EXHIBIT D

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Easter et al.

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(54) **CORROSION-RESISTANT POLISHING PAD CONDITIONER**

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(52) **U.S. Cl.** **438/691**; 438/692

(58) **Field of Search** 438/691, 692, 438/693; 451/56, 72, 910; 427/249.8, 249.11, 249.12

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(57) **ABSTRACT**

The present invention provides a method of manufacturing a semiconductor device using a polishing apparatus having a polishing pad conditioning wheel. In one embodiment, the polishing pad conditioning wheel comprises a conditioning head, a setting alloy, an abrasive material, and a corrosion resistant coating. The conditioning head has opposing first and second faces with the first face being coupleable to the polishing apparatus. The setting alloy is coupled to the conditioning head at the second face, and the abrasive material is embedded in the setting alloy, which is substantially covered by the corrosion resistant coating.

9 Claims, 2 Drawing Sheets

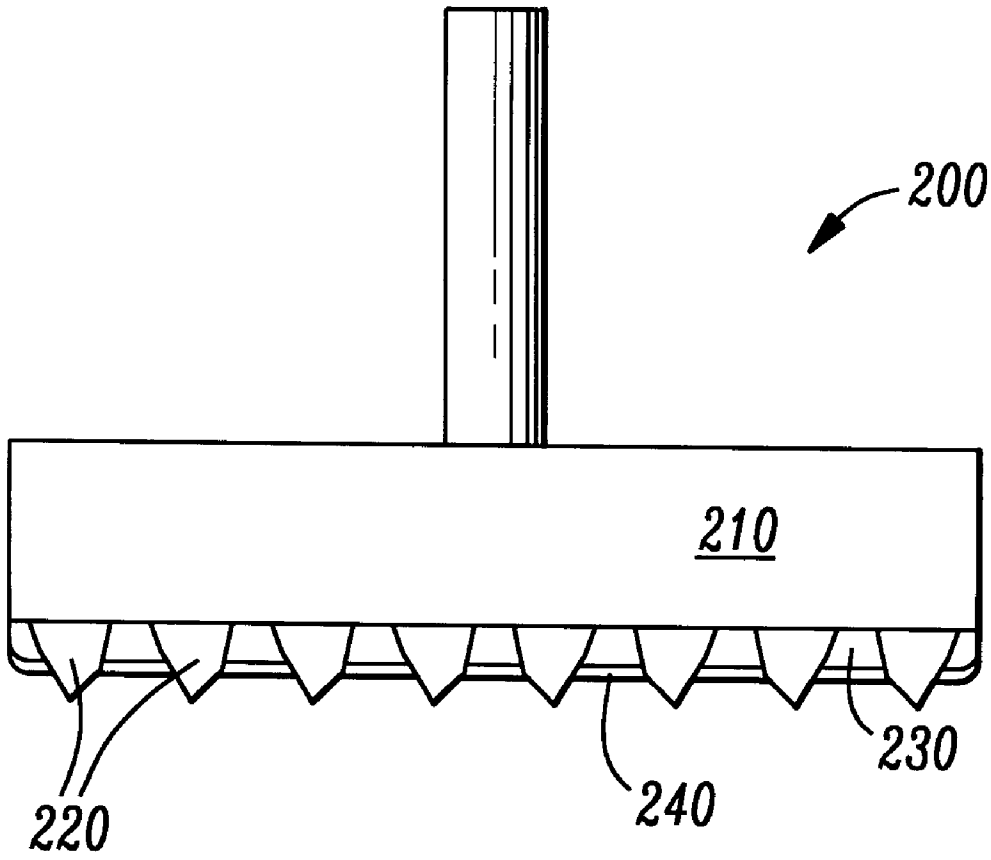


FIG. 1
(PRIOR ART)

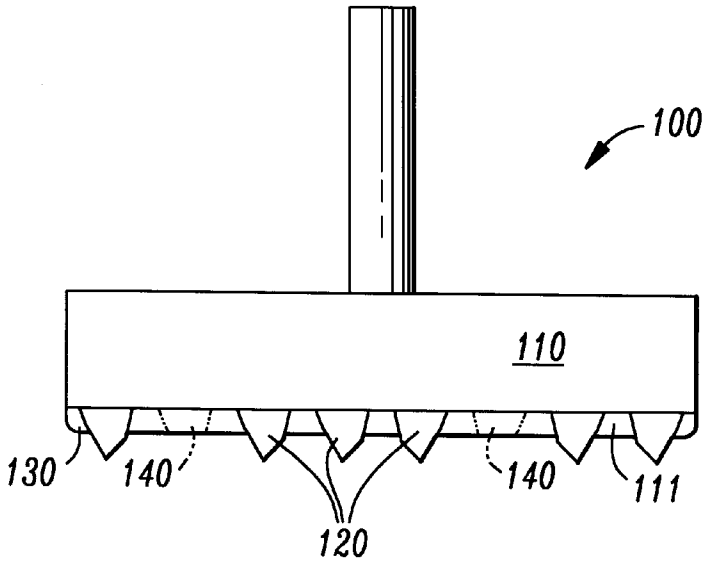


FIG. 2

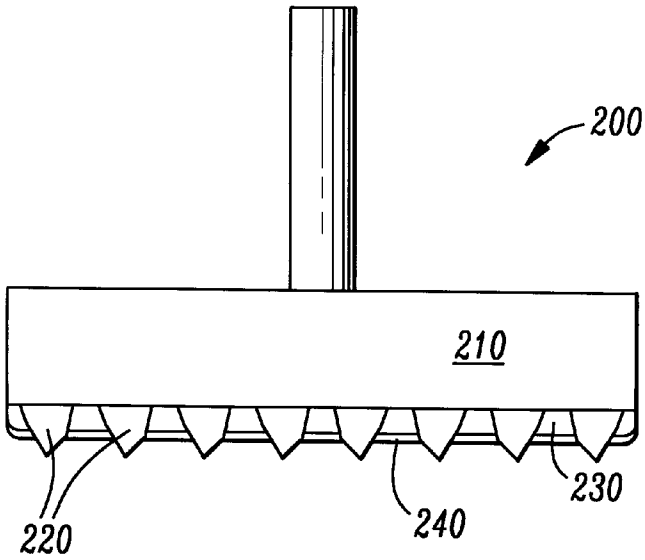


FIG. 3

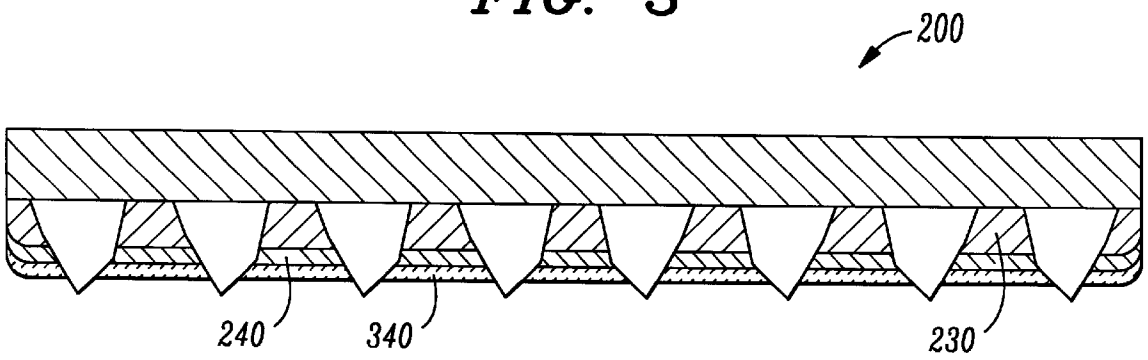
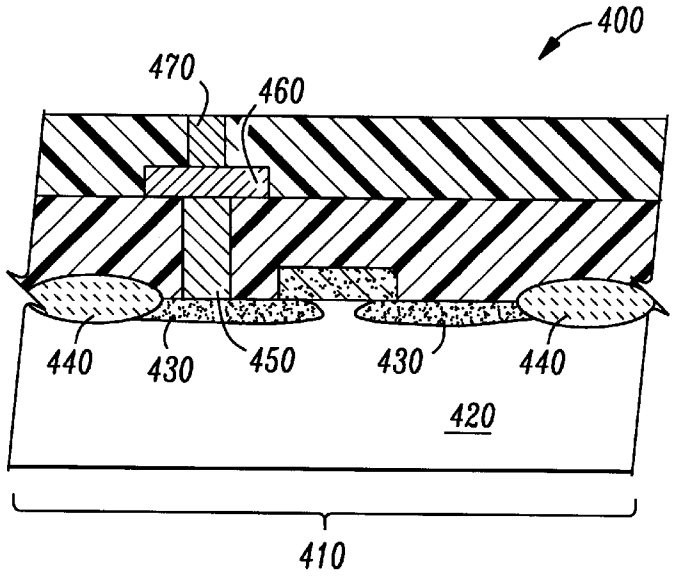


FIG. 4



CORROSION-RESISTANT POLISHING PAD CONDITIONER

TECHNICAL FIELD OF THE INVENTION

The present invention is directed, in general, to a semiconductor wafer polishing apparatus and, more specifically, to a polishing pad conditioner having improved corrosion resistance against the chemicals of a chemical/mechanical planarization process.

BACKGROUND OF THE INVENTION

Chemical mechanical planarization (CMP) is an essential process in the manufacture of semiconductor chips today. Dielectric and metal layers used in chip fabrication must be made extremely flat and of precise thickness in order to pattern the sub-micron sized features that comprise a semiconductor device. During CMP, the combination of chemical etching and mechanical abrasion produces the required flat, precise surface for subsequent depositions. The polishing pad is usually made of polyurethane and has small pores to carry the slurry under the wafer. As a result of the polishing process, pad material and slurry residues collect in the pores, plugging them, and reducing the polish rate due to slurry starvation. When the pad becomes clogged, it becomes necessary to "condition" the pad to restore its full functionality. That is, the accumulated material must be removed before it completely clogs the pad and results in a smooth, glazed surface that does not effectively polish the semiconductor wafer. A nickel/chromium conditioning wheel with a surface of diamond abrasives embedded in a nickel/chromium setting alloy is used to condition the pad. The conditioning wheel is pressed against the polishing pad by a conditioning wheel actuator, e.g., a hydraulic arm, and the pad and conditioning wheel are rotated while de-ionized water is flowed to rinse away abraded material. The diamond elements remove embedded particles, slurry, and polishing by-products from the polishing pad. The conditioning proceeds until the pad is "re-surfaced" and new pores are exposed.

As the conditioning wheel is rotated against the polishing pad, the wheel, setting alloy, and the diamonds come in contact with the chemical/mechanical slurry. Conventional conditioners for an oxide polisher have useable lifetime of about 15,000 wafers. On the other hand, conventional conditioners for a tungsten metal polisher have a useable lifetime of only about 5,000 to 7,000 wafers. While nickel/chromium is generally considered a chemically-resistant alloy, the slurries used to planarize metal layers, especially tungsten, are very corrosive. As a consequence, the chemicals of the slurry attack the nickel/chromium setting alloy and, over time, loosen the diamond crystals, causing them to fall out of the polishing surface. Of course, this reduces the effective surface area of the conditioning wheel and slows the conditioning process.

Accordingly, what is needed in the art is a conditioning wheel that is highly resistive to the effects of the corrosive oxidants primarily found in metal polishing slurries.

SUMMARY OF THE INVENTION

To address the above-discussed deficiencies of the prior art, the present invention provides a method of manufacturing a semiconductor device using a polishing apparatus having a polishing pad conditioning wheel. In one embodiment, the polishing pad conditioning wheel comprises a conditioning head, a setting alloy, an abrasive material, and a corrosion resistant coating. The conditioning head has opposing first and second faces with the first face being coupleable to the polishing apparatus. The setting alloy is coupled to the conditioning head at the second face, and the abrasive material is embedded in the setting alloy, which is substantially covered by the corrosion resistant coating.

Thus, in a broad scope, the present invention provides a protective, corrosion-resistant coating on otherwise corrosion-vulnerable setting alloys. As a consequence, the setting alloys are better protected by the corrosion-resistant coating and its oxidized by-products so that the integrity of the corrosion-resistant coating is not jeopardized, which would ultimately result in dislodging of the abrasive material. While the discussion regarding the present invention is directly oriented toward preventing the deleterious effects of metal polishing slurries, it should be readily apparent to one who is skilled in the art that the invention is equally applicable to other, less damaging, polishing slurries.

In one particularly advantageous embodiment, the corrosion resistant coating is a chromium/aluminum/yttrium alloy. In one aspect of this particular embodiment, the chromium/aluminum/yttrium alloy may be either a nickel/chromium/aluminum/yttrium alloy or a cobalt/chromium/aluminum/yttrium alloy. The coating is highly corrosion and oxidation resistant.

The setting alloy is preferably a hard facing metal alloy, such as a nickel/chromium/iron alloy. Example of some suitable hard facing metal alloys are: Inconel® 718, Inconel® 718 LC, Hastelloy®, and Illium-R®. Other useable hard facing alloys of well known stainless steels (SS) include: 309 SS, 347 SS, 430 SS, and 18-8 stainless steel. In one particular embodiment, the corrosion resistant coating is highly adherent to the setting alloy.

The abrasives employed in the present invention are well known to those who are skilled in the art and include abrasives, such as diamonds. Other abrasives typically used on conditioning rings, however, are also within the scope of the present invention.

The foregoing has outlined, rather broadly, preferred and alternative features of the present invention so that those skilled in the art may better understand the detailed description of the invention that follows. Additional features of the invention will be described hereinafter that form the subject of the claims of the invention. Those skilled in the art should appreciate that they can readily use the disclosed conception and specific embodiment as a basis for designing or modifying other structures for carrying out the same purposes of the present invention. Those skilled in the art should also realize that such equivalent constructions do not depart from the spirit and scope of the invention in its broadest form.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

FIG. **1** illustrates a sectional view of a conventional semiconductor polishing pad conditioning head;

FIG. **2** illustrates a sectional view of one embodiment of a semiconductor polishing pad conditioning head constructed according to the principles of the present invention;

FIG. **3** illustrates a sectional view of the polishing pad conditioning head of FIG. **2** following exposure to an oxidizing environment; and

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