SUB-PAD FORMATION UTILIZING UV-CURABLE FORMULATION

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This Application claims priority to and the benefit of United States Provisional Application No. 63/561,528 filed on March 5, 2024 and which is incorporated herein by reference in its entirety for all purposes.

TECHNICAL FIELD

[0002] This disclosure generally relates to pads for use chemical mechanical planarization (CMP) processes used in in the fabrication of semiconductor devices. More particularly, this disclosure relates to a sub-pad, a method of forming a sub-pad from a UV-curable formulation, and a CMP pad including the sub-pad formed from a UV-curable formulation.

BACKGROUND

[0003] An integrated circuit is typically formed on a substrate by the sequential deposition of conductive, semi-conductive, and/or insulative layers on a silicon wafer. A variety of fabrication processes require planarization of at least one of these layers on the substrate. For example, for certain applications (e.g., polishing of a metal layer to form vias, plugs, and lines in the trenches of a patterned layer), an overlying layer is planarized until the top surface of a patterned layer is exposed. In other applications (e.g., planarization of a dielectric layer for photolithography), an overlying layer is polished until a desired thickness remains over the underlying layer. Chemical-mechanical planarization (CMP) is one method of planarization. This planarization method typically involves a substrate being mounted on a carrier head. The exposed surface of the substrate is typically placed against a polishing pad on a rotating platen. The carrier head provides a controllable load (e.g., a downward force) on the substrate to push it against the rotating polishing pad. A polishing liquid, such as a slurry with abrasive particles, can also be disposed on the surface of the polishing pad during polishing.

[0004] An objective of these fabrication processes (e.g., fabrication of an integrated circuit) is to achieve high polishing uniformity. As a result, an objective of the manufacture of polishing pads for use in these fabrication processes is to provide a polishing pad with uniform pressure distribution, while maintaining consistency in mechanical properties from polishing pad to polishing pad.

SUMMARY

[0005] Conventional polishing pads include a top sheet, the surface of which contacts the surface to be polished, and a sub-pad, which provides support for the top sheet. Typically, sub-pad materials utilized in the semiconductor industry for CMP applications include thermal set materials, which are then laminated to the top sheet using an adhesive. The foregoing process requires multiple steps, introduces additional chemicals (e.g., solvents) for the lamination process, and potentially introduces pad inconsistencies as a

result of uneven adhesion.

[0006] Thus, there remains a need in the art for alternative polishing pads, as well as alternative methods for manufacturing such polishing pads, that are easy to prepare and facilitate improved polishing performance to meet the increasingly challenging polishing requirements of new integrated circuit designs. The disclosure provides such polishing pads and methods. These and other advantages of the disclosure, as well as additional inventive features, will be apparent from the description of the disclosure provided herein.

[0007] The disclosure provides a UV-cured sub-pad for chemical-mechanical planarization comprising (a) a (meth)acrylate monomer unit and (b) an oligomer unit selected from a difunctional (meth)acrylate-capped polyether urethane oligomer unit, a difunctional (meth)acrylate-capped polyester urethane oligomer unit, a difunctional (meth)acrylate-capped urethane oligomer unit, and a combination thereof.

[0008] The disclosure also provides a polishing pad for chemical-mechanical planarization comprising a top sheet and a UV-cured sub-pad described herein, wherein the UV-cured sub-pad is bound to a surface of the top sheet.

[0009] The disclosure also provides a method of preparing the polishing pad for chemical-mechanical planarization described herein, the method comprising: (i) providing a top sheet having a polishing side and a side opposite the polishing side, (ii) applying a UV-curable composition to the side opposite the polishing side, (iii) uniformly spreading the UV-curable composition on the side opposite the polishing side, and (iv) UV curing the UV-curable composition to provide the polishing pad.

[0010] The disclosure further provides an apparatus for performing the method of preparing the polishing pad for chemical-mechanical planarization described herein, the apparatus comprising (i) a jig comprising a circular recess, (ii) a doctor blade, and (iii) a UV light source.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. 1A is a schematic showing a side view of an exemplary arrangement for preparing the polishing pad for chemical-mechanical planarization described herein, where **1** is a top sheet of a polishing pad, **2** is a sub-pad of a polishing pad, **3** is a side wall of a recess of a jig (e.g., a carrier board), and **4** is a light source. FIG. 1A shows an exemplary recess in the jig of 95 mil (i.e., approximately 2.4 mm).

[0012] FIG. 1B is a schematic showing a top-view of an exemplary arrangement for preparing the polishing pad for chemical-mechanical planarization described herein. FIG. 1B shows an exemplary diameter of the polishing pad of 32 inches (i.e., approximately 81 cm).

[0013] FIG. 2 is a schematic showing an exemplary jig (e.g., a carrier board), where **5** is a circular recess in the jig, **6** is a trough, and **7** is a punchout hole.

[0014] FIG. 3 is a schematic showing an exemplary apparatus for preparing the polishing pad for chemical-mechanical planarization described herein, where **8** is a jig (e.g., a carrier board) with a circular

recess (**5**), a trough (**6**), and a punchout hole (**7**), **9** is a doctor blade, and **10** is a light source.

[0015] While the disclosure is amenable to various modifications and alternative forms, specifics thereof have been shown by way of example in the drawings and will be described in detail below. It is to be understood, however, that the intention is not to limit the disclosure to the embodiment(s) described. On the contrary, the disclosure is intended to cover all modifications, equivalents, and alternatives falling within the scope of the disclosure as defined by the appended claims.

DETAILED DESCRIPTION

[0016] Among those benefits and improvements that have been disclosed, other objects and advantages of this disclosure will become apparent from the following description taken in conjunction with the accompanying figures. Detailed embodiments of the present disclosure are disclosed herein; however, it is to be understood that the disclosed embodiments are merely illustrative of the disclosure that may be embodied in various forms. In addition, each of the examples given regarding the various embodiments of the disclosure which are intended to be illustrative, and not restrictive.

[0017] Throughout the specification and claims, the following terms take the meanings explicitly associated herein, unless the context clearly dictates otherwise. The phrases "in one embodiment," "in an embodiment," and "in some embodiments" as used herein do not necessarily refer to the same embodiment(s), though it may. Furthermore, the phrases "in another embodiment" and "in some other embodiments" as used herein do not necessarily refer to a different embodiment, although it may. All embodiments of the disclosure are intended to be combinable without departing from the scope or spirit of the disclosure.

[0018] As used herein, the term "based on" is not exclusive and allows for being based on additional factors not described, unless the context clearly dictates otherwise.

[0019] As used in this specification and the appended claims, the singular forms "a", "an", and "the" include plural referents unless the content clearly dictates otherwise. As used in this specification and the appended claims, the term "or" is generally employed in its sense including "and/or" unless the content clearly dictates otherwise.

[0020] The term "about" generally refers to a range of numbers that is considered equivalent to the recited value (e.g., having the same function or result). In many instances, the term "about" may include numbers that are rounded to the nearest significant figure.

[0021] The disclosure provides a UV-cured sub-pad for chemical-mechanical planarization comprising (a) a (meth)acrylate monomer unit and (b) an oligomer unit selected from a difunctional (meth)acrylate-capped polyether urethane oligomer unit, a difunctional (meth)acrylate-capped polyester urethane oligomer unit, a difunctional (meth)acrylate-capped urethane oligomer unit, and a

combination thereof.

[0022] The UV-cured sub-pad for chemical-mechanical planarization comprises a (meth)acrylate monomer unit. As used herein, the term "(meth)acrylate" refers to methacrylate and acrylate variants. Thus, as used herein, "(meth)acrylate" is interchangeable with "methacrylate and/or acrylate." The (meth)acrylate monomer unit can be formed from any polymerizable (i.e., UV-curable) monomer comprising a methacrylate group and/or an acrylate group. In other words, the term "unit" refers to the polymeric residue remaining after polymerization (i.e., UV curing). For example, the polymerizable (i.e., UV-curable) monomer can be acrylic acid, methacrylic acid, 2-hydroxyethyl acrylate, 2-hydroxyethyl methacrylate, methyl acrylate, methyl methacrylate, ethyl methacrylate, isobornyl acrylate, isobornyl methacrylate, isoamyl acrylate, isoamyl methacrylate, isodecyl acrylate, isodecyl methacrylate, hexanediol diacrylate, hexanediol dimethacrylate, trimethylolpropane triacrylate, 2-(tert-butyl) methacrylate, 2-(tert-butylamino)ethyl methacrylate, trimethylolpropane trimethacrylate, salts thereof, or a combination thereof. Thus, in some embodiments, the sub-pad comprises a (meth)acrylate monomer unit formed from acrylic acid, methacrylic acid, 2-hydroxyethyl acrylate, 2-hydroxyethyl methacrylate, methylacrylate, methyl methacrylate, ethyl methacrylate, isobornyl acrylate, isobornyl methacrylate, isoamyl acrylate, isoamyl methacrylate, isodecyl acrylate, isodecyl methacrylate, hexanediol diacrylate, hexanediol dimethacrylate, trimethylolpropane triacrylate, 2-(tert-butyl) methacrylate, 2-(tert-butylamino)ethyl methacrylate, trimethylolpropane trimethacrylate, salts thereof, or combinations thereof. In certain embodiments, the sub-pad comprises a (meth)acrylate monomer unit formed from isobornyl acrylate, isobornyl methacrylate, or a combination thereof.

[0023] The UV-cured sub-pad for chemical-mechanical planarization can comprise any suitable amount of the (meth)acrylate monomer unit. For example, the UV cured sub-pad for chemical-mechanical planarization can comprise about 95 wt.% or less of the (meth)acrylate monomer unit, e.g., about 90 wt.% or less, about 85 wt.% or less, about 80 wt.% or less, about 75 wt.% or less, about 70 wt.% or less, about 65 wt.% or less, about 60 wt.% or less, about 55 wt.% or less, or about 50 wt.% or less of the (meth)acrylate monomer unit.

Alternatively, or in addition, the UV cured sub-pad for chemical-mechanical planarization can comprise about 1 wt.% or more of the (meth)acrylate monomer unit, for example, about 5 wt.% or more, about 10 wt.% or more, 15 wt.% or more, about 20 wt.% or more, about 25 wt.% or more, about 30 wt.% or more, about 40 wt.% or more, or about 50 wt.% or more of the (meth)acrylate monomer unit. Thus, the UV cured sub-pad for chemical-mechanical planarization can comprise the (meth)acrylate monomer unit in any amount bounded by any two of the aforementioned endpoints, as appropriate.

[0024] For example, in some embodiments, the (meth)acrylate monomer unit can be present in the UV cured sub-pad for chemical-mechanical planarization in an amount of about 1 wt.% to about 95 wt.%, e.g., about 1 wt.% to about 90 wt.%, about 1 wt.% to about 80 wt.%, about 1 wt.% to about 70 wt.%, about 1 wt.% to about 60 wt.%, about 1 wt.% to about 50 wt.%, about 5 wt.% to about 95 wt.%,

about 5 wt.% to about 90 wt.%, about 5 wt.% to about 80 wt.%, about 5 wt.% to about 70 wt.%, about 5 wt.% to about 60 wt.%, about 5 wt.% to about 50 wt.%, about 10 wt.% to about 95 wt.%, about 10 wt.% to about 90 wt.%, about 10 wt.% to about 80 wt.%, about 10 wt.% to about 70 wt.%, about 10 wt.% to about 60 wt.%, about 10 wt.% to about 50 wt.%, about 25 wt.% to about 95 wt.%, about 25 wt.% to about 90 wt.%, about 25 wt.% to about 80 wt.%, about 25 wt.% to about 70 wt.%, about 25 wt.% to about 60 wt.%, about 25 wt.% to about 50 wt.%, about 50 wt.% to about 95 wt.%, about 50 wt.% to about 90 wt.%, about 50 wt.% to about 80 wt.%, about 50 wt.% to about 70 wt.%, or about 50 wt.% to about 60 wt.%. In some embodiments, the UV cured sub-pad for chemical-mechanical planarization comprises from about 25 wt.% to about 50 wt.% of the (meth)acrylate monomer unit. In certain embodiments, the UV cured sub-pad for chemical- mechanical planarization comprises from about 30 wt.% to about 50 wt.% of the (meth)acrylate monomer unit.

[0025] The UV-cured sub-pad for chemical-mechanical planarization comprises an oligomer unit selected from a difunctional (meth)acrylate-capped polyether urethane oligomer unit, a difunctional (meth)acrylate-capped polyester urethane oligomer unit, a difunctional (meth)acrylate-capped urethane oligomer unit, and a combination thereof.

[0026] In some embodiments, the UV-cured sub-pad for chemical-mechanical planarization comprises a difunctional (meth)acrylate-capped polyether urethane oligomer unit. In certain embodiments, the sub-pad comprises an aromatic polyether urethane di(meth)acrylate oligomer unit, an aliphatic polyether urethane di(meth)acrylate oligomer unit, or a combination thereof. For example, the sub-pad can comprise an oligomer unit formed from BR-202 (aromatic polyether urethane methacrylate), BR-204 (aromatic polyether urethane methacrylate), BR-3042 (aromatic polyether urethane methacrylate), BR-5541 (aliphatic polyether urethane methacrylate), BR-1044MB (aliphatic polyether urethane methacrylate), BR-543 (aliphatic polyether urethane acrylate), BR-543MB (aliphatic polyether urethane acrylate), BR-374 (aliphatic polyether urethane acrylate), BR-541S (aliphatic polyether urethane acrylate), or BR-345 (aliphatic polyether urethane acrylate), which are commercially available from Bomar Chemicals. In certain embodiments, the sub- pad comprises an oligomer unit formed from BR-204 (aromatic polyether urethane methacrylate), BR-543 (aliphatic polyether urethane acrylate), BR-374 (aliphatic polyether urethane acrylate), or a combination thereof.

[0027] In some embodiments, the UV-cured sub-pad for chemical-mechanical planarization comprises a difunctional (meth)acrylate-capped polyester urethane oligomer unit. In certain embodiments, the sub-pad comprises an aliphatic polyester urethane di(meth)acrylate oligomer unit. For example, the sub-pad can comprise an oligomer unit formed from XR-741MS (aliphatic polyester urethane methacrylate), BR-742M (aliphatic polyester urethane methacrylate), BR-742S (aliphatic polyester urethane methacrylate), BR-7432GI30 (aliphatic polyester urethane methacrylate), BR-752MS (aliphatic polyester urethane acrylate), or BR-744BT (aliphatic polyester urethane acrylate), which are commercially available from Bomar Chemicals. In certain embodiments, the sub-pad comprises an oligomer unit formed

from BR-744BT (aliphatic polyester urethane acrylate).

[0028] In some embodiments, the UV-cured sub-pad for chemical-mechanical planarization comprises a difunctional (meth)acrylate-capped urethane oligomer unit. In certain embodiments, the sub-pad comprises a polybutadiene urethane di(meth)acrylate oligomer unit. For example, the sub-pad can comprise an oligomer unit formed from BR-640D (aliphatic polybutadiene urethane acrylate), BR-641E (aliphatic polybutadiene urethane acrylate), or BR-643 (aliphatic polybutadiene urethane acrylate), which are commercially available from Bomar Chemicals.

[0029] The UV-cured sub-pad for chemical-mechanical planarization can comprise any suitable amount of the oligomer unit. For example, the UV cured sub-pad for chemical- mechanical planarization can comprise about 95 wt.% or less of the oligomer unit, e.g., about 90 wt.% or less, about 85 wt.% or less, about 80 wt.% or less, about 75 wt.% or less, about 70 wt.% or less, about 65 wt.% or less, about 60 wt.% or less, about 55 wt.% or less, or about 50 wt.% or less of the oligomer unit. Alternatively, or in addition, the UV cured sub-pad for chemical-mechanical planarization can comprise about 1 wt.% or more of the oligomer unit, for example, about 5 wt.% or more, about 10 wt.% or more, 15 wt.% or more, about 20 wt.% or more, about 25 wt.% or more, about 30 wt.% or more, about 40 wt.% or more, or about 50 wt.% or more of the oligomer unit. Thus, the UV cured sub-pad for chemical-mechanical planarization can comprise the oligomer unit in any amount bounded by any two of the aforementioned endpoints, as appropriate.

[0030] For example, in some embodiments, the oligomer unit can be present in the UV cured sub-pad for chemical-mechanical planarization in an amount of about 1 wt.% to about 95 wt.%, e.g., about 1 wt.% to about 90 wt.%, about 1 wt.% to about 80 wt.%, about 1 wt.% to about 70 wt.%, about 1 wt.% to about 60 wt.%, about 1 wt.% to about 50 wt.%, about 5 wt.% to about 95 wt.%, about 5 wt.% to about 90 wt.%, about 5 wt.% to about 80 wt.%, about 5 wt.% to about 70 wt.%, about 5 wt.% to about 60 wt.%, about 5 wt.% to about 50 wt.%, about 10 wt.% to about 95 wt.%, about 10 wt.% to about 90 wt.%, about 10 wt.% to about 80 wt.%, about 10 wt.% to about 70 wt.%, about 10 wt.% to about 60 wt.%, about10 wt.% to about 50 wt.%, about 25 wt.% to about 95 wt.%, about 25 wt.% to about 90 wt.%, about 25 wt.% to about 80 wt.%, about 25 wt.% to about 70 wt.%, about 25 wt.% to about 60 wt.%, about 25 wt.% to about 50 wt.%, about 50 wt.% to about 95 wt.%, about 50 wt.% to about 90 wt.%, about 50 wt.% to about 80 wt.%, about 50 wt.% to about 70 wt.%, or about 50 wt.% to about 60 wt.% of the oligomer unit. In some embodiments, the UV cured sub-pad for chemical-mechanical planarization comprises from about 50 wt.% to about 75 wt.% of the oligomer unit. In certain embodiments, the UV cured sub-pad for chemical-mechanical planarization comprises from about 50 wt.% to about 70 wt.% of the oligomer unit.

[0031] In some embodiments, the UV-cured sub-pad for chemical-mechanical planarization further comprises an additive selected from a pore filler, a pigment, or a combination thereof. In certain embodiments, the UV-cured sub-pad for chemical- mechanical planarization further comprises a pore filler. The UV-cured sub-pad for chemical-mechanical planarization can comprise the pore filler in any

suitable amount, when present, but generally, the UV-cured sub-pad for chemical-mechanical planarization comprises the pore filler in an amount from about 1 wt.% to about 10 wt.% (e.g., about 1 wt.% to about 5 wt.% or about 2 wt.% to about 4 wt.%).

[0032] In some embodiments, the UV-cured sub-pad for chemical-mechanical planarization further comprises one or more additional components resulting from the manufacturing process. For example, the sub-pad can comprise a photo-initiator or a derivative thereof, e.g., a residual component from an acylphosphine oxide, an α- aminoalkylphenone, an α-dialkoxyacetophenone, an α-hydroxyalkylphenone, a benzyl ketal, a benzoin ether, an anthraquinone, a benzophenone, polyurethane acrylate or a thioxanthone. Additionally, the UV-cured sub-pad for chemical-mechanical planarization may further comprise various diluents, pore filler, and pigments.

[0033] In some embodiments, the UV-cured sub-pad for chemical-mechanical planarization is circular. The circular sub-pad can have any suitable diameter. For example, the UV cured sub-pad for chemical-mechanical planarization can have a diameter of about 2 cm or more, e.g., about 5 cm or more, about 10 cm or more, about 25 cm or more, about 50 cm or more, about 60 cm or more, or about 70 cm or more. Alternatively, or in addition, the UV cured sub-pad for chemical-mechanical planarization can have a diameter of about 200 cm or less, e.g., about 150 cm or less, about 100 cm or less, about 90 cm or less, about 80 cm or less, about 70 cm or less, about 60 cm or less, or about 50 cm or less. Thus, the UV cured sub-pad for chemical-mechanical planarization can have a diameter in any amount bounded by any two of the aforementioned endpoints, as appropriate.

[0034] For example, in some embodiments, the UV cured sub-pad for chemical- mechanical planarization can have a diameter of about 2 cm to about 200 cm, e.g., about 2 cm to about 150 cm, about 2 cm to about 100 cm, about 2 cm to about 90 cm, about 2 cm to about 80 cm, about 2 cm to about 70 cm, about 2 cm to about 60 cm, about 2 cm to about 50 cm, 5 cm to about 200 cm, about 5 cm to about 150 cm, about 5 cm to about 100 cm, about 5 cm to about 90 cm, about 5 cm to about 80 cm, about 5 cm to about 70 cm, about 5 cm to about 60 cm, about 5 cm to about 50 cm, 25 cm to about 200 cm, about 25 cm to about 150 cm, about 25 cm to about 100 cm, about 25 cm to about 90 cm, about 25 cm to about 80 cm, about 25 cm to about 70 cm, about 25 cm to about 60 cm, about 25 cm to about 50 cm, 50 cm to about 200 cm, e.g., about 50 cm to about 150 cm, about 50 cm to about 100 cm, about 50 cm to about 90 cm, about 50 cm to about 80 cm, or about 50 cm to about 70 cm. In some embodiments, the sub-pad is circular and has a diameter of about 5 cm to about 150 cm. In some embodiments, the sub-pad is circular and has a diameter of about 50 cm to about 100 cm. In certain embodiments, the sub-pad is circular and has a diameter of about 70 cm to about 90 cm.

[0035] The UV-cured sub-pad for chemical-mechanical planarization can have any suitable thickness. For example, the UV cured sub-pad for chemical-mechanical planarization can have a thickness of about 0.1 mm or more, e.g., about 0.2 mm or more, about 0.3 mm or more, about 0.4 mm or more, or about 0.5 mm or more. Alternatively, or in addition, the UV cured sub-pad for chemical-

mechanical planarization can have a thickness of about 2 mm or less, e.g., about 1.8 mm or less, about 1.6 mm or less, about 1.4 mm or less, about 1.2 mm or less, or about 1 mm or less. Thus, the UV cured sub-pad for chemical- mechanical planarization can have a thickness in any amount bounded by any two of the aforementioned endpoints, as appropriate.

[0036] For example, in some embodiments, the UV cured sub-pad for chemical- mechanical planarization can have a thickness of about 0.1 mm to about 2 mm, e.g., about 0.1 mm to about 1.8 mm, about 0.1 mm to about 1.6 mm, about 0.1 mm to about 1.4 mm, about 0.1 mm to about 1.2 mm, about 0.1 mm to about 1 mm, about 0.2 mm to about 2 mm, about0.2 mm to about 1.8 mm, about 0.2 mm to about 1.6 mm, about 0.2 mm to about 1.4 mm, about 0.2 mm to about 1.2 mm, about 0.2 mm to about 1 mm, about 0.3 mm to about 2 mm, about 0.3 mm to about 1.8 mm, about 0.3 mm to about 1.6 mm, about 0.3 mm to about 1.4 mm, about 0.3 mm to about 1.2 mm, about 0.3 mm to about 1 mm, about 0.4 mm to about 2 mm, about 0.4 mm to about 1.8 mm, about 0.4 mm to about 1.6 mm, about 0.4 mm to about 1.4 mm, about 0.4 mm to about 1.2 mm, about 0.4 mm to about 1 mm, about 0.5 mm to about 2 mm, about 0.5 mm to about 1.8 mm, about 0.5 mm to about 1.6 mm, about 0.5 mm to about 1.4 mm, about 0.5 mm to about 1.2 mm, or about 0.5 mm to about 1 mm. In some embodiments, the sub-pad has a thickness of about 0.1 mm to about 2 mm. In certain embodiments, the sub-pad has a thickness of about 0.5 mm to about 1 mm.

[0037] In some embodiments, the UV cured sub-pad for chemical-mechanical planarization has a uniform thickness with a variation in thickness of less than about 20%, less than about 15%, less than about 10%, less than about 5%, less than about 1%, or less than about 0.1% at every position of the UV cured sub-pad relative to the average thickness of the UV cured sub-pad.

[0038] The UV-cured sub-pad for chemical-mechanical planarization can have any suitable hardness. For example, the UV cured sub-pad for chemical-mechanical planarization can have a hardness of about 25 Shore A or more, e.g., about 30 Shore A or more, about 31 Shore A or more, about 32 Shore A or more, about 33 Shore A or more, about 34 Shore A or more, or about 35 Shore A or more. Alternatively, or in addition, the UV cured sub-pad for chemical-mechanical planarization can have a hardness of about 100 Shore A or less, e.g., about 99 Shore A or less, about 98 Shore A or less, about 97 Shore A or less, about 96 Shore A or less, about 95 Shore A or less, about 94 Shore A or less, about 93 Shore A or less, about 92 Shore A or less, about 91 Shore A or less, about 90 Shore A or less, about 85 Shore A or less, or about 80 Shore A or less. Thus, the UV cured sub-pad for chemical-mechanical planarization can have hardness in any amount bounded by any two of the aforementioned endpoints, as appropriate.

[0039] For example, in some embodiments, the UV cured sub-pad for chemical- mechanical planarization can have a hardness of about 25 Shore A to about 100 Shore A, e.g., about 25 Shore A to about 99 Shore A, about 25 Shore A to about 98 Shore A, about 25 Shore A to about 97 Shore A, about 25 Shore A to about 96 Shore A, about 25 Shore A to about 95 Shore A, about 25 Shore A to about 94 Shore

A, about 25 Shore A to about 93 Shore A, about 25 Shore A to about 92 Shore A, about 25 Shore A to about 91 Shore A, about 25 Shore A to about 90 Shore A, about 25 Shore A to about 85 Shore A, about 25 Shore A to about 80 Shore A, about 30 Shore A to about 100 Shore A, about 30 Shore A to about 99 Shore A, about 30 Shore A to about 98 Shore A, about 30 Shore A to about 97 Shore A, about 30 Shore A to about 96 Shore A, about 30 Shore A to about 95 Shore A, about 30 Shore A to about 94 Shore A, about 30 Shore A to about 93 Shore A, about 30 Shore A to about 92 Shore A, about 30 Shore A to about 91 Shore A, about 30 Shore A to about 90 Shore A, about 30 Shore A to about 85 Shore A, about 30 Shore A to about 80 Shore A, about 31 Shore A to about 100 Shore A, about 31 Shore A to about 99 Shore A, about 31 Shore A to about 98 Shore A, about 31 Shore A to about 97 Shore A, about 31 Shore A to about 96 Shore A, about 31 Shore A to about 95 Shore A, about 31 Shore A to about 94 Shore A, about 31 Shore A to about 93 Shore A, about 31 Shore A to about 92 Shore A, about 31 Shore A to about 91 Shore A, about 31 Shore A to about 90 Shore A, about 31 Shore A to about 85 Shore A, about 31 Shore A to about 80 Shore A, about 35 Shore A to about 100 Shore A, about 35 Shore A to about 99 Shore A, about 35 Shore A to about 98 Shore A, about 35 Shore A to about 97 Shore A, about 35 Shore A to about 96 Shore A, about 35 Shore A to about 95 Shore A, about 35 Shore A to about 94 Shore A, about 35 Shore A to about 93 Shore A, about 35 Shore A to about 92 Shore A, about 35 Shore A to about 91 Shore A, about 35 Shore A to about 90 Shore A, about 35 Shore A to about 85 Shore A, or about 35 Shore A to about 80 Shore A. In some embodiments, the sub- pad has a hardness of about 30 Shore A to about 100 Shore A. In certain embodiments, the sub-pad has a hardness of about 30 Shore A to about 95 Shore A.

[0040] The disclosure also provides a polishing pad for chemical-mechanical planarization comprising a top sheet and a UV-cured sub-pad described herein, wherein the UV-cured sub-pad is bound to a surface of the top sheet (i.e., the surface of the top sheet opposite to the surface that performs the polishing). The polishing pad for chemical- mechanical planarization comprises a top sheet and a UV-cured sub-pad described herein. The top sheet can be any suitable top sheet capable of performing chemical-mechanical planarization, many of which are known in the art and are commercially available. In some embodiments, the top sheet is a woven top sheet. In other embodiments, the top sheet is an unwoven top sheet.

[0041] In some embodiments, the UV-cured sub-pad is bound to a surface of the top sheet without the use of an adhesive. For example, the UV-cured sub-pad can be bound directly to a surface of the top sheet by way of UV curing. Without wishing to be bound by any particular theory, it is believed that the manufacturing process disclosed herein, which includes UV curing, provides a cross-linked UV-cured sub-pad that is intertwined with the top sheet by way of the UV curing, thereby eliminating the necessity for an adhesive.

[0042] In other embodiments, the UV-cured sub-pad is bound to a surface of the top sheet with the use of an adhesive (e.g., by way of a lamination process).

[0043] In some embodiments, the polishing pad for chemical-mechanical planarization is circular.

The circular polishing pad can have any suitable diameter. For example, the polishing pad for chemical-mechanical planarization can have a diameter of about 2 cm or more, e.g., about 5 cm or more, about 10 cm or more, about 25 cm or more, about 50 cm or more, about 60 cm or more, or about 70 cm or more. Alternatively, or in addition, the polishing pad for chemical-mechanical planarization can have a diameter of about 200 cm or less, e.g., about 150 cm or less, about 100 cm or less, about 90 cm or less, about 80 cm or less, about 70 cm or less, about 60 cm or less, or about 50 cm or less. Thus, the polishing pad for chemical-mechanical planarization can have a diameter in any amount bounded by any two of the aforementioned endpoints, as appropriate.

[0044] For example, in some embodiments, the polishing pad for chemical-mechanical planarization can have a diameter of about 2 cm to about 200 cm, e.g., about 2 cm to about 150 cm, about 2 cm to about 100 cm, about 2 cm to about 90 cm, about 2 cm to about 80 cm, about 2 cm to about 70 cm, about 2 cm to about 60 cm, about 2 cm to about 50 cm, 5 cm to about 200 cm, about 5 cm to about 150 cm, about 5 cm to about 100 cm, about 5 cm to about 90 cm, about 5 cm to about 80 cm, about 5 cm to about 70 cm, about 5 cm to about 60 cm, about 5 cm to about 50 cm, 25 cm to about 200 cm, about 25 cm to about 150 cm, about 25 cm to about 100 cm, about 25 cm to about 90 cm, about 25 cm to about 80 cm, about 25 cm to about 70 cm, about 25 cm to about 60 cm, about 25 cm to about 50 cm, 50 cm to about 200 cm, e.g., about 50 cm to about 150 cm, about 50 cm to about 100 cm, about 50 cm to about 90 cm, about 50 cm to about 80 cm, or about 50 cm to about 70 cm. In some embodiments, the polishing pad is circular and has a diameter of about 5 cm to about 150 cm. In some embodiments, the polishing pad is circular and has a diameter of about 50 cm to about 100 cm. In certain embodiments, the polishing pad is circular and has a diameter of about 70 cm to about 90 cm.

[0045] The polishing pad for chemical-mechanical planarization can have any suitable thickness. For example, the polishing pad for chemical-mechanical planarization can have a thickness of about 0.5 mm or more, e.g., about 0.75 mm or more, about 1 mm or more, about 1.5 mm or more, or about 2 mm or more. Alternatively, or in addition, the polishing pad for chemical-mechanical planarization can have a thickness of about 4 mm or less, e.g., about 3.5 mm or less, about 3 mm or less, about 3.5 mm or less, or about 2 mm or less. Thus, the polishing pad for chemical-mechanical planarization can have a thickness in any amount bounded by any two of the aforementioned endpoints, as appropriate.

[0046] For example, in some embodiments, the polishing pad for chemical-mechanical planarization can have a thickness of about 0.5 mm to about 4 mm, e.g., about 0.5 mm to about 3.5 mm, about 0.5 mm to about 3 mm, about 0.5 mm to about 2.5 mm, about 0.5 mm to about 2 mm, 0.75 mm to about 4 mm, about 0.75 mm to about 3.5 mm, about 0.75 mm to about 3 mm, about 0.75 mm to about 2.5 mm, about 0.75 mm to about 2 mm, 1 mm to about 4 mm, about 1 mm to about 3.5 mm, about 1 mm to about 3 mm, about 1 mm to about 2.5 mm, about 1 mm to about 2 mm, 1.5 mm to about 4 mm, about 1.5 mm to about 3.5 mm, about 1.5 mm to about 3 mm, about 1.5 mm to about 2.5 mm, about 1.5 mm to about 2 mm, 2 mm to about 4 mm, about 2 mm to about 3.5 mm, about 2 mm to about 3 mm, or about 2 mm to about 2.5

mm. In some embodiments, the polishing pad has a thickness of about 0.5 mm to about 4 mm. In certain embodiments, the polishing pad has a thickness of about 2 mm to about 3 mm.

[0047] In some embodiments, the polishing pad for chemical-mechanical planarization has a uniform thickness with a variation in thickness of less than about 20%, less than about 15%, less than about 10%, less than about 5%, less than about 1%, or less than 0.1%, at every position of the polishing pad for chemical-mechanical planarization relative to the average thickness of the polishing pad for chemical-mechanical planarization.

[0048] The disclosure also provides a method of preparing the polishing pad for chemical-mechanical planarization described herein, the method comprising: (i) providing a top sheet having a polishing side and a side opposite the polishing side, (ii) applying a UV-curable composition to the side opposite the polishing side, (iii) uniformly spreading the UV-curable composition on the side opposite the polishing side, and (iv) UV curing the UV-curable composition to provide the polishing pad. A side view and a top view of an exemplary arrangement for preparing the polishing pad for chemical-mechanical planarization described herein are provided at FIGS. 1A and 1B, respectively.

[0049] Without wishing to be bound by any particular theory, it is believed that the method described herein provides a polishing pad for chemical-mechanical planarization (i) with increased durability and stability compared to conventional methods, (ii) in higher yields (i.e., less waste materials) than conventional methods, (iii) at lower costs than conventional methods, and (iv) more efficiently than conventional methods.

[0050] The method comprises providing a top sheet having a polishing side and a side opposite the polishing side. The top sheet can be any suitable top sheet disclosed herein. In that respect, the top sheet can be any suitable top sheet capable of performing chemical-mechanical planarization, many of which are known in the art and are commercially available. In some embodiments, the top sheet is a woven top sheet. In other embodiments, the top sheet is an unwoven top sheet. The top sheet can have any suitable thickness. For example, the top sheet can have a thickness of about 0.1 mm or more, e.g., about 0.2 mm or more, about 0.3 mm or more, about 0.4 mm or more, or about 0.5 mm or more. Alternatively, or in addition, the top sheet can have a thickness of about 3 mm or less, e.g., about 2.5 mm or less, or about 2 mm or less. Thus, the top sheet can have a thickness in any amount bounded by any two of the aforementioned endpoints, as appropriate.

[0051] For example, in some embodiments, the top sheet can have a thickness of about 0.1 mm to about 3 mm, e.g., about 0.1 mm to about 2.5 mm, about 0.1 mm to about 2 mm, about 0.2 mm to about 3 mm, about 0.2 mm to about 3.5 mm, about 0.2 mm to about 2 mm, about 0.3 mm to about 3 mm, about 0.3 mm to about 2.5 mm, about 0.3 mm to about 2 mm, about 0.4 mm to about 3 mm, about 0.4 mm to about 2.5 mm, about 0.4 mm to about 2 mm, about 0.5 mm to about 3 mm, about 0.5 mm to about 2.5 mm, or about 0.5 mm to about 2 mm. In some embodiments, the sub-pad has a thickness of about 0.5 mm to about 2 mm. In certain embodiments, the sub-pad has a thickness of about 1 mm to about 2 mm.

[0052] The method comprises applying a UV-curable composition to the side opposite the polishing side. The UV-curable composition can be applied by any suitable method. For example, the UV-curable composition can be poured, sprayed, or brushed on the side opposite the polishing side. In some embodiments, the method further comprises applying a vacuum to the polishing side of the top sheet prior to applying the UV-curable composition to the side opposite the polishing side of the top sheet.

[0053] In some embodiments, the UV-curable composition comprises (a) a (meth)acrylate monomer and (b) an oligomer selected from a difunctional (meth)acrylate- capped polyether urethane oligomer, a difunctional (meth)acrylate-capped polyester urethane oligomer, a difunctional (meth)acrylate-capped urethane oligomer, and a combination thereof.

[0054] In some embodiments, the UV-curable composition comprises a (meth)acrylate monomer. The (meth)acrylate monomer can be any polymerizable (i.e., UV-curable) monomer comprising a methacrylate group and/or an acrylate group. For example, the (meth)acrylate monomer can be acrylic acid, methacrylic acid, 2-hydroxyethyl acrylate, 2- hydroxyethyl methacrylate, methyl acrylate, methyl methacrylate, ethyl methacrylate, isobornyl acrylate, isobornyl methacrylate, isoamyl acrylate, isoamyl methacrylate, isodecyl acrylate, isodecyl methacrylate, hexanediol diacrylate, hexanediol dimethacrylate, trimethylolpropane triacrylate, 2-(tert-butyl) methacrylate, 2-(tert-butylamino)ethyl methacrylate, trimethylolpropane trimethacrylate, salts thereof, or a combination thereof. Thus, in some embodiments, the (meth)acrylate monomer is acrylic acid, methacrylic acid, 2- hydroxyethyl acrylate, 2-hydroxyethyl methacrylate, methyl acrylate, methyl methacrylate, ethyl methacrylate, isobornyl acrylate, isobornyl methacrylate, isoamyl acrylate, isoamyl methacrylate, isodecyl acrylate, isodecyl methacrylate, hexanediol diacrylate, hexanediol dimethacrylate, trimethylolpropane triacrylate, 2-(tert-butyl) methacrylate, 2-(tert-butylamino)ethyl methacrylate, trimethylolpropane trimethacrylate, salts thereof, or combinations thereof. In certain embodiments, the UV-curable composition comprises isobornyl acrylate, isobornyl methacrylate, or a combination thereof.

[0055] The UV-curable composition can comprise any suitable amount of the (meth)acrylate monomer. For example, the UV-curable composition can comprise about 95 wt.% or less of the (meth)acrylate monomer based on the sum total weight of polymerizable monomers and oligomers, e.g., about 90 wt.% or less, about 85 wt.% or less, about 80 wt.% or less, about 75 wt.% or less, about 70 wt.% or less, about 65 wt.% or less, about 60 wt.% or less, about 55 wt.% or less, or about 50 wt.% or less of the (meth)acrylate monomer based on the sum total weight of polymerizable monomers and oligomers. Alternatively, or in addition, the UV-curable composition can comprise about 1 wt.% or more of the (meth)acrylate monomer based on the sum total weight of polymerizable monomers and oligomers, for example, about 5 wt.% or more, about 10 wt.% or more, 15 wt.% or more, about 20 wt.% or more, about 25 wt.% or more, about 30 wt.% or more, about 40 wt.% or more, or about 50 wt.% or more of the (meth)acrylate monomer based on the sum total weight of polymerizable monomers and oligomers. Thus, the UV-curable composition can comprise the (meth)acrylate monomer in any amount bounded by any two

of the aforementioned endpoints, as appropriate.

[0056] For example, in some embodiments, the (meth)acrylate monomer can be present in the UV-curable composition in an amount of about 1 wt.% to about 95 wt.% based on the sum total weight of polymerizable monomers and oligomers, e.g., about 1 wt.% to about 90 wt.%, about 1 wt.% to about 80 wt.%, about 1 wt.% to about 70 wt.%, about 1 wt.% to about 60 wt.%, about 1 wt.% to about 50 wt.%, about 5 wt.% to about 95 wt.%, about 5 wt.% to about 90 wt.%, about 5 wt.% to about 80 wt.%, about 5 wt.% to about 70 wt.%, about 5 wt.% to about 60 wt.%, about 5 wt.% to about 50 wt.%, about 10 wt.% to about 95 wt.%, about 10 wt.% to about 90 wt.%, about 10 wt.% to about 80 wt.%, about 10 wt.% to about 70 wt.%, about 10 wt.% to about 60 wt.%, about 10 wt.% to about 50 wt.%, about 25 wt.% to about 95 wt.%, about 25 wt.% to about 90 wt.%, about 25 wt.% to about 80 wt.%, about 25 wt.% to about 70 wt.%, about 25 wt.% to about 60 wt.%, about 25 wt.% to about 50 wt.%, about 50 wt.% to about 95 wt.%, about 50 wt.% to about 90 wt.%, about 50 wt.% to about 80 wt.%, about 50 wt.% to about 70 wt.%, or about 50 wt.% to about 60 wt.% based on the sum total weight of polymerizable monomers and oligomers. In some embodiments, the UV-curable composition comprises from about 25 wt.% to about 50 wt.% of the (meth)acrylate monomer based on the sum total weight of polymerizable monomers and oligomers. In certain embodiments, the UV-curable composition comprises from about 30 wt.% to about 50 wt.% of the (meth)acrylate monomer based on the sum total weight of polymerizable monomers and oligomers.

[0057] In some embodiments, the UV-curable composition comprises an oligomer selected from a difunctional (meth)acrylate-capped polyether urethane oligomer, a difunctional (meth)acrylate-capped polyester urethane oligomer, a difunctional (meth)acrylate-capped urethane oligomer, and a combination thereof.

[0058] In some embodiments, the UV-curable composition comprises a difunctional (meth)acrylate-capped polyether urethane oligomer. In certain embodiments, the UV-curable composition comprises an aromatic polyether urethane di(meth)acrylate oligomer, an aliphatic polyether urethane di(meth)acrylate oligomer, or a combination thereof. For example, the UV-curable composition can comprise an oligomer selected from BR-202 (aromatic polyether urethane methacrylate), BR-204 (aromatic polyether urethane methacrylate), BR-3042 (aromatic polyether urethane methacrylate), BR-5541 (aliphatic polyether urethane methacrylate), BR-1044MB (aliphatic polyether urethane methacrylate), BR-543 (aliphatic polyether urethane acrylate), BR-543MB (aliphatic polyether urethane acrylate), BR-374 (aliphatic polyether urethane acrylate), BR-541S (aliphatic polyether urethane acrylate), and BR-345 (aliphatic polyether urethane acrylate), which are commercially available from Bomar Chemicals. In certain embodiments, the UV-curable composition comprises an oligomer selected from BR-204 (aromatic polyether urethane methacrylate), BR-543 (aliphatic polyether urethane acrylate), BR-374 (aliphatic polyether urethane acrylate), and a combination thereof.

[0059] In some embodiments, the UV-curable composition comprises a difunctional (meth)acrylate-capped polyester urethane oligomer. In certain embodiments, the UV-curable composition comprises an

aliphatic polyester urethane di(meth)acrylate oligomer. For example, the UV-curable composition can comprise an oligomer selected from XR-741MS (aliphatic polyester urethane methacrylate), BR-742M (aliphatic polyester urethane methacrylate), BR-742S (aliphatic polyester urethane methacrylate), BR-7432GI30 (aliphatic polyester urethane methacrylate), BR-752MS (aliphatic polyester urethane acrylate), and BR- 744BT (aliphatic polyester urethane acrylate), which are commercially available from Bomar Chemicals. In certain embodiments, the UV-curable composition comprises BR-744BT (aliphatic polyester urethane acrylate).

[0060] In some embodiments, the UV-curable composition comprises a difunctional (meth)acrylate-capped urethane oligomer. In certain embodiments, the UV-curable composition comprises a polybutadiene urethane di(meth)acrylate oligomer. For example, the UV-curable composition can comprise an oligomer selected from BR-640D (aliphatic polybutadiene urethane acrylate), BR-641E (aliphatic polybutadiene urethane acrylate), and BR-643 (aliphatic polybutadiene urethane acrylate), which are commercially available from Bomar Chemicals.

[0061] The UV-curable composition can comprise any suitable amount of the oligomer selected from a difunctional (meth)acrylate-capped polyether urethane oligomer, a difunctional (meth)acrylate-capped polyester urethane oligomer, a difunctional (meth)acrylate-capped urethane oligomer, and a combination thereof. For example, the UV-curable composition can comprise about 95 wt.% or less of the oligomer based on the sum total weight of polymerizable monomers and oligomers, e.g., about 90 wt.% or less, about 85 wt.% or less, about 80 wt.% or less, about 75 wt.% or less, about 70 wt.% or less, about 65 wt.% or less, about 60 wt.% or less, about 55 wt.% or less, or about 50 wt.% or less of the oligomer based on the sum total weight of polymerizable monomers and oligomers.

Alternatively, or in addition, the UV-curable composition can comprise about 1 wt.% or more of the oligomer based on the sum total weight of polymerizable monomers and oligomers, for example, about 5 wt.% or more, about 10 wt.% or more, 15 wt.% or more, about 20 wt.% or more, about 25 wt.% or more, about 30 wt.% or more, about 40 wt.% or more, or about 50 wt.% or more of the oligomer based on the sum total weight of polymerizable monomers and oligomers. Thus, the UV-curable composition can comprise the oligomer selected from a difunctional (meth)acrylate-capped polyether urethane oligomer, a difunctional (meth)acrylate-capped polyester urethane oligomer, a difunctional (meth)acrylate-capped urethane oligomer, and a combination thereof, in any amount bounded by any two of the aforementioned endpoints, as appropriate.

[0062] For example, in some embodiments, the oligomer selected from a difunctional (meth)acrylate-capped polyether urethane oligomer, a difunctional (meth)acrylate-capped polyester urethane oligomer, a difunctional (meth)acrylate-capped urethane oligomer, and a combination thereof, can be present in the UV-curable composition in an amount of about 1 wt.% to about 95 wt.% based on the sum total weight of polymerizable monomers and oligomers, e.g., about 1 wt.% to about 90 wt.%, about 1 wt.% to about 80 wt.%, about 1 wt.% to about 70 wt.%, about 1 wt.% to about 60 wt.%, about 1 wt.% to about 50 wt.%,

about 5wt.% to about 95 wt.%, about 5 wt.% to about 90 wt.%, about 5 wt.% to about 80 wt.%, about 5 wt.% to about 70 wt.%, about 5 wt.% to about 60 wt.%, about 5 wt.% to about 50 wt.%, about 10 wt.% to about 95 wt.%, about 10 wt.% to about 90 wt.%, about 10 wt.% to about 80 wt.%, about 10 wt.% to about 70 wt.%, about 10 wt.% to about 60 wt.%, about 10 wt.% to about 50 wt.%, about 25 wt.% to about 95 wt.%, about 25 wt.% to about 90 wt.%, about 25 wt.% to about 80 wt.%, about 25 wt.% to about 70 wt.%, about 25 wt.% to about 60 wt.%, about 25 wt.% to about 50 wt.%, about 50 wt.% to about 95 wt.%, about 50 wt.% to about 90 wt.%, about 50 wt.% to about 80 wt.%, about 50 wt.% to about 70 wt.%, or about 50 wt.% to about 60 wt.% based on the sum total weight of polymerizable monomers and oligomers. In some embodiments, the UV-curable composition comprises from about 50 wt.% to about 75 wt.% of the oligomer selected from a difunctional (meth)acrylate-capped polyether urethane oligomer, a difunctional (meth)acrylate-capped polyester urethane oligomer, a difunctional (meth)acrylate-capped urethane oligomer, and a combination thereof, based on the sum total weight of polymerizable monomers and oligomers. In certain embodiments, the UV-curable composition comprises from about 50 wt.% to about 70 wt.% of the oligomer selected from a difunctional (meth)acrylate-capped polyether urethane oligomer, a difunctional (meth)acrylate-capped polyester urethane oligomer, a difunctional (meth)acrylate-capped urethane oligomer, and a combination thereof, based on the sum total weight of polymerizable monomers and oligomers.

[0063] In some embodiments, the UV-curable composition further comprises an additive selected from a pore filler, a pigment, and a combination thereof. In certain embodiments, the UV-curable composition further comprises a pore filler. The UV-curable composition can comprise the pore filler in any suitable amount, when present, but generally, the UV-curable composition comprises the pore filler in an amount from about 1 wt.% to about 10 wt.% (e.g., about 1 wt.% to about 5 wt.% or about 2 wt.% to about 4 wt.%) based on the total weight of the UV-curable composition.

[0064] In some embodiments, the UV-curable composition further comprises a photo- initiator. The photo-initiator can be any suitable initiator capable of forming a reactive species upon irradiation with light. In some embodiments, the photo-initiator is selected from an acylphosphine oxide, an α-aminoalkylphenone, an α-dialkoxyacetophenone, an α- hydroxyalkylphenone, a benzyl ketal, a benzoin ether, an anthraquinone, a benzophenone, a thioxanthone, and combinations thereof. In certain embodiments, the UV-curable composition comprises an acylphosphine oxide photo-initiator such as, for example, phenylbis(2,4,6-trimethylbenzoyl) phosphine oxide.

[0065] The method comprises uniformly spreading the UV-curable composition on the side opposite the polishing side. As used herein, the term "uniform" or "uniformly" refers to a variation in a specific property (i.e., thickness when referring to "uniformly spreading" or a "uniform coating") of less than about 20% (e.g., less than about 15%, less than about 10%, less than about 5%, less than about 1%, or less than about 0.1%) at every position of a component relative to the average of the component as a whole. The UV-curable composition can be spread by any suitable means so as to provide a uniform amount, with a

thickness described herein, of the UV-curable composition on the side opposite the polishing side. For example, the UV-curable composition can be spread by gravity, a doctor blade, a spatula, or the like. In some embodiments, the UV-curable composition is uniformly spread on the side opposite the polishing side using a doctor blade.

[0066] The method comprises UV curing the UV-curable composition to provide the polishing pad. The UV-curable composition can be cured by any suitable means at any suitable wavelength, which induces polymerization of the polymerizable monomers and oligomers. In some embodiments, the UV-curable composition is UV cured with light at a wavelength of about 350 nm to about 420 nm, e.g., about 350 nm to about 415 nm, about 350 nm to about 410 nm, about 350 nm to about 405 nm, about 350 nm to about 400 nm, about 355 nm to about 420 nm, about 355 nm to about 415 nm, about 355 nm to about 410 nm, about 355 nm to about 405 nm, about 355 nm to about 400 nm, about 360 nm to about 420 nm, about 360 nm to about 415 nm, about 360 nm to about 410 nm, about 360 nm to about 405 nm, about 360 nm to about 400 nm, about 365 nm to about 420 nm, about 365 nm to about 415 nm, about 365 nm to about 410 nm, about 365 nm to about 405 nm, or about 365 nm to about 400 nm. In certain embodiments, the UV-curable composition is UV cured with light at a wavelength of about 365 nm to about 405 nm.

[0067] In some embodiments, the UV-curable composition is UV cured with a UV light attached to a doctor blade. For example, the UV-curable composition can be cured while uniformly spreading the UV-curable composition on the side opposite the polishing side. In other words, steps (iii) and (iv) of the claimed method can occur simultaneously.

[0068] The disclosure further provides an apparatus for performing the method of preparing the polishing pad for chemical-mechanical planarization described herein, the apparatus comprising (i) a jig comprising a circular recess, (ii) a doctor blade, and (iii) a UV light source.

[0069] In some embodiments, the apparatus for performing the method described herein comprises a jig comprising a circular recess. As used herein, "jig" refers to any object (e.g., a carrier board) having a circular recess for holding (a) the top sheet and (b) the UV-curable composition or the UV-cured sub-pad for chemical-mechanical planarization. The depth of the recess of the jig is not particularly limited; however, the depth of the recess is set to the desirable thickness of the polishing pad for chemical-mechanical planarization. In certain embodiments, the jig further comprises a hole in the recess. The hole in the recess can be used (a) for applying a vacuum to the polishing side of the top sheet prior to applying the UV-curable composition to the side opposite the polishing side of the top sheet and/or (b) to punch out (i.e., a punchout hole) the polishing pad for chemical-mechanical planarization upon completion. Alternatively, or additionally, the jig further comprises a trough peripheral to the recess. The trough can be used to collect excess UV-curable composition formed as a result of uniformly spreading the UV-curable composition (e.g., by using a doctor blade). An exemplary jig (e.g., a carrier board) comprising a punchout hole and a trough is depicted in FIG. 2.

[0070] In some embodiments, the apparatus for performing the method described herein comprises a

doctor blade. As the jig passes underneath the doctor blade, the UV-curable composition is spread on the top sheet within the circular recess thereby forming a uniform coating with the UV-curable composition, as depicted in FIG. 3.

[0071] In some embodiments, the apparatus for performing the method described herein comprises a UV light source. As the jig passes underneath the UV light source, the UV- curable composition is cured, as depicted in FIG. 3. The light source can emit light at any suitable wavelength. In some embodiments, the light source emits light at a wavelength of about 350 nm to about 420 nm, e.g., about 350 nm to about 415 nm, about 350 nm to about 410 nm, about 350 nm to about 405 nm, about 350 nm to about 400 nm, about 355 nm to about 420 nm, about 355 nm to about 415 nm, about 355 nm to about 410 nm, about 355 nm to about 405 nm, about 355 nm to about 400 nm, about 360 nm to about 420 nm, about360 nm to about 415 nm, about 360 nm to about 410 nm, about 360 nm to about 405 nm, about 360 nm to about 400 nm, about 365 nm to about 420 nm, about 365 nm to about 415 nm, about 365 nm to about 410 nm, about 365 nm to about 405 nm, or about 365 nm to about 400 nm. In certain embodiments, the light source emits light at a wavelength of about 365 nm to about 405 nm.

[0072] Aspects, including embodiments, of the disclosure described herein may be beneficial alone or in combination, with one or more other aspects or embodiments. Without limiting the foregoing description, certain non-limiting embodiments of the disclosure numbered 1-43are provided below. As will be apparent to those of skill in the art upon reading this disclosure, each of the individually numbered embodiments may be used or combined with any of the preceding or following individually numbered embodiments. This is intended to provide support for all such combinations of embodiments and is not limited to combinations of embodiments explicitly provided below:

EMBODIMENTS

[0073] (1) In embodiment (1) is presented a UV-cured sub-pad for chemical-mechanical planarization comprising

(a) a (meth)acrylate monomer unit and

(b) an oligomer unit selected from a difunctional (meth)acrylate-capped polyether urethane oligomer unit, a difunctional (meth)acrylate-capped polyester urethane oligomer unit, a difunctional (meth)acrylate-capped urethane oligomer unit, and a combination thereof.

[0074] (2) In embodiment (2) is presented the UV-cured sub-pad of embodiment (1), wherein the sub-pad is circular and has a diameter of about 5 cm to about 150 cm.

[0075] (3) In embodiment (3) is presented the UV-cured sub-pad of embodiment (1), wherein the sub-pad is circular and has a diameter of about 50 cm to about 100 cm.

[0076] (4) In embodiment (4) is presented the UV-cured sub-pad of embodiment (1), wherein the sub-pad is circular and has a diameter of about 70 cm to about 90 cm.

[0077] (5) In embodiment (5) is presented the UV-cured sub-pad of any one of embodiments (1)-(4),

wherein the sub-pad has a thickness of about 0.1 mm to about 2 mm.

[0078] (6) In embodiment (6) is presented the UV-cured sub-pad of any one of embodiments (1)-(4), wherein the sub-pad has a thickness of about 0.5 mm to about 1 mm.

[0079] (7) In embodiment (7) is presented the UV-cured sub-pad of any one of embodiments (1)-(6), wherein the sub-pad comprises a (meth)acrylate monomer unit formed from acrylic acid, methacrylic acid, 2-hydroxyethyl acrylate, 2-hydroxyethyl methacrylate, methyl acrylate, methyl methacrylate, ethyl methacrylate, isobornyl acrylate, isobornyl methacrylate, isoamyl acrylate, isoamyl methacrylate, isodecyl acrylate, isodecyl methacrylate, hexanediol diacrylate, hexanediol dimethacrylate, trimethylolpropane triacrylate, 2-(tert-butyl) methacrylate, 2-(tert-butylamino)ethyl methacrylate, trimethylolpropane trimethacrylate, salts thereof, or combinations thereof.

[0080] (8) In embodiment (8) is presented the UV-cured sub-pad of any one of embodiments (1)-(7), wherein the sub-pad comprises a difunctional (meth)acrylate-capped polyether urethane oligomer unit.

[0081] (9) In embodiment (9) is presented the UV-cured sub-pad of embodiment (8), wherein the sub-pad comprises an aromatic polyether urethane di(meth)acrylate oligomer unit, an aliphatic polyether urethane di(meth)acrylate oligomer unit, or a combination thereof.

[0082] (10) In embodiment (10) is presented the UV-cured sub-pad of any one of embodiments (1)-(9), wherein the sub-pad comprises a difunctional (meth)acrylate-capped polyester urethane oligomer unit.

[0083] (11) In embodiment (11) is presented the UV-cured sub-pad of embodiment (10), wherein the sub-pad comprises an aliphatic polyester urethane di(meth)acrylate oligomer unit.

[0084] (12) In embodiment (12) is presented the UV-cured sub-pad of any one of embodiments (1)-(11), wherein the sub-pad comprises a difunctional (meth)acrylate-capped urethane oligomer unit.

[0085] (13) In embodiment (13) is presented the UV-cured sub-pad of embodiment (12), wherein the sub-pad comprises a polybutadiene urethane di(meth)acrylate oligomer unit.

[0086] (14) In embodiment (14) is presented the UV-cured sub-pad of any one of embodiments (1)-(13), wherein the sub-pad has a hardness of about 30 Shore A to about 100 Shore A.

[0087] (15) In embodiment (15) is presented the UV-cured sub-pad of any one of embodiments (1)-(13), wherein the sub-pad has a hardness of about 30 Shore A to about 95 Shore A.

[0088] (16) In embodiment (16) is presented a polishing pad for chemical-mechanical planarization comprising a top sheet and a UV-cured sub-pad of any one of embodiments (1)- (15), wherein the UV-cured sub-pad is bound to a surface of the top sheet.

[0089] (17) In embodiment (17) is presented the polishing pad of embodiment (16), wherein the UV-cured sub-pad is bound to a surface of the top sheet without an adhesive.

[0090] (18) In embodiment (18) is presented the polishing pad of embodiment (16) or embodiment (17), wherein the UV-cured sub-pad is bound directly to a surface of the top sheet by way of UV curing.

[0091] (19) In embodiment (19) is presented the polishing pad of any one of embodiments (16)-(18), wherein the polishing pad is circular and has a diameter of about 5 cm to about 150 cm.

[0092] (20) In embodiment (20) is presented the polishing pad of any one of embodiments (16)-(18), wherein the polishing pad is circular and has a diameter of about 50 cm to about 100 cm.

[0093] (21) In embodiment (21) is presented the polishing pad of any one of embodiments (16)-(18), wherein the polishing pad is circular and has a diameter of about 70 cm to about 90 cm.

[0094] (22) In embodiment (22) is presented the polishing pad of any one of embodiments (16)-(21), wherein the polishing pad has a thickness of about 0.5 mm to about 4 mm.

[0095] (23) In embodiment (23) is presented the polishing pad of any one of embodiments (16)-(21), wherein the polishing pad has a thickness of about 2 mm to about 3 mm.

[0096] (24) In embodiment (24) is presented a method of preparing the polishing pad for chemical-mechanical planarization of any one of embodiments (16)-(23), the method comprising:

(i) providing a top sheet having a polishing side and a side opposite the polishing side, applying a UV-curable composition to the side opposite the polishing side,

(ii) uniformly spreading the UV-curable composition on the side opposite the polishing side, and

(iii) UV curing the UV-curable composition to provide the polishing pad.

[0097] (25) In embodiment (25) is presented the method of embodiment (24), wherein the UV-curable composition comprises

(a) a (meth)acrylate monomer and

(b) an oligomer selected from a difunctional (meth)acrylate-capped polyether urethane oligomer, a difunctional (meth)acrylate-capped polyester urethane oligomer, a difunctional (meth)acrylate-capped urethane oligomer, and a combination thereof.

[0098] (26) In embodiment (26) is presented the method of embodiment (25), wherein the (meth)acrylate monomer is acrylic acid, methacrylic acid, 2-hydroxyethyl acrylate, 2- hydroxyethyl methacrylate, methyl acrylate, methyl methacrylate, ethyl methacrylate, isobornyl acrylate, isobornyl methacrylate, isoamyl acrylate, isoamyl methacrylate, isodecyl acrylate, isodecyl methacrylate, hexanediol diacrylate, hexanediol dimethacrylate, trimethylolpropane triacrylate, 2-(tert-butyl) methacrylate, 2-(tert-butylamino)ethyl methacrylate, trimethylolpropane trimethacrylate, salts thereof, or combinations thereof.

[0099] (27) In embodiment (27) is presented the method of embodiment (25) or embodiment (26), wherein the UV-curable composition comprises a difunctional (meth)acrylate-capped polyether urethane oligomer.

[0100] (28) In embodiment (28) is presented the method of embodiment (27), wherein the UV-curable composition comprises an aromatic polyether urethane di(meth)acrylate oligomer, an aliphatic polyether urethane di(meth)acrylate oligomer, or a combination thereof.

[0101] (29) In embodiment (29) is presented the method of any one of embodiments (25)- (28), wherein the UV-curable composition comprises a difunctional (meth)acrylate-capped polyester urethane

oligomer.

[0102] (30) In embodiment (30) is presented the method of embodiment (29), wherein the UV-curable composition comprises an aliphatic polyester urethane di(meth)acrylate oligomer.

[0103] (31) In embodiment (31) is presented the method of any one of embodiments (25)- (30), wherein the UV-curable composition comprises a difunctional (meth)acrylate-capped urethane oligomer.

[0104] (32) In embodiment (32) is presented the method of embodiment (31), wherein the UV-curable composition comprises a polybutadiene urethane di(meth)acrylate oligomer.

[0105] (33) In embodiment (33) is presented the method of any one of embodiments (25)- (32), wherein the UV-curable composition further comprises a photo-initiator.

[0106] (34) In embodiment (34) is presented the method of embodiment (33), wherein the photo-initiator is selected from an acylphosphine oxide, an α-aminoalkylphenone, an α- dialkoxyacetophenone, an α-hydroxyalkylphenone, a benzyl ketal, a benzoin ether, an anthraquinone, a benzophenone, a thioxanthone, and combinations thereof.

[0107] (35) In embodiment (35) is presented the method of any one of embodiments (25)- (34), wherein the UV-curable composition further comprises an additive selected from a pore filler, a pigment, or a combination thereof.

[0108] (36) In embodiment (36) is presented the method of any one of embodiments (24)- (35), wherein the UV-curable composition is uniformly spread on the side opposite the polishing side using a doctor blade.

[0109] (37) In embodiment (37) is presented the method of any one of embodiments (24)- (36), wherein the UV-curable composition is UV cured with light at a wavelength of about 350 nm to about 420 nm.

[0110] (38) In embodiment (38) is presented the method of any one of embodiments (24)- (36), wherein the UV-curable composition is UV cured with light at a wavelength of about 365 nm to about 405 nm.

[0111] (39) In embodiment (39) is presented the method of any one of embodiments (24)- (38), wherein the UV-curable composition is UV cured with a UV light attached to a doctor blade.

[0112] (40) In embodiment (40) is presented the method of any one of embodiments (24)- (39), wherein the method further comprises applying a vacuum to the polishing side of the top sheet prior to applying the UV-curable composition to the side opposite the polishing side of the top sheet.

[0113] (41) In embodiment (41) is presented an apparatus for performing the method of any one of embodiments (24)-(40), the apparatus comprising:

(i) a jig comprising a circular recess,

(ii) a doctor blade, and

(iii) a UV light source.

[0114] (42) In embodiment (42) is presented the apparatus of embodiment (41), wherein the jig

further comprises a hole in the recess.

[0115] (43) In embodiment (43) is presented the apparatus of embodiment (41) or embodiment (42), wherein the jig further comprises a trough peripheral to the recess.

EXAMPLES

[0116] These following example further illustrates the disclosure but, of course, should not be construed as in any way limiting its scope.

EXAMPLE 1

[0117] This example provides exemplary UV-curable compositions containing an oligomer and a (meth)acrylate monomer for the preparation of UV-cured sub-pads for chemical-mechanical planarization, as well as an analysis of their physical properties.

[0118] UV-Curable Compositions 1A-1D contained an oligomer (i.e., BR-204 (aromatic polyether urethane methacrylate), BR-374 (aliphatic polyether urethane acrylate), BR-543 (aliphatic polyether urethane acrylate), or BR-744BT (aliphatic polyester urethane acrylate)), commercially available from Bomar Chemicals, and a (meth)acrylate monomer (i.e., isobornyl acrylate) in a weight ratio of 70:30. In addition, UV-Curable Compositions 1A-1D contained 2-4 wt.% of a pore filler and phenylbis(2,4,6-trimethylbenzoyl) phosphine oxide as a photoinitiator. The physical properties of UV-Curable Compositions 1A-1D are set forth in Table 1.

Table 1. UV-Curable Composition Physical Properties as a Function of Oligomer

UV-Curable Composition	**Oligomer**	**Density (g/cm^3 @ 25 °C)**	**Viscosity (cP @ 25 °C)**
1A	BR-204	1.03	2,100
1B	BR-374	1.1	3,600
1C	BR-543	1.03	14,000
1D	BR-744BT	1.11	23,000

UV-Curable Compositions 1A-1D were applied to a top sheet for chemical-mechanical planarization on the side opposite the polishing side using a doctor blade assembly. The coated top sheets were passed under a UV light at a wavelength of 365 nm to 405 nm, thereby curing UV-Curable Compositions 1A-1D. The physical properties of the UV-cured sub-pad resulting from UV-Curable Compositions 1A-1D are set forth in Table 2.

Table 2. UV-Cured Sub-Pad Physical Properties as a Function of Oligomer

UV-Curable Composition	Hardness (Shore A)	Tensile Strength (MPa [psi])	Tensile Elongation (%)	Elastic Modulus (MPa [ksi])
1A	39A	0.6 [90]	120	0.9 [0.13]
1B	49A	4.1 [600]	290	–
1C	56A	3.3 [480]	85	8.3 [1.2]
1D	75A	6.9 [1,000]	160	16.5 [2.4]

[0119] 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.

[0120] The use of the terms "a" and "an" and "the" and "at least one" and similar referents in the context of describing the disclosure (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 use of the term "at least one" followed by a list of one or more items (for example, "at least one of A and B") is to be construed to mean one item selected from the listed items (A or B) or any combination of two or more of the listed items (A and B), 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 disclosure and does not pose a limitation on the scope of the disclosure unless otherwise claimed. No language in the specification should be construed as indicating any non-claimed element as essential to the practice of the disclosure.

[0121] Preferred embodiments of this disclosure are described herein, including the best mode known to the inventors for carrying out the disclosure. 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 disclosure to be practiced otherwise than as specifically described herein. Accordingly, this disclosure 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 disclosure unless otherwise indicated herein or otherwise clearly contradicted by context.

CLAIMS:

1. A UV-cured sub-pad for chemical-mechanical planarization comprising

(a) a (meth)acrylate monomer unit and

(b) an oligomer unit selected from a difunctional (meth)acrylate-capped polyether urethane oligomer unit, a difunctional (meth)acrylate-capped polyester urethane oligomer unit, a difunctional (meth)acrylate-capped urethane oligomer unit, or a combination thereof.

2. The UV-cured sub-pad of claim 1, wherein the sub-pad is circular and has a diameter of about 50 cm to about 100 cm.

3. The UV-cured sub-pad of claim 1, wherein the sub-pad has a thickness of about 0.1 mm to about 2 mm.

4. The UV-cured sub-pad of claim 1, wherein the sub-pad has a thickness of about 0.5 mm to about 1 mm.

5. The UV-cured sub-pad of claim 1, wherein the sub-pad comprises a (meth)acrylate monomer unit formed from acrylic acid, methacrylic acid, 2-hydroxyethyl acrylate, 2-hydroxyethyl methacrylate, methyl acrylate, methyl methacrylate, ethyl methacrylate, isobornyl acrylate, isobornyl methacrylate, isoamyl acrylate, isoamyl methacrylate, isodecyl acrylate, isodecyl methacrylate, hexanediol diacrylate, hexanediol dimethacrylate, trimethylolpropane triacrylate, 2-(tert-butyl) methacrylate, 2-(tert-butylamino)ethyl methacrylate, trimethylolpropane trimethacrylate, salts thereof, or combinations thereof.

6. The UV-cured sub-pad of claim 1, wherein the sub-pad comprises a difunctional (meth)acrylate-capped polyether urethane oligomer unit.

7. The UV-cured sub-pad of claim 1, wherein the sub-pad comprises a difunctional (meth)acrylate-capped polyester urethane oligomer unit.

8. The UV-cured sub-pad of claim 1, wherein the sub-pad comprises a difunctional (meth)acrylate-capped urethane oligomer unit.

9. The UV-cured sub-pad of claim 1, wherein the sub-pad has a hardness of about 30 Shore A to about 100 Shore A.

10. A polishing pad for chemical-mechanical planarization comprising:

a top sheet and a UV-cured sub-pad, the UV-cured sub-pad for chemical-mechanical planarization comprising

(a) a (meth)acrylate monomer unit and

(b) an oligomer unit selected from a difunctional (meth)acrylate-capped polyether urethane oligomer unit, a difunctional (meth)acrylate-capped polyester urethane oligomer unit, a difunctional (meth)acrylate-capped urethane oligomer unit, and a combination thereof,

wherein the UV-cured sub-pad is bound to a surface of the top sheet.

11. The polishing pad of claim 10, wherein the UV-cured sub-pad is bound to a surface of the top sheet without an adhesive.

12. The polishing pad of claim 10, wherein the UV-cured sub-pad is bound directly to a surface of the top sheet by way of UV curing.

13. The polishing pad of claim 10, wherein the polishing pad is circular and has a diameter of about 50 cm to about 100 cm.

14. The polishing pad of claim 10, wherein the polishing pad has a thickness of about 0.5 mm to about 4 mm.

15. A method of preparing a polishing pad for chemical-mechanical planarization comprising:

(i) providing a top sheet having a polishing side and a side opposite the polishing side,

(ii) applying a UV-curable composition to the side opposite the polishing side,

(iii) uniformly spreading the UV-curable composition on the side opposite the polishing side, and

(iv) UV curing the UV-curable composition to provide the polishing pad.

16. The method of claim 15, wherein the UV-curable composition comprises

(a) a (meth)acrylate monomer and

(b) an oligomer selected from a difunctional (meth)acrylate-capped polyether urethane oligomer, a difunctional (meth)acrylate-capped polyester urethane oligomer, a difunctional (meth)acrylate-capped urethane oligomer, and a combination thereof.

17. The method of claim 15, wherein the (meth)acrylate monomer is acrylic acid, methacrylic acid, 2-hydroxyethyl acrylate, 2-hydroxyethyl methacrylate, methyl acrylate, methyl methacrylate, ethyl methacrylate, isobornyl acrylate, isobornyl methacrylate, isoamyl acrylate, isoamyl methacrylate, isodecyl acrylate, isodecyl methacrylate, hexanediol diacrylate, hexanediol

dimethacrylate, trimethylolpropane triacrylate, 2-(tert-butyl) methacrylate, 2-(tert-butylamino)ethyl methacrylate, trimethylolpropane trimethacrylate, salts thereof, or combinations thereof.

18. The method of claim 15, wherein the UV-curable composition comprises a difunctional (meth)acrylate-capped polyether urethane oligomer.

19. The method of claim 15, wherein the UV-curable composition comprises a difunctional (meth)acrylate-capped polyester urethane oligomer.

20. The method of claim 15, wherein the UV-curable composition comprises a difunctional (meth)acrylate-capped urethane oligomer unit.