# METHOD AND APPARATUS FOR SURFACE TREATMENT USING INORGANIC ACID AND OZONE

## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

The invention relates to methods and apparatus for treating surfaces of articles, such as semiconductor wafers, using combinations of inorganic acid and ozone.

### 2. Description of Related Art

Semiconductor wafers undergo a variety of wet processing stages during manufacture of integrated circuits, one of which is removal of photoresist from the wafer. When the photoresist is stripped by a wet process, among the techniques used for that stripping is a SOM (sulfuric acid ozone mixture) process. These processes involve dissolving ozone in sulfuric acid so that the ozone reacts with the sulfuric acid to form dipersulfuric acid or peroxydisulfuric acid ($H_2S_2O_8$), as shown by the following equation:

$$2HSO_4^- + O_3 \text{ <===> } O_2 + H_2O + S_2O_8^{2-}$$

Ozone that does not react with sulfuric acid can also dissolve as such into the sulfuric acid solution, and thus serve as an oxidizing agent for the material to be stripped.

SOM processes typically dissolve ozone into hot sulfuric acid (110 to 150°C) before the mixture is dispensed onto a semiconductor wafer for a certain amount of time.

~~What is c~~Claim~~ed is~~:

1. A method for treating a surface of an article, comprising :

contacting ozone and an inorganic acid at a sub-ambient temperature in a range of from about 3°C to less than 20°C, to form a liquid mixture comprising ozone dissolved in the inorganic acid;

dispensing said liquid mixture onto a surface of an article to be treated ~~an inorganic acid~~, said liquid mixture ~~inorganic acid~~ having a first temperature;

forming a liquid layer of ~~a~~ said liquid mixture ~~of the inorganic acid and ozone~~ on the surface of the article to be treated;

heating the surface of the article to be treated during or after dispensing said liquid mixture~~the inorganic acid~~, to a second temperature;

wherein the second temperature is at least 30°C greater than the first temperature.

2. The method according to claim 1, wherein said article is a semiconductor wafer, and wherein said surface to be treated comprises photoresist that includes ions implanted during a previous processing stage.

3. The method according to claim 2, wherein the semiconductor wafer is positioned on a spin chuck in a single wafer wet processing station.

4. The method according to claim 1, wherein the inorganic acid is an aqueous solution of sulphuric acid at a concentration of at least 90 mass% or pure sulphuric acid (oleum)~~.~~.

~~5. The method according to claim 1, wherein the liquid mixture has a temperature in the range of from about 3°C to less than 20°C.~~

~~6. The method according to claim 1, further comprising mixing said inorganic acid with ozone prior to dispensing the inorganic acid onto the surface of the article to be treated .~~

~~7.~~5. The method according to claim 1, wherein the article to be treated is present in a processing chamber, the method further comprising introducing gaseous ozone into the processing chamber ~~containing gaseous ozone and the inorganic acid and ozone are combined by the ozone diffusing through a layer of inorganic acid formed in the surface of the article to be treated~~.

~~8.~~6. The method according to claim 1, further comprising heating the surface of the article to be treated during or after dispensing the liquid mixture, to a temperature in excess of 50°C.

~~9.~~7. The method according to claim ~~9~~1, wherein the surface is heated to a temperature in excess of 100°C.

~~10. An apparatus for treating a surface of an article, comprising :~~

~~a chamber for receiving an article to be treated;~~

~~a dispenser for dispensing a treatment liquid onto the article;~~

~~a tank for storing an inorganic acid;~~

~~an ozone generator in communication with said chamber or an acid supply line entering or exiting said tank; and~~

~~a heater for rapidly heating a surface of an article to be treated to a temperature at least 30 °C greater than a temperature of the inorganic acid when applied to the article.~~

~~11. The apparatus according to claim 10, wherein said heater is an infrared heater disposed inside said chamber and adapted to heat a surface of an article disposed within said chamber to a temperature in excess of 50 °C.~~

~~12. The apparatus according to claim 10, wherein said apparatus is a single wafer wet processing station comprising a spin chuck adapted to hold a semiconductor wafer, and said nozzle is positioned relative to said spin chuck so as to dispense said treatment liquid downwardly onto an upwardly facing surface of the semiconductor wafer.~~

~~13. The apparatus according to claim 10, wherein said heater is an infrared heater disposed adjacent said chamber and separated from an interior of said chamber by a sheet of transparent material .~~

~~14. The apparatus according to claim 10, wherein said heater is an infrared heater comprising a plurality of concentric IR heating elements, said heating elements being individually tunable so as to ensure uniform heating of the surface of the article.~~

~~15. The apparatus according to claim 13, wherein said sheet of transparent material is recessed within said chuck and is separated from the article to be treated by a gap of less than 10 mm.~~