POLISHING PAD COMPRISING TRANSMISSIVE REGION

BACKGROUND OF THE INVENTION

[0001] Chemical-mechanical polishing ("CMP") processes are used in the manufacturing of microelectronic devices to form flat surfaces on semiconductor wafers, field emission displays, and many other microelectronic substrates. For example, the manufacture of semiconductor devices generally involves the formation of various process layers, selective removal or patterning of portions of those layers, and deposition of yet additional process layers above the surface of a semiconducting substrate to form a semiconductor wafer. The process layers can include, by way of example, insulation layers, gate oxide layers, conductive layers, and layers of metal or glass, etc. It is generally desirable in certain steps of the wafer process that the uppermost surface of the process layers be planar, i.e., flat, for the deposition of subsequent layers. CMP is used to planarize process layers wherein a deposited material, such as a conductive or insulating material, is polished to planarize the wafer for subsequent process steps.

[0002] In polishing the surface of a substrate, it is often advantageous to monitor the polishing process in situ. One method of monitoring the polishing process in situ involves the use of a polishing pad having an aperture or window. The aperture or window provides a portal through which light can pass to allow the inspection of the substrate surface by an optical detection system during the polishing process. Polishing pads having apertures or windows are known and have been used to polish substrates, such as semiconductor devices. For example, U.S. Patent 6,171,181 discloses a polishing pad comprising a one-piece molded article having a translucent region and an opaque region. The translucent region is formed by solidification of a flowable polymeric material which is initially translucent so that a portion of the polymeric material retains its transparency after solidification. Rapid cooling of a region of the flowable polymeric material results in solidification of the region to minimize crystallization of the material in the region and to provide the amorphous translucent region. U.S. Patent 6,840,843 discloses a polishing pad comprising a translucent region, wherein the translucent region is prepared by compressing a region of a porous polymeric polishing pad substrate so as to provide the translucent region.

[0003] However, the apertures or windows often have properties that differ from the rest of the polishing pad, such as porosity, hardness, resistance to wear, and the like. These property differences often lead to non-uniform polishing of substrates. Additionally, apertures or windows have typically been designed to allow maximum transmission of light to the target substrate and to the detector. This fact does not take into consideration that

different substrates and different detectors may require a different quality or quantity of light for optimum end point detection. Thus, there remains in the art a need for improved polishing pads with optically transmissive regions.

BRIEF SUMMARY OF THE INVENTION

[0004] A first aspect of the present invention provides a polishing pad comprising an optically transmissive region, wherein the polishing pad comprises (a) a polishing pad body comprising a first region and a second region, wherein the first region is opaque, wherein the second region is optically transmissive, wherein the second region has at least one recess formed therein, and (b) at least one translucent insert integrated into the at least one recess, wherein the polishing pad body comprises a first porous material and the at least one translucent insert comprises a second porous material that differs from the first porous material.

[0005] A second aspect of the present invention provides a method for making a polishing pad having an optically transmissive region, comprising the steps of (a) providing a polishing pad body, wherein the polishing pad body comprises a first porous material, (b) forming at least one recess within the polishing pad body, (c) providing at least one translucent insert, wherein the translucent insert comprises a second porous material that differs from the first porous material, and (d) adhering the at least one translucent insert to the recess to provide a polishing pad having at least one optically transmissive region.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING(S)

[0006] FIG. 1 is a cross-sectional view of a polishing pad in accordance with an embodiment of the invention.

[0007] FIG. 2 is a cross-sectional view of a polishing pad in accordance with an embodiment of the invention.

[0008] Figures 3A-3C depicts representative surface textures of translucent windows in accordance with certain embodiments of the invention.

[0009] FIG. 4 is a cross-sectional view of a polishing pad in accordance with an embodiment of the invention.

[0010] FIG. 5 is a cross-sectional view of a polishing pad in accordance with an embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0011] The invention provides a polishing pad comprising an optically transmissive region. The polishing pad comprises (a) a polishing pad body comprising a first region and a second region, wherein the first region is opaque, wherein the second region is optically transmissive, wherein the second region has at least one recess formed therein, and (b) at least one translucent insert integrated into the at least one recess, wherein the polishing pad body comprises a first porous material and the at least one translucent insert comprises a second porous material that differs from the first porous material.

[0012] The polishing pad can have any suitable dimensions. Typically, the polishing pad is circular in shape (as is used in rotary polishing tools) or is produced as a looped linear belt (as is used in linear polishing tools). Preferably, the polishing pad is circular.

[0013] The polishing pad body can comprise any suitable material. Desirably, the polishing pad body comprises a polymer resin. The polymer resin can be any suitable polymer resin. Typically, the polymer resin is selected from the group consisting of thermoplastic elastomers, thermoset polymers, polyurethanes (e.g., thermoplastic polyurethanes), polyolefins (e.g., thermoplastic polyolefins), polycarbonates, water soluble polymers like polyethyleneoxide, glycols, poly(vinyl alcohols), biodegradable polymers such as poly(lactic acid), poly(hydroxyl butyrate), polymers which are crosslinkable by UV or gamma radiation, polysilicones, polysiloxanes, polyvinylalcohols, nylons, elastomeric rubbers, elastomeric polyethylenes, polytetrafluoroethylenes, polyethyleneterephthalates, polyimides, polyaramides, polyarylenes, polyacrylates, polystyrenes, polymethylmethacrylates, copolymers thereof, and mixtures thereof. Preferably, the polymer resin is a polyurethane, more preferably, a thermoplastic polyurethane.

[0014] The polishing pad body can be produced using any suitable technique, many of which are known in the art. For example, the polishing pad body can be formed by methods such as casting and extrusion. The polymer resin may be a thermoplastic material which is heated to a temperature at which it will flow and is then formed into a desired shape by casting or extrusion. The polymer resin may provide a porous structure by its natural configuration. In other embodiments, the porous structure may be introduced through the use of various production techniques known in the art (e.g., foaming, blowing, and the like). Representative methods providing a porous structure comprising closed-cell pores include foaming processes such as a supercritical fluid (SCF) process, a phase inversion process, a spinodal or bimodal decomposition process, or a pressurized gas injection process, all of which are well known in the art. A representative method providing a porous structure

comprising open-cell pores comprises sintering particles of a thermoplastic polymer, such as a polyurethane, to provide an open-cell porous structure.

[0015] The pad comprises a body comprising a first region and a second region, wherein the first region is opaque, and wherein the second region is optically transmissive. The first region of the polishing pad body is porous and has a first void volume. The first void volume is non-zero and can be any suitable non-zero void volume. For example, the first void volume can be 5% or more (e.g., 10%% or more, or 20% or more, or 30% or more, or 40% or more). Alternatively, or in addition, the first void volume can be 70% or less (e.g., 60% or less, or 50% or less, or 45% or less, or 40% or less). The first void volume can be bounded by any two of the aforementioned void volumes. Thus, for example, the first void volume can be 20% to 70%, or 20% to 60%, or 20% to 50%, or 25% to 70%, or 25% to 60%, or 25% to 50%.

[0016] The first region of the polishing pad body can have any suitable average pore size. For example, the first region of the polishing pad body can have an average pore size of 500 μm or less (e.g., 300 μm or less, or 200 μm or less). In one preferred embodiment, the first region of the polishing pad body has an average pore size of 50 μm or less (e.g., 40 μm or less, or 30 μm or less). In another preferred embodiment, the first region of the polishing pad body has an average pore size of 1 μm to 20 μm (e.g., 1 μm to 15 μm, or 1 μm to 10 μm).

[0017] Typically the first region of the polishing pad body comprises predominantly closed cells (i.e., pores); however, the first region of the polishing pad body can also comprise open cells. Preferably, the first region of the polishing pad body comprises 5% or more (e.g., 10% or more) closed cells based on the total void volume. More preferably, the first region of the polishing pad body comprises 20% or more (e.g., 30% or more, 40% or more, or 50% or more) closed cells based on the total void volume.

[0018] The second region of the polishing pad body can be porous, substantially non-porous, or completely non-porous. The second region of the polishing pad body typically has a void volume which is smaller than the void volume of the first region of the polishing pad body.

[0019] The first region of the polishing pad body is substantially or entirely opaque. In one embodiment, a portion of the polishing pad body, which is substantially or entirely opaque, is compressed to form a second region of the polishing pad body that is optically transmissive. The term "optically transmissive" as used herein, refers to the ability to transmit at least a portion of light contacting the surface of the polishing pad and can be used to describe slightly, partially, substantially, and completely translucent or transparent

materials. The at least one second region of the polishing pad body preferably is at least optically transmissive to light having a wavelength of 390-3500 nm, more preferably visible light, and most preferably visible light from a laser light source, particularly as used in a polishing device to be used with the polishing pad.

[0020] Without wishing to be bound by any particular theory, it is believed that the pores in the polishing pad body cause light passing through the porous structure to scatter, thereby reducing the translucency of the polishing pad body or rendering the polishing pad body opaque. The degree of light scattering is believed to be a function of average pore size and average pore volume. It is further believed that compressing the polishing pad body reduces the light-scattering effect of the pores by reducing the porosity of the polishing pad body in the region that is compressed. As a result, the compressed region (i.e., the second region of the polishing pad body) has an increased light transmittance (i.e., decreased level of light scattering and increased translucence) as compared to the polishing pad body that is not compressed (i.e., the first region of the polishing pad body).

[0021] As will be appreciated by those of ordinary skill in the art, the degree of translucence provided in this manner will depend, at least in part, on the degree to which the porous polymer structure is compressed (i.e., the degree to which the porosity of the porous polymer structure is reduced). For example, the polishing pad body can be compressed by 10-50% (e.g., 20-40%) of its thickness prior to compression (i.e., the non-compressed thickness of the polishing pad body).

[0022] Compression of the polishing pad body to form at least one recess can be performed in any suitable manner known in the art. As will be appreciated by those of ordinary skill in the art, the most effective technique of compression will depend, at least in part, on the particular polymer used in the fabrication of the polishing pad body. The polishing pad body can be compressed, for example, by use of RF welding techniques, by use of calendar rollers, or by use of various pressing mechanisms known in the art, such as a platen press, stamping machine, and the like. Furthermore, heat can be used, either alone or in conjunction with other compression techniques, to achieve a compressed structure. For example, the polishing pad body can be heated to a temperature approaching, meeting, or exceeding its softening or melting temperature for a time sufficient to allow the pores of the second region of the polishing pad body to collapse under the weight of the polymer used in the construction of the polishing pad body. Alternatively, heat can be applied to the polishing pad body before, during, or after compressing of the polishing pad body using another compression technique. For example, an RF welding process can use a die or dies in

conjunction with application of radiofrequency energy in the megahertz region to cause heating of the polishing pad body that is in contact with the die or dies to cause compression of the region of the polishing pad body. In another example, a heated press or heated rollers can be used to compress the polishing pad body so as to compress a region of the polishing pad body. When using heat in conjunction with another compression technique to compress the polishing pad body, the polishing pad body is preferably heated to a temperature that approaches, meets, or exceeds the softening or melting temperature of the polishing pad body.

[0023] In another embodiment, the second region of the polishing pad body is provided with at least one recess, wherein the at least one recess is formed in one face (i.e., one surface) of the polishing pad body. The said recess, or recessed area, can be formed by removing pad material from the face of the pad using any suitable manner, such as with the use of a router tool. In one embodiment the material is removed from the recess area via a rotary cutting tool which is mounted on a computer numerical controlled (CNC) router table. Depth of cut, position of the recess, rotational speed of the cutting tool and planarity of the recess are controlled by a programming code. In another embodiment, the second region of the polishing pad body is provided with a first recess and a second recess, wherein the first and second recesses are formed by removing pad material on opposite faces of the polishing pad body.

[0024] The polishing pad comprises at least one translucent insert integrated into the at least one recessed area. The translucent window comprises a porous material that is different from the material used in the preparation of the polishing pad body. The translucent insert can comprise any suitable material. Desirably, the translucent insert comprises a polymer resin. The polymer resin can be as described herein for use in the preparation of the polishing pad body. Preferably, the polymer resin used in the preparation of the translucent insert is a thermoplastic polymer.

[0025] FIG. 1 depicts an embodiment of the inventive polishing pad. The insert 20 is integrated into a recess in the polishing pad body to form a transmissive region. A subpad 30 is affixed to the bottom surface of polishing pad body 10.

[0026] The translucent insert can be prepared using any suitable method, such as any of the methods described herein for the preparation of the polishing pad body. In a preferred embodiment, the translucent insert is prepared by casting or extrusion of a thermoplastic polymer resin (e.g., a thermoplastic polyurethane), followed by pressurized gas injection process. For example, the thermoplastic polymer resin can be extruded to provide a sheet of

window blank material, which is then subjected to high pressure carbon dioxide in a pressure chamber, followed by heating to cause absorbed carbon dioxide to expand and to foam the polymer resin. This insert material is then die cut to the final shape of the recess on the face of the polishing pad body and integrated into the recess using RF welding.

[0027] The translucent insert has a void volume that is non-zero. For example, the void volume of the translucent insert can be 1% or more (e.g., 2% or more, or 3% or more, or 4% or more, or 5% or more). Alternatively, or in addition, the void volume of the translucent insert can be 25% or less (e.g., 20% or less, or 15% or less). The void volume of the translucent insert can be bounded by any two of the aforementioned void volumes. Thus, for example, the void volume of the translucent insert can be 1% to 25%, or 1% to 20%, or 1% to 15%, or 1% to 10%, or 25% to 60%, or 25% to 50%.

[0028] The translucent insert can have any suitable average pore size. For example, the translucent insert can comprise pores having an average pore size of 50 μm or less (e.g., 40 μm or less, or 30 μm or less). In a preferred embodiment, the translucent insert comprises pores having an average pore size of 1 μm to 20 μm (e.g., 1 μm to 15 μm, or 1 μm to 10 μm).

[0029] Typically the translucent insert comprises predominantly closed cells (i.e., pores); however, the translucent insert can also comprise open cells. Preferably, the translucent insert comprises 5% or more (e.g., 10% or more) closed cells based on the total void volume. More preferably, the translucent insert comprises 20% or more (e.g., 30% or more, 40% or more, or 50% or more) closed cells based on the total void volume.

[0030] The translucent insert can be integrated into the at least one recess by use of any suitable technique. Non-limiting examples of suitable techniques include welding techniques and the use of adhesives. Preferably, the translucent insert is integrated into the at least one recess by use of a welding technique, more preferably by use of RF welding or ultrasonic welding. RF welding involves positioning a translucent insert to be welded into a recess on the polishing pad body and using a die to direct the welding process. High frequency waves in the megahertz scale are passed through the materials with the result that the pieces are heated and the translucent insert becomes integrated into the recess. Ultrasonic welding involves the use of high frequency sound waves to melt the materials comprising the translucent window and the polishing pad body in the recess and thereby cause the materials to flow together so that the translucent insert becomes integrated into the recess. Typically, the source of ultrasonic waves is a sound-generating metal tuning device (e.g., a "horn") that converts a high-frequency electrical signal into sound in the kilohertz scale, although any suitable source of ultrasonic sound can be used. The horn can be any suitable horn, for

example, a stainless steel horn. The horn can have any suitable shape or configuration and preferably is machined to have a similar shape, or even an identical shape, to the shape of the translucent insert.

[0031] In certain embodiments, the translucent insert is formed in situ in a recess in the polishing pad body. After formation of the recess, a precursor to the translucent insert is placed within the recess and then converted into the translucent insert. For example, particles of a thermoplastic polyurethane can be placed into the recess, followed by heating and/or compression, such as by use of RF welding, to provide a sintered translucent insert integrated into the recess.

[0032] In certain embodiments, the polishing pad comprises at least two translucent inserts integrated into recesses formed in opposite faces of the polishing pad body, which translucent inserts desirably are aligned with each other. In these embodiments, the at least two translucent inserts can be the same or different. The at least two translucent inserts can comprise the same or different polymer resins. When the at least two translucent inserts are different, the translucent insert which is on the front face of the polishing pad is porous, while the translucent insert which is opposite to the front face of the polishing pad may be porous or may be substantially or even completely nonporous.

[0033] FIG. 2 depicts an embodiment of the inventive polishing pad comprising two translucentinserts. Translucent inserts 20 and 40 are aligned and integrated into opposing recesses on polishing pad body 10. A subpad 30 is affixed to the bottom surface of polishing pad body 10.

[0034] In some embodiments, the translucent insert has a surface texture. The surface texture facilitates the lateral transport of a polishing composition, or the abrasive particles across the surface of the translucent window. The surface texture can be provided using any suitable technique, an example of which is through embossing the surface of the translucent window. Embossing can provide a variety of patterns as depicted in FIGS. 3A-3C. For example, embossing can be used to create a dimple pattern as depicted in FIG. 3A, a hexagonal pattern as depicted in FIG. 3B, or a reversed hexagonal pattern as depicted in FIG. 3C. Other suitable surface texture patterns can be readily envisioned by one of ordinary skill in the art.

[0035] The surface texture can be embossed into a surface of the translucent window by using an RF welding tool having features that transfer to the surface of the translucent window during the welding process to integrate the translucent window into the polishing pad body. Alternatively, the surface texture can be embossed into a surface of the translucent

insert prior to integration into the polishing pad body. In addition, the formation of a surface texture on the surface of a foamed translucent insert typically results in the formation of higher and lower porosity regions within the translucent insert corresponding to the different degrees of compression that result in formation of the texture pattern.

[0036] The surface texture of the translucent insert can be tailored to provide a desired amount of light transmission. The presence of a surface texture can result in greater light scattering of an incident beam of radiation, thus the density and type of surface texture can be selected to provide the desired light transmission properties. In addition, alteration of the degree of porosity of the translucent window by, for example, embossing also can affect light scattering caused by pores.

[0037] The translucent insert optionally contains soluble particles incorporated into the translucent insert. When present, the soluble particles preferably are dispersed throughout the translucent insert. Such soluble particles partially or completely dissolve in the liquid carrier of the polishing composition during chemical-mechanical polishing. Typically, the soluble particles are water-soluble particles. For example, the soluble particles can be any suitable water-soluble particles, such as particles of materials selected from the group consisting of dextrins, cyclodextrins, mannitol, lactose, hydroxypropylcelluloses, methylcelluloses, starches, proteins, amorphous non-cross-linked polyvinyl alcohol, amorphous non-cross-linked polyvinyl pyrrolidone, polyacrylic acid, polyethylene oxide, water-soluble photosensitive resins, sulfonated polyisoprene, and sulfonated polyisoprene copolymer. The soluble particles also can be inorganic water-soluble particles, such as particles of materials selected from the group consisting of potassium acetate, potassium nitrate, potassium carbonate, potassium bicarbonate, potassium chloride, potassium bromide, potassium phosphate, magnesium nitrate, calcium carbonate, and sodium benzoate. When the soluble particles dissolve, the translucent window can be left with open pores corresponding to the size of the soluble particles.

[0038] In an embodiment, the translucent insert comprises a first thermoplastic polymer and a second thermoplastic polymer, wherein the first and second thermoplastic polymers are immiscible and form distinct phases within the translucent insert. The refractive index of the translucent insert will depend on the refractive indices of the thermoplastic polymers used in its formation and their relative amounts and can be varied based on the aforesaid parameters.

[0039] The translucent insert can be of any suitable shape, dimension, or configuration. For example, the translucent insert can have the shape of a circle, an oval, a rectangle, or a square. When the translucent insert is oval or rectangular in shape, the insert typically has a

maximum length of 3 cm to 8 cm. When the translucent insert is circular or square in shape, the translucent insert typically has a diameter or width of 1 cm to 4 cm. The translucent insert typically has a thickness of 0.1 cm to 5 cm (e.g., 0.1 cm to 3 cm, or 0.1 cm to 1 cm).

[0040] The polishing pad can comprise any suitable number of translucent inserts. The translucent insert or inserts can be positioned in any suitable location of the polishing pad body.

[0041] In an embodiment, the polishing pad further comprises a wear indicator located in the transmissive region. The wear indicator desirably changes the end point signal generated by the polishing apparatus to provide notice that the polishing pad is ready to be changed for a new polishing pad. The window wear indicator typically is integrated into the recessed area of the pad between the recessed area and the translucent insert. Non-limiting examples of suitable wear indicators include a colored thermoplastic urethane layer, a polarized thermoplastic urethane layer, a thermoplastic urethane layer comprising a fluorescing agent, a polymer layer with unique light transmission properties, an oxidized layer, a polymer comprising thermochromic dyes, a moisture indicating layer for detection of window leaks, and a wavelength filtering layer. FIG. 4 depicts an embodiment of the inventive polishing pad comprising opposing translucent inserts 20 and 40 integrated into polishing pad body 10, with wear indicator 50 interposed between translucent insert 20 and polishing pad 10. A subpad 30 is affixed to the bottom surface of polishing pad 10.

[0042] When the polishing pad comprises two translucent inserts oppositely disposed from one another and integrated into first and second recesses formed on opposite faces of the polishing pad body, the translucent insert integrated into the back surface of the polishing pad can be coplanar with the back surface of the polishing pad, recessed from the back surface of the polishing pad, or can extend beyond the back surface of the polishing pad. A translucent insert that extends beyond the back surface of the polishing pad is depicted in FIG. 5. A first translucent insert 20 is integrated into a first recess on the polishing surface of polishing pad body 10 and is coplanar with the polishing surface, and a second translucent insert 40 is integrated into a second, opposite recess on the bottom surface of the polishing pad body 10 and extends beyond the bottom surface of polishing pad body 10. In use, compression of the affixed subpad 30 by a platen (not shown) allows the platen to apply pressure to the second translucent insert 40. The pressure applied to the second translucent insert 40 is transmitted to the first translucent insert 20 and can help prevent an air pocket from forming between first translucent insert 20 and a substrate being polished.

[0043] A polishing pad in accordance with the invention can be used alone or optionally can be used as one layer of a multi-layer stacked polishing pad, as illustrated in FIGS. 1, 2, 4, and 5. For example, the inventive polishing pad can be used in combination with a subpad. The subpad can be any suitable subpad. Suitable subpads include polyurethane foam subpads, impregnated felt subpads, microporous polyurethane subpads, or sintered urethane subpads. The subpad typically is softer than the polishing pad of the invention and therefore is more compressible than the polishing pad. In some embodiments, the subpad is harder and is less compressible than the polishing pad. The subpad contains at least one window or aperture to expose the transmissive region of the polishing pad. The subpad optionally comprises grooves, channels, hollow sections, and the like. When the polishing pad of the invention is used in combination with a subpad, typically there is an intermediate backing layer such as a polyethyleneterephthalate film, coextensive with and between the polishing pad and the subpad.

[0044] A polishing pad of the invention has a polishing surface which optionally further comprises grooves, channels, and/or perforations which facilitate the lateral transport of a polishing composition across the surface of the polishing pad. Such grooves, channels, or perforations can be in any suitable pattern and can have any suitable depth and width. The polishing pad can have two or more different groove patterns. For example, a combination of large grooves and small grooves can be used. The grooves can be in the form of slanted grooves, concentric grooves, spiral or circular grooves, XY crosshatch pattern, and can be continuous or non-continuous in connectivity. Preferably, the polishing pad has a polishing surface that comprises at least small grooves produced by standard pad conditioning methods. Typically, the translucent window is not provided with the same grooves, channels, and/or perforations as for the polishing pad.

[0045] The invention further provides a method of polishing a substrate, which method comprises (i) providing a substrate to be polished, (ii) contacting the substrate with a polishing system comprising the inventive polishing pad described herein and a polishing composition, and (iii) abrading at least a portion of the substrate with the polishing system to polish the substrate.

[0046] The polishing composition can be any suitable polishing composition. The polishing composition typically comprises an aqueous carrier, a pH adjustor, and optionally an abrasive. Depending on the type of workpiece being polished, the polishing composition optionally can further comprise oxidizing agents, organic acids, complexing agent, pH buffers, surfactants, corrosion inhibitors, anti-foaming agents, and the like.

[0047] The following examples further illustrate the invention but, of course, should not be construed as in any way limiting its scope.

EXAMPLE 1

[0048] This example demonstrates the effect of the texturing patterns of the translucent insert on the % transmission of laser light through a transmissive region of a polishing pad of the present invention.

[0049] Samples were prepare by cutting pieces of a porous polyurethane foam polishing pad (D-200, Cabot Microelectronics, Aurora, IL) and forming a recess on the polishing surface side using a router tool. The recesses were 30 mil deep and formed in a oblong shape. The polishing pad pieces were between 53 and 56 mil thick.

[0050] Translucent inserts of thermoplastic polyurethane having a Shore D hardness of 55 were prepared with different texture patterns formed on their surfaces. The texture was formed by An RF welding process using patterned aluminum tools. The pattern was formed either by laser engraving or by chemical etching of the aluminum tool surface. The tool patterns were made by Mold-Tech Inc. (Carol Stream, IL). The translucent inserts were then integrated into the recesses formed in the polishing pad pieces by RF welding to form the transmissive regions for testing.

[0051] Laser light from a 655 nm laser light source was directed through each of the transmissive regions being tested. The laser light transmitted was detected using a Newport optical power meter, model 1931-C (Newport Corporation, Irvine, CA). The results of the tests are shown in Table 1. The pattern number of the Mold-Tech tool is given as reference with the description of the texture pattern. As can be seen from the data, a wide range of % transmission values can be generated depending on the pattern chosen for the translucent insert. Different patterned inserts can thus be selected, and hence different transmissive regions formed in polishing pads, to provide the optimum % transmission to optimize end point detection for the polishing application.

Table 1.

Pattern Description	M-T number	% Transmission
No texture	N.A.	44.5
Small grid	MT-11640	14.5
Dimple pattern	MT-11605	8.9
Reverse Hex	MT-11610	3.0
Hex patterns	MT-11600	2.5
Large grid	MT-11475	1.4
Random pattern	MT-11430	1.3
Random pattern	MT-11570	2.8
Random pattern	MT-11050	3.2

[0052] All references, including publications, patent applications, and patents, cited herein are hereby incorporated by reference to the same extent as if each reference were individually and specifically indicated to be incorporated by reference and were set forth in its entirety herein.

[0053] The use of the terms "a" and "an" and "the" and similar referents in the context of describing the invention (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. The terms "comprising," "having," "including," and "containing" are to be construed as open-ended terms (i.e., meaning "including, but not limited to,") unless otherwise noted. Recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually recited herein. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or exemplary language (e.g., "such as") provided herein, is intended merely to better illuminate the invention and does not pose a limitation on the scope of the invention unless otherwise claimed. No language in the specification should be construed as indicating any non-claimed element as essential to the practice of the invention.

[0054] Preferred embodiments of this invention are described herein, including the best mode known to the inventors for carrying out the invention. Variations of those preferred embodiments may become apparent to those of ordinary skill in the art upon reading the foregoing description. The inventors expect skilled artisans to employ such variations as

appropriate, and the inventors intend for the invention to be practiced otherwise than as specifically described herein. Accordingly, this invention includes all modifications and equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed by the invention unless otherwise indicated herein or otherwise clearly contradicted by context.

CLAIMS

1. A polishing pad comprising an optically transmissive region, wherein the polishing pad comprises: (a) a polishing pad body comprising a first region and a second region, wherein the first region is opaque, wherein the second region is optically transmissive, wherein the second region has at least one recess formed therein, and (b) at least one translucent insert integrated into the at least one recess, wherein the polishing pad body comprises a first porous material and the at least one translucent insert comprises a second porous material that differs from the first porous material.

2. The polishing pad of claim 1, wherein the polishing pad body comprises a first thermoplastic polymer and the at least one translucent insert comprises a second thermoplastic polymer that differs from the first thermoplastic polymer.

3. The polishing pad of claim 1, wherein the translucent insert comprises a first thermoplastic polymer and a second thermoplastic polymer, and wherein the first and second thermoplastic polymers are immiscible and form distinct phases within the translucent window.

4. The polishing pad of claim 1, wherein the translucent insert further comprises particles of a material that differs from the second porous material.

5. The polishing pad of claim 4, wherein the particles comprise a material that is soluble in water.

6. The polishing pad of claim 1, wherein the translucent insert has a void volume of 0.1% to 10%.

7. The polishing pad of claim 1, wherein the translucent insert has a polishing surface with a texture.

8. The polishing pad of claim 1, wherein the second region has a first recess and a second recess formed therein, and wherein the first recess has a first translucent insert integrated therein, and the second recess has a second translucent insert integrated therein.

9. The polishing pad of claim 8, wherein the face of the polishing pad body comprising the second recess defines a plane, and wherein a surface of the second translucent insert is substantially coplanar with the plane.

10. The polishing pad of claim 8, wherein the face of the polishing pad body comprising the second recess defines a plane, and wherein a surface of the second translucent insert extends beyond the plane.

11. A method for making a polishing pad having an optically transmissive region, comprising the steps of:

(a) providing a polishing pad body, wherein the polishing pad body comprises a first porous material,

(b) forming at least one recess within the polishing pad body,

(c) providing at least one translucent insert , wherein the translucent insert comprises a second porous material that differs from the first porous material, and

(d) adhering the at least one translucent insert to the recess to provide a polishing pad having at least one optically transmissive region.

12. The method of claim 11, wherein the polishing pad body comprises a first thermoplastic polymer and the at least one translucent insert comprises a second thermoplastic polymer that differs from the first thermoplastic polymer.

13. The method of claim 11, wherein the translucent insert comprises a first thermoplastic polymer and a second thermoplastic polymer, and wherein the first and second thermoplastic polymers are immiscible and form distinct phases within the translucent insert.

14. The method of claim 11, wherein the translucent insert further comprises particles of a material that differs from the second porous material.

15. The method of claim 11, wherein the translucent insert is formed prior to adhering the translucent insert to the recess.

16. The method of claim 11, wherein the translucent insert is formed by placement of a precursor of the translucent insert within the recess and then conversion of the precursor to the translucent insert.

17. The method of claim 11, wherein the step of forming a recess within the polishing pad body comprises use of an energy input selected from the group consisting of pressure, heat, radio frequency irradiation, ultrasonic welding, and combinations thereof.

18. The method of claim 11, wherein the step of forming a recess within the polishing pad body comprises use of a router tool.

19. The method of claim 11, wherein the step of adhering the at least one translucent insert to the recess comprises use of an energy input selected from the group consisting of solvent adhesion, pressure, heat, radio frequency irradiation, ultrasonic welding, and combinations thereof.

20. The method of claim 11, wherein the translucent insert has a polishing surface with a texture.