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(54) **SEMICONDUCTOR POLISHING PAD**

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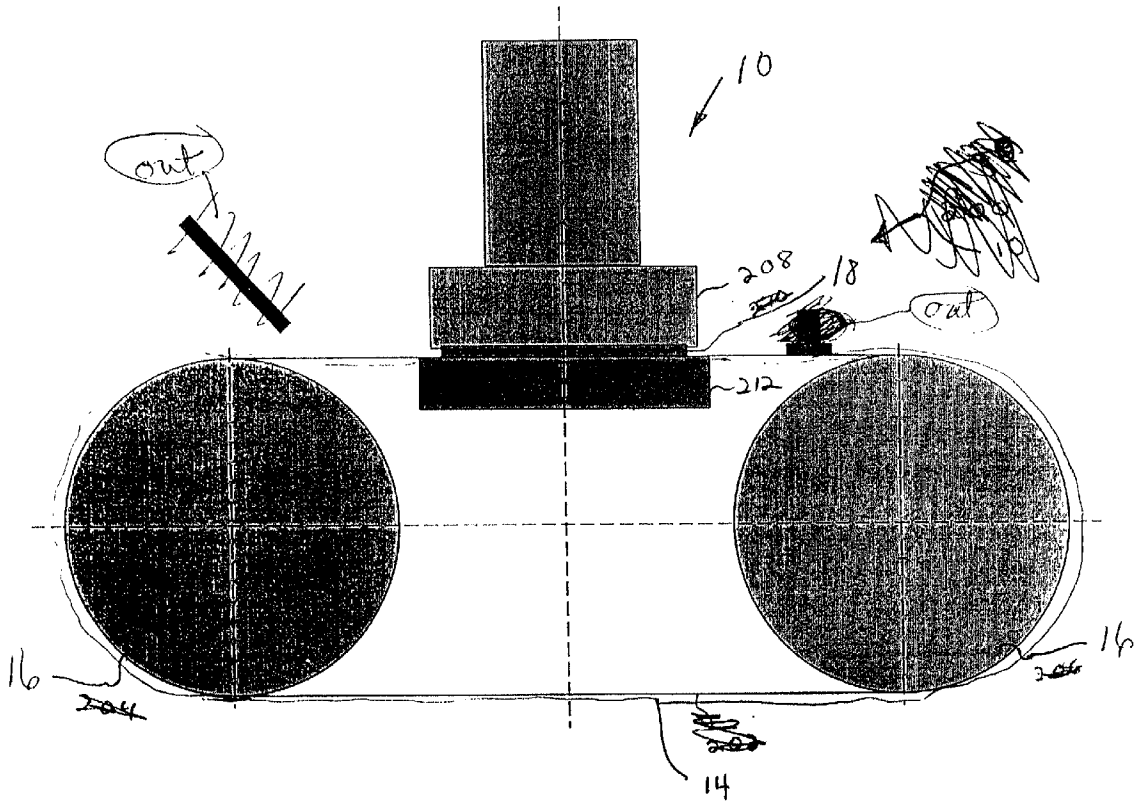
(52) **U.S. Cl.** **451/489**; 156/345.13

(57) **ABSTRACT**

A belt has a polishing pad with one or more polishing pad sections joined to the belt by an adhesive layer. A seam joint is reinforced with caulking material. Edge portions of the seam joint are beveled or dovetailed. Parallel stress relief grooves in the upper surface of the polishing pad prevent delamination of the polishing pad from the belt.



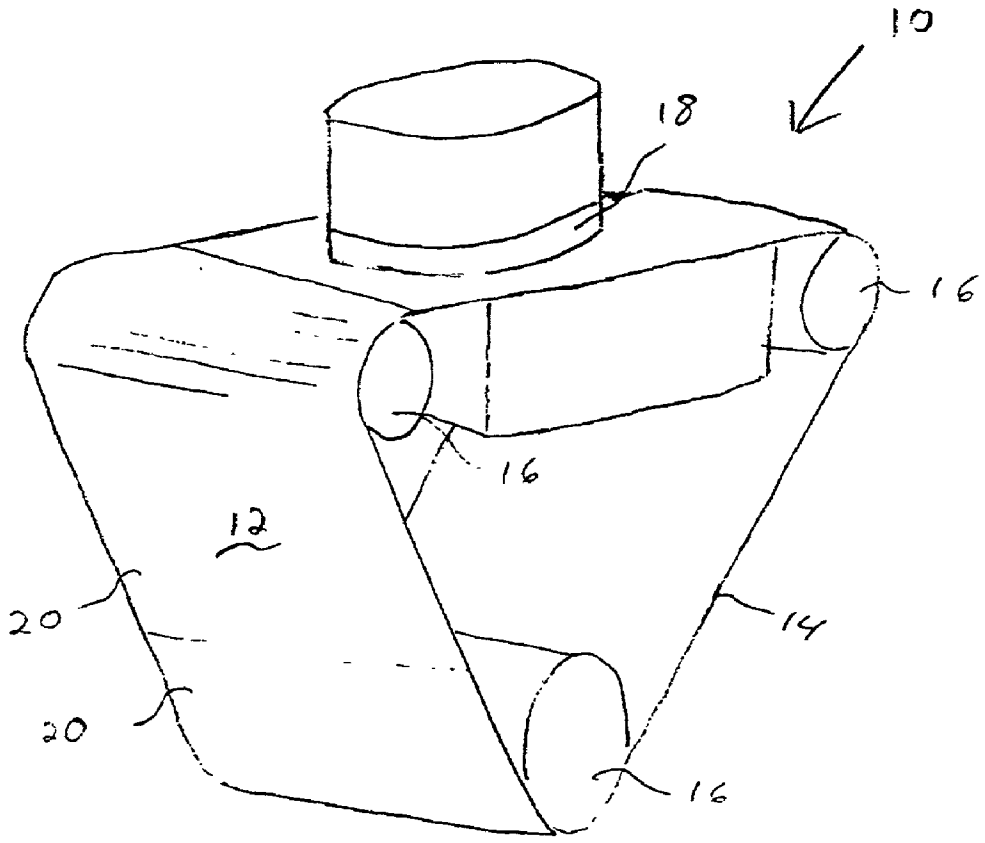


FIG. 1

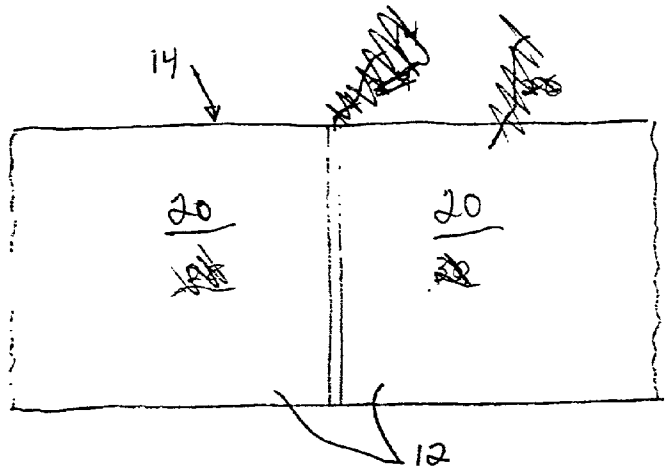


FIG. 2

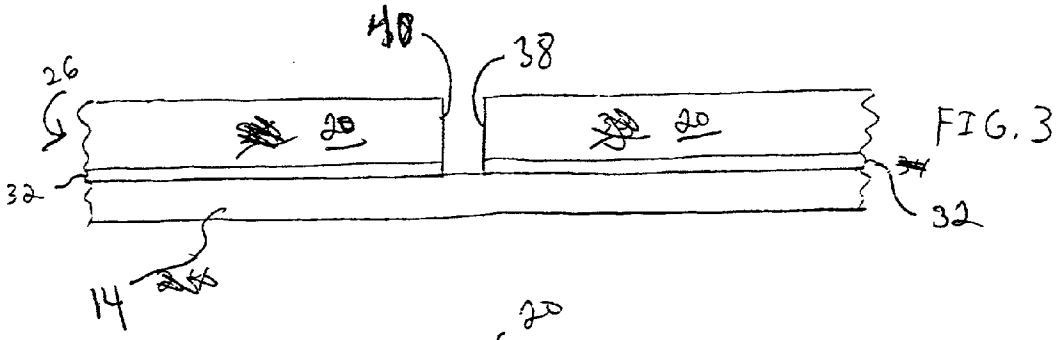


FIG. 3

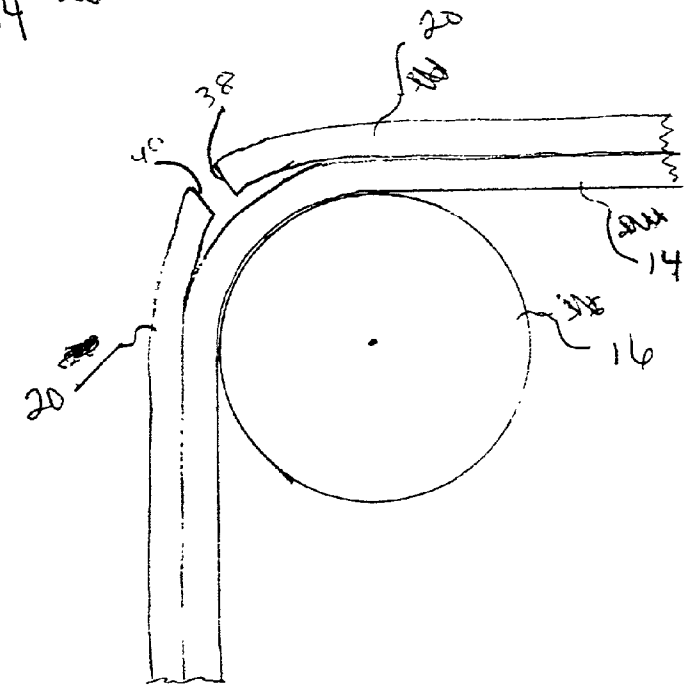


FIG. 4

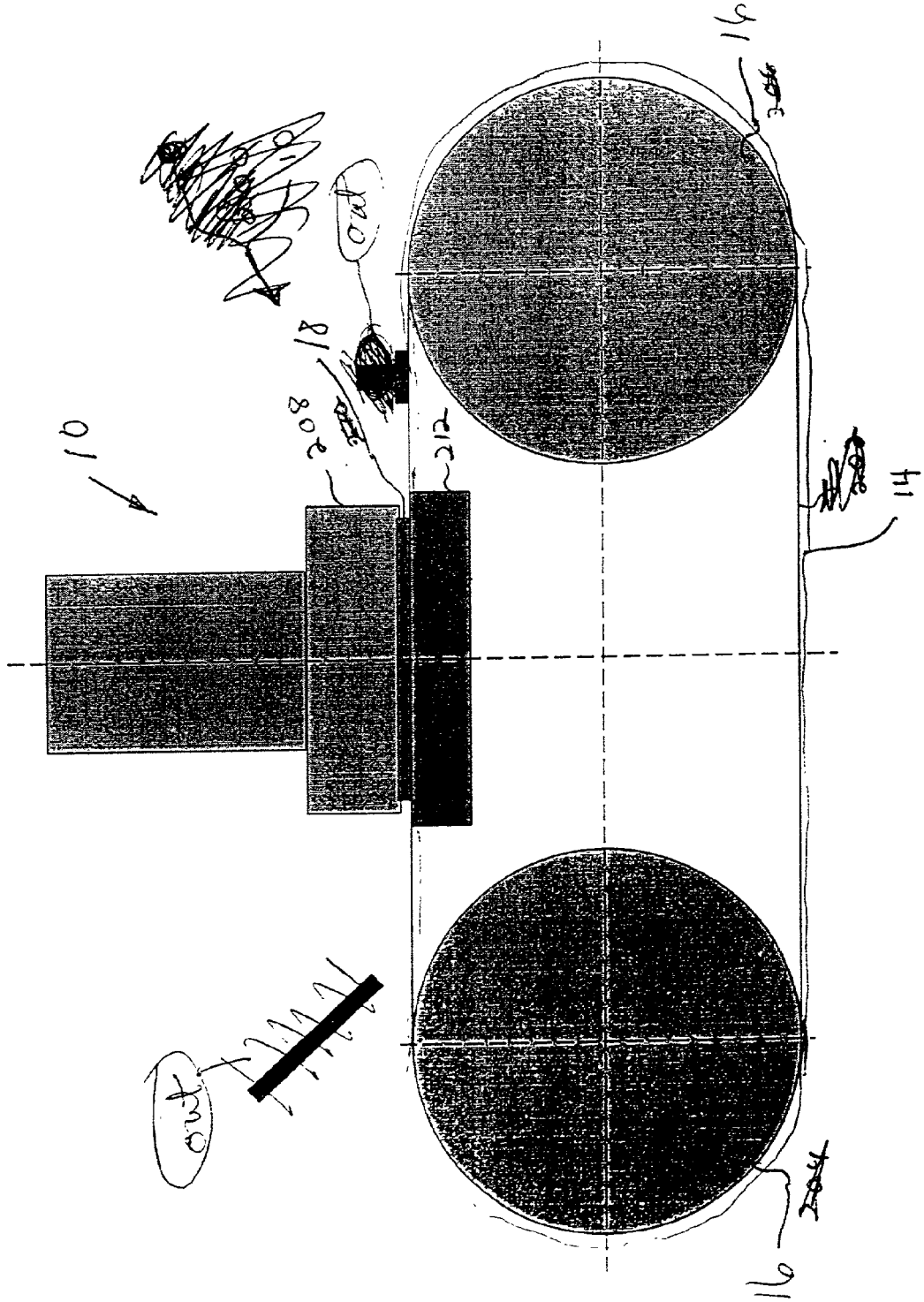


FIG 5.

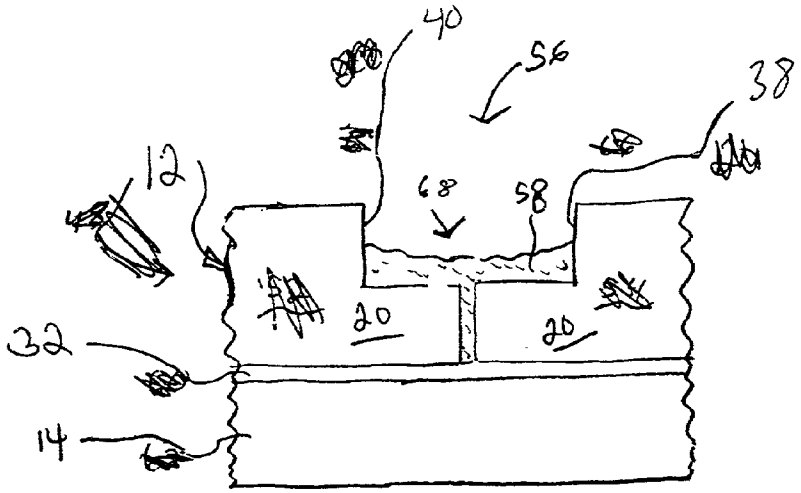


FIG. 6

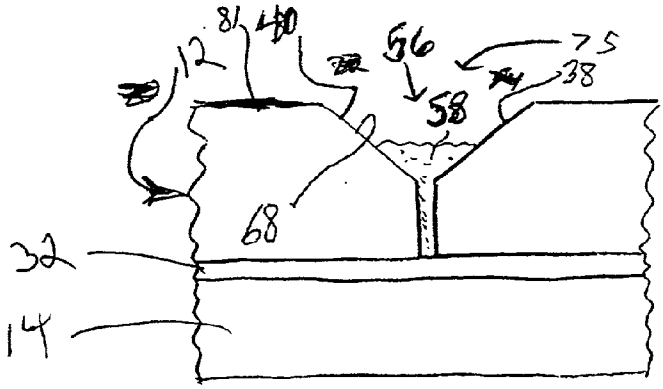


FIG. 7

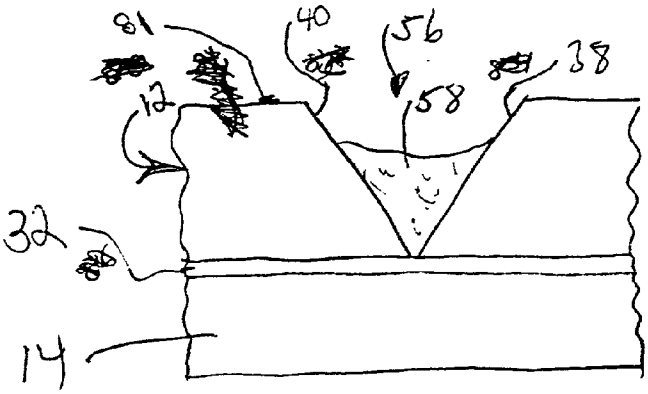


FIG. 8

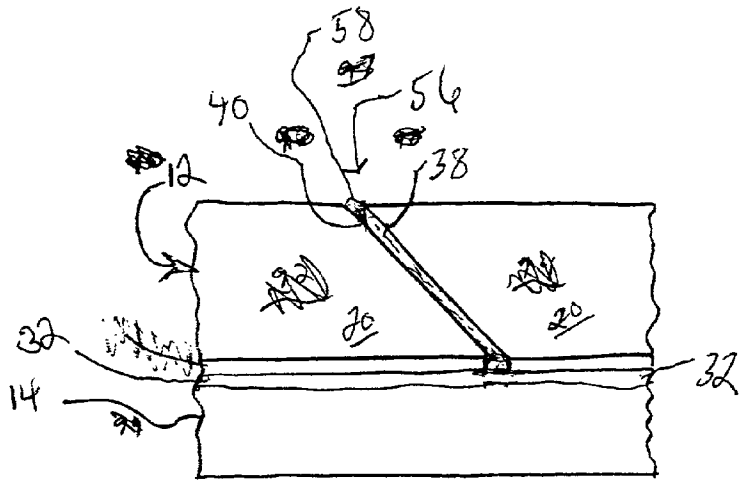


FIG. 9

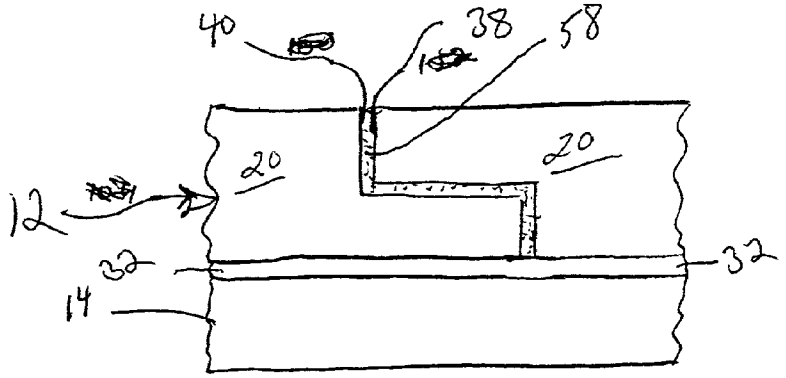


FIG. 10

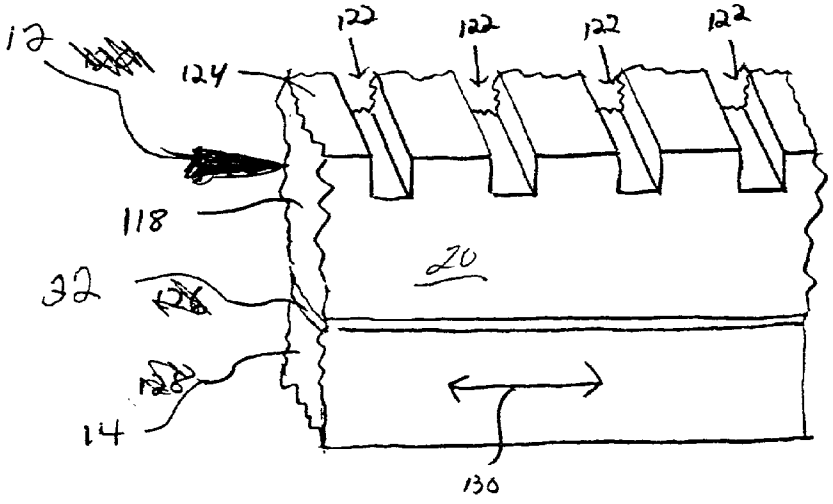


FIG. 11

SEMICONDUCTOR POLISHING PAD

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of provisional application serial No. 60/201,629 filed May 3, 2000.

FIELD OF THE INVENTION

[0002] This invention relates to a polishing pad and belt for polishing and planarizing semiconductor substrate surfaces.

DISCUSSION OF RELATED ART

[0003] According to U.S. Pat. No. 5,593,344, a known polishing fixture includes a continuous belt, a polishing pad adhered to the belt, and multiple rollers over which the belt revolves in a continuous belt movement. The polishing pad is comprised of a single piece pad or, alternatively, multiple, individual pad sections that are positioned adjacent to one another across an outer surface of the belt. As the belt revolves, the polishing pad moves to polish and planarize one or more semiconductor wafers that are held against the polishing pad. Unfortunately as the belt revolves over the curved surface on each the rollers, each pad section bends to correspond to the curvature of the belt rollers. Repeated bending of the pad sections places a significant amount of stress on the pad. This stress results in stretching and bunching up of an adhesive layer between the belt and each of the pad sections, which can lead to delamination of the pad sections from the belt. Consequently, a need exists for a polishing belt with a polishing pad that is less likely to stretch, bunch up, and/or delaminate when curved around rollers or other non-planar features of a semiconductor polishing fixture.

SUMMARY OF THE INVENTION

[0004] According to the invention, a polishing pad adapted for mounting on a belt is provided with a seam joint between opposed edge portions of the pad, which decreases the likelihood of stretching, bunching up, and/or delaminating of an adhesive layer between the belt and the pad.

[0005] Embodiments of the invention will now be described by way of example with reference to the accompanying drawings, according to which:

[0006] **FIG. 1** is a perspective view representative of a polishing belt fixture that includes a known polishing pad;

[0007] **FIG. 2** is a top plan view of a known polishing pad adhered to a polishing belt;

[0008] **FIG. 3** is a side plan view of a known polishing pad adhered to a polishing belt.

[0009] **FIG. 4** is a side plan view of a known polishing pad of which polishing pad sections have become delaminated from the belt;

[0010] **FIG. 5** is a side plan view of an exemplary polishing pad fixture that includes an exemplary polishing pad and belt;

[0011] FIGS. **6-8** are respective side plan views of reinforced seam joints between pad sections or between pad ends of exemplary embodiments of the polishing pad and belt of the present invention.

[0012] **FIGS. 9 and 10** are respective side plan views of alternative configurations of seam joints for exemplary embodiments of the polishing pad;

[0013] **FIG. 11** is representative of a side plan view of an exemplary embodiment of a polishing pad that includes parallel stress relief grooves.

DETAILED DESCRIPTION

[0014] **FIG. 1** discoses that integrated circuits are typically fabricated from semiconductor substrates or semiconductor wafers **18**. The surfaces of semiconductor wafers **18** are finely polished and planarized using chemical mechanical polishing (CMP) processes. Many of these polishing CMP processes use a polishing fixture **10** that includes a polishing belt **14**. **FIG. 1** discloses a polishing fixture **10** that includes a polishing belt **14** that is configured to revolve over a plurality of belt rollers **16**. The belt **14** includes a polishing pad **12** adhered thereto. The polishing pad **12** has individual pad sections **20** that are adjacent to each other across the outer surface of the belt **14**. As the belt **14** moves, each of the sections **20** is operative to polish and planarize one or more semiconductor wafers **18** that are held adjacent the polishing pad **12**.

[0015] **FIG. 2** discloses a known polishing belt **14** with a polishing pad **12** adhered thereto. The polishing pad **12** includes independent sections **20**. **FIG. 3** discloses that each prior art polishing pad section **20** includes a corresponding independent adhesive layer **32** that is operative to adhere the polishing pad section **20** to the surface of the belt **14**. Unfortunately the revolving configuration of the belt **14** over belt rollers **16** requires that each of the pad sections **20** periodically bend to correspond to the curvature of the belt rollers **16**. Bending of the pad **12** and of the pad sections **20** places a significant amount of stress on the pad **12**. This stress results in stretching and bunching up of the adhesive layers **32** between the pad **12** and the belt **14** which can lead to delamination of the sections **20** of the pad **12** from the belt **14**.

[0016] **FIG. 4** discloses the belt **14** curving around a roller **16**, which has caused delamination. The opposed edge portions **38** and **40** of the sections **20** have lost their adhesive connection with the belt **14**. Such delamination can significantly reduce the expected operational lifetime of the polishing pad **12** and can degrade the polishing performance of the pad **12**. Consequently, there exists a need for an improved polishing belt **14** with a polishing pad **12** that is less likely to stretch, bunch up, and/or delaminate when curved around rollers **16** or other non-planar features of a semiconductor polishing fixture **10**.

[0017] The invention provides a polishing pad **12** and belt **14** for polishing semiconductor wafers **18**, which includes features for maintaining a strong bond with the polishing pad **12** and belt **14**. Further, features of the invention are operative to reduce the likelihood of stretching the adhesive layer **32** between the polishing pad **12** and the belt **14**. Further, features of the invention reduce the likelihood of bunching up of an adhesive layer **32** between the polishing pad **12** and the belt **14**. Further, features of the invention reduce the likelihood of delamination of portions of the polishing pad **12** from the belt **14**. Further, features of the invention maintain adhesion between the polishing pad **12** and the belt **14** as the belt **14** and polishing pad **12** bend around a belt roller **16**.

[0018] An exemplary embodiment of the invention includes, a semiconductor polishing belt **14** that includes a delamination resistant polishing pad **12** bonded thereto. In one exemplary embodiment the polishing pad **12** includes a plurality of adjacent polishing pad sections **20** that are bonded to the outer surface of the belt **14**. In an alternative exemplary embodiment the polishing pad **12** is comprised of a single polishing pad section **20** that is bonded to the outer surface of the belt **14**. Such a single polishing pad section **20** has a length that corresponds to the outer circumference of the belt **14**.

[0019] In another exemplary embodiment the belt **14** is comprised of a stainless steel mesh in the shape of a continuous loop that is operatively flexible for traveling around rollers **16** of a polishing pad fixture. The polishing pad sections **20** in the exemplary embodiment are comprised of a flexible and elastic polymer such as a polyurethane. The polishing pad sections **20** are machine laminated to the outer surface of the belt **14** with an adhesive layer **32** comprised of an adhesive such as a flexible double-sided pressure sensitive or contact adhesive. In the exemplary embodiment with multiple pad sections **20** bonded to the belt **14**, the seam joints **56** between adjacent pad sections **20**, include features which decrease the likelihood of the adhesive layer **32** stretching, bunching up, and/or delaminating. In the exemplary embodiment of the present invention with a single polishing pad **12** bonded to the belt **14**, the seam joint **56** between adjacent ends of the pad **12**, include features which decrease the likelihood of the adhesive layer **32** stretching, bunching up, and/or delaminating

[0020] In one exemplary embodiment these features include a polishing pad **12** with adjacent edges of pad sections **20** or pad ends that are cooperatively beveled or dovetailed to interlock and/or overlap with each other. In another exemplary embodiment the seam joints **56** between adjacent pad sections **20** or pad ends are reinforced with a caulking material such as an elastic polymer. By reinforcing the seam joints **56**, with interlocking or overlapping seams and/or caulking the present exemplary invention is operative to prevent the adhesive layer **32** from stretching and/or delaminating from the belt **14** as the polishing pad **12** of the belt **14** curves around belt rollers **16** or other non-planar features of a polishing fixture **10**.

[0021] In other exemplary embodiments of the present invention, the polishing pad **12** includes a plurality of parallel grooves spaced across the width of the pad **12** in a transverse direction with respect to the direction of movement of the polishing belt **14**. The grooves are operative to further relieve stress on the polishing pad **12** and minimize the occurrence of pad **12** delamination as the polishing pad **12** bends responsive to the curvature of a belt roller **16**.

[0022] Referring now to the drawings and particularly to **FIG. 5**, there is shown therein a a side plan view representative of an exemplary semiconductor polishing fixture **10** that includes an exemplary polishing pad **12** and belt **14** of the present invention. This described polishing fixture **10** is representative of a polishing pad apparatus, which includes two belt rollers **16**. However, alternative exemplary embodiments of the pad **12** and belt **14** may be used with other polishing fixtures with a plurality of belt rollers **16** of various sizes, configurations, and orientations, including the polishing fixture **10** shown in **FIG. 1**.

[0023] The polishing fixture **10** further includes a semiconductor support **208**, that is operative to place a semiconductor wafer **18** adjacent the polishing pad **12** and belt **14** of the present invention. The exemplary polishing fixture **10** further includes a base **212** on the opposite side of the pad **12** and belt **14** as the semiconductor wafer **18**. The base **212** is operative to prevent the relatively planer surface of the pad **12** and belt **14** that is adjacent the semiconductor wafer **18** from being deformed by the downward force of the semiconductor support **208**.

[0024] The exemplary embodiment of the polishing pad **12** and belt **14** for use with the polishing fixture **10** has an inner circumference of between 90 and 110 inches. The exemplary width of the belt **14** is between 20 and 40 inches. However, it is to be understood that alternative embodiments of the pad **12** and belt **14** may have other sizes based on the relative dimensions of the polishing fixture **10** that the pad **12** and belt **14** is installed thereon. For example the exemplary polishing fixture **10** is shown with one semiconductor support **208**; however, alternative embodiments of the exemplary pad **12** and belt **14** may have sufficient width and length to be mounted on a polishing fixture **10** that is operative to simultaneously polish a plurality of semiconductor wafers **18**.

[0025] **FIG. 6** shows an exemplary embodiment of a polishing pad **12**. The polishing pad **12** includes pad portions **20** that are adhesively bonded to a belt **14**. In one exemplary embodiment the pad portions **20** are representative of discrete pad sections **20** that are placed adjacent to one another along the outer surface of the belt **14**. Such pad sections **20** have lengths between 20 and 40 inches. In another exemplary embodiment the pad portions **20** are representative of opposite ends of a single polishing pad section **20** that is bonded to the outer surface of the belt **14**. Such a single polishing pad section **20** has a length that corresponds to the outer circumference of the belt **14**.

[0026] The exemplary belt **14** is constructed of a flexible stainless steel mesh that is operative to rotate about the belt rollers **16** at a rate of between 400 and 1000 linear feet per minute. However, alternative embodiments of the belt **14** may be comprised of other flexible materials that are resistant to stretching. The exemplary polishing pad **12** is comprised of a polyurethane, however, alternative embodiments of the polishing pad **12** may be comprised of other elastic polymer materials.

[0027] In the exemplary embodiment of the present invention a seam joint **56** between the polishing pad portions **20** is reinforced with a caulking material **58**. The caulking material **58** is operative to create a flexible bond between polishing pad portions **20**, which reinforces the seam joint **56**. In the exemplary embodiment the caulking material **58** is comprised of an elastic polymer such as polyurethane or a uv-urethane. However, it is to be understood that the present invention encompasses any flexible caulking material **58** that is operative to bind pad portions **52** and **54** of the polishing pad **12**.

[0028] By caulking the seam joints **56** between two or more polishing pad sections **20**, the polishing pad **12** may be manufactured as a continuous sheet which subsequently is bonded to the belt **14**, rather than bonding multiple independent pad sections **20** to the belt **14** as is done in the prior art. In one exemplary embodiment the polishing pad **12** is

machine laminated with an adhesive layer **32** that spans two or more pad sections **20** of the polishing pad **12**. The adhesive layer **32** is comprised of a flexible double sided pressure sensitive or contact adhesive that is operative to bond the polishing pad **12** to the belt **14**.

[**0029**] To provide sufficient surface area for the caulking material **58** to reinforce the seam joint **56**, the pad edge portions **40** and **38** are manufactured with contours which provide a channel **68** for receiving the caulking material **58**. As shown in **FIG. 6**, one exemplary embodiment of the present invention includes a channel **68** that is rectangular in shape. In this described exemplary embodiment the width of the rectangular channel **68** is between 30 and 100 mils. Also in this described exemplary embodiment the depth of the channel **68** is between 20 and 30 mils, which is generally half the thickness of the pad **12**. However, it is to be understood that the present invention encompasses any suitable dimensions for the channel **68** that are operative to provide sufficient surface area for the caulking material **58** to reinforce the seam joint **56**.

[**0030**] **FIG. 7** shows an alternative exemplary embodiment of a polishing pad **12** with pad edge portions **38** and **40** that are partially beveled or angled. These exemplary contours of the pad edge portions **38** and **40** form a triangular shaped channel **68** between the upper surface **81** of the polishing pad **12** and the adhesive layer **32**, which is operative to receive a caulking material **58** for reinforcing seam joint **56**. **FIG. 8** shows another alternative exemplary embodiment of a polishing pad **12** with pad edge portions **38** and **40** that are beveled or angled between the upper surface **81** of the polishing pad **12** and the adhesive layer **32**.

[**0031**] Although rectangular and triangular channels **68** have been described, it is to be understood that the present invention encompasses any other shape or contour of channels **68** between pad sections **20** which are operative to receive a caulking material **58** for reinforcing the section joints of polishing pads **12**. Alternative embodiments of the present invention may have channels **68** with other shapes and contours including convex and concave curvatures, or any other shape that is operative to provide sufficient surface area for a caulking material **58** to provide a strong and flexible bond between pad edge portions **38** and **40** of a seam joint **56**.

[**0032**] For the exemplary embodiment of the polishing pad **12** that is comprised of multiple polishing pad sections **20**, each of the seam joints **56** between polishing pad sections **20** may be reinforced as previously described. For the exemplary polishing pad **12** that is comprised of a single polishing pad section **20** bonded to the outer circumference of the belt **14**, the seam joint **56** between the opposed ends of the polishing pad **12** may be reinforced as previously described.

[**0033**] **FIGS. 9 and 10** show alternative exemplary embodiments of a reinforced polishing pad **12**. In these exemplary embodiments, the polishing pad **12** includes pad edge portions **38** and **40** that are cooperatively contoured to mate in an interlocking and/or overlapping relation with each other. For example in **FIG. 9**, polishing pad **12** includes two pad portions **20** with corresponding pad edge portions **38** and **40** which are cooperatively beveled or angled to interlock or overlap. Such an exemplary configuration is operative to reinforce the seam joint **56** between pad portions **20** and prevent the polishing pad **12** from delaminating from the belt **14**.

[**0034**] **FIG. 10** is representative of another exemplary embodiment of a polishing pad **12** with pad edge portions **38** and **40** which are cooperatively dovetailed. Each of these described exemplary interlocking and/or overlapping features of the present invention are operative to reinforce the seam joints **56** between adjacent pad sections **20** or pad ends which minimizes the stretching, bunching up and delamination of the polishing pad **12**.

[**0035**] In these described exemplary interlocking and/or overlapping seam joint **56** embodiments an adhesive layer **32** may not only be used to bond the polishing pad **12** to the belt **14**, but may further be applied between adjacent pad edge portions **38** and **40** of the seam joints **56**. Also as previously described a caulking material **58** comprised of an elastic polymer such as a polyurethane for example may also be applied between the adjacent pad edge portions **38** and **40** of each interlocking and/or overlapping seam joint **56**. In addition, the present invention further comprises other configurations and contours of interlocking and/or overlapping edge portions **38** and **40** including cooperatively concave and convex curved contours and shapes.

[**0036**] **FIG. 11** is representative of another exemplary embodiment of a polishing pad **12** bonded to a belt **14** of the present invention. Here the polishing pad **12** includes a polishing layer **118** with a plurality of parallel grooves **122** in an upper surface **124** of the polishing layer **118**. As with the previously described embodiments, the polishing pad **12** includes an adhesive layer **32** that is operative to bond the polishing pad **12** to a belt **14**. In the exemplary embodiment each of the grooves **122** are orientated transversely with respect to the direction of movement **130** of the belt **14**. However alternative exemplary embodiments of the polishing pad **12** may include grooves that are orientated along the surface **124** of the polishing pad **12** at other angles. As the polishing pad **12** curves around a belt roller **16**, the grooves **122** enable the polishing pad **12** to relieve stresses on the adhesive bond between the polishing pad **12** and belt **14**. Relief of this stress minimizes the stretching, bunching up and delamination of the adhesive layer **32** that occurs in prior art designs.

[**0037**] In the exemplary embodiment the grooves range between about 5 and 45 mils in depth. The width of the grooves range between about 5 and 60 mils and each groove is spaced every 50 to 500 mils along the top surface **124** of the polishing pad **12**. In this described exemplary embodiment the grooves have planar vertical side walls that are normal to the top surface of the pad **12**. However, alternative embodiments may have angled and/or curved walls depending on the dimensions of the pad **12** and the expected amount of curvature that the pad **12** will undergo when moving over a belt roller **16**.

[**0038**] Although embodiments of the invention have been described, other embodiments and modifications of the invention are intended to be covered by the spirit and scope of the appended claims.

What is claimed is:

1. A polishing pad adapted for mounting on a belt, characterised by: a seam joint between opposed edge por-

tions of the polishing pad, and a caulking material in the seam joint bonding to the opposed edge portions, which decreases the likelihood of stretching, bunching up, and/or delaminating of the pad from the belt.

2. The polishing pad according to claim 1, wherein the polishing pad has one polishing pad section with a length that corresponds to the outer circumference of the belt, and wherein the polishing pad section has the opposed edge portions.

3. The polishing pad according to claim 1, wherein the polishing pad has multiple polishing pad sections having the opposed edge portions.

4. The polishing pad according to claim 1, wherein the seam joint is provided with a channel.

5. The polishing pad and belt according to claim 1, wherein the opposed polishing pad edge portions have contours forming a channel.

6. The polishing pad according to claim 5, wherein the depth of the channel is half the thickness of the polishing pad.

7. The polishing pad according to claim 5, wherein the channel has a triangular shape.

8. The polishing pad according to claim 5, wherein the contours have angled slopes.

9. The polishing pad according to claim 1, wherein the caulking material is polyurethane.

10. The polishing pad according to claim 1, and further comprising: adhesive laminating the polishing pad to a belt, and the caulking material prevents the polishing pad from delaminating from the belt as the pad and the belt rotate over rollers in a semiconductor polishing fixture.

11. The polishing pad according to claim 1, wherein a polishing surface of the polishing pad includes stress relief grooves oriented transversely relative to a direction of rotation of the polishing pad in a polishing pad fixture.

12. A reinforced semiconductor polishing pad and belt comprising: a belt; a polishing pad in adhesive connection with the belt, wherein the polishing pad includes a polishing surface that is operative to polish and planarize a semiconductor substrate, and wherein the polishing pad includes at least one seam joint between two opposed polishing pad edge portions, and wherein each of the opposed polishing pad edge portions are cooperatively contoured in overlapping relation.

13. The reinforced semiconductor polishing pad and belt according to claim 12, wherein the polishing pad is comprised of one polishing pad section with a length that corresponds to the outer circumference of the belt, wherein the opposed polishing pad edge portions correspond to the ends of the one polishing pad section.

14. The reinforced semiconductor polishing pad and belt according to claim 12, wherein the polishing pad is comprised of at least two polishing pad sections, wherein the opposed polishing pad edge portions correspond to adjacent ends of the two polishing pad sections.

15. The reinforced semiconductor polishing pad and belt according to claim 12, wherein the opposed polishing pad edge portions are cooperatively beveled.

16. The reinforced semiconductor polishing pad and belt according to claim 12, wherein the opposed polishing pad edge portions are cooperatively dove-tailed.

17. The reinforced semiconductor polishing pad and belt according to claim 12, wherein the belt is comprised of a stainless steel mesh.

18. The reinforced semiconductor polishing pad and belt according to claim 12, wherein seam joint is orientated in a generally transverse direction with respect to the direction of rotation of the belt in a polishing pad fixture.

19. The reinforced semiconductor polishing pad and belt according to claim 12, wherein the polishing surface includes a plurality of parallel stress relief grooves in an upper surface of the polishing pad, wherein the parallel stress relief grooves are oriented in a generally transverse direction with respect to the direction of rotation of the belt in a polishing pad fixture.

20. A delamination resistant semiconductor polishing pad and belt characterised by: a belt; and a polishing pad in adhesive connection with the belt, wherein the polishing pad includes a polishing surface that is operative to polish and planarize a semiconductor substrate, wherein the polishing surface includes a plurality of parallel stress relief grooves therein.

21. The delamination resistant semiconductor polishing pad and belt according to claim 20, wherein the parallel stress relief grooves are oriented in a generally transverse direction with respect to the direction of rotation of the belt across at least one belt roller **16** of a polishing pad fixture.

22. The delamination resistant semiconductor polishing pad and belt according to claim 21, wherein the parallel stress relief grooves each have a depth of generally between 5 and 45 mils.

23. The delamination resistant semiconductor polishing pad and belt according to claim 22, wherein the parallel stress relief grooves each have a width of generally between 5 and 60 mils.

24. The delamination resistant semiconductor polishing pad and belt according to claim 23, wherein the distance between parallel stress relief grooves along the upper surface of the polishing pad is generally between 50 and 500 mils.

25. The delamination resistant semiconductor polishing pad and belt according to claim 21, wherein the stress relief grooves have a generally rectangular cross-sectional shape.

26. The delamination resistant semiconductor polishing pad and belt according to claim 20, wherein the stress relief grooves span the width of the polishing pad.

* * * * *