacting stationary light-receivers that
are positioned adjacent at the outer periphery of the platen. The light-receiver devices allow the condition of the flat surface of the wafer to be monitored during the abrasive lapping or polishing procedure.

[0013] It is difficult to position electrically-active wafer-surface monitoring stationary light or radiation devices within the confines of the rotary-platen spindle body. However, it is very simple to mount these passive-device mirrors in small open channels that extend radially along the horizontal annular width of the platen. No active light-source devices or light-sensor devices are incorporated into the body of the rotary platen spindle. Instead, only very small and durable passive devices such as reflective mirrors are incorporated into just the rotating platen body. The required stationary active light-source devices or light-sensor devices are mounted adjacent to the outer periphery of the rotating platen with no physical contact of the light or radiation source devices or the light or radiation receivers with the moving platen.

[0014] The light source can emit white light including light having wavelengths of 200-800 nanometers. Xenon lamps or xenon mercury lamps can also be used as a light source. The wavelengths of light can vary depending upon the wafer-surface property being detected. In some cases the desired wavelengths may extend to about 1550 nm. Laser light sources can also be used. The light can be emitted continuously or it can be emitted at controlled intervals with a sampling frequency of from 2 to 200 milliseconds or more. The light receiver device or detector can also be a spectrometer that measures the intensity of light over a portion of the electromagnetic spectrum.

[0015] The light wafer surface monitoring system can make measurements at different locations and at radii on a wafer as the wafer rotates using different-technology light sources and light detectors. The same areas on a wafer surface can be monitored by devices having different wavelengths. Multiple wafer radii location measurements can be made simultaneously when multiple light measurement devices are activated simultaneously.

[0016] Often sample measurements are made at different light frequencies on wafers or other substrates at different stages of polishing the wafers or substrates. This data is accumulated over a period of time to characterize the state of completion, the existence of undesirable surface features, excessive surface abrasion or surface defects of the wafer during these known polishing conditions. Comparison of the accumulated empirical data with that obtained from a wafer or substrate being processed by an abrading system control system using algorithms based on past empirical data allows accurate predictions of the state of surface condition of the processed wafers or substrates. The algorithms are used by a processor, field programmable control circuit or ASIC to execute code, access look-up tables (e.g., from memory) or process signals or information received from reflected or collected light or radiation to determine distances, alignment or other distance or angular parameters of the platen, the abrasive surface, extent of abrading done and/or abrading remaining.

[0017] The dynamically-measured wafer-surface data also allows many of the polishing system parameters such as the duration of the workpiece abrading procedure, the workpiece abrading pressures and the workpiece abrading speeds and the platen abrading speeds to be actively controlled during the abrading procedures. These dynamic measurements can be made to increase the efficiency of the abrading system, to increase the productivity of the abrading system and to provide higher quality wafer or other substrate abraded surfaces. Over-abrading of the wafers or substrates can be avoided and under-abrading of the wafers or substrates can also be avoided.

[0018] Using flexible and transparent backings for abrasive disks is well established in the abrasive industry. Backing materials are extruded in web form that is used as a backing for the manufacturing of the abrasive disks. These extruded web backings are produced from many transparent polymers including polyester. The web materials are optically clear and can readily transmit light having a wide range of wavelengths. Sometimes, as for raised-island abrasive disks, the extruded web is converted into individual disks to which raised island structures are attached. Abrasive particles are then attached to the top flat surfaces of these island structures that are used. For example, a transparent polyester backing material is used for lapping or polishing abrasive products including the “IMPERIAL” Diamond Lapping Film (hereinafter IDIF) which is commercially available from Minnesota Mining and Manufacturing Company (3M Company), St. Paul, Minn. Many of the flexible polymers commonly used for backing materials for abrasive disks are transparent to the light and radiation sources used here for monitoring the surface condition of abraded wafers.

[0019] The use of flexible and transparent backings for abrasive disks is also described for use with abrasive articles having raised-island structures where light or radiant energy is transmitted though the backing material. For example, in U.S. Pat. No. 7,632,434 (Duescher), “ABRASIVE AGGLOMERATE COATED RAISED ISLAND ARTICLES”, the use of optically clear backing materials for abrasive-coated raised island flexible abrasive disks that have annular bands of abrasive coated raised islands is described. Photosensitive or light-cure activated island foundation material is deposited in island shapes on the surface of the transparent backing material to form the island structures. Here, radiant energy is transmitted through the thickness of the abrasive-island backing to cure or solidify the raised-island structures that are present on the far side of the backing from the irradiation source.

[0020] The description of transmitting light or radiation through the thickness of the transparent backing material is made in column 70, line 56 of U.S. Pat. No. 7,632,434: “In another method, the photosensitive island material may be co-extruded directly onto the surface of the backing material to create an integral bond between the backing and the island foundation. The photosensitive island foundation material may be filled with a variety of materials including organic and inorganic materials. The photo light source may be applied to the exposed coated side of the foundation material, or alternatively, through the backside of an optically clear backing material.”. Here, the abrasive coated raised island structures are not necessarily transparent to a light source or radiation but the uncoated recessed areas of the bakings between the island structures are transparent to a light source or radiation.

[0021] The use of polyester material, that is commonly optically clear in its commercially available condition, is referred to in many abrasive article patent references. For example, in U.S. Pat. No. 7,752,700 (Duescher), “RAISED ISLAND ABRASIVE AND PROCESS OF MANUFACTURE”, the use of optically clear backing materials for abrasive-coated raised island flexible abrasive disks that have annular bands of abrasive coated raised islands is described. The description of the use of polyester for a backing material
for an abrasive disk having raised islands is made in column 22, line 11 of U.S. Pat. No. 7,752,700: “... to a raised island abrasive disk having a thin 0.003 inch (76.2 micrometer) thick polyester backing.”

0022 In U.S. Pat. No. 7,520,800 (Duescher), “RAISED ISLAND ABRASIVE, LAPPING APPARATUS AND METHOD OF USE AND PROCESS OF MANUFACTURE”, the use of optically clear backing materials for abrasive-coated raised island flexible abrasive disks is described in column 107, line 3: “The web backing may include polyester, PET (polyethylene terephthalate). If desired, a Kapton® based material may be used to provide a backing with a high glass transition temperature ...”. And the polyester web backing for raised island abrasive is also described in U.S. Pat. No. 7,520,800 in column 117, line 38 “Then, free-formed drops of this abrasive particle slurry can be deposited on the top surface of rigid raised island foundations that are attached to a thin flexible backing made of polyester or metal sheet material. The backing sheet having raised island foundations that are top-coated with an abrasive slurry can be ...” .

0023 Raised island abrasive disks that are used for lapping or polishing semiconductor wafers offer another advantage. These raised island disks are cooled with free-flowing water. This water travels along the recessed areas between the raised islands and is flung off the surface of the disk by centrifugal force created by the rotational speed of the platen. This water continually washes the surface of the transparent “windows” that are an inherent part of the polyester, or other polymer material used as a backing for the raised-island abrasive disks. Likewise this water can be used to clean the through hole windows made from glass, quartz or polymers that protect the light beam minors that are mounted in the radial passageways in the platen body. Compressed air can be directed at these platen periphery windows to remove abraded debris and keep them clean for efficient passage of the light beams to and from the stationary light sources and receiver or detector devices that are adjacent to the rotating platen. Because the flat-surfaced windows located on the top flat surfaces of the platen are protected form abraded debris and coolant water by the attached flexible raised-island abrasive disks that cover the windows, these windows only require periodic cleaning.

0024 The use of abrasive disks having abrasive coated raised islands allows the abrasive disks to be operated at very high abrading speeds in the presence of coolant water without hydroplaning of the workpieces. Hydroplaning of the workpieces can tilt the workpiece substrates and cause the workpiece to have non-flat surfaces. The raised island abrasive disks typically have transparent backings that allow effective transmittal of the wafer-surface monitoring light through the thickness of the backing. However, abrasive disks or CMP polishing pads that do not have transparent backings can be used by providing through-holes through the thickness of the abrasive disk or CMP pads to allow light beams to pass through these holes. Also, transparent windows can be attached to these abrasive disks or CMP pads. Likewise, platen that have coatings or surface layers of solid abrasive particles can also be used with this system by providing through-holes in the thickness of the solid abrasive coating or by providing windows that are incorporated into the solid abrasive coating or layer.

0025 The present invention references commonly assigned U.S. Pat. Nos. 5,910,041; 5,967,882; 5,993,298; 6,048,254; 6,102,777; 6,120,352; 6,149,506; 6,607,157; 6,752,700; 6,769,096; 7,632,434 and 7,520,800, 8,062,098, 8,256,091 and commonly assigned U.S. Patent application published numbers 20050118939 and U.S. patent application Ser. Nos. 12/661,212; 12/799,841; 12/807,765; 12/807,794; 12/807,802; 13/207,871; 13/267,305; 13/280,983; 13/351,415; 13,370,246, and 13/417,485 and all contents of which are incorporated herein by reference.

0026 Various abrading machines and abrading processes are described in U.S. Pat. No. 5,893,796 (Birang et al.), U.S. Pat. No. 6,190,254 (Swedel et al.), U.S. Pat. No. 6,334,807 (Lebel et al.), U.S. Pat. No. 6,464,824 (Hofmann et al.), U.S. Pat. No. 6,489,624 (Ushio et al.), U.S. Pat. No. 6,511,363 (Yamane et al.), U.S. Pat. No. 6,618,130 (Chen), U.S. Pat. No. 6,645,045 (Okawa), U.S. Pat. No. 6,670,200 (Ushio et al.), U.S. Pat. No. 6,676,482 (Bibby, Jr. et al.), U.S. Pat. No. 6,806,948 (Katz et al.), U.S. Pat. No. 7,042,581 (Schietinger et al.), U.S. Pat. No. 8,257,142 (Muldowney et al.), U.S. Pat. No. 8,260,446 (David et al.) All references cited or referenced herein are hereby incorporated by reference in their entirety.

SUMMARY OF THE INVENTION

0027 In particular, the present invention relates to actively monitoring the surface of semiconductor wafer workpieces as they being lapped or polished by abrasive material. Light beams are projected horizontally through the outer periphery edge of a rotating platen where they contact reflective mirrors that are mounted on the platen body. The mirrors direct the horizontal light from the light source to a near-vertical direction through a window opening in the horizontal surface of the platen. This reflected light also passes through the transparent backing of an abrasive disk that is attached in flat-surfaced contact with the flat platen surface. These abrasive disks have abrasive coated raised-island structures that have recessed areas between the islands. Light can be transmitted through the disk backing in the recessed areas between the islands.

0028 The light reflected from the mirror then impinges directly on the abraded surface of a wafer substrate or other flat-surfaced workpiece that is in abrading contact with the abrasive coating on the top surface of the islands. These light beams are then reflected off the surface of the wafer in a near-vertical direction to contact a mirror that is located with the body of the rotating platen. This mirror then directs the light in a horizontal direction where it is routed through a transparent window located at the outer periphery edge of the platen to contact a stationary light receptor device. The light receptor measures the intensity and the wavelength characteristics of the light that was reflected from the wafer surface. The measurements of the light receptor device are used to determine the amount of material that was removed from the surface of the wafer and the surface condition of the wafer. This information is used to control the polishing times, the abrading pressure and the abrading speed used to polish the wafer.

0029 When light beams or other types of reflected radiation impinges upon the rotating surface of the wafer, the frequency of the light can be optimized to determine the characteristics of the abrading or polishing action upon the wafer surface. Empirical data collected from past use of this light monitoring system can be used to successfully determine the state-of-finish of the wafer surface.

0030 The use of raised island abrasive disks in these lapping or polishing procedures allows very high abrading
speeds to be used. These raised island disks have a precision-thickness over the full annular abrading surface of the abrasive disk. The flexible precision-thickness disks are confor-
mally attached to platenst that have a precision-flat annular
disk-mounting surface to provide a precision-flat rotating
abrasive surface. The precision-flat abrading surface provides
smooth abrading contact with the workpiece or wafer sub-
strates and provides uniform abrading over the full abraded
surface of the workpieces or wafers. Higher abrading speeds
offer substantial increases in the productivity of the wafer
polishing procedures. The time of production is reduced and
the costs of production are reduced.

During the polishing procedures, the raised island
abrasive disk is cooled with continuous streams of water. This
water continually washes-off the surface of the disk backing
between the raised islands which provides a clean surface for
efficient transmittal of light through the backing to and from
the wafer surface.

The expensive and complex electrical-signal slip
rings that are used in conventional light-source wafer surface
monitoring systems to provide power from a stationary
source through a rotating platen drive shaft to the rotating
light source and light sensor device and to transmit signals
from the light sensor device to the stationary polishing
machine control system are eliminated. Also, a wide variety
of stationary light sources and light sensors, having different
light wave lengths, can be simply mounted adjacent to the
outer periphery of the rotating platen. These light sources
and light sensors can have substantial sizes and are not con-
strained in size to fit in internal chambers in the rotating platen
body. Further, maintenance and modifications can be easily
made without disassembly of the platen body to provide
access to the light sources and light sensors.

The mirrors that are mounted within the body of the
rotating platen are very small and require only small radial
passageways in the body of the platen. Because the mirrors
are passive devices, they do not require maintenance or other
types of service. The same mirrors can be used to transmit
the light waves and radiation from a variety of light monitoring
devices. Multiple sets of light monitoring devices having
different light frequencies can be mounted around the periph-
ery of the rotating platen to measure different wafer surface
characteristics of the wafers as they are being polished. A
single set of rotating mirrors can service multiple light moni-
toring devices.

The windows that are used to seal the horizontal flat
surface of the platen and the circumferential perimeter of
the platen from liquids and abrading debris can be constructed
from a wide range of materials. The windows that are attached
to the horizontal flat surface of the platen are installed where
they have a precision-flat planar surface that is co-planar with
the precision-flat planar surface of the annular abrading sur-
face of the platen where the horizontal windows are attached.
The platen radial chambers that contain the mirrors are com-
pletely sealed and can be filled with inert gases to avoid water
condensation on the mirror surfaces or to enhance light trans-
mision. The sealed chambers can also be purged as desired to
replace the existing gas atmosphere or to introduce a different
type of gas into the sealed chamber. The sealed platen radial
chambers can also contain a replaceable desiccant material to
absorb water vapor contained in the chamber. These window
materials comprise polymers such as polyester, polycarbon-
ate, polyurethane, and others, that have good light transmittal
characteristics for select light wavelengths and also glass,
quartz, diamond, sapphire, aluminum oxide and wear-resis-
tant glasses.

The windows can be polished periodically to
remove scratches and can have films of materials deposited by
vapor deposition or other techniques on the window surfaces
to enhance transmission of selected frequencies of light. The
windows located on the other perimeter of the platen are
typically curved to provide a smooth surface that can be easily
cleaned and not attract depositions of debris. The platen
perimeter windows can be periodically or continually cleaned
with water jets or by compressed-air jets to remove water
films on the windows. The flat-surfaced windows located on
the top flat surfaces of the platen are protected from abrading
debris and coolant water by the attached flexible raised-island
abrasive disks that cover the windows where these windows
only require periodic cleaning.

The surface measurement data provided by the light
monitoring system can be used to determine the amount of
material that was removed from the surface of a flat-lapped
workpiece substrates and the surface condition of the sub-
strates. This information is used to control the lapping times,
the abrading pressure and the abrading speed used to flat-lap
the substrates.

This light monitoring system is robust, durable,
simple and well-suited for use in the harsh abrading environ-
ment of wafer lapping or polishing. It can also be used to
determine the micro-finish smoothness of the surface polish
on workpieces such as annular fluid-seal devices during lap-
ing operations.

**BRIEF DESCRIPTION OF THE DRAWINGS**

**Fig. 1** is a cross section view of a platen with abraded wafer surface monitoring mirrors.

**Fig. 2** is a top view of a platen with abraded wafer surface monitoring mirrors.

**Fig. 2A** is a cross section view of a platen external wafer surface monitoring system.

**Fig. 2B** is a cross section view of a platen internal wafer surface monitoring system.

**Fig. 3** is a top view of a platen with multiple abraded wafer surface monitoring mirrors.

**Fig. 4** is a top view of an abraded wafer surface with multiple monitored sites.

**Fig. 5** is a top view of a platen with multiple abraded wafer surface monitoring devices.

**Fig. 6** is a top view of a platen and raised island abrasive disk with a wafer monitor device.

**Fig. 7** is a cross section view of a platen and raised island abrasive mirror monitor device.

**Fig. 8** is a top view of a raised island abrasive disk with transparent monitor device gaps.

**Fig. 9** is an isometric view of a raised island abrasive disk with transparent monitor gaps.

**Fig. 10** is an isometric view of an abrasive disk with individual raised islands.

**Fig. 11** is a cross section view of a platen window and wafer surface monitoring mirrors.

**Fig. 12** is a cross section view of a platen window and wafer optic fiber monitoring system.

**Fig. 13** is a cross section view of a platen and multiple optic fibers for monitoring wafers.

**Fig. 14** is a cross section view of a platen and an optic fiber lens for monitoring wafers.
FIG. 15 is a top view of a platen and raised island disk with in-line wafer monitor devices.

FIG. 16 is a top view of a platen and raised island disk with multiple wafer monitor devices.

FIG. 17 is an isometric view of a floating platen optical wafer surface monitoring system.

FIG. 18 is an isometric view of three-point fixed-position spindles mounted on a base.

FIG. 19 is an isometric view of wire-driven workholders in a double-sided abrasive system.

FIG. 20 is an isometric view of wire-driven workholders on a single or double-sided system.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 is a cross section view of a platen with abraded wafer surface monitoring mirrors. An abrasive disk 4 having abrasive coated raised islands 2 that are attached to the disk 4 transparent backing 5 is attached to a flat-surfaced rotary platen 36. A rotary wafer substrate 6 has an abraded surface 8 that is in abrading contact with the abrasive-coated raised islands 2 and a top surface 10. A light source 18 projects a beam of light 20 through a transparent window 22 that is attached to the outer periphery of the platen 36 where a mirror 26 directs the beam of light 20 through a transparent window 28 and through the disk 4 transparent backing 5 to impinge on a select location 12 on the wafer 6 abraded surface 8. This light beam 20 is reflected back from the wafer 6 abraded surface 8 as a light beam 14 through the disk 4 transparent backing 5 and through the transparent window 28 and to a mirror 24 that directs the return-beam of light 14 through the platen 36 transparent window 22 to a light sensor receiver 16. Both of the mirrors 24 and 26 and the transparent windows 22 and 28 are attached to the platen 36 and rotate with the platen 36. The light source 18 and the light sensor 16 are stationary. An option is to combine the two independent mirrors 24 and 26 into a single mirror device (not shown). The platen 36 is attached to a rotary shaft 30 that is supported by bearings 32 that are supported by a machine base 34. The wafer substrate 6 can also be a workpiece that is lapped or polished.

FIG. 2 is a top view of a platen with abraded wafer surface monitoring mirrors. An abrasive disk 40 having abrasive coated raised islands 44 that are attached to the disk 40 transparent backing 47 is attached to a flat-surfaced rotary platen 42. A rotary wafer substrate 38 has an abraded surface that is in abrading contact with the abrasive-coated raised islands 44. A light source 53 projects a beam of light 52 through a transparent window 50 that is attached to the outer periphery of the platen 42 where a combination-mirror 48 directs the beam of light 52 through the transparent window 58 and through the disk 40 transparent backing 47 to impinge on the wafer 40 abraded surface. This light beam 52 is reflected back from the wafer 40 abraded surface as a light beam 56 through the disk 40 transparent backing 47 and through the transparent window 58 and to the mirror 48 that directs the return-beam of light 56 through the platen 42 transparent window 50 to a light sensor receiver 54.

The combination-mirror 48 and the transparent windows 50 and 58 are attached to the platen 42 and rotate with the platen 42. The light source 53 and the light sensor 54 are stationary. The wafer substrate 38 is shown in outline wafer-form 46 above the transparent window 48 and mirror 50. The transparent windows 50 and 58 and the mirror 58 are aligned along a radial line 43 that extends form the center of rotation of the platen 42 to the outer periphery of the platen 42 and the abrasive disk 40 is positioned on the platen 42 where a channel 45 that exists between adjacent raised islands 44 is aligned to be coincident with the radial line 43.

FIG. 2A is a cross section view of a prior art platen external wafer surface monitoring system. An abrasive disk 2a that has an opening 8a is attached to a rotating platen 20a that has an opening 18a which allows a light beam 16a from a light source 14a to contact the flat abraded surface 6a of a rotatable wafer or workpiece substrate 4a where it is reflected back as a light beam 10a to a light receiver 12a. Both the light source 14a and the light receiver 12a are stationary while both the platen 20a and the wafer 4a are rotated. It is required that the abrasive disk 2a hole opening 18a and the platen 20a hole opening 18a are aligned to be coincident to allow free passage of the light beams 10a and 16a.

FIG. 2B is a cross section view of a prior art platen internally mounted wafer surface monitoring system. An abrasive disk 22a or abrasive web 22a or chemical mechanical planarization (CMP) abrasive pad 22a that has an integral transparent window 32a that is located in an opening 34a in the abrasive pad 22a is attached to a rotating platen 48a that has an opening 26a which allows a light beam 24a from a light source 40a to contact the flat abraded surface 30a of the rotatable wafer or workpiece substrate 28a where it is reflected back as light beam 36a to a light receiver 38a.

Here, the light source 40a projects the beam of light 24a through a transparent window 35a that is attached to the flat surface of the platen 48a in the opening 26a and through the disk 22a transparent window 32a to impinge on the wafer 28a abraded surface 30a. This light beam 24a is reflected back from the wafer 28a abraded surface 30a as a light beam 36a through the disk 22a transparent window 32a and through the platen 48a transparent window 35a and to the light sensor receiver 38a.

Both the light source 40a and the light receiver 38a are attached to the rotating platen 48a and rotate with the platen 48a. It is required that the abrasive disk, web or pad 22a transparent window 32a and the platen 48a hole opening 26a are aligned to be coincident to allow free passage of the light beams 24a and 36a. As the platen 48a is rotated, a slip-ring device 46a is used to provide electrical power to the rotating light source 40a and light receiver 38a through electrical wires 42a. Also, the slip-ring device 46a is used to provide electrical connection of electrical signals from the rotating light receiver 38a to the stationary polishing machine electrical control system (not shown) with the use of electrical wires 44a.

FIG. 3 is a top view of a platen with multiple abraded wafer surface monitoring mirrors. An abrasive disk 86 having abrasive coated raised islands 66 that are attached to the disk 86 transparent backing 85 is attached to a flat-surfaced rotary platen 84. A rotary wafer substrate 60 has an abraded surface that is in abrading contact with the abrasive-coated raised islands 66. A stationary light source 77 projects a beam of light 76 through a transparent window 74 that is attached to the outer periphery of the platen 84 where a combination send-and-return light beam mirror 72 directs the beam of light 76 through a transparent window 82 that is attached to the flat surface of the platen 84 and through the disk 86 transparent backing 85 to impinge on the wafer 60 abraded surface. This light beam 76 is reflected back from the wafer 60 abraded surface as a light beam 80 through the disk 86 transparent backing 85 and through the transparent window 82 and to the
mirror 72 that directs the return-beam of light 80 through the platen 84 transparent window 74 to a stationary light sensor receiver 78.

[0068] The combination-mirror 72 and the transparent windows 74 and 82 are attached to the platen 84 and rotate with the platen 84. The light source 77 and the light sensor 78 are stationary. The wafer substrate 60 is shown in outline wafer-form 70 above the transparent window 82 and mirror 72. The transparent windows 74 and 82 and the mirror 72 are aligned along a radial line 69 that extends from the center of rotation of the platen 84 to the outer periphery of the platen 84 and the abrasive disk 86 is positioned on the platen 84 where a channel 68 that exists between adjacent raised islands 66 is aligned to be coincident with the radial line 69. Light beams 76 and 80 can be transmitted through the disk 86 transparent backing 85 in these channel areas 68 that are continually cleaned by the application of coolant water (not shown) to the disk 86 as the platen 84 is rotated.

[0069] Light sources 77, 63 and 89 can provide light having different wavelength frequencies and light sensors 78, 88 and 64 can receive and analyze the magnitude and characteristics of the light that is reflected from the different light sources to determine the real-time state of completion or condition of the polished or lapped wafer 60 abraded surface as the wafer 60 is being abraded. In one embodiment, two or more independent sets of radially aligned transparent windows 74 and 82 and mirrors 72 can be attached to a platen 84 where the independent sets of transparent windows 74, 90 and 82 and mirrors 72 and 62 can be located at different radial positions on the platen 84 to sequentially monitor the state of polishing condition at different locations on the wafer 60 abraded surface as the platen 84 rotates.

[0070] Independent channels 68 that exists between adjacent abrasive coated raised islands 66 attached to the abrasive disks 86 can be provided where the circumferential location of these channels 68 are aligned with the multiple stationary wafer 60 abraded surface monitoring stations that have paired mirrors 72 and platen transparent windows 74 and 82 which are located around the circumference of the platen 84.

[0071] FIG. 4 is a top view of an abraded wafer surface with multiple monitored sites. A rotating polished wafer substrate or lapped workpiece 92 can be monitored circumferential positions 94 on the wafer substrate 92 and at different radial locations 97 to create random or selected monitored locations 96 on the wafer 92 abraded surface 98. The circumferential locations 94 that are monitored on the wafer 92 can be established with the use of encoders (not shown) attached to the rotating wafer 92 carrier (not shown) rotation shaft (not shown) to control the timing of activation of the wafer 92 surface 98 light sources (not shown). Process control systems can be used to provide continuous light from the light sources or to provide periodic activation of the light or to provide controlled pulse lengths of the light at specified times.

[0072] FIG. 5 is a top view of a platen with multiple abraded wafer surface monitoring devices. An abrasive disk 112 having abrasive coated raised islands 108 that are attached to the disk 112 transparent backing 125 is attached to a flat-surfaced rotary platen 126. A rotary wafer substrate (not shown) has an abraded surface that is in abrading contact with the abrasive-coated raised islands 108. A stationary light source 119 projects a beam of light 118 through a transparent window 116 that is attached to the outer periphery of the platen 126 where a combination send-and-return light beam mirror 102, 114 directs the beam of light 118 through a transparent win-

dow 124 that is attached to the flat surface of the platen 126 and through the disk 112 transparent backing 125 to impinge on the wafer abraded surface. This light beam 118 is reflected back from the wafer abraded surface as a light beam 122 through the disk 112 transparent backing 125 and through the transparent window 124 and to the mirror 102, 114 that directs the return-beam of light 122 through the platen 126 transparent window 116 to a stationary light sensor receiver 120.

[0073] The combination-mirror 102, 114 and the transparent windows 116 and 124 are attached to the platen 126 and rotate with the platen 126. The light source 119 and the light sensor 120 are stationary. The transparent windows 116 and 124 and the mirror 102, 114 are aligned along a radial line 113 that extends from the center of rotation of the platen 126 to the outer periphery of the platen 126 and the abrasive disk 112 is positioned on the platen 126 where a channel 110 that exists between adjacent raised islands 108 is aligned to be coincident with the radial line 113. Light beams 118 and 122 can be transmitted through the disk 112 transparent backing 125 in these channel areas 110 that are continually cleaned by the application of coolant water (not shown) to the disk 112 as the platen 126 is rotated.

[0074] The disk 112 channel areas 110 have widths 128 and a circumferential distance 132 between them and also a circumferential distance 130 between an selected number of them to correspond to a matching circumferential distance 130 between the wafer surface measurement stations 117 where each individual station 117 is comprised of a light source 119, a light receiver sensor 120, transparent windows 116, and 124 and a mirror 102, 114. The rotatable platen 126 can rotate bi-directionally but is shown here as rotating in the direction 106.

[0075] Stationary light sources 119, 103 and 133 and the stationary light sensors 120, 134 and 104 are located a distance 100 from and adjacent to the outer periphery of the rotatable platen 126 can provide lights having different wavelength frequencies and light sensor 120, 134 and 104 can receive and analyze the magnitude and characteristics of the light that is reflected from the different light sources 119, 103 and 133 to determine the real-time state of completion or condition of the polished or lapped wafer abraded surface as the wafer is being abraded. In one embodiment, two or more independent sets of radially aligned transparent windows 116 and 124 and mirrors 102, 114 can be attached to a platen 126 where the independent sets of transparent windows 116, 136 and 124 and mirrors 102, 114 can be located at different radial positions on the platen 126 to sequentially monitor the state of polishing condition at different locations on the wafer abraded surface as the platen 126 rotates.

[0076] Independent channels 110 that exists between adjacent abrasive coated raised islands 108 attached to the abrasive disks 112 can be provided where the circumferential location of these channels 110 are aligned with the multiple stationary wafer abraded surface monitoring stations that have paired mirrors 102, 114 and platen transparent windows 116 and 124 which are located around the circumference of the platen 126.

[0077] FIG. 6 is a top view of a platen and raised island abraded disk with a wafer monitor device. A rotary flat-surfaced platen 148 has an abrasive disk 150 that has attached abrasive-coated raised islands 156 that have island walls 158 that have a distance 140 between adjacent island 156 walls 158. Reflecting mirrors 144 have a radial distance 146.
between the mirrors 144 and the outer perimeter 149 of the platen 148. The mirror 144 and the transparent window 142 that is attached to the platen 148 flat surface have a nominal width 152 that is prefered to be less than the width 140 of the recessed channel 141 between the opposed island walls 158 to allow unimpeded transmittal of light beams (not shown) through the thickness of the disk 150 transparent backing 151 in the channel 141 area. The platen 148 has a transparent window 154 on its outer perimeter 149.

[0078] FIG. 7 is a cross section view of a platen and raised island abrasive mirror monitor device. An abrasive disk 160 having abrasive coated raised islands 162 that are attached to the disk 160 transparent backing 170 is attached to a flat-surfaced rotary platen 190. A rotary wafer substrate 166 has an unabraded surface 164 that is shown above abrading contact with the abrasive-coated raised islands 162. A light source 178 projects a beam of light 180 through a transparent window 182 that is attached to the outer periphery 172 of the platen 190 where a mirror 186 directs the beam of light 180 through a transparent window 188 and through the disk 160 transparent backing 170 to impinge on a selected location 168 on the wafer 166 unabraded surface 164. This light beam 180 is reflected back from the wafer 166 unabraded surface 164 as a light beam 174 through the disk 160 transparent backing 170 and through the transparent window 188 and to a mirror 184 that directs the return-beam of light 174 through the platen 190 transparent window 182 to a light sensor receiver 176. Both of the mirrors 184 and 186 and the transparent windows 182 and 188 are attached to the platen 190 and rotate with the platen 190.

[0079] The mirrors 184 and 186 that are attached to the platen 190 are enclosed in a platen chamber 183 that is sealed to prevent moisture, abrading debris or other contaminants from entering the chamber 183. Contaminates entering the platen chamber 183 could reduce the light reflectivity of the mirrors 184 and 186. The light source 178 and the light sensor 176 are stationary. An option is to combine the two independent mirrors 184 and 186 into a single mirror device (not shown). The wafer substrate 166 can also be a workpiece that is lapped or polished.

[0080] FIG. 8 is a top view of a raised island abrasive disk with transparent monitor device gaps. An abrasive disk 193 having a transparent backing 194 has attached abrasive-coated raised islands 198 having an island width 192 measured at the outer periphery of the islands 198. A channel 196 exists in the gap between the adjacent islands 198 where the channel gap 196 has a width 200 and the circumferential distance between adjacent islands 198 channels 196 is 204 and the circumferential distance between select groups of disk 193 island 198 channels 196 is 202.

[0081] FIG. 9 is an isometric view of a raised island abrasive disk with transparent monitor gaps. A flexible abrasive disk 214 has attached raised island structures 210 that are top-coated with abrasive particles 212 where the island structures 210 are attached to a disk 214 transparent backing 216. The raised-island disk 214 has annular bands of abrasive-coated 212 raised islands 210 where the annular bands have a radial width of 218. Each island 210 has a typical width 206. The islands 210 can be circular as shown here or can have a variety of shapes comprising radial bars (not shown) where the abrasive-coated 212 raised islands 210 allow the abrasive disks 214 to be used successfully at very high abrading speeds in the presence of coolant water without hydroplaning of the workpieces (not shown).

[0082] There are channel gap openings 218 that exist on the abrasive disk 214 between the raised island structures 210 where light beams can pass through the thickness of the disk 214 transparent backing 216 especially at selected areas 220 and 224. The abrasive disks 214 can be manufactured where there is a specified distance 222 between the selected areas 220 and 224 to allow these abrasive disks 214 to be used on a platen (not shown) that has wafer-surface monitoring stations (not shown) at these same selected areas 220 and 224 locations. When these disks 214 are attached to a surface of the platen, the disk 214 is aligned circumferentially with the platen so that the selected areas 220 and 224 locations are coincident with the wafer-platen surface-monitoring stations to allow light to be transmitted through the abrasive disk 214 selected areas 220 and 224 of the transparent backing 216.

[0083] FIG. 10 is an isometric view of a portion of an abrasive disk with individual raised islands. A transparent backing sheet 230 has raised island structures 228 that are top-coated with an abrasive-slurry layer mixture 232 which is filled with abrasive particles 226.

[0084] FIG. 11 is a cross section view of a platen transparent window and wafer surface monitoring mirrors. An abrasive disk 239 having abrasive coated raised islands 234 that are attached to the disk 239 transparent backing 252 is attached to a flat-surfaced rotary platen 250. A rotary wafer substrate 238 has an unabraded surface 235 that is shown in abrading contact with the abrasive-coated 236 raised islands 234. A light source (not shown) projects a beam of light 242 through a transparent window (not shown) that is attached to the outer periphery of the platen 250 where a mirror 246 directs the beam of light 242 through a transparent window 248 attached to the flat surface of the platen 250 and through the disk 239 transparent backing 252 to impinge on a selected location 237 on the wafer 238 unabraded surface 235. This light beam 242 is reflected back from the wafer 238 unabraded surface 235 as a light beam 240 through the disk 239 transparent backing 252 and through the transparent window 248 and to a mirror 244 that directs the return-beam of light 240 through the platen 250 transparent window to a light sensor receiver (not shown). Both of the mirrors 244 and 246 and the transparent window 248 are attached to the platen 250 and rotate with the platen 250. The light source and the light sensors are stationary. An option is to combine the two independent mirrors 244 and 246 into a single mirror device (not shown). The wafer substrate 238 can also be a workpiece that is lapped or polished.

[0085] FIG. 12 is a cross section view of a platen transparent window and wafer optic fiber monitoring system. An abrasive disk 265 having abrasive coated 266 raised islands 254 that are attached to the disk 265 transparent backing 258 is conformally attached to a flat-surfaced rotary platen 278. A rotary wafer substrate 260 has an unabraded surface 263 that is shown in abrading contact with the abrasive-coated 256 raised islands 254. A light source 268 projects a beam of light 272 through a transparent window 264 that is attached to the outer periphery of the platen 278 where an optic fiber cable 276 directs the beam of light 272 through a transparent window 262 attached to the flat surface of the platen 278 and through the disk 265 transparent backing 258 to impinge on the wafer 260 unabraded surface 263. This light beam 272 is reflected back from the wafer 260 unabraded surface 263 as a light beam 270 through the disk 265 transparent backing 258 and through the transparent window 262 and to an optic fiber cable 274 that directs the return-beam of light 270 through the
platen 278 transparent window 264 to a light sensor receiver 266. Both of the fiber optic cables 274 and 276 and the transparent windows 262 and 264 are attached to the platen 278 and rotate with the platen 278. The light source 268 and the light sensor 266 are stationary. The wafer substrate 260 can also be a workpiece that is lapped or polished.

[0086] FIG. 13 is a cross section view of a platen and multiple optic fibers for monitoring wafers. A flexible abrasive disk 286 having abrasive coated raised islands 280 that are attached to the disk 286 transparent backing 281 is conformally attached to a flat-surfaced rotary platen 304. A rotary or stationary wafer or workpiece substrate 282 has an abraded surface 283 that is shown above abrading contact with the abrasive-coated raised islands 280. At least one light source 292 projects beams of light 296 through a transparent window 288 that is attached to the outer periphery of the platen 304 where multiple optic fiber cables 300 direct the beams of light 296 through a transparent window 302 attached to the flat surface of the platen 304 and through the abrasive disk 286 transparent backing 281 to impinge on the wafer or workpiece 282 abraded surface 283 at a target area 284. The light beams 296 are reflected back from the wafer 282 abraded surface 283 as light beams 294 through the disk 286 transparent backing 281 and through the transparent window 302 to an optic fiber cable 289 that directs the return-beams of light 294 through the platen 304 transparent window 288 to at least one light sensor receiver 292.

[0087] Both of the fiber optic cables 298 and 300 and the transparent window 302 and 288 are attached to the platen 304 and rotate with the platen 304. The light sources 292 and the light sensors 290 are stationary. The wafer substrate 282 can also be a workpiece that is lapped or polished.

[0088] The abrasive raised islands that are attached to the abrasive disk transparent backings that are used in this system for monitoring the abraded substrate abraded surfaces can be island structures that are top-coated with a liquid abrasive particle adhesive slurry mixture. Also, in another embodiment, the island structures can be top-coated with a liquid adhesive and abrasive particles deposited on the adhesive. In an additional embodiment, the raised islands can be constructed from solidified abrasive particle filled polymer mixtures. In another embodiment, the raised islands can have very shallow heights that range from 0.001 inches to 0.015 inches and also can have island heights that range to 0.500 inches high. In an additional embodiment, the raised islands can be formed by metal plating abrasive particles into island shapes that are attached to a transparent backing material.

[0089] FIG. 14 is a cross section view of a platen and an optic fiber lens for monitoring wafers. An abrasive disk 317 having abrasive 308 coated raised islands 306 that are attached to the disk 317 transparent backing 310 is conformally attached to a flat-surfaced rotary platen 332. A rotary or stationary wafer substrate 312 has an abraded surface 315 that is shown in abrading contact with the abrasive-coated 308 raised islands 306. A light source 320 projects a beam of light 324 through a transparent window 326 that is attached to the outer periphery of the platen 332 where an optic fiber cable 334 directs the beam of light 324 into a mirror device 336 which directs the beam of light 324 through a transparent window 314 attached to the flat surface of the platen 332 and through the disk 317 transparent backing 310 to impinge on the wafer 312 abraded surface 315. This light beam 324 is reflected back from the wafer 312 abraded surface 315 as a light beam 322 through the disk 317 transparent backing 310 and through the transparent window 314 into a collector-lens device 330 and to an optic fiber cable 328 that directs the return-beam of light 322 through the platen 332 transparent window 326 to a light sensor receiver 318.

[0090] The wide-entry-width of the concave-shaped collector lens 330 allows the light beam 322 that is reflected from the wafer 312 abraded surface 315 to change horizontal position as the thickness or height 316 of the abrasive 308 coated raised islands 306 varies. The thickness or height 316 of the abrasive 308 coated raised islands 306 changes as the islands 306 wears down during the abrading process. Also, different abrasive disks 317 have raised islands 306 of different heights. Both of the fiber optic cables 328 and 334, the mirror device 336, the collector-lens device 330 and the transparent windows 314 and 326 are attached to the platen 332 and rotate with the platen 332. The light source 320 and the light sensor 318 are stationary. The wafer substrate 312 can also be a workpiece that is lapped or polished.

[0091] FIG. 15 is a top view of a platen and raised island disk with in-line wafer monitor devices. An abrasive disk 348 having a transparent backing 349 has abrasive raised islands 338 that are attached to the disk 348 transparent backing 349 where the flexible abrasive disk 348 is attached conformally with the flat surface of a rotary platen 346. A transparent window 350 is attached to the outer periphery of the platen 346. Also, multiple light-reflective mirrors 344 and one or more transparent windows 342 are attached to the outer periphery of the platen 346. The multiple light-reflective mirrors 344 and one or more transparent windows 342 are positioned between the vertical walls 340 of the horizontal abrasive disk 348 where the multiple light-reflective mirrors 344 and one or more transparent windows 342 and the platen 346 window 350 are shown positioned between the island 338 walls 340 and aligned along a radial line that extends from the periphery of the platen 346 to the rotational center (not shown) of the platen 346.

[0092] FIG. 16 is a top view of a platen and raised island disk with multiple wafer monitor device. An abrasive disk 372 having abrasive coated raised islands 356 that are attached to the disk 372 transparent backing 373 is attached to a flat-surfaced rotary platen 371. A rotary wafer substrate (not shown) has an abraded surface that is in abrading contact with the abrasive-coated raised islands 356. A stationary light source 365 projects a beam of light 364 through a transparent window 362 that is attached to the outer periphery of the platen 371 where a combination send-and return light beam mirror 360 directs the beam of light 364 through a transparent window 370 that is attached to the flat surface of the platen 371 and through the disk 372 transparent backing 373 to impinge on the wafer abraded surface. This light beam 364 is reflected back from the wafer abraded surface as a light beam 368 through the disk 372 transparent backing 373 and through the transparent window 370 and to the mirror 360 that directs the return-beam of light 368 through the platen 371 transparent window 362 to a stationary light sensor receiver 366.

[0093] The combination-mirror 360 and the transparent windows 362 and 370 are attached to the platen 371 and rotate with the platen 371. The light source 365 and the light sensor 366 are stationary. The transparent windows 362 and 370 and the multiple mirrors 360 are aligned along a radial line 359 that extends from the center of rotation of the platen 371 to the outer periphery of the platen 371 and the abrasive disk 372 is positioned on the platen 371 where a channel 358 that exists
between adjacent raised islands 356 is aligned to be coincident with the radial line 359. Light beams 364 and 368 can be transmitted through the disk 372 transparent backing 373 in these channel areas 358 that are continually cleaned by the application of coolant water (not shown) to the disk 372 as the platen 371 is rotated.

[0094] Light sources 365, 353 and 374 can provide light having different wavelength frequencies and light sensors 366, 375 and 352 can receive and analyze the magnitude and characteristics of the light that is reflected from the different light sources to determine the real-time state of completion or condition of the polished or lapped wafer abraded surface as the wafer is being abraded. In one embodiment, two or more independent sets of radially aligned transparent windows 362 and 370 and mirrors 360 can be attached to a platen 371 where the independent sets of transparent windows 362 and 370 and mirrors 360 can be located in-line at different radial positions on the platen 371 to sequentially monitor the state of polishing condition at different locations on the wafer abraded surface as the platen 371 rotates.

[0095] FIG. 17 is an isometric view of an abrading system 387 having three-point-fixed-position rotating workpiece spindles supporting a floating rotating abrasive platen having a optical wafer surface monitoring system. Three evenly-spaced rotatable spindles 380 (one not shown) having rotating tops 406 that have attached workpieces 382 supporting a floating abrasive platen 392. The platen 392 has a vacuum, or other, abrasive disk attachment device (not shown) that is used to attach an annular abrasive disk 396 to the precision-flat platen 392 abrasive-disk mounting surface 385. The abrasive disk 396 is in flat abrasive surface contact with all three of the workpieces 382. The rotating floating platen 392 is driven through a spherical-action universal-joint type of device 386 having a platen drive shaft 388 to which is applied an abrasive contact force 390 to control the abrading pressure applied to the workpieces 382. The workpiece rotary spindles 380 are mounted on a granite, or other material, base 408 that has a flat surface 410. The three workpiece spindles 380 have spindle top surfaces that are co-planar. The workpiece spindles 380 can be interchanged or a new workpiece spindle 380 can be changed with an existing spindle 380 where the flat top surfaces of the spindles 380 are co-planar. Here, the equal-thickness workpieces 382 are in the same plane and are abraded uniformly across each individual workpiece 382 surface by the platen 392 precision-flat planar abrasive disk 396 abrading surface. The planar abrading surface 385 of the floating platen 392 is approximately co-planar with the flat surface 410 of the granite base 408.

[0096] The spindle 380 rotating surfaces spindle tops 406 can be driven by different techniques comprising spindle 380 internal spindle shafts (not shown), external spindle 380 flexible drive belts (not shown) and spindle 380 internal drive motors (not shown). The individual spindle 380 spindle tops 406 can be driven independently in both rotation directions and at a wide range of rotation speeds including very high speeds of 3,000 rpm or greater. Rotation speeds of 3,000 rpm provide an abrading speed of 10,000 wafer surface feet per minute (3,048 meters per minute) which is required for high speed abrasive lapping. When the spindle 380 spindle tops 406 have a flat-surfaced diameter of 12 inches (300 mm) spindle tops 406 this allows 300 mm semiconductor wafers to be attached in flat-surfaced contact to the spindle tops 406. Typically the spindles 380 are air bearing spindles 380 that are very stiff to maintain high rigidity against abrading forces. The air bearing spindles 380 are more resistant to applied spindle forces such as abrading forces than roller bearing spindles 380 which also have limited rotation speed capabilities when they have large spindle top 406 diameters. Also, the air bearing spindles 380 have very low friction and can operate at very high rotational speeds. However, suitable roller bearing spindles 380 can also be used in place of air bearing spindles, particularly if they are operated at low speeds.

[0097] Abrasive disks (not shown) can be attached to the spindle 380 spindle tops 406 to abrade the platen 392 annular flat surface 385 by rotating the spindle tops 406 while the platen 392 flat surface 385 is positioned in abrading contact with the spindle abrasive disks that are rotated in selected directions and at selected rotational speeds when the platen 392 is rotated at selected speeds and selected rotation direction when applying a controlled abrading force 390. Here, the precision-flatness of the platen 392 annular flat surface 385 can be re-established by this simple abrading procedure.

[0098] The top surfaces 378 of the individual three-point spindle 380 rotating spindle tops 406 can be also be abraded by the platen 392 planar abrasive disk 396 by placing the platen 392 and the abrasive disk 396 in flat conformal contact with the top surfaces 378 of the workpiece spindles 380 as both the platen 392 and the spindle tops 406 are rotated in selected directions when an abrading pressure force 390 is applied. The top surfaces 378 of the spindles 380 abraded by the platen 392 also results in all of the spindle 380 top surfaces 378 being in a common plane. Here again, the precision-flatness of the platen 392 annular flat surface 385 can be re-established by this simple abrading procedure.

[0099] The granite base 408 is known to provide a time-stable precision-flat surface 410 to which the precision-flat three-point spindles 380 can be mounted. One unique capability provided by this abrading system 394 is that the primary datum-reference can be the fixed-position granite base 408 flat surface 410. Here, spindles 380 can all have the precisely equal heights where they are mounted on a precision-flat surface 410 of a granite base 408 where the flat surfaces of the spindle tops 378 are co-planar with each other.

[0100] When the abrading system is initially assembled it can provide extremely flat abrading workpiece 382 spindle 380 top 406 mounting surfaces and extremely flat planer 392 abrading surfaces 385. The extreme flatness accuracy of the abrading system 394 provides the capability of abrading ultra-thin and large-diameter and high-value workpieces 382, such as semiconductor wafers, at very high abrading speeds with a fully automated workpiece 382 robotic device (not shown).

[0101] In addition, the system 394 can provide unprecedented system 394 component flatness and workpiece abrading accuracy by using the system 394 components to “abradively dress” other of these same-machine system 394 critical components such as the spindle tops 406 and the platen 392 planar-surface 385. These spindle top 406 and the platen 392 annular planar surface 385 component dressing actions can be alternatively repeated on each other to progressively bring the system 394 critical components comprising the spindle tops 406 and the platen 392 planar-surface 385 into a higher state of operational flatness perfection than existed when the system 394 was initially assembled. This system 394 self-dressing process is simple, easy to do and can be done as often as desired to re-establish the precision flatness of the system 394 component or to improve their flatness for specific abrading operations.
This single-sided abrading system 394 self-enhancement surface-flattening process is unique among conventional floating-platen abrasive systems. Other abrading systems use floating platens but these systems are typically double-sided abrading systems. These other systems comprise slurry lapping and micro-grinding (flat-honing) systems that have rigid bearing-supported rotated lower abrasive coated platens. They also have equal-thickness flat-surfaced workpieces in flat contact with the annular abrasive surfaces of the lower platens. The floating upper platen annular abrasive surface is in abrading contact with these multiple workpieces where these multiple workpieces support the upper floating platen as it is rotated. The result is that the floating platens of these other floating platen systems are supported by a single-item moving-reference device, the rotating lower platen.

Large diameter rotating lower platens that are typically used for double-sided slurry lapping and micro-grinding (flat-honing) often have substantial abrasive-surface out-of-plane variations. These undesired abrasion surface variations are due to many causes comprising: relatively compliant (non-stiff) platen support bearings that transmit or magnify bearing dimension variations to the outboard tangential abrading surfaces of the lower platen abrasive surface; radial and tangential out-of-plane variations in the large platen surface; time-dependent platen material creep distortions; abrading machine operating-temperature variations that result in expansion or shrinkage distortion of the lower platen surface; and the constant wear-down of the lower platen abrading surface by abrading contact with the workpieces that are in moving abrading contact with the lower platen abrasive surface. The single-sided abrading system 394 is completely different than the double-sided system (not shown).

The floating platen 392 system 394 performance is based on supporting a floating abrasive platen 392 on the top surfaces 378 of three-point spaced fixed-position rotary workpiece spindles 380 that are mounted on a stable machine base 408 flat surface 410 where the top surfaces 378 of the spindles 380 are precisely located in a common plane. The top surfaces 378 of the spindles 380 can be approximately or substantially co-planar with the precision-flat surface 410 of a rigid fixed-position granite, or other material, base 408 or the top surfaces 378 of the spindles 380 can be precisely co-planar with the precision-flat surface 410 of a rigid fixed-position granite, or other material, base 408. The three-point support is required to provide a stable support for the floating platen 392 as rigid components, in general only contact each other at three points. As an option, additional spindles 380 can be added to the system 394 by attaching them to the granite base 408 at locations between the original three spindles 380.

Another technique can be used to precisely align the top surfaces 378 of three-point spaced fixed-position rotary workpiece spindles 380 that are mounted on a stable machine base 408 flat surface 410 where the top surfaces 378 of the spindles 380 are precisely located in a common plane is to mount all three individual spindles 380 on two-piece mounts (not shown) that have spherical action. Theses spherical- action mounts can have air-bearing films between a rotor (not shown) that the spindle 380 is attached to and the rotor-housing (not shown) to provide zero-friction spherical motion of the rotor and spindle 380 when the flat surfaces 410 where the top surfaces 378 of the spindles 380 are precisely aligned in a common plane. This co-planar alignment can be accomplished with the use of laser alignment tools or even the precision-flat planar abrading surface 385 of the floating platen 392 can be used to co-planar align the top surfaces 378 of the spindles 380 by placing the precision-flat planar abrading surface 385 of the floating platen 392 in contact with the three top surfaces 378 of the spindles 380 during the alignment procedure. After co-planar alignment procedure is completed, the spherical mount rotors are locked to the rotor housings.

This three-point workpiece spindle abrading system 394 can also be used for abrasive slurry lapping (not shown), for micro-grinding (flat-honing) (not shown) and also for chemical mechanical planarization (CMP) (not shown) abrading to provide ultra-flat abraded workpieces 382.

The abrading system 387 having three-point fixed-position rotating workpiece spindles supporting a floating rotating abrasive platen having a optical wafer surface monitoring system has a multiple combination light source and light receiver device 402 that are position around the circumference of the floating 392 platen that transmit light beams 384 through the windows 400 that are attached to the floating platen 392 platen. These light beams 384 are directed at reflective mirrors 398 or optic fiber cables (not shown) that reflect the light beams 384 through a window (not shown) that is attached to the platen 392 planar surface 385 to a target area 404 on the abraded surface of the workpieces 382. The light beams 384 are reflected back from the abraded surface of the workpieces 382 that are attached to the three top surfaces 378 of the spindles 380 through the platen 392 window with the use of mirrors 398 or with optic fiber cables through the window 400 where they are directed at the combination light source and light receiver device 402.

FIG. 18 is an isometric view of three-point fixed-position spindles mounted on a granite base. A granite base 36 has a precision-flat top surface 412 that supports three attached workpiece spindles 418 that have rotatable driven tops 416 where flat-surfaced workpieces 414 are attached to the flat-surfaced spindle tops 416.

FIG. 19 is an isometric view of wire-driven workholders in a double-sided abrading system. The abrading system 442 has three-point fixed-position rotating workholders 464 that support a floating rotating abrasive upper platen 444. Flexible abrasive disks 434 having annular bands of abrasive are attached to the platen 444 that has a precision-flat annular surface 446 where the flexible flat abrasive disk 434 conforms to the platen 444 flat annular surface 446. The abrasive disks 434 can have a continuous disk backing (not shown) or the annular abrasive disks 434 can have center hole (not shown). Flat-surfaced workpieces 454 are contained in annular workholders 464 where the workpieces 454 are in abrading contact with both the upper platen 444 abrasive disk 434 and also the lower platen 462 abrasive disk 458 where the abrasive disk 458 is attached to the lower platen 462 flat annular abrasive surface 460. There are three workholders 464 that are equally-spaced around the circumference of the lower platen 462 flat annular surface 460. The upper flat surfaces of the three equal-thickness and equal-sized workpieces 454 provide three-point support for the floating upper platen 444 as the workpieces 454 are also in flat contact with the lower platen 462 abrasive disk 458. The workholders 464 centers of rotation (not shown) are located at the circumferential center (not shown) of the lower platen 462 flat annular surface 460. The upper floating platen 444 flat annular surface 446 and the lower rigidly-mounted rotating platen 462 flat annular surface 460 are concentric with each other. Also, both the upper
floating platen 444 and the lower rigidly mounted platen 462 are independently rotated in both rotation directions. Both the upper floating platen 444 abrasive disk 434 and the lower rigidly mounted platen 462 abrasive disk 458 simultaneously abrade both opposed flat surfaces of the workpieces 454 where the workpieces 454 abrading pressure is applied by a controlled force 440 that is applied to the upper floating platen 444. The upper floating platen 444 is rotated by a spherical-action device 436 that has a drive shaft 438 where the spherical-action device 436 restrains the upper platen 444 in a platen 444 flat annular surface 446 annular radial direction. The abrading force 440 is evenly distributed to the three workpieces 454 because the three workholders 464 are equally spaced around the circumference of the lower platen 462.

[0110] The workholders 464 are rotated by drive-wires 426 that are contained in wire-grooves 456 that surround the outer circumference of the workholders 464. The workholders 464 are restrained in a radial direction of the lower platen 462 flat annular surface 460 by contact of the annular disk type workholders 464 with the disk-idlers 428 where the force-tensioned wire 426 applies forces that urge the workholders 464 radially against spaced-pairs of the disk-idlers 428. Tension in the wire 426 is provided by a wire tensioning device (not shown) and the wire 426 is also driven by a wire-drive motor 422. Because the workholders 464 are sandwiched between the upper platen 444 and the lower platen 462, the workholders 464 are held in a stable horizontal position and not tilted-up from the flat horizontal surface of the lower platen 462 flat annular surface 460. The workholder 464 flexible drive wire 426 is small in diameter which allows the workholder annular disks 464 to have small workholder 464 disk-thicknesses where the wire 426 diameter size can range from less than 0.002 inches to greater than 0.100 inches and the workholder disks 464 can have a workholder disk 464 thickness from 0.005 inches to greater than 1.00 inches. Typically the wire 426 material comprises a metal, a metal alloy, polymers, monofilament or stranded fish lines and natural materials comprising cotton, silk or other fibers, and the wire 426 may be comprised of a single strand or of woven strands that are joined together to form a continuous wire 426 loop. An example of high-strength, small-diameter wires that are capable of high tensions and good fatigue life is a wire 426 category that is referred to as music wire. The diameters of the disk-idlers 428 are sufficiently large to minimize the fatigue life of the wire 426 as it is routed and driven around the disk-idlers 428, wire-idlers 430, a drive motor 422 motor pulley 424 and the workholders 464. These small diameter flexible drive-wires 426 can be easily butt-welded together to form high-strength joints using induction heating and axial compression of the two wire 426 ends (not shown) together. After butt-welding the wire 426, the welded joint (not shown) is abraded to provide a uniform wire 426 diameter across the weld-joint area. The annular workholders 464 can be driven at very high speeds by the drive wire 426 and the workholders 464 can be driven in both clockwise and counterclockwise directions at selected speeds by changing the direction of rotation of the wire 426 drive motor 422 that is operated at various rotational speeds. Though not preferred, the wire 426 may comprise a long length of a wire 426 material that is moved in one direction for a period of time, and then in an opposed direction for another period of time, where this wire 426 direction-reversing process is repeated.

[0111] The wire-driven workholder double-sided abrading system 442 has a floating rotatable abrasive upper platen 444 and a rotateable lower abrasive platen 462 where both the floating rotating abrasive upper platen 444 and the rotateable lower abrasive platen 462 has multiple stationary combination light source and light receiver devices 452 that are positioned around the circumference of either or both the floating rotating abrasive upper platen 444 and the rotating lower abrasive platen 462 that transmit light beams 432 through the windows 450 that are attached to both the floating rotating abrasive upper platen 444 and the rotating lower abrasive platen 462. These light beams 432 are directed at reflective mirrors 448 or optic fiber cables (not shown) that reflect the light beams 432 through a window (not shown) that is attached to both the floating rotating abrasive upper platen 444 and the lower abrasive platen 462 planar surface 446 to a target area 463 on the abraded surface of the workpieces 454. The light beams 432 are reflected back from the abraded surface of the workpieces 454 through both the floating rotating abrasive upper planer 444 and the lower abrasive platen 462 windows (not shown) that are attached to both the floating rotating abrasive upper platen 444 and the lower abrasive platen 462 planar surface 446 and with the use of mirrors 448 or with optic fiber cables through the windows 450 where they are directed at the combination light source and light receiver device 452.

[0112] FIG. 20 is in a workholder-driven workholders on a lower abrasive platen of a single-sided or double-sided abrading system. The abrading system 486 has three-point fixed-position rotating workholders 476 that support a floating rotating abrasive platen (not shown). Flexible abrasive disks 498 having annular bands 500 of abrasive are attached to the bottom platen 502 that each has a precision-flat annular surface 496 where the flexible flat abrasive disk 498 conforms to the platen 502 flat annular surface 496. The abrasive disks 498 can have a continuous disk backing (not shown) or the annular abrasive disks 498 can have center hole 490. Flat-surfaced workpieces 478 are contained in annular workholders 476 where the workpieces 478 are in abrading contact with both the upper platen (not shown) abrasive disk (not shown) and also the lower platen 502 abrasive disk 498. There are three workholders 476 that are equally-spaced around the circumference of the lower platen 502 flat annular surface 496. The upper flat surfaces of the three equal-thickness and equal-sized workpieces 478 provide three-point support for the floating upper platen as the workpieces 478 are also in flat contact with the lower platen 502 abrasive disk 498. The workholders 476 centers of rotation 480 are located at the circumferential center (not shown) of the lower platen 502 flat annular surface 496. The upper floating platen flat annular surface and the lower rigidly-mounted rotating platen 502 flat annular surface 496 are concentric with each other. Also, both the upper floating platen and the lower rigidly mounted platen 502 are independently rotated in both clockwise and counterclockwise rotation directions. The lower platen 502 rotates about an axis 484. Both the rotating upper floating platen abrasive disk and the lower rigidly mounted platen 502 abrasive disk 498 simultaneously abrade both opposed flat surfaces of the workpieces 478 where the workpieces 478 abrading pressure is applied by a controlled force (not shown) that is applied to the upper floating platen. Smaller-sized workpieces 492 in a workholder 494 are shown here as an option-substitute for the large-sized workpieces 478 at one of the three workholders 476 even though workpieces 478 having
equal sizes would typically be abraded at all three workholders 476 in an abrading operation. The upper floating platen is rotated by a spherical-action device (not shown) that has a drive shaft (not shown) where the spherical-action device restrains the upper platen in a upper platen flat annular surface annular radial direction. The abrading force is evenly distributed to the three workpieces 478 because the three workholders 476 are equally spaced around the circumference of the lower platen 502 with the result that the abrading pressure on each of the workpieces 478 is equal for all of the equal-sized (only) workpieces 478.

[0113] The workholders 476 are rotated by a drive-wire 470 that is contained in a wire-groove 55 that surrounds the outer circumference of the workholders 476. The workholders 476 are restrained in a radial direction of the lower platen 502 flat annular surface 496 by contact of the annular disk type workholders 476 with the wire-idlers 470 where the force-tensioned wire 470 applies forces that urge the workholders 476 radially against spaced-pairs of the disk-idlers 472. Tension in the wire 470 is provided by a wire tensioning device (not shown). When desired, the wire 470 tension can be adjusted by adjusting the wire tensioning device to prevent tilting of the workholders 476 when the workpieces 478 and 492 are loaded into or removed from the workholders 476 when the workpieces 478 and 492 are not contacted by the upper floating platen abrasive surface.

[0114] The wire 470 is driven by a wire-drive motor 466 that has a wire drive pulley 468 and the drive pulley 468 can be constructed to allow the wire 470 to have multiple wraps around the pulley 468 to provide increased drive friction between the wire 470 and the pulley 468. Large diameter workpieces 478 comprising 300 mm (12 inch) diameter semiconductor wafers can be mounted in a workholder 476 or multiple small workpieces 482 or 492 can be mounted in a workholder 476.

[0115] The optical measurement devices that are incorporated in to a rotating platen to monitor the surface condition of wafer or other substrates being abraded on that platen is described. In one embodiment, a rotatable platen abrading machine apparatus is described where a light beam from a stationary light is used to monitor the abraded condition of the surface of a workpiece abraded by an abrasive coating on the platen comprising:

[0116] a) a rotatable circular abrading platen having a horizontal flat annular abrading surface, a platen center of rotation, a platen outer circumference, a platen outer circumference vertical wall, a platen sealed internal chamber, a transparent window that is attached to the platen flat horizontal annular abrading surface, a transparent window that is attached to the platen outer circumference vertical wall, at least one reflective mirror device that is enclosed in the platen sealed internal chamber and is attached to the platen, a platen radial line that extends from the platen center of rotation to the platen outer circumference wherein the platen sealed internal chamber, the transparent window that is attached to the platen flat horizontal annular abrading surface, the transparent window that is attached to the platen outer circumference vertical wall and the at least one reflective mirror device are nominally aligned along the platen radial line that extends from the platen center of rotation to the platen outer circumference;

[0117] b) the platen flat annular abrading surface has an abrasive coating or has an attached abrasive coated disk wherein there are non-abrasive areas in the platen annular surface abrasive coating or there are non-abrasive areas in the attached abrasive coated disk where the non-abrasive areas in the platen abrasive coating or the non-abrasive areas of the attached abrasive coated disk are aligned to be coincident with the transparent window that is attached to the platen flat horizontal annular abrading surface and where light or radiant energy can be transmitted through the platen abrasive coating non-abrasive areas or light or radiant energy can be transmitted through the non-abrasive areas of the abrasive coated disk that is attached to the platen;

[0118] c) at least one workpiece having a flat abraded surface and a workpiece radius where the at least one workpiece is in flat abrading contact with the platen abrasive coating or in flat abrading contact with the abrasive coating on the abrasive disk that is attached to the platen where the workpiece abraded surface is periodically in alignment with the transparent window that is attached to the platen flat horizontal annular abrading surface when the platen is rotated wherein the at least one reflective mirror device that is enclosed in the platen sealed internal chamber is periodically positioned in line-of-sight alignment with the workpiece abraded surface through the transparent window that is attached to the platen flat horizontal annular abrading surface and through the platen abrasive coating non-abrasive areas or the at least one reflective mirror device is in line-of-sight alignment through the transparent window that is attached to the platen flat horizontal annular abrading surface and through the non-abrasive areas of the abrasive coated disk that is attached to the platen;

[0119] d) at least one stationary light source or radiation energy device is located adjacent to the outer periphery of the rotatable platen;

[0120] e) at least one stationary light receiver or radiation energy receiver device is located adjacent to the outer periphery of the rotatable platen;

[0121] f) wherein beams of light or radiation energy that are generated by the at least one stationary light source or radiation energy device is directed nominally horizontally through the transparent window that is attached to the platen outer circumference vertical wall where the beams of light or radiation energy impinges on the surface of the at least one reflective mirror device that is enclosed in the platen sealed internal chamber where the beams of light or radiation energy are reflected toward the abraded surface of the workpiece by the at least one mirror device in a near-vertical direction through the transparent window that is attached to the platen flat horizontal annular abrading surface and through the platen abrasive coating non-abrasive areas or through the non-abrasive areas of the abrasive coated disk that is attached to the platen to impinge on the abraded surface of the at least one workpiece that reflects the beams of light or radiation energy toward the abraded surface of the workpiece in a near-vertical direction through the platen abrasive coating non-abrasive areas or through the non-abrasive areas of the abrasive coated disk that is attached to the platen and through the transparent window that is attached to the platen flat horizontal annular abrading surface to impinge on at least one reflective mirror device that reflects the beams of light or radiation energy in a near-horizontal direction through the trans-
parent window that is attached to the platen outer circumference vertical wall where the beams of light or radiation energy are directed to contact the at least one stationary light receiver or radiation energy receiver device that is located adjacent to the outer periphery of the rotating platen;

[0122] g) wherein the at least one stationary light receiver or radiation energy receiver device that receives the beams of light or radiation energy determine the intensity of or other characteristics of the impinging light or radiation energy from the at least one workpiece abraded surface to provide measurements that allow determination of the state of completion of the abrading action, the existence of surface defects or the existence of undesirable surface features on the stationary or moving at least one workpiece’s flat abraded surface that is in flat abrading contact with the platen abrasive coating.

[0123] In another embodiment of the platen apparatus, the abrasive coated disk is a flexible abrasive disk, having an annular band of abrasive coated raised-island structures that are attached to a transparent backing, where the flexible abrasive disk is attached to the platen where the flexible abrasive disk annular band of abrasive coated raised-island structures is coincident with the platen flat annular abraded surface and where there are recessed areas between the individual raised island structures that expose the transparent backing wherein a selected recessed area having the exposed backing between the individual raised island structures is aligned to be coincident with the transparent window that is attached to the platen flat horizontal annular abraded surface wherein light or radiant energy can be transmitted through the backing in the selected recessed area having the exposed backing between the individual raised island structures.

[0124] Also, the abrasive coated disk can be a flexible abrasive disk having a backing, that has a backing thickness, and an annular band of abrasive coating that has an abrasive coating thickness where the annular band of abrasive coating is attached to the flexible abrasive disk backing wherein the flexible abrasive disk is attached to the platen where the flexible abrasive disk annular band of abrasive is coincident with the platen flat annular abraded surface and where there is at least one through-hole that extends through the thickness of the flexible abrasive disk coating and extends through the thickness of the flexible abrasive disk backing wherein a selected through-hole is aligned to be coincident with the transparent window that is attached to the platen flat horizontal annular abraded surface wherein light or radiant energy can be transmitted through the transparent window that is attached to the platen flat horizontal annular abraded surface and through the selected through-hole.

[0125] In addition, the platen abrasive coating can be an annular band of a rigid abrasive layer, having a rigid abrasive layer thickness, where there is at least one through-hole that extends through the thickness of the rigid abrasive layer wherein a selected through-hole is aligned to be coincident with the transparent window that is attached to the platen flat horizontal annular abraded surface wherein light or radiant energy can be transmitted through the transparent window that is attached to the platen flat horizontal annular abraded surface and through the selected through-hole.

[0126] Further, the abrasive coated disk can be a flexible chemical mechanical planarization pad having a chemical mechanical planarization pad thickness that is attached to the platen where there is at least one through-hole that extends through the thickness of the chemical mechanical planarization pad wherein a selected through-hole is aligned to be coincident with the transparent window that is attached to the platen flat horizontal annular abraded surface wherein light or radiant energy can be transmitted through the transparent window that is attached to the platen flat horizontal annular abraded surface and through the selected through-hole.

[0127] In another embodiment, the platen can have multiple sets of components comprised of a platen sealed internal chamber, a transparent window that is attached to the platen flat horizontal annular abraded surface, a transparent window that is attached to the platen outer circumference vertical wall, at least one reflective mirror device that is enclosed in the platen sealed internal chamber and is attached to the platen, a respective platen radial line that extends from the platen center of rotation to the platen outer circumference wherein the platen sealed internal chamber, the transparent window that is attached to the platen flat horizontal annular abraded surface, the transparent window that is attached to the platen outer circumference vertical wall and the at least one reflective mirror device are nominally aligned along the respective platen radial lines that extend from the platen center of rotation to the platen outer circumference and multiple sets of these components are positioned around the circumference of the platen.

[0128] Further, the platen can be configured where the at least one reflective mirror device that is enclosed in the platen sealed internal chamber is replaced by at least one flexible optic fiber cable that is enclosed in the platen sealed internal chamber wherein the at least one optic fiber cable has optic fiber cable entry and optic fiber cable exit surfaces wherein beams of light or radiation energy generated by the at least one stationary light source or radiation energy device are directed nominally horizontally through the transparent window that is attached to the platen outer circumference vertical wall wherein light or radiation energy impinge on the optic fiber cable entry surface of the at least one optic fiber cable where the beams of light or radiation energy are transmitted toward the abraded surface of the workpiece by the at least one optic fiber cable and exit the at least one optic fiber cable at the optic fiber cable exit surface in a near-vertical direction through the transparent window that is attached to the platen flat horizontal annular abraded surface and through the platen abrasive coating non-abrasive areas or through the non-abrasive areas of the abrasive coated disk that is attached to the platen to impinge on the abraded surface of the at least one workpiece that reflects the beams of light or radiation energy toward the abraded surface of the workpiece in a near-vertical direction through the platen abrasive coating non-abrasive areas or through the non-abrasive areas of the abrasive coated disk that is attached to the platen and through the transparent window that is attached to the platen flat horizontal annular abraded surface to impinge on the optic fiber cable entry surface of the at least one optic fiber cable that transmits the beams of light or radiation energy through the at least one optic fiber cable to exit at least one optic fiber cable at the optic fiber cable exit surface in a near-horizontal direction and are directed through the transparent window that is attached to the platen outer circumference vertical wall wherein light or radiation energy are directed to contact the at least one stationary light receiver or radiation energy receiver device that is located adjacent to the outer periphery of the rotating platen.
Also, the platen optical measurement apparatus can be configured where the platen has a set of selected components where the set of selected components is comprised of a platen sealed internal chamber, at least one transparent window that is attached to the platen flat horizontal annular abrading surface, a transparent window that is attached to the platen outer circumference vertical wall, multiple reflective mirror devices that are enclosed in the platen sealed internal chamber and are attached to the platen, a respective platen radial line that extends from the platen center of rotation to the platen outer circumference wherein the platen sealed internal chamber, the at least one transparent window that is attached to the platen flat horizontal annular abrading surface, the transparent window that is attached to the platen outer circumference vertical wall and the multiple reflective mirror devices are nominally aligned along the respective platen radial line that extends from the platen center of rotation to the platen outer circumference wherein the multiple reflective mirror devices are located sequentially along the platen radial line that extends from the platen center of rotation to the platen outer circumference wherein the multiple reflective mirror devices receive beams of light or radiation energy that are generated by the at least one stationary light source or radiation energy device to reflect them to impinge on individual selected areas at multiple radii locations on the abraded surfaces of the at least one workpieces and the multiple reflective mirror devices reflect beams of light or radiation energy that are reflected from individual selected areas at multiple radii locations on the abraded surfaces of the at least one workpieces in a near-horizontal direction to at least one stationary light receiver or radiation energy receiver device.

In another embodiment of the platen optical measurement apparatus, the platen has a set of selected components where the set of selected components is comprised of a platen sealed internal chamber, at least one transparent window that is attached to the platen flat horizontal annular abrading surface, a transparent window that is attached to the platen outer circumference vertical wall, multiple flexible optic fiber cables that are enclosed in the platen sealed internal chamber and are attached to the platen, a respective platen radial line that extends from the platen center of rotation to the platen outer circumference wherein the multiple reflective mirror devices are located sequentially along the respective platen radial line that extends from the platen center of rotation to the platen outer circumference wherein the multiple reflective mirror devices receive beams of light or radiation energy that are generated by the at least one stationary light source or radiation energy device to reflect them to impinge on individual selected areas at multiple radii locations on the abraded surfaces of the at least one workpieces and the multiple reflective mirror devices reflect beams of light or radiation energy that are reflected from individual selected areas at multiple radii locations on the abraded surfaces of the at least one workpieces to at least one stationary light receiver or radiation energy receiver device.

Further, the stationary light source or radiation energy device is described where the light or radiation energy sources can emit white light including light having wavelengths of 200 to 800 nanometers and the light or radiation energy sources can emit light or radiation energy having wavelengths that extend to about 1550 nm or more and where xenon lamps or xenon mercury lamps can also be used as a light source.

Further, the stationary light source or radiation energy devices is described where the light or radiation energy sources can emit light or radiation energy continuously or it can be emitted at controlled intervals with a sampling frequency from 2 to 200 milliseconds or more.

In another embodiment, the rotatable platen abrading machine apparatus is described where the measurement outputs of the at least one stationary light receiver or radiation energy receiver devices is transmitted to a rotatable platen abrading machine abrading machine system control device that analyzes the stationary light receiver or radiation energy receiver devices measurement outputs and uses analytical algorithms to actively control the abrading system parameters comprising the duration of the workpiece abrading procedure, the workpiece abrading pressures and the workpiece abrading speeds and the platen abrading speeds during the abrading procedures.

Further, the rotatable platen abrading machine apparatus is described where the rotatable platen abrading machine apparatus is used to polish or to flat-lap semiconductor wafer substrates.

A process is described where the abraded condition of the surface of a workpiece abraded by an abrasive coating on an abrading machine rotatable platen is monitored using light that is reflected off the workpiece comprising:

1. Providing a rotatable circular abrading platen having a horizontal flat annular abrading surface, a platen center of rotation, a platen outer circumference, a platen outer circumference vertical wall, a platen sealed internal chamber, a transparent window that is attached to the platen flat horizontal annular abrading surface, a transparent window that is attached to the platen outer circumference vertical wall, at least one reflective mirror device that is enclosed in the platen sealed internal chamber and is attached to the platen, a platen radial line that extends from the platen center of rotation to the platen outer circumference wherein the platen sealed internal chamber, the transparent window that is attached to the platen flat horizontal annular abrading surface, the transparent window that is attached to the platen outer circumference vertical wall and the at least one reflective mirror device are nominally aligned along the platen radial line that extends from the platen center of rotation to the platen outer circumference;

2. Providing that the platen flat annular abrading surface has an abrasive coating or has an attached abrasive coated disk wherein there are non-abrasive areas in the platen annular surface abrasive coating or there are non-abrasive areas in the attached abrasive coated disk where the non-abrasive areas in the platen abrasive coating or the non-abrasive areas of the attached abrasive coated disk are aligned to be coincident with the trans-
parent window that is attached to the platen flat horizontal annular abrading surface and where light or radiant energy can be transmitted through the platen abrasive coating non-abrasive areas or light or radiant energy can be transmitted through the backing in the non-abrasive areas of the abrasive coated disk that is attached to the platen;

[0139] c) providing at least one workpiece having a flat abraded surface and a workpiece radius where the at least one workpiece is in flat abrading contact with the platen abrasive coating or in flat abrading contact with the abrasive coating on the abrasive disk that is attached to the platen where the workpiece abraded surface is periodically in alignment with the transparent window that is attached to the platen flat horizontal annular abrading surface when the platen is rotated wherein the at least one reflective mirror device that is enclosed in the platen sealed internal chamber is periodically positioned in line-of-sight alignment with the workpiece abraded surface through the transparent window that is attached to the platen flat horizontal annular abrading surface and through the platen abrasive coating non-abrasive areas or the at least one reflective mirror device is in line-of-sight alignment through the transparent window that is attached to the platen flat horizontal annular abrading surface and through the non-abrasive areas of the abrasive coated disk that is attached to the platen;

[0140] d) providing at least one stationary light source or radiation energy device is located adjacent to the outer periphery of the rotatable platen;

[0141] e) providing at least one stationary light receiver or radiation energy receiver device is located adjacent to the outer periphery of the rotatable platen;

[0142] f) providing beams of light or radiation energy that are generated by the at least one stationary light source or radiation energy device is directed nominally horizontally through the transparent window that is attached to the platen outer circumference vertical wall where the beams of light or radiation energy impinges on the surface of the at least one reflective mirror device that is enclosed in the platen sealed internal chamber where the beams of light or radiation energy are reflected toward the abraded surface of the workpiece by the at least one mirror device in a near-vertical direction through the transparent window that is attached to the platen horizontal annular abrading surface and through the platen abrasive coating non-abrasive areas or through the non-abrasive areas of the abrasive coated disk that is attached to the platen to impinge on the abraded surface of the at least one workpiece that reflects the beams of light or radiation energy toward the abraded surface of the workpiece in a near-vertical direction through the platen abrasive coating non-abrasive areas or through the non-abrasive areas of the abrasive coated disk that is attached to the platen and through the transparent window that is attached to the platen horizontal annular abrading surface to impinge on at least one reflective mirror device that reflects the beams of light or radiation energy in a near-horizontal direction through the transparent window that is attached to the platen outer circumference vertical wall where the beams of light or radiation energy are directed to contact the at least one stationary light receiver or radiation energy receiver device that is located adjacent to the outer periphery of the rotatable platen;

[0143] g) using the at least one stationary light receiver or radiation energy receiver device that receives the beams of light or radiation energy determine the intensity of or other characteristics of the impinging light or radiation energy from the at least one workpiece abraded surface to provide measurements that allow determination of the state of completion of the abrading action, the existence of surface defects or the existence of undesirable surface features on the stationary or moving at least one workpiece’s flat abraded surface that is in flat abrading contact with the platen abrasive coating.

[0144] A rotatable platen abrading machine apparatus is described where the measurement outputs of the at least one stationary light receiver or radiation energy receiver devices is transmitted to a rotatable platen abrading machine abrading machine system control device that analyzes the stationary light receiver or radiation energy receiver devices measurement outputs and uses analytical algorithms to actively control the abrading system parameters comprising the duration of the workpiece abrading procedure, the workpiece abrading pressures and the workpiece abrading speeds and the platen abrading speeds during the abrading procedures.

[0145] In a further embodiment, in the process of monitoring the wafer surfaces, the abrasive coated disk is a flexible abrasive disk, having an annular band of abrasive coated raised-island structures that are attached to a transparent backing, where the flexible abrasive disk is attached to the platen where the flexible abrasive disk annular band of abrasive coated raised-island structures is coincident with the platen flat annular abrading surface and where there are recessed areas between the individual raised island structures that expose the transparent backing wherein a selected recessed area having the exposed backing between the individual raised island structures is aligned to be coincident with the transparent window that is attached to the platen flat horizontal annular abrading surface where light or radiant energy can be transmitted through the backing in the selected recessed area having the exposed backing between the individual raised island structures.

[0146] In another embodiment, in the process of monitoring the wafer surfaces, a set of selected components is described where the set of selected components is comprised of a platen sealed internal chamber, at least one transparent window that is attached to the platen flat horizontal annular abrading surface, a transparent window that is attached to the platen outer circumference vertical wall, multiple reflective mirror devices that are enclosed in the platen sealed internal chamber and are attached to the platen, a respective platen radial line that extends from the platen center of rotation to the platen outer circumference wherein the platen sealed internal chamber, the at least one transparent window that is attached to the platen flat horizontal annular abrading surface, the transparent window that is attached to the platen outer circumference vertical wall and the multiple reflective mirror devices are nominally aligned along the respective platen radial line that extends from the platen center of rotation to the platen outer circumference wherein the multiple reflective mirror devices receive beams of light or radiation energy that are generated by the at least one stationary light source or radia-
tion energy device to reflect them to impinge on individual
selected areas at multiple radii locations on the abraded sur-
faces of the at least one workpieces and the multiple reflective
mirror devices reflect beams of light or radiation energy that
are reflected from individual selected areas at multiple radii
locations on the abraded surfaces of the at least one work-
pieces to at least one stationary light receiver or radiation
energy receiver device.

[0147] In another embodiment, the rotatable platen abrading
machine apparatus is described where the abrasive-coated
platen is a floating-platen that is in abrading contact simulta-
nously with at least one flat-surfaced workpieces that are
attached to three individual rotatable workpiece spindles that
are mounted on a rigid abrading machine base where the
rotatable circular abrading platen apparatus has the described
components to optically measure the surface condition of the
abraded surface of the at least one workpieces during the
abrading procedure using the stationary at least one stationary
light source or radiation energy device and the at least one
stationary light receiver or radiation energy receiver device.

[0148] In an additional embodiment, the rotatable platen
abrading machine apparatus is described where two of the
rotatable circular abrading platen are used on a double-sid-
ed abrading system having an upper rotatable circular
abrading platen and a lower rotatable circular abrading platen
where the at least one workpieces that have two opposed flat
surfaces are positioned between the upper rotatable circular
abrading platen and the lower rotatable circular abrading
platen wherein both of the two opposed flat surfaces of the at
least one workpieces are abraded simultaneously by the
abrading coatings on the upper rotatable circular abrading
platen and on the lower rotatable circular abrading platen
where either or both the upper rotatable circular abrading
platen apparatus and the lower rotatable circular abrading
platen apparatus has the described components to optically
measure the surface condition of one or both abraded surfaces
of the at least one workpieces during the abrading procedure
using the stationary at least one stationary light source or
radiation energy device and the at least one stationary light
receiver or radiation energy receiver device.

What is claimed:

1. A rotatable platen abrading machine apparatus compris-
ing a stationary light source that provides a light beam used to
monitor an abraded condition of a surface of a workpiece
abraded by an abrasive coating on the platen, the apparatus
further comprising:

a) a rotatable circular abrading platen having a horizontal
flat annular abrading surface, a platen center of rotation,
a platen outer circumference, a platen outer circumfer-
ence vertical wall, a platen sealed internal chamber, a
transparent window that is attached to the platen flat
horizontal annular abrading surface, a transparent win-
dow that is attached to the platen outer circumference
vertical wall, at least one i) reflective mirror device or ii)
a light capture and transmission device that is enclosed
in the platen sealed internal chamber and is attached to
the platen, a platen radial line that extends from the
platen center of rotation to the platen outer circumfer-
ence

wherein the platen sealed internal chamber, the transparent
window that is attached to the platen flat horizontal annular
abrading surface, the transparent window that is attached to
the platen outer circumference vertical wall and the at least
one reflective mirror device are nominally aligned along the
platen radial line that extends from the platen center of rota-
tion to the platen outer circumference;

b) the platen flat annular abrading surface has an abrasive
coating or an attached abrasive coated disk with non-
abrasive areas in the platen annular surface abrasive
coating or in the attached abrasive coated disk wherein
the non-abrasive areas are aligned to be coincident with
the transparent window that is attached to the platen flat
horizontal annular abrading surface and where light or
radiant energy can be transmitted through the platen
abrasive coating non-abrasive areas or light or radiant
energy can be transmitted through the non-abrasive
areas of the abrasive coated disk that is attached to the
platen;

c) at least one workpiece having a flat abraded surface and
a workpiece radius wherein the at least one workpiece is
in flat abrading contact with the platen abrasive coating
or in flat abrading contact with the abrasive coating on
the abrasive disk that is attached to the platen wherein
the workpiece abraded surface is periodically in align-
ment with the transparent window that is attached to the
platen flat horizontal annular abrading surface when the
platen is rotated wherein the at least one reflective mirror
device that is enclosed in the platen sealed internal
chamber is periodically positioned in line-of-sight align-
ment with the workpiece abraded surface through the
transparent window that is attached to the platen flat
horizontal annular abrading surface and through the
platen abrasive coating non-abrasive areas or the at least
one reflective mirror device is in line-of-sight alignment
through the transparent window that is attached to the
platen flat horizontal annular abrading surface and
through the non-abrasive areas attached to the platen;

d) the at least one stationary light source or radiation
energy device is located adjacent to the outer periphery
of the rotatable platen;

e) an at least one stationary light receiver or radiation
energy receiver device located adjacent to the outer periphery
of the rotatable platen;

f) wherein beams of light or radiation energy that are gen-
erated by the at least one stationary light source or radia-
tion energy device is directed nominally horizontally
through the transparent window that is attached to the
platen outer circumference vertical wall where the beams
of light or radiation energy impinges on the surface
of the at least one reflective mirror device that is
enclosed in the platen sealed internal chamber wherein
the beams of light or radiation energy are reflected
toward the abraded surface of the workpiece by the at
least one mirror device in a near-vertical direction
through the transparent window that is attached to the
platen flat horizontal annular abrading surface and
through the platen abrasive coating non-abrasive areas
or through the non-abrasive areas of the abrasive coated
disk that is attached to the platen to impinge on the
abraded surface of the at least one workpiece that reflects
the beams of light or radiation energy in a near-vertical
direction through the platen non-abrasive areas attached
to the platen and through the transparent window that is
attached to the platen flat horizontal annular abrading
surface to impinge on at least one reflective mirror
device that reflects the beams of light or radiation
energy in a near-horizontal direction through the transparent
window that is attached to the platen outer circumfer-
ence vertical wall wherein the beams of light or radiation energy are directed to contact the at least one stationary light receiver or radiation energy receiver device that is located adjacent to the outer periphery of the rotating platen;

g) wherein the at least one stationary light receiver or radiation energy receiver device that receives the beams of light or radiation energy determines the intensity of or other characteristics of the impinging light or radiation energy from the at least one workpiece abraded surface to provide measurements that allow determination of the state of completion of the abrading action, the existence of surface defects or the existence of undesirable surface features on the stationary or moving at least one workpiece's flat abraded surface that is in flat abrading contact with the platen abrasive coating.

2. The abrasive coated disk of claim 1 wherein an abrasive coated disk is present on the platen and the abrasive coated disk is a flexible abrasive disk, having an annular band of abrasive coated raised-island structures that are attached to a transparent backing, wherein the flexible abrasive disk is attached to the platen, wherein the flexible abrasive disk annular band of abrasive coated raised-island structures is coincident with the platen flat annular abrading surface and wherein there are recessed areas between the individual raised island structures that expose the transparent backing, wherein a selected recessed area having the exposed backing between the individual raised island structures is aligned to be coincident with the transparent window that is attached to the platen flat horizontal annular abrading surface, wherein light or radiant energy can be transmitted through the backing in the selected recessed area having the exposed backing between the individual raised island structures.

3. The abrasive coated disk of claim 1 wherein the abrasive coated disk is a flexible abrasive disk having a backing with a backing thickness, and an annular band of abrasive coating that has an abrasive coating thickness, wherein the annular band of abrasive coating is attached to the flexible abrasive disk backing, wherein the flexible abrasive disk is attached to the platen, wherein the flexible abrasive disk annular band of abrasive is coincident with the platen flat annular abrading surface and wherein there is at least one through-hole that extends through the thickness of the flexible abrasive disk abrading coating and extends through the thickness of the flexible abrasive disk backing, wherein a selected through-hole is aligned to be coincident with the transparent window that is attached to the platen flat horizontal annular abrading surface, wherein light or radiant energy can be transmitted through the transparent window that is attached to the platen flat horizontal annular abrading surface and through the selected through-hole.

4. The platen flat annular abrading surface abrasive coating of claim 1 where the platen abrasive coating is an annular band of a rigid abrasive layer, having a rigid abrasive layer thickness, where there is at least one through-hole that extends through the thickness of the rigid abrasive layer wherein a selected through-hole is aligned to be coincident with the transparent window that is attached to the platen flat horizontal annular abrading surface wherein light or radiant energy can be transmitted through the transparent window that is attached to the platen flat horizontal annular abrading surface and through the selected through-hole.

5. The abrasive coated disk of claim 1 wherein the abrasive coated disk is a flexible chemical mechanical planarization pad having a chemical mechanical planarization pad thickness that is attached to the platen, wherein there is at least one through-hole that extends through the thickness of the chemical mechanical planarization pad, wherein a selected through-hole is aligned to be coincident with the transparent window that is attached to the platen flat horizontal annular abrading surface such that light or radiant energy can be transmitted through the transparent window that is attached to the platen flat horizontal annular abrading surface and through the selected through-hole.

6. The platen of claim 1 further comprising multiple sets of components comprised of a platen sealed internal chamber, a transparent window that is attached to the platen flat horizontal annular abrading surface, a transparent window that is attached to the platen outer circumference vertical wall, at least one reflective mirror device that is enclosed in the platen sealed internal chamber and is attached to the platen, a respective platen radial line that extends from the platen center of rotation to the platen outer circumference wherein the platen sealed internal chamber, the transparent window that is attached to the platen flat horizontal annular abrading surface, the transparent window that is attached to the platen outer circumference vertical wall and the at least one reflective mirror device are nominally aligned along the respective platen radial lines that extend from the platen center of rotation to the platen outer circumference and multiple sets of these components are positioned around the circumference of the platen.

7. The platen of claim 1 wherein a light capture and transmission device is present as at least one flexible optic fiber cable that is enclosed in the platen sealed internal chamber, wherein the at least one optic fiber cable has optic fiber cable entry and optic fiber cable exit surfaces, wherein beams of light or radiation energy generated by the at least one stationary light source or radiation energy device are directed nominally horizontally through the transparent window that is attached to the platen outer circumference vertical wall where the beams of light or radiation energy impinge on the optic fiber cable entry surface of the at least one optic fiber cable where the beams of light or radiation energy are transmitted toward the abraded surface of the workpiece by the at least one optic fiber cable and exit the at least one optic fiber cable at the optic fiber cable exit surface in a near-vertical direction through the transparent window that is attached to the platen flat horizontal annular abrading surface and through the platen abrasive coating non-abrasive areas or through the non-abrasive areas of the abrasive coated disk that is attached to the platen to impinge on the abraded surface of the at least one workpiece that reflects the beams of light or radiation energy in a near-vertical direction through the platen abrasive coating non-abrasive areas or through the non-abrasive areas of the abrasive coated disk that is attached to the platen and through the transparent window that is attached to the platen flat horizontal annular abrading surface to impinge on the optic fiber cable entry surface of the at least one optic fiber cable that transmits the beams of light or radiation energy through the at least one optic fiber cable to exit at least one optic fiber cable at the optic fiber cable exit surface in a near-horizontal direction and are directed through the transparent window that is attached to the platen outer circumference vertical wall where the beams of light or radiation energy are directed to contact the at least one stationary light receiver or radiation energy receiver device that is located adjacent to the outer periphery of the rotating platen.
8. The platen of claim 1 having a set of selected components where the set of selected components comprise a platen sealed internal chamber, at least one transparent window that is attached to the platen flat horizontal annular abrading surface, a transparent window that is attached to the platen outer circumference vertical wall, multiple reflective mirror devices that are enclosed in the platen sealed internal chamber and are attached to the platen, a respective platen radial line that extends from the platen center of rotation to the platen outer circumference wherein the platen sealed internal chamber, the at least one transparent window that is attached to the platen flat horizontal annular abrading surface, the transparent window that is attached to the platen outer circumference vertical wall and the multiple reflective mirror devices are nominally aligned along the respective platen radial line that extends from the platen center of rotation to the platen outer circumference wherein multiple reflective mirror devices are located sequentially along the platen radial line that extends from the platen center of rotation to the platen outer circumference wherein the multiple reflective mirror devices receive beams of light or radiation energy generated by the at least one stationary light source or radiation energy device, wherein the multiple reflective mirror devices reflect them to impinge the beams of light or radiation energy on individual selected areas at multiple radial locations on the abraded surfaces of the at least one workpieces and the multiple reflective mirror devices reflect beams of light or radiation energy that are reflected from individual selected areas at multiple radii locations on the abraded surfaces of the at least one workpiece in a near-horizontal direction to at least one stationary light receiver or radiation energy receiver device.

9. The platen of claim 7 having a set of selected components where the set of selected components is comprised of a platen sealed internal chamber, at least one transparent window that is attached to the platen flat horizontal annular abrading surface, a transparent window that is attached to the platen outer circumference vertical wall, multiple flexible optic fiber cables that are enclosed in the platen sealed internal chamber and are attached to the platen, a respective platen radial line that extends from the platen center of rotation to the platen outer circumference wherein the platen sealed internal chamber, the at least one transparent window that is attached to the platen flat horizontal annular abrading surface, the transparent window that is attached to the platen outer circumference vertical wall and the multiple flexible optic fiber cables are nominally aligned along the respective platen radial line that extends from the platen center of rotation to the platen outer circumference, wherein multiple flexible optic fiber cables receive beams of light or radiation energy that are generated by the at least one stationary light source or radiation energy device, wherein the multiple flexible optic fiber cables impinge the beams of light or radiation energy on individual selected areas at multiple radial locations on the abraded surfaces of the at least one workpieces and the multiple flexible optic fiber cables transmit beams of light or radiation energy that are reflected from individual selected areas at multiple radial locations on the abraded surfaces of the at least one workpieces to at least one stationary light receiver or radiation energy receiver device.

10. The at least one reflective mirror devices of claim 1 wherein an individual reflective mirror device is used to reflect a first horizontal beam of light or radiation energy to a near-vertical direction and the same at least one reflective mirror device can reflect a second near-vertical direction beam of light or radiation energy to a horizontal direction.

11. The stationary light source or radiation energy devices of claim 1 wherein the light or radiation energy sources emits white light including light having wavelengths of 200 to 800 nanometers and/or the light or radiation energy sources emit light or radiation energy having wavelengths that extend to about 1550 nm or more.

12. The stationary light source or radiation energy devices of claim 1 wherein the light or radiation energy sources can emit light or radiation energy continuously or at controlled intervals with a sampling frequency of at least between 2 to 200 milliseconds.

13. The rotatable platen abrading machine apparatus of claim 1 wherein the measurement outputs of the at least one stationary light receiver or radiation energy receiver devices is transmitted to a rotatable platen abrading machine abrading machine system control device that analyzes the stationary light receiver or radiation energy receiver devices measurement outputs and uses analytical algorithms to actively control the abrading system parameters comprising the duration of the workpiece abrading procedure, the workpiece abrading pressures and the workpiece abrading speeds and the platen abrading speeds during the abrading procedures.

14. The rotatable platen abrading machine apparatus of claim 1 has a semiconductor wafer substrates on the platen.

15. A process of monitoring abraded conditions of the surface of a workpiece abraded by an abrasive coating on an abrading machine rotatable platen using light that is reflected off the workpiece comprising:

a) providing a rotatable circular abrading platen having a horizontal flat annular abrading surface, a platen center of rotation, a platen outer circumference, a platen outer circumference vertical wall, a platen sealed internal chamber, a transparent window that is attached to the platen flat horizontal annular abrading surface, a transparent window that is attached to the platen outer circumference vertical wall, at least one reflective mirror device that is enclosed in the platen sealed internal chamber and is attached to the platen, a platen radial line that extends from the platen center of rotation to the platen outer circumference, wherein the platen sealed internal chamber, the transparent window that is attached to the platen flat horizontal annular abrading surface, the transparent window that is attached to the platen outer circumference vertical wall and the at least one reflective mirror device are nominally aligned along the platen radial line that extends from the platen center of rotation to the platen outer circumference;

b) providing the platen flat annular abrading surface with an abrasive coating or an attached abrasive coated disk wherein there are non-abrasive areas in the platen annular surface abrasive coating or in the attached abrasive coated disk where the non-abrasive areas are aligned to be coincident with the transparent window that is attached to the platen flat horizontal annular abrading surface and, wherein light or radiant energy can be transmitted through the platen abrasive coating non-abrasive areas or light or radiant energy can be transmitted through the non-abrasive areas of the abrasive coated disk that is attached to the platen.
c) providing at least one workpiece having a flat abraded surface and a workpiece radius wherein the at least one workpiece is in flat abrading contact with the platen abrasive coating or in flat abrading contact with the abrasive disk that is attached to the platen, wherein the workpiece abraded surface is periodically in alignment with the transparent window that is attached to the platen flat horizontal annular abrading surface when the platen is rotated, wherein the at least one reflective mirror device that is enclosed in the platen sealed internal chamber is periodically positioned in line-of-sight alignment with the workpiece abraded surface through the transparent window that is attached to the platen flat horizontal annular abrading surface and through the platen abrasive coating non-abrasive areas or the at least one reflective mirror device is in line-of-sight alignment through the transparent window that is attached to the platen flat horizontal annular abrading surface and through the non-abrasive areas of the abrasive coated disk that is attached to the platen;

d) providing at least one stationary light source or radiation energy device is located adjacent to the outer periphery of the rotatable platen;

e) providing at least one stationary light receiver or radiation energy receiver device is located adjacent to the outer periphery of the rotatable platen;

f) providing beams of light or radiation energy that are generated by the at least one stationary light source or radiation energy device and directed nominally horizontally through the transparent window that is attached to the platen outer circumference vertical wall where the beams of light or radiation energy impinges on the surface of the at least one reflective mirror device that is enclosed in the platen sealed internal chamber, wherein the beams of light or radiation energy are reflected toward the abraded surface of the workpiece by the at least one mirror device in a near-vertical direction through the transparent window that is attached to the platen flat horizontal annular abrading surface and through the platen abrasive coating non-abrasive areas or through the non-abrasive areas of the abrasive coated disk that is attached to the platen to impinge on the abraded surface of the at least one workpiece that reflects the beams of light or radiation energy toward the abraded surface of the workpiece in a near-vertical direction through the transparent window that is attached to the platen flat horizontal annular abrading surface to impinge on at least one reflective mirror device that reflects the beams of light or radiation energy in a near-horizontal direction through the transparent window that is attached to the platen outer circumference vertical wall, wherein the beams of light or radiation energy are directed to contact the at least one stationary light receiver or radiation energy receiver device that is located adjacent to the outer periphery of the rotatable platen;

g) using the at least one stationary light receiver or radiation energy receiver device that receives the beams of light or radiation energy to determine the intensity of or other characteristics of the impinging light or radiation energy from the at least one workpiece abraded surface to provide measurements that allow determination by a processor of the state of completion of the abrading action, the existence of surface defects or the existence of undesirable surface features on the stationary or moving at least one workpiece’s flat abraded surface that is in flat abrading contact with the platen abrasive coating.

16. The process of claim 15 wherein the measurement outputs of the at least one stationary light receiver or radiation energy receiver devices are transmitted to a rotatable platen abrading machine abrading machine system control device comprising a processor that analyzes the stationary light receiver or radiation energy receiver devices measurement outputs and executes code that performs analytical algorithms to actively control the abrading system parameters comprising the duration of the workpiece abrading procedure, the workpiece abrading pressures and the workpiece abrading speeds during the abrading procedures.

17. The process of claim 15 wherein the abrasive coated disk is a flexible abrasive disk, having an annular band of abrasive coated raised-island structures attached to a transparent backing, wherein the flexible abrasive disk is attached to the platen, wherein the flexible abrasive disk annular band of abrasive coated raised-island structures is coincident with the platen flat annular abrading surface and wherein there are recessed areas between the individual raised island structures that expose the transparent backing, wherein a selected recessed area having the exposed backing between the individual raised island structures is aligned to be coincident with the transparent window that is attached to the platen flat horizontal annular abrading surface and wherein light or radiation energy is transmitted through the backing in the selected recessed area having the exposed backing between the individual raised island structures.

18. The process of claim 15 wherein a set of selected components is provided, wherein the set of selected components comprises a platen sealed internal chamber, at least one transparent window that is attached to the platen flat horizontal annular abrading surface, a transparent window that is attached to the platen outer circumference vertical wall, multiple reflective mirror devices that are enclosed in the platen sealed internal chamber and are attached to the platen, a respective platen radial line that extends from the platen center of rotation to the platen outer circumference, wherein the platen sealed internal chamber, the at least one transparent window that is attached to the platen flat horizontal annular abrading surface, the transparent window that is attached to the platen outer circumference vertical wall and the multiple reflective mirror devices are nominally aligned along the respective platen radial line that extends from the platen center of rotation to the platen outer circumference where multiple reflective mirror devices are located sequentially along the platen radial line that extends from the platen center of rotation to the platen outer circumference, wherein the multiple reflective mirror devices receive beams of light or radiation energy generated by the at least one stationary light source or radiation energy device to reflect them to impinge on individual selected areas at multiple radii locations on the abraded surfaces of the at least one workpieces and the multiple reflective mirror devices reflect beams of light or radiation energy that are reflected from individual selected areas at multiple radii locations on the abraded surfaces of the at least
one workpieces in a near-horizontal direction to at least one stationary light receiver or radiation energy receiver device.

19. The rotatable platen abrading machine apparatus of claim 1 wherein the abrasive-coated platen is a floating-platen in abrading contact simultaneously with at least one flat-surfaced workpiece that is attached to one of three individual rotatable workpiece spindles that are mounted on a rigid abrading machine base, wherein the rotatable circular abrading platen apparatus has the components to optically measure the surface condition of the abraded surface of the at least one workpiece during an abrading procedure using the stationary at least one stationary light source or radiation energy device and the at least one stationary light receiver or radiation energy receiver device.

20. The rotatable platen abrading machine apparatus of claim 1 wherein two of the rotatable circular abrading platens are used on a doubled-sided abrading system having an upper rotatable circular abrading platen and a lower rotatable circular abrading platen, wherein the at least one workpiece that has two opposed flat surfaces are positioned between the upper rotatable circular abrading platen and the lower rotatable circular abrading platen, wherein both the two opposed flat surfaces of the at least one workpieces are abraded simultaneously by the abrading coatings on the upper rotatable circular abrading platen and on the lower rotatable circular abrading platen, wherein either or both the upper rotatable circular abrading platen apparatus and the lower rotatable circular abrading platen apparatus has the components to optically measure the surface condition of one or both abraded surfaces of the at least one workpieces during the abrading procedure using the stationary at least one stationary light source or radiation energy device and the at least one stationary light receiver or radiation energy receiver device.

* * * * *