The purpose of this study was to determine what effects, if any, differing chemical sequences had on the particle levels of silicon wafers. The chemical solutions studied are: sulfuric acid, hydrogen peroxide mix (SPM); ammonium hydroxide, hydrogen peroxide, DI water mix (APM); hydrochloric acid, hydrogen peroxide, DI water mix (HPM); dilute hydrofluoric acid (DHF).

The findings show that some changes in chemical sequencing can significantly alter particle levels (e.g., APM and DHF ordering; the use of SPM), while others show no effect (e.g., HPM and APM ordering).

INTRODUCTION

The thorough elimination of contamination is a major concern in the production of semiconductor devices. Ions, metals, organics and particles are all important contaminants that must be removed from the wafer surface. The various chemical mixtures and sequences used in the semiconductor industry each have strengths and weaknesses in removing the different types of contaminants. The negative impacts of ions and heavy metals have been documented. 1-5 Several studies on the metal removal ability of various chemical mixtures and sequences 6-12 and the efficiency of various solutions to remove organic contamination 6,13-15 have also been reported. In the case of particles, a recent review has detailed many of the problems associated with their presence. 16 While much effort has been expended on trying to remove the particles from the wafer environment (the air, chemicals, water and gases that come into contact with the wafer), only a few studies report particle counts on the wafer as a function of the chemical sequences used to clean the wafer. To add to this data base, this study was undertaken to further explore and document the effects on particle levels of changing sequences with four common cleaning solutions. These solutions, and their abbreviations, are listed in Table I.
Table I. Cleaning Solutions

SPM, Sulfuric acid hydrogen Peroxide Mix
- $4H_2SO_4 : 1H_2O_2$

APM, Ammonium hydroxide, hydrogen Peroxide, DI Water Mix
- $1NH_4OH : 1H_2O_2 : 5H_2O$

HPM, Hydrochloric acid, hydrogen Peroxide, DI water Mix
- $1HCl : 1H_2O_2 : 5H_2O$

DHF, Dilute Hydrofluoric acid
- $1HF : 100H_2O$

EXPERIMENTAL

Particle counts were obtained using an Aeronca WIS-150 Particle Scanner, which was calibrated with a surface contamination standard obtained from VLSI Standards, San Jose. The particle scanner was run with an edge exclusion of 4 mm. Data are reported as changes in particle levels (i.e., post-processing particle levels minus pre-processing particle levels) for <0.5 μm and >0.5 μm size ranges.

All wafers were 100 mm (100) silicon. Two separate groups of tests were run approximately one month apart. All comparisons are made within one group. There were three wafers per run in wafer carrier slots 2, 13 and 24 (i.e., second position from the bottom, middle of the carrier and second position from the top). This was done to insure that any effects seen were not position dependent, but were representative of the entire carrier. Three runs were made for each chemical sequence. All runs were made in an FSI ZEUS Acid Processing System. The chemicals were semiconductor low mobile ion grade from Allied Chemical. The seven different chemical sequences tested are listed in Table II. The initial particle counts and the changes in particle counts, which occurred with processing, are shown for both sets of data in Table III. The values given are the average and standard deviation for the nine wafers used in that chemical sequence; i.e., three wafers per run, three runs per sequence. All wafers, unless otherwise indicated, were first processed using the FSI "B" Clean (see Table II), so that they would have a common starting basis.

Table II. Cleaning Solution Sequences

FSI "A" Clean - SPM + APM + DHF + HPM
FSI "B" Clean - SPM + DHF + APM + HPM
FSI "C" Clean - DHF + APM + HPM

APM + HPM
HPM + APM
SPM + DHF + APM
APM