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(54) **MULTIPLE WINDOW PAD ASSEMBLY**

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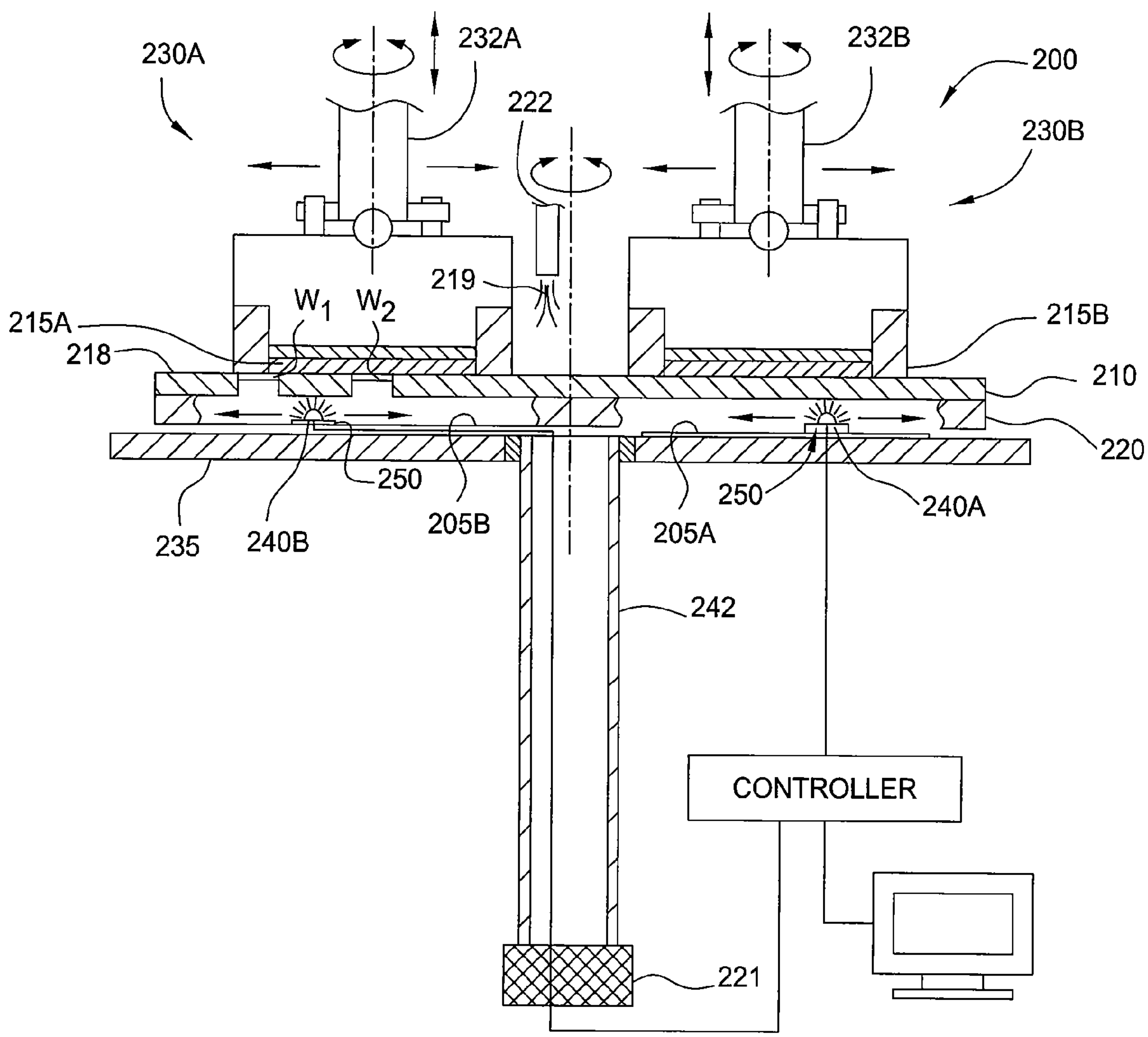
(57) **ABSTRACT**

A method and apparatus for detecting and obtaining a metric indicative of a polishing process is described. The apparatus includes a polishing pad having an optically transparent region adapted to obtain polishing metric from at least one substrate from at least two distinct radial positions of the polishing pad. The method includes obtaining a polishing metric from at least two substrates being polished simultaneously on a single polishing pad.



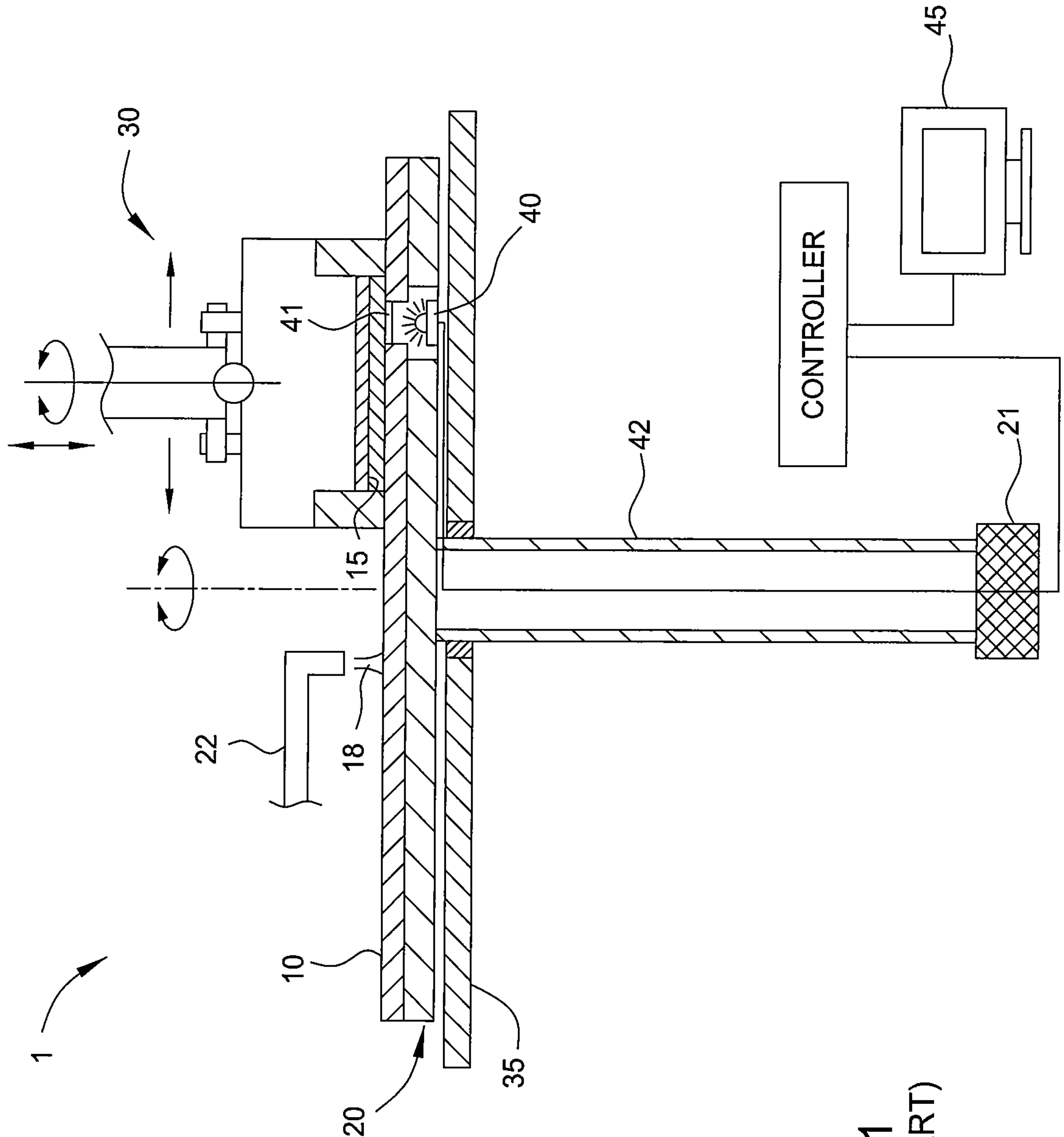


FIG. 1
(PRIOR ART)

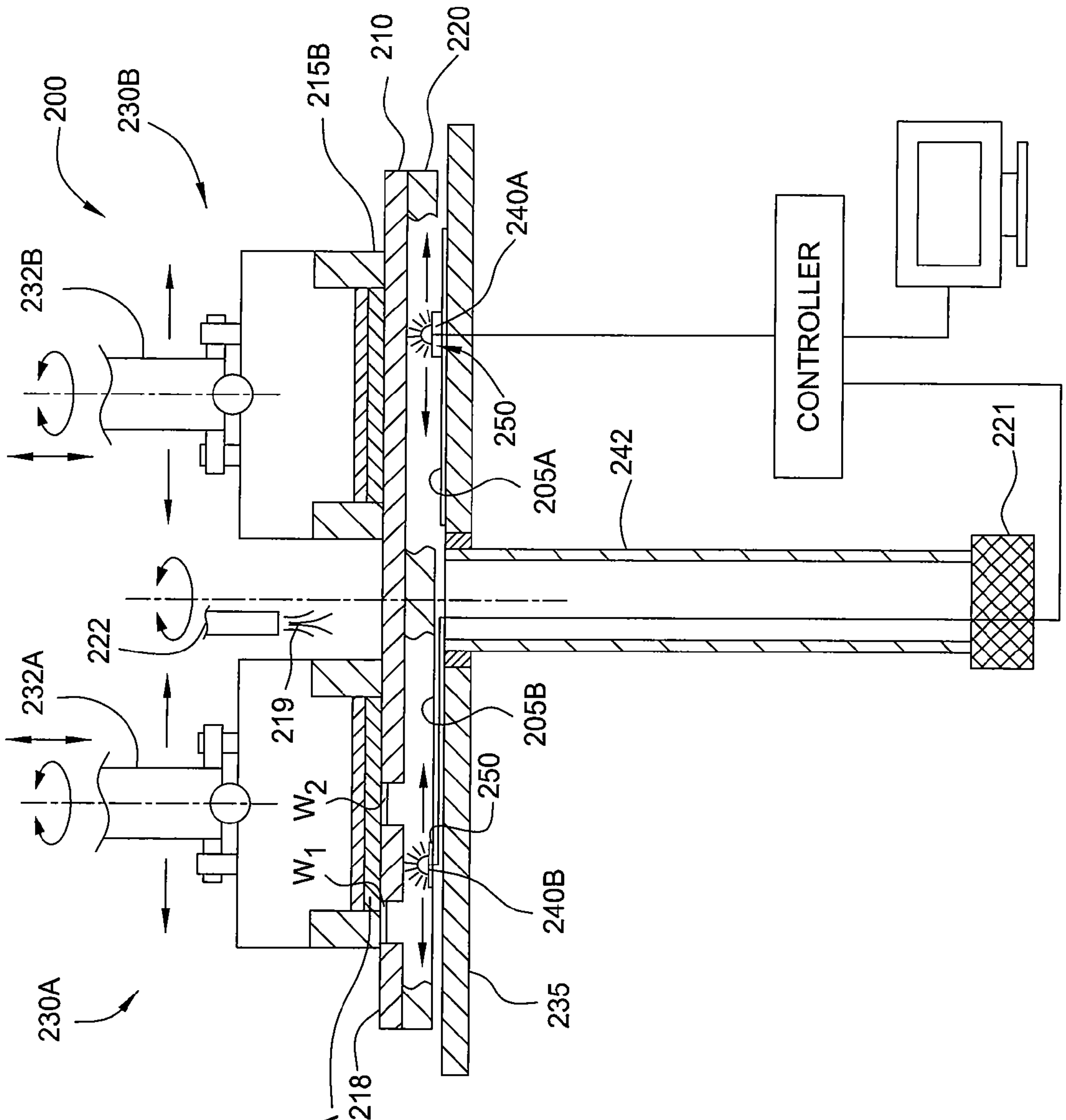

200
230B
232B
215B
210
220
240A
250
205A
242
221
CONTROLLER
222
219
232A
W2
W1
250
205B
240B
230A
215A
218
235

FIG. 2

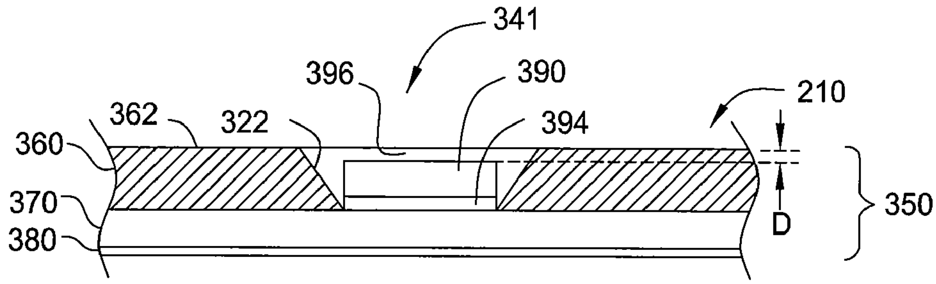

341
396
390
210
362
322
394
360
370
350
D
380

FIG. 3

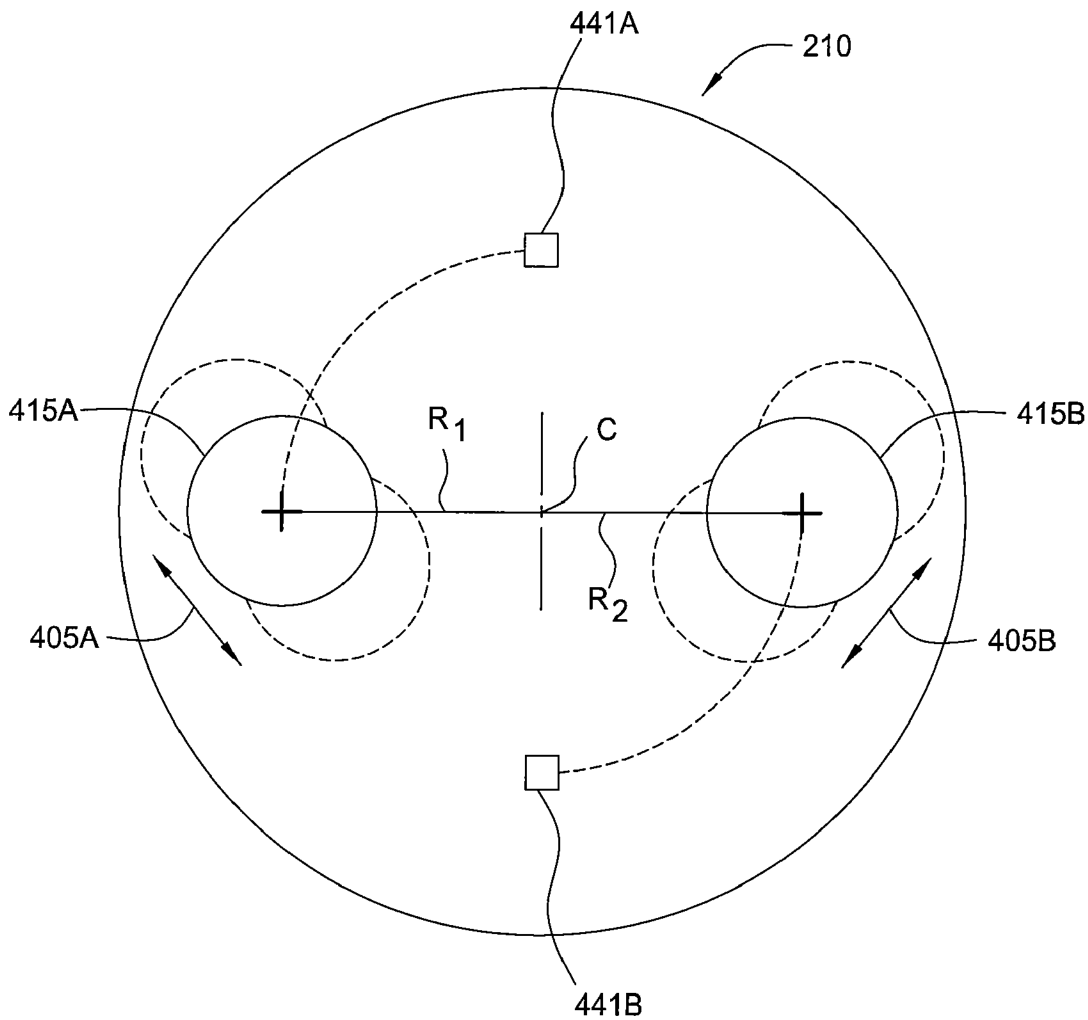

441A
210
415A
R1
C
415B
R2
405A
405B
441B

FIG. 4

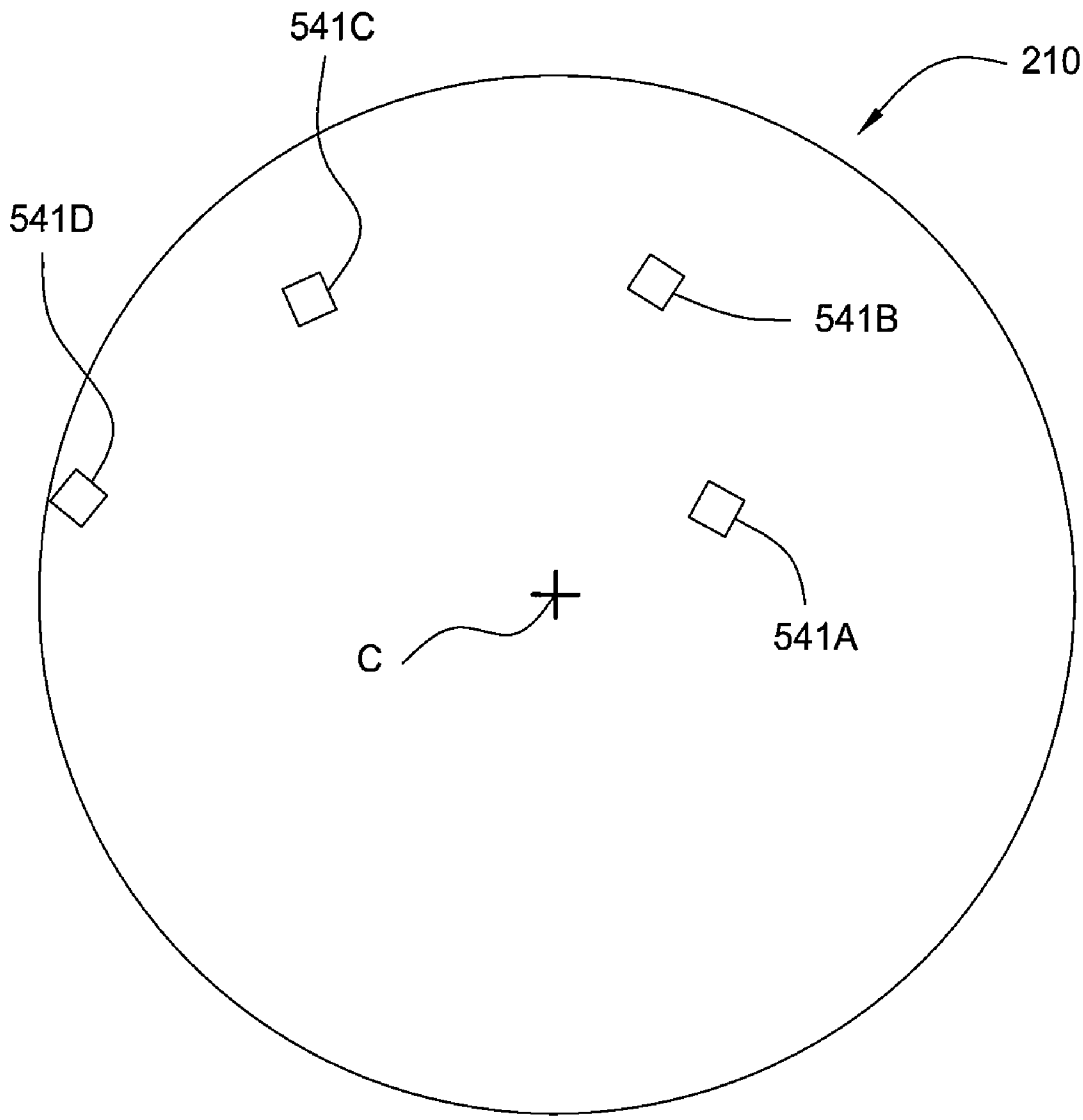


FIG. 5

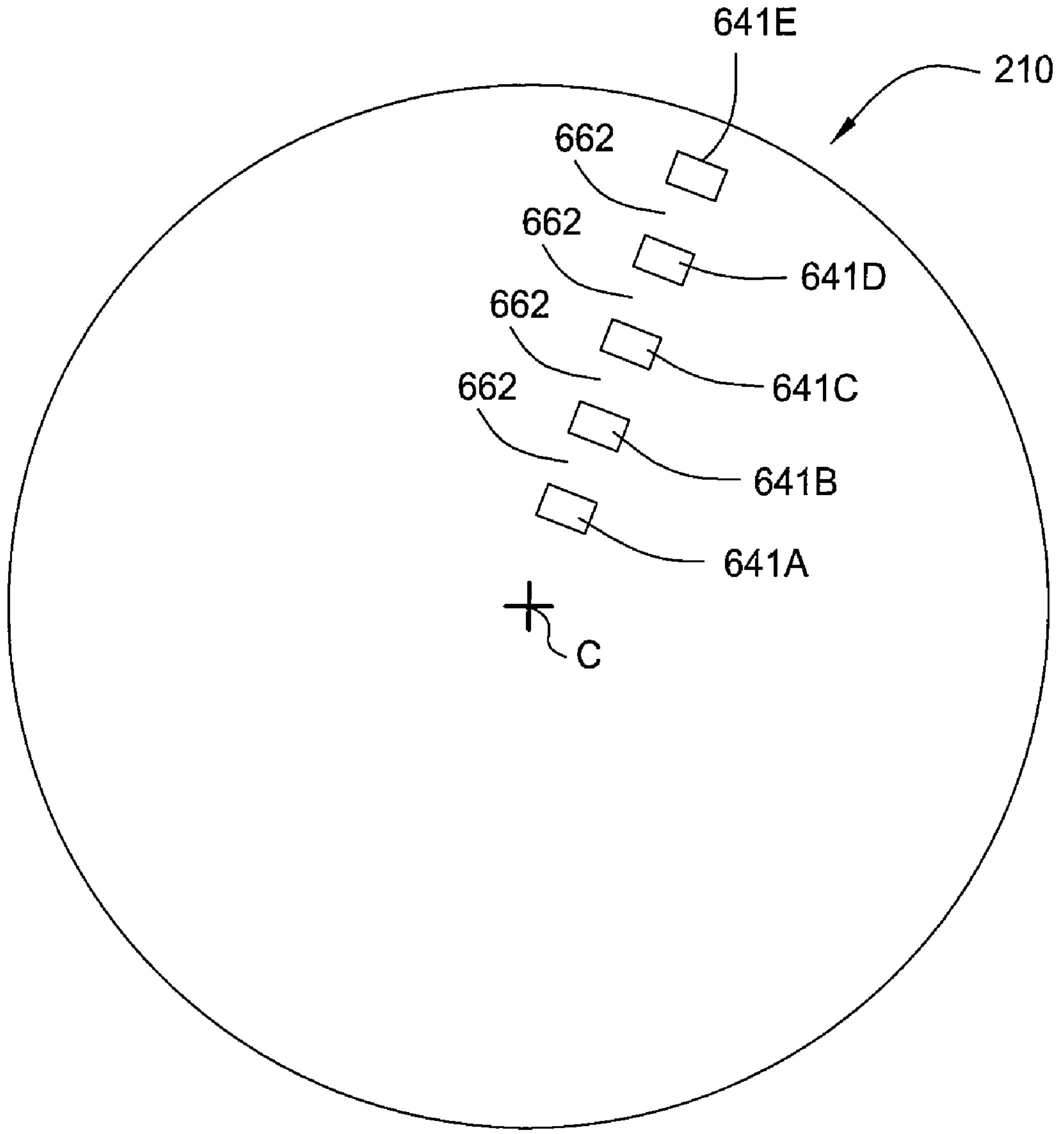


FIG. 6

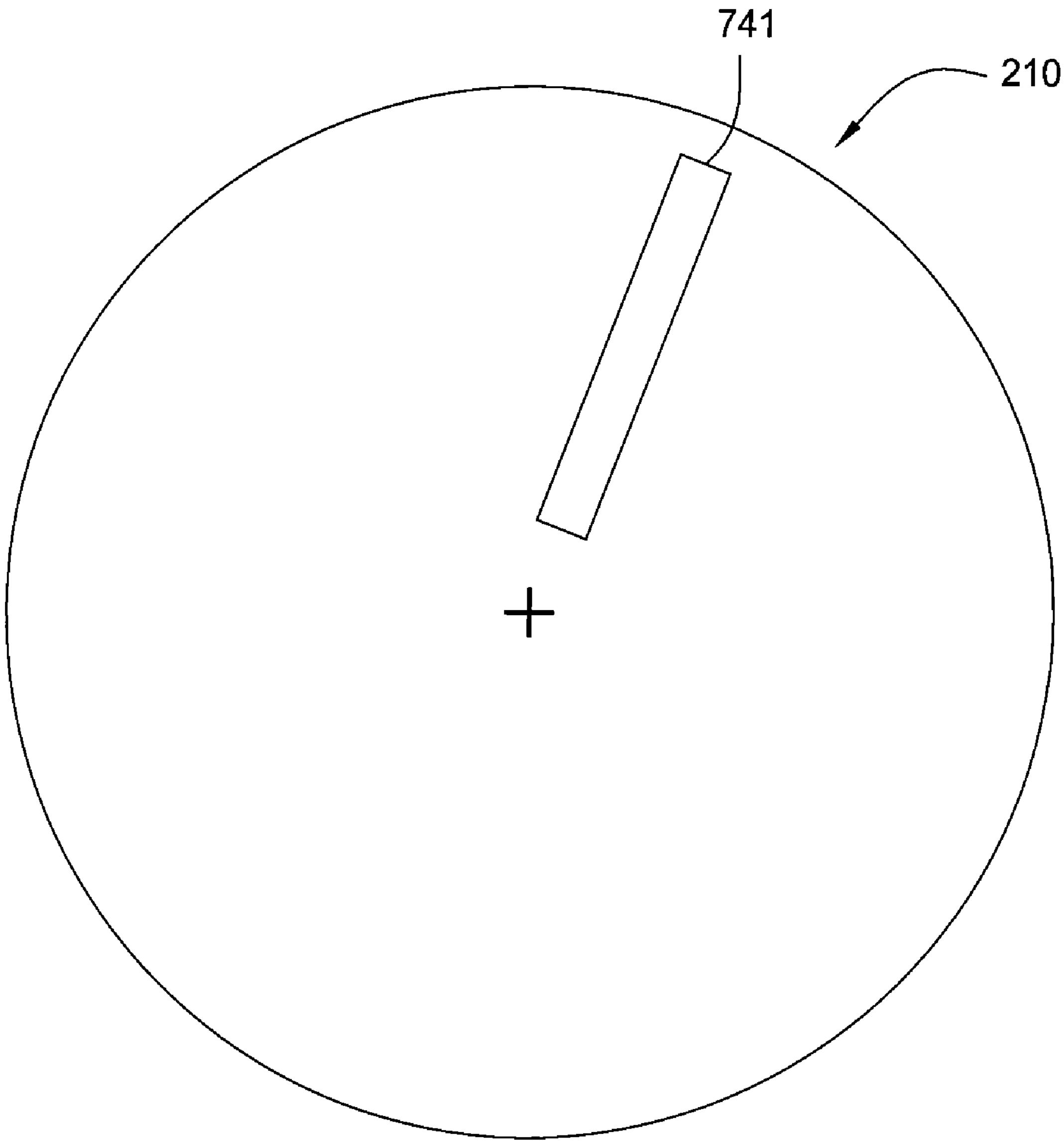


FIG. 7

MULTIPLE WINDOW PAD ASSEMBLY

CROSS-REFERENCE TO RELATED APPLICATIONS:

[0001] This application claims benefit of U.S. Provisional Patent Application Ser. No. 61/059,622 (Attorney Docket 013037L), filed Jun. 6, 2008, which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] Embodiments described herein generally relate to a chemical mechanical polishing system suitable for use in semiconductor manufacturing. More specifically, to a pad assembly suitable for use in chemical mechanical polishing system.

[0004] 2. Description of the Related Art

[0005] In the fabrication of electronic devices on semiconductor substrates, the use of chemical mechanical polishing, or CMP, has gained favor due to the widespread use of damascene interconnects structures during integrated circuit manufacturing. Although many commercially available CMP systems have demonstrated robust polishing performance, the move to smaller line widths requiring more precise fabrication techniques, along with a continual need for increased throughput and lower cost of consumables, drives an ongoing effort for polishing system improvements. Moreover, most conventional polishing systems have relatively limited flexibility for changes to processing routines, thereby limiting the diversity of processes that may be run through a single tool. Thus, new processing routines may require new or dedicated tools, or costly downtime for substantial tool configurational changes.

[0006] During CMP, various methods and apparatus have been developed to signal an endpoint to the polishing process. One conventional endpoint detection apparatus uses an optical sensor adapted to obtain a metric from the substrate being polished, such as a reflection from a layer or layers on the substrate, to gauge material removal and/or prevent over polishing. The conventional CMP pads may include a single, small transparent region or window that is generally transmissive to light or an electromagnetic signal as shown in FIG. **1**.

[0007] FIG. **1** shows a conventional CMP station **1**, partly in cross-section, that may be a stand-alone unit or part of a larger system. The CMP station **1** generally includes a platen **20** with a polishing pad **10** mounted thereon, and a carrier head assembly **30** for holding a substrate to be polished, such as a semiconductor substrate **15**, against the upper surface of the polishing pad **10**. The polishing pad **10** has an upper surface serving as a polishing surface which is brought into sliding contact with the substrate **15** to be polished. A polishing liquid supply nozzle **22** is disposed above the platen **20** for supplying a polishing liquid **18** onto the polishing pad **10**.

[0008] The polishing pad **10** may be a polymer material, which may be solely dielectric or, alternatively, at least partially conductive to facilitate electrochemical dissolution of material from the substrate **15** in an electrochemical mechanical polishing (ECMP) process. In another conventional application, the polishing pad **10** may contain fixed abrasives. Thus, the polishing liquid **18** may be a slurry or an electrolytic fluid depending on the polishing process used.

[0009] The platen **20** is coupled to a shaft **42** and motor **21** to rotate the platen **20** and polishing pad **10** about an axis. The carrier head assembly **30** is coupled to a shaft, which is coupled to a motor and a lifting/lowering device (not shown) that is adapted to urge the held substrate **15** against the polishing surface of the polishing pad **10**. The carrier head assembly **30** may be rotatable to provide movement of the held substrate **15** relative to the polishing pad **10**. The carrier head assembly **30** may also be adapted to sweep the held substrate **15** in a linear or arcuate motion across the polishing surface of polishing pad **10**. The carrier head assembly **30** is typically configured to hold the substrate **15** and provide movement relative to the polishing pad **10** along a pre-determined radial position or area of the polishing pad **10** during processing.

[0010] An optical sensor **40** is provided in the platen **20** for measuring a film thickness of an insulating film (or layer) or a metallic film (or layer) formed on the surface of the substrate **15**. The optical sensor **40** may be coupled in or on the platen **20** as shown, or coupled to a base **35** at a suitable radial location. The optical sensor **40** is typically fixed to the base **35** in that radial location. The optical sensor **40** may be a light-emitting element and a light-detecting element or an electromagnetic signal transmitter/receiver. The polishing pad **10** has a single transparent window **41** mounted therein and aligned with the optical sensor **40** for allowing signals from the optical sensor **40** to pass therethrough. The optical sensor **40** is electrically connected to a controller and the controller is connected to a display unit **45** for inspection by a user. Although the carrier head assembly **30** rotates and/or sweeps, the location of the window **41** and/or optical sensor are typically chosen based on the substrate **15** location in the pre-determined radial area or position of the polishing pad **10** during processing in order to facilitate access of the optical sensor **40** to the substantial geometric center of the substrate **15** during rotational and/or sweeping movement.

[0011] While the conventional CMP station **1** is suitable for performing a polishing process and endpoint detection on a single substrate **15** at a pre-determined radial area of the polishing pad **10**, it may not be suitable for performing a polishing process and endpoint detection on more than one substrate and/or on a system where the pre-determined radial position of the substrate may change. In one example, one or more substrates held in respective carrier head assemblies may be caused to contact the polishing pad at the same time. In another example, a first substrate may be caused to contact the polishing pad **10** at or near a perimeter of the polishing pad **10**, while a second substrate may be caused to contact the polishing pad **10** at or near a center of the polishing pad **10**. In both of these examples, the optical sensor **40** may not be in a suitable position to access the substrate for a reliable endpoint detection metric to be obtained.

[0012] What is needed is a CMP polishing station and polishing pad that is configured to adapt to various polishing motions and positional changes of the substrate being polished, which will provide enhanced flexibility and/or provide a more reliable endpoint detection metric.

SUMMARY OF THE INVENTION

[0013] Embodiments described herein provide a method and apparatus for detecting and obtaining a metric indicative of a polishing process. The apparatus includes a polishing pad having an optically transparent region adapted to obtain polishing metric from at least one substrate from at least two distinct radial positions of the polishing pad. The method includes obtaining a polishing metric from at least two substrates being polished simultaneously on a single polishing pad.

[0014] In one embodiment, a polishing pad assembly is described. The polishing pad includes a circular body comprising a polishing material having a polishing surface, and at least two portions formed in the polishing surface that are transparent to light and electromagnetic radiation, each of the at least two portions comprising a transmissive window disposed below a plane defined by the polishing surface and the transmissive window is coupled to the body by a bonding agent.

[0015] In another embodiment, a polishing pad assembly is described. The polishing pad assembly includes a circular body comprising a polishing material having a polishing surface, and a linear strip positioned along a portion of the radius of the polishing surface that is transparent to light and electromagnetic radiation, the linear strip occupying at least one half of the radius of the polishing surface and comprising a transmissive window coupled to the body by a bonding agent and disposed below a plane defined by the polishing surface.

[0016] In another embodiment, a method for obtaining a polishing metric while polishing at least two substrates simultaneously on a single circular polishing pad is described. The method includes providing rotational movement of the polishing pad relative to each of the at least two substrates, providing at least one optical sensor in selective communication with a surface of both of the at least two substrates at different radial positions, emitting light or an electromagnetic signal toward each substrate at intervals corresponding with the rotational movement of the polishing pad, and receiving a reflected signal from a surface of at least one of the substrates indicative of polishing progress.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] So that the manner in which the above recited features of the present invention can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

[0018] FIG. **1** is cross-sectional view of a conventional chemical mechanical polishing station according to the prior art.

[0019] FIG. **2** is a cross-sectional view of one embodiment of a chemical mechanical polishing station.

[0020] FIG. **3** is a cross-sectional view of a portion of one embodiment of polishing pad.

[0021] FIG. **4** is a top view of one embodiment of a polishing pad.

[0022] FIG. **5** is a top view of another embodiment of a polishing pad.

[0023] FIG. **6** is a top view of another embodiment of a polishing pad.

[0024] FIG. **7** is a top view of another embodiment of a polishing pad.

[0025] To facilitate understanding, identical reference numerals have been used, where possible, to designate identical elements that are common to the figures. It is contemplated that elements disclosed in one embodiment may be beneficially utilized on other embodiments without specific recitation.

DETAILED DESCRIPTION

[0026] Embodiments described herein provide a polishing system and pad assembly suitable for use in a polishing process. The polishing system and pad assembly is capable of providing a metric indicative of polishing performance at any radial location or radial area of the polishing pad surface and/or facilitate endpoint detection of a polishing process at multiple locations of the polishing pad surface. In one embodiment, a polishing system is described that is adapted to perform a polishing process on at least two substrates simultaneously while providing a polishing metric, such as endpoint data, on each of the at least two substrates.

[0027] FIG. **2** shows a simplified view of a chemical mechanical polishing (CMP) station **200**, partly in cross-section, that may be a stand-alone unit or part of a larger polishing system. The CMP station **200** includes a platen **220** with a polishing pad **210** mounted thereon. In this embodiment, the CMP station **200** includes two carrier head assemblies shown as **230**A and **230**B. Each carrier head assembly **230**A, **230**B is adapted to hold substrates, such as semiconductor substrates **215**A, **215**B, respectively, to be polished. Each carrier head assembly **230**A, **230**B is configured to urge the respective substrate against the upper surface of the polishing pad **210**. The polishing pad **210** has an upper surface serving as a polishing surface **218**, which is brought into sliding contact with each substrate **215**A, **215**B to be polished. A polishing liquid supply nozzle **222** is disposed above the platen **220** for supplying a polishing liquid **219** onto the polishing pad **210**.

[0028] The polishing pad **210** also includes one or more windows, such as a window W_1 and W_2 that are formed or disposed in the polishing pad **210**. Each of the one or more windows W_1 and W_2 are positioned in the polishing pad **210** to provide enhanced access to an optical sensor at more than one location on the polishing pad **210**. Additionally, if a single window is used, the single window provides a larger opening in the polishing pad **210** to provide a large access area to the optical sensor for endpoint detection and process monitoring.

[0029] The polishing pad **210** may be a polymer material, which may be solely dielectric to facilitate removal of materials from each of the substrates **215**A, **215**B. Alternatively, the polishing pad **210** may be at least partially conductive to facilitate electrochemical dissolution of material from the each of the substrates **215**A, **215**B in an electrochemical mechanical polishing (ECMP) process. Suitable polymeric materials that may be used include polyurethane, polycarbonate, fluoropolymers, PTFE, PTFA, polyphenylene sulfide (PPS), or combinations thereof, and other polishing materials used in polishing substrate surfaces. In one embodiment, polishing pad **210** includes at least a polishing surface made of a polymeric material, such as open-pored or closed-pored polyurethane material typically used in the fabrication of polishing pads for service in the polishing of semiconductor wafers. In another application, the polishing pad **210** may contain fixed abrasives. Thus, the polishing liquid **219** may be a slurry or an electrolytic fluid depending on the polishing process used.

[0030] While only two carrier head assemblies **230**A, **230**B are shown, more carrier heads may be provided to hold additional substrates so that the surface area of polishing pad **210**

may be used efficiently. Thus, the number of carrier head assemblies adapted to hold substrates for a simultaneous polishing process may be based, at least in part, on the surface area of the polishing pad **210**. While only one polishing liquid supply nozzle **222** is shown, additional nozzles, such as one or more dedicated polishing liquid supply nozzles per carrier head assembly may be used.

[0031] The platen **220** is coupled to a shaft **242** and a motor **221** to rotate the platen **220** and the polishing pad **210** about an axis. Each of the carrier head assemblies **230**A, **230**B are coupled to a shaft **232**A, **232**B, which may be coupled to a motor and a lifting/lowering device (not shown) that is adapted to urge the respective substrates **215**A, **215**B against the polishing surface **218** of the polishing pad **210**. The carrier head assemblies **230**A, **230**B may be rotatable to provide movement of the respective substrates **215**A, **215**B relative to the polishing pad **210**. The carrier head assemblies **230**A, **230**B may also be adapted to sweep the respective substrates **215**A, **215**B in a linear or arcuate motion across the polishing surface **218** of polishing pad **210**. In one embodiment, the carrier head assemblies **230**A, **230**B are disposed on a circular track (not shown) mounted above the polishing pad **210**.

[0032] At least one optical sensor **240**A is provided on the CMP station **200** for measuring a thickness of an insulating film (or layer) or a metallic film (or layer) formed on the surface of the substrates **215**A, **215**B. As an option, an additional optical sensor **240**B may be coupled to the CMP station **200**. In one embodiment, the optical sensor **240**A is coupled to a base **235** and is stationary relative to any rotational movement of the platen **220** and/or the polishing pad **210**.

[0033] In one embodiment, the optical sensor **240**A is movable, at least in a linear direction, relative to the platen **220** and/or the polishing pad **210**. One or both of the platen **220** and the base **235** may include a recessed portion and a track **205**A disposed therein allowing linear movement of the optical sensor **240**A (and **240**B). In one embodiment, the optical sensor **240**A may be coupled to the track **205**A disposed on the base **235** and movable along the track by a linear actuator **250**, such as a servo or stepper motor, or a magnetic actuator. In one application, the optical sensor **240**A is configured to be selectively positioned at different positions along at least one half of a dimension of the base **235** or the polishing pad **210**, as chosen by the user or determined by the polishing parameters, in order to align with one or more windows formed in the polishing pad **210**.

[0034] In another embodiment, the optical sensor **240**B is coupled in or on the platen **220** and configured to rotate with the platen **220** and polishing pad **210**. In this embodiment, the optical sensor **240**B may be coupled to a linear track **205**B disposed on a lower surface of the platen **220** and is movable along the track by a linear actuator **250**, such as a servo or stepper motor, or a magnetic actuator. In one application, the optical sensor **240**B is configured to be selectively positioned at differing radial positions along at least one half of a dimension of the platen **220** and/or polishing pad **210**, as chosen by the user or determined by the polishing parameters, in order to align with one or more windows, such as window W_1 and window W_2 formed in the polishing pad **210**. In this embodiment, electrical connections or wires may be disposed through the shaft **242**, or a wireless electrical and signal connection may be provided to control the optical sensor **240**B. The optical sensor **240**B may be a light-emitting element and a light-detecting element or an electromagnetic signal transmitter/receiver.

[0035] FIG. **3** is a cross-sectional view of a portion of one embodiment of polishing pad **210**. The polishing pad **210** includes a body **350**, which includes a polishing layer **360**, a supporting layer **370** and an adhesive layer **380** enabling adhesion to the platen. The polishing pad **210** also includes one or more optical windows **341** (only one is shown in the cross-sectional portion of polishing pad **210** shown in FIG. **3**). The polishing layer **360** can include a compressible material, such as a polymeric foam, and has a polishing surface **362**. The polishing layer **360** can be grown on the supporting layer **370** or a pressure sensitive adhesive (PSA) layer may be disposed between the polishing layer **360** and the supporting layer **370**. For example, a polymer layer can be grown on supporting layer **370** to form the polishing layer **360** so that a PSA layer is not needed between the supporting layer **370** and polishing layer **360**.

[0036] An opening **322** extends through polishing layer **360** to house a transmissive window **390**, which is transparent to light or electromagnetic radiation. The transmissive window **390** can be formed of one or more polymeric materials, such as, a polyurethane or a halogenated polymer (e.g., polychlorotrifluoroethylene (PCTFE), perfluoroalkoxy (PFA), fluorinated ethylene propylene (FEP), or polytetra-fluoroethylene (PTFE)). In some embodiments, the transmissive window **390** can be formed of a material having a Shore D hardness of from about 20-80. If the hardness for the material for transmissive window **390** is not within a desired range, two materials having two different hardness can be combined to provide a material with hardness in the desired range. For example, liquid forms of two materials having two different hardness can be combined in a ratio calculated to achieve the desired hardness, then the combined material can be cured and cut to size to form transmissive window **390**.

[0037] A window recess **396** may be defined between the plane in which polishing surface **362** lies and the plane in which the upper surface of the transmissive window **390** lies. The window recess **396** is designed to be of a predetermined depth D to ensure that when the compressible material forming the polishing layer **360** is compressed, the transmissive window **390** does not extend beyond the polishing layer **360** and contact the substrate that is being polished. The predetermined depth of the window recess **396** is also designed to be small enough so that air bubbles do not form in any chemical polishing solution that leaks between transmissive window **390** and a substrate during polishing. For example, the window recess **396** can be 3-4 mils deep. Selection of a specific depth to ensure that the transmissive window **390** does not contact a substrate may be determined by the compressibility of the polishing layer **360** and the load applied to the substrate during polishing. In some applications, the upper surface of the transmissive window **390** may at least incidentally contact the substrate being polished. In this application, the transmissive window **390** may be adapted to provide a polishing surface.

[0038] In some embodiments, an opening is formed through the supporting layer **370** to allow the optical sensor **240**A (and/or **240**B) (FIG. **2**)) to monitor the substrate. However, in the embodiment shown in FIG. **3**, the supporting layer **370** does not include an opening below the transmissive window **390**. In this embodiment, the supporting layer **370** may be formed from a transparent material to allow monitoring of polishing progress through the material. The supporting layer **370** can be formed of an incompressible and fluid-impermeable polymer. For example, supporting layer **370** can be formed of polyethylene terephthalate ("PET") or a MYLAR® material.

[0039] The transmissive window **390** is secured to supporting layer **370** by a window bonding adhesive **394**. The transmissive window **390** can be bonded using window bonding adhesive **394** directly to the supporting layer **370** (as shown in FIG. **3**), or to an optional adhesive or PSA layer between supporting layer **370** and polishing layer **360** (not shown). Alternatively, the transmissive window **390** could be adhered directly to the adhesive layer disposed between the supporting layer **370** and the polishing layer **360** (without the window bonding layer). The window bonding adhesive **394** is composed of a material that seals any gap between the transmissive window **390** support layer, such as supporting layer **370** or a PSA layer, and transmissive window **390**. The window bonding adhesive **394** also supports the transmissive window **390** against shear stress during polishing. The window bonding adhesive **394** can include an adhesive sealant, such as a viscous rubber-like glue. For example, for some PSA layers, the window bonding adhesive **394** can include one-part room temperature vulcanizing ("RTV") silicone TSE399™ or TSE397™ materials, which are distributed by GE Silicones of Waterford, N.Y.

[0040] FIG. **4** is a top view of one embodiment of a polishing pad **210** having two optical windows **441**A and **441**B that may be similar to the optical window **341** described in FIG. **3**. The first optical window **441**A is positioned at a first radial location along a first radial path R_1 of substrate **415**A and the second optical window **441**B is positioned along a second radial path R_2 of substrate **415**B. In one embodiment, R_1 and R_2 are equal such that both optical windows **441**A, **441**B are positioned the same distance from the center C of the polishing pad **210**. In this embodiment, the substrates **415**A and **415**B are rotated relative to the rotating polishing pad **210** and additionally sweep relative to the rotating polishing pad **210** in a direction generally indicated as sweep paths **405**A and **405**B, and each optical window is positioned to allow light or an electromagnetic signal from the optical sensor (FIG. **2**) to impinge the center of the respective sweep path **405**A and **405**B. While each of the sweep paths **405**A and **405**B are shown as linear, it is understood that the sweep path may be arcuate as well.

[0041] While not shown, a single, movable optical sensor (**240**A or **240**B of FIG. **2**) is aligned with the first optical window **441**A and second optical window **441**B during each revolution of the polishing pad **210**. Alternatively, the optical sensor is aligned with the first optical window **441**A and second optical window **441**B at a specified interval or intervals based on one or more revolutions of the polishing pad **210**. For example, the controller (FIG. **2**) contains an algorithm allowing the optical sensor to move between the two optical windows **441**A and **441**B corresponding with each revolution of the polishing pad **210**. Alternatively, the single optical sensor may move between the two optical windows **441**A and **441**B at alternating intervals based on a fraction of one revolution of the polishing pad **210**. In one application, the optical sensor may alternate between optical windows **441**A, **441**B at every other revolution. In another application, the optical sensor may move between the two optical windows at or about each half revolution of the polishing pad **210**. Alternatively, two optical sensors (**240**A and **240**B of FIG. **2**) may be dedicated to and positioned to align with each optical window **441**A, **441**B. In this manner, an endpoint metric may be provided for each substrate **415**A and **415**B as the respective substrate passes an optical window at each revolution, or at any specified periodicity.

[0042] In another application, the optical windows **441**A, **441**B may be positioned at a specific radius or distance from the center C to overlap with a sweep path of either or both of the substrates **415**A, **415**B in a manner that provides an endpoint metric at different locations on a single substrate. For example, substrate **415**A and its respective sweep path **405**A may be centered at R_1, which is the same radial position of optical window **441**A. While an algorithm may be provided to provide a signal and metric as the substantial geometric center of substrate **415**A passes optical window **441**A, the optical window **441**B may provide a signal and a metric from another portion of substrate **415**A. Alternatively, an algorithm may be provided to provide a signal and metric as any portion of the substrate **415**A passes optical window **441**A and the optical window **441**B may provide a signal and a metric from a different portion of substrate **415**A. This allows more accurate endpoint determination as the periodicity is increased and/or a greater surface of the substrate is surveyed. In one example, an endpoint metric may be obtained from a center of the substrate and another endpoint metric may be obtained from a periphery of the same substrate at each revolution of the polishing pad **210** (or at any specified periodicity), which in this example is substrate **415**A.

[0043] FIG. **5** is a top view of another embodiment of a polishing pad **210** having four optical windows **541**A-**541**D, wherein each optical window **541**A-**541**D may be similar to the optical window **341** described in FIG. **3**. In this embodiment, each optical window **541**A-**541**D is positioned at four specific radial locations on the polishing pad **210**. While the pattern of optical windows **541**A-**541**D are shown in an arcuate or spiral pattern on the polishing pad **210**, the optical windows **541**A-**541**D may be any pattern, such as in a cross-shape or X shape, or a linear pattern. Additionally, while four optical windows **541**A-**541**D are shown, the polishing pad **210** may have any number of windows.

[0044] FIG. **6** is a top view of another embodiment of a polishing pad **210**. In this embodiment, the polishing pad includes five optical windows **641**A-**641**E that may be similar to the optical window **341** shown in FIG. **3**. The optical windows **641**A-**641**E are arranged in a linear fashion, such as in a radial line. In this embodiment, the optical windows **641**A-**641**E are separated by polishing material **662**, which is part of the polishing surface of the polishing pad **210**. Although five optical windows **641**A-**641**E are shown, any number of optical windows may be used.

[0045] Collectively, the optical windows **641**A-**641**E and polishing material **662** between each optical window covers at least about one half of the radius of the polishing pad **210**. For example, if the polishing pad **210** has a diameter of about 42 inches, which corresponds to a radius of 21 inches, the collective length of the optical windows **641**A-**641**E and polishing material **662** between each optical window covers at least about 10.5 inches. In another embodiment, the optical windows **641**A-**641**E and polishing material **662** between each optical window collectively covers at least about 75% to about 90% of the radius of the polishing pad **210**. For example, if the polishing pad **210** has a diameter of about 42 inches, which corresponds to a radius of 21 inches, the collective length of the optical windows **641**A-**641**E and polishing material **662** between each optical window covers about 15.7 inches to about 18.9 inches.

[0046] In another embodiment, the optical windows **641**A-**641**E may be spaced along the radial line in a manner that spaces each optical window at specific radial distances from center C and/or an outside diameter of the polishing pad **210**. In one example, if the polishing pad **210** has a diameter of about 42 inches, which corresponds to a radius of 21 inches, the center of each optical window **641**A-**641**E may be spaced at about 4 inch increments. In another embodiment, the perimeter optical window **641**E may be spaced about 1-2 inches from the outer diameter of the polishing pad **210**, and the remaining optical windows may be spaced, either equally or unequally, towards the center C.

[0047] FIG. **7** is a top view of another embodiment of a polishing pad **210**. In this embodiment, the polishing pad includes a single radially elongated optical window **741** that may be similar to the optical window **341** shown in FIG. **3**, with the exception of occupying a greater portion of the area of the polishing pad **210**. In this embodiment, the optical window **741** is arranged in a linear fashion, such as in a line corresponding to a radius, and includes no polishing material therebetween. While the optical window **741** is disposed along a radius of the polishing pad **210**, the optical window **741** may be disposed on the polishing pad **210** as a chord, or a segment thereof (not shown). In another embodiment (not shown), optical window **741** may be formed as an arc.

[0048] In the embodiments shown in FIGS. **5-7**, a single, movable optical sensor, such as optical sensor **240**A or **240**B (FIG. **2**) is aligned with the optical windows **541**A-**541**D or **641**A-**641**E, or at various points along the single optical window **741** during each revolution of the polishing pad **210**, or at specified intervals, such as every half revolution or every other revolution of the polishing pad **210**. For example, the controller (FIG. **2**) contains an algorithm allowing the optical sensor to move between various positions corresponding with each revolution of the polishing pad **210**, or the optical sensor may move between positions to align with the optical window(s) at alternating revolutionary intervals, such as half revolutions, one-quarter revolutions, among other intervals. Alternatively, more than one optical sensor may be dedicated to and positioned to align with one or more of the optical windows **541**A-**541**D or **641**A-**641**E. In another alternative, more than one optical sensor may be positioned, either fixed or movable relative to the polishing pad **210** and/or platen (not shown), to be aligned with various points along the single optical window **741** at each revolution or at any specified periodicity. In this manner, an endpoint metric may be provided for one or more substrates as the respective substrate passes an optical window and/or optical sensor at each revolution, or at any specified periodicity. In yet another application, at least one optical sensor may be configured to align with one or more optical sensors to provide an endpoint metric at more than one location on a single substrate.

[0049] The inventive polishing pad is configured to adapt to various polishing motions and/or positional changes of a substrate or substrates being polished on the pad. The polishing pad as described herein provides enhanced flexibility and/or a more reliable endpoint detection metric of the substrate or substrates being polished. Modification of a polishing pad as described herein minimizes the available polishing surface of the polishing pad as additional sections of the polishing surface are removed for installation of additional or larger windows. Further, properties of the pad, such as flatness, hardness and other properties are changed when additional or larger windows are added. Thus, modification of a polishing pad meets general reluctance in the field due to the aforementioned problems. However, the inventive polishing pad with multiple and/or larger windows has provided a more precise endpoint metric and enables an endpoint metric at a greater frequency.

[0050] While the foregoing is directed to embodiments of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

What is claimed is:

1. A polishing pad assembly, comprising:

a circular body comprising a polishing material having a polishing surface; and

at least two portions formed in the polishing surface that are transparent to light and electromagnetic radiation, each of the at least two portions comprising a transmissive window disposed below a plane defined by the polishing surface and the transmissive window is coupled to the body by a bonding agent.

2. The polishing pad assembly of claim **1**, wherein the at least two portions are disposed at different radial positions within the circular body.

3. The polishing pad assembly of claim **1**, wherein the circular body comprises a supporting layer.

4. The polishing pad assembly of claim **3**, wherein the transmissive window is adhered to the supporting layer.

5. The polishing pad assembly of claim **3**, wherein the supporting layer comprises a material that is transparent to light and electromagnetic radiation.

6. The polishing pad assembly of claim **3**, wherein the at least two portions are disposed in the supporting layer.

7. The polishing pad assembly of claim **1**, wherein the circular body comprises an adhesive layer opposite the polishing surface.

8. The polishing pad assembly of claim **7**, wherein the adhesive layer is transparent to light and electromagnetic radiation.

9. A polishing pad assembly, comprising:

a circular body comprising a polishing material having a polishing surface; and

a linear strip positioned along a portion of the radius of the polishing surface that is transparent to light and electromagnetic radiation, the linear strip occupying at least one half of the radius of the polishing surface and comprising a transmissive window coupled to the body by a bonding agent and disposed below a plane defined by the polishing surface.

10. The polishing pad assembly of claim **9**, wherein the circular body comprises a supporting layer.

11. The polishing pad assembly of claim **10**, wherein the transmissive window is adhered to the supporting layer.

12. The polishing pad assembly of claim **10**, wherein the supporting layer comprises a material that is transparent to light and electromagnetic radiation.

13. The polishing pad assembly of claim **9**, wherein the linear strip comprises one or more optical windows separated by a polishing material.

14. The polishing pad assembly of claim **9**, wherein the linear strip occupies about 75% of the radius of the polishing surface.

15. The polishing pad assembly of claim **9**, wherein the linear strip occupies about 90% of the radius of the polishing surface.

16. A method for obtaining a polishing metric while polishing at least two substrates simultaneously on a single circular polishing pad, comprising:

providing rotational movement of the polishing pad relative to each of the at least two substrates;

providing at least one optical sensor in selective communication with a surface of both of the at least two substrates at different radial positions;

emitting light or an electromagnetic signal toward each substrate at an interval corresponding with the rotational movement of the polishing pad; and

receiving a reflected signal from a surface of at least one of the substrates indicative of polishing progress.

17. The method of claim **16**, further comprising:

moving the at least one optical sensor to different radial positions at each revolution of the polishing pad.

18. The method of claim **16**, further comprising:

moving the at least one optical sensor to different radial positions at substantially each half revolution of the polishing pad.

19. The method of claim **16**, wherein the interval equals one revolution of the polishing pad.

20. The method of claim **16**, wherein the interval equals every other revolution of the polishing pad.

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