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Steigerwald

(54) **ELECTROCHEMICALLY POLISHING CONDUCTIVE FILMS ON SEMICONDUCTOR WAFERS**

(76) Inventor: **Joseph M. Steigerwald**, Forest Grove, OR (US)

Correspondence Address:
TROP PRUNER & HU, PC
1616 S. VOSS ROAD, SUITE 750
HOUSTON, TX 77057-2631 (US)

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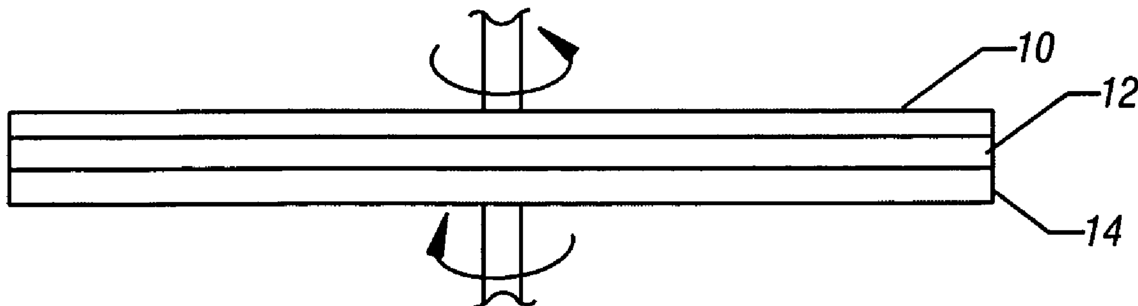
(57) **ABSTRACT**

An electropolish process may remove a conductive film from a semiconductor wafer. An electropolish apparatus having a pad over a platen may make surface-to-surface electrical contact with the conductive film of the wafer across the entire surface of the pad and the conductive film on the wafer. An electric field may be applied through openings in the pad and electrodes which receive potential by feedthroughs that extend through the platen to those electrodes. The electrodes in the feedthroughs may be electrically isolated from the pad and the platen. As a result, more uniform application of electrical potential across the surface to be polished may be achieved in some embodiments.



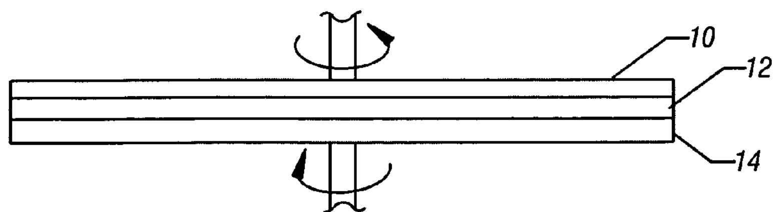


FIG. 1

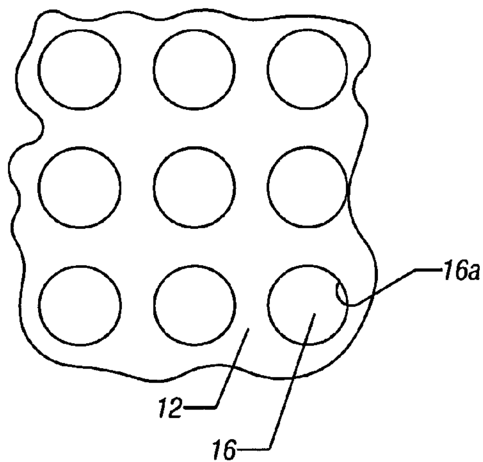


FIG. 2

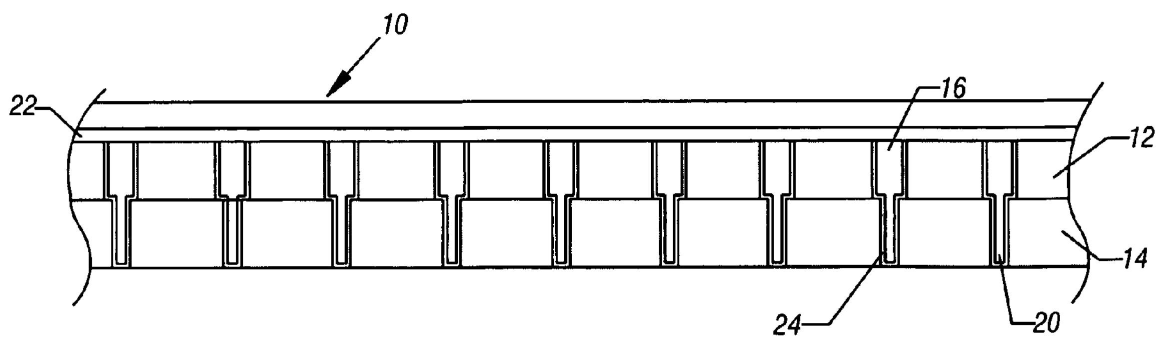


FIG. 3

ELECTROCHEMICALLY POLISHING CONDUCTIVE FILMS ON SEMICONDUCTOR WAFERS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a divisional of U.S. patent application Ser. No. 10/722,801, filed on Nov. 26, 2003.

BACKGROUND

[0002] This invention relates generally to processing integrated circuits.

[0003] In the course of semiconductor wafer fabrication, a metal film formed on a semiconductor wafer may be polished. Conventionally, electrochemical polishing may be utilized. An abrasive fluid may be applied between the metal surface of the semiconductor wafer and a polishing platen. A potential may be applied between the semiconductor wafer and the polishing platen and the platen and semiconductor wafer may be counter rotated. As a result, the metal film may be polished.

[0004] Generally electropolish processes need uniform electrical contact to the metal film being polished. One limitation of electropolish processes is that the electrical contact to the film is made via contact to the edge of the wafer or at a few discrete points on the front of the wafer.

[0005] Thus, the electropolish process is dependent on the resistance of the film between the contact point and the area of the film being polished. As the film is thinned, the resistance of the film increases and eventually the film becomes discontinuous. As a result, the removal process is significantly slowed and may subsequently be halted in some areas.

[0006] Thus, conventional electropolish processes suffer from an inability to remove the entire metal film due to the increase in resistivity at the end of the process. Patches of metal may remain at the end of the conventional process.

[0007] Thus, there is a need for better ways to implement electrochemical polishing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] **FIG. 1** is a side elevational view of one embodiment of the present invention;

[0009] **FIG. 2** is a partial, greatly enlarged, top plan view of a portion of the pad in accordance with one embodiment of the present invention; and

[0010] **FIG. 3** is an enlarged, partial, vertical, cross-sectional view through a portion of the wafer pad and platen shown in **FIG. 1** in accordance with one embodiment of the present invention.

DETAILED DESCRIPTION

[0011] Referring to **FIG. 1**, a semiconductor wafer **10** with a downwardly facing conductive surface may be rotated in a first direction indicated by a counterclockwise arrow. An electropolish platen **14** and pad **12** may be rotated in the opposite direction indicated by a clockwise arrow. As a result, the conductive film on the wafer **10** may be electropolished.

[0012] In some cases, an abrasive polish fluid material may be used between the semiconductor wafer **10** and the pad **12**. Pressure may or may not be exerted.

[0013] Referring to **FIG. 2**, the upper surface of the pad **12** includes an array of regularly spaced, cut-out regions **16*a***. In one embodiment, these cut-out regions **16*a*** have the circular configuration shown in **FIG. 2**. As a result, electrical contact may be made through the pad **12** to the conductive surface of the semiconductor wafer **10**. At the same time, an electric field may be applied through the cut-out region **16*a*** to the conductive surface of the semiconductor wafer **10**. Therefore, electrical contact can be made directly to the conductive film on the semiconductor wafer **10** and an electric field may still be applied to that wafer.

[0014] Referring to **FIG. 3**, the platen **14** may have a passage formed therethrough which allows a feedthrough **20** to provide electrical communication to a counter electrode **16**. The counter electrode **16** is exposed by the cut-out region **16*a*** formed in the pad **12**. Thus, an electrical potential may be supplied through the platen **14** (from the bottom side) to the electrode **16** to set up an electric field between the conductive film **22** of the semiconductor wafer **10** and the counter electrode **16**. The conductive film **22** may be a metal layer to be polished in one embodiment.

[0015] An insulative film **24** separates the feedthrough **20** and the counter electrode **16** from the pad **12** and the platen **14**. In one embodiment, the pad **12** and the platen **14** are electrically conductive so that an electrical potential may be conveyed through the platen **14** to the pad **12** and thereafter to the film **22**. Thus, the film **22** is at one polarity and the counter electrode **16** is at another polarity, setting up an electric field. The circularly shaped edge of the cut-out region **16*a*** may be effective in providing a polishing action.

[0016] An electrical potential may be provided through the insulative film **24** upwardly from below to the feedthrough **20** to the electrode **16** in one embodiment of the present invention. A potential of the opposite polarity is applied from below the platen **14** to the film **22** via the conductive platen **14** and pad **12**, in one embodiment. The electric field between the film **22** and the counter electrode **16** may be proportional to the voltage difference between the platen **14** and the electrode **16** in one embodiment of the present invention. That electric field drives the electrochemical polish process. The pad **12** serves the dual function of providing an abrasive surface, as well as electrical contact to the film **22** being polished.

[0017] Thus, in some embodiments, uniform electrical contact may be made to the film **22** being polished. As a result, the electropolish process may be less dependent on the resistance of the film **22** because a wide contact surface may be had between the film **22** and the pad **12** in some embodiments. As a result, the film **22** removal process may not be significantly slowed or halted in some areas. This may improve the ability to remove the entire film **22** in some embodiments.

[0018] While the present invention has been described-with respect to a limited number of embodiments, those skilled in the art will appreciate numerous modifications and variations therefrom. It is intended that the appended claims cover all such modifications and variations as fall within the true spirit and scope of this present invention.

What is claimed is:

1. A polishing pad for an electrochemical polishing process comprising:

a conductive body and a plurality of regularly spaced openings through said body; and

an electrode in said openings connectable to a potential, said electrode insulated from said body.

2. The pad of claim 1 wherein said openings have a circular shape.

3. The pad of claim 1 including an insulator between said electrode and said body.

4. An electrochemical polishing apparatus comprising:

a platen;

a pad positioned over said platen, said pad being conductive; and

a plurality of electrodes formed within openings in said pad, said electrodes being electrically isolated from said pad.

5. The apparatus of claim 4 wherein said platen is electrically conductive.

6. The apparatus of claim 4 including insulators to insulate said electrode electrically from said pad.

7. The apparatus of claim 4 wherein said electrodes extend through said pad and said platen.

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