DETERMINATION OF MINIMUM OXYGEN PRECIPITATE GROWTH CONDITIONS FOR GETTERING OF COPPER AND NICKEL

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The gettering capacity of oxygen precipitates and external gettering systems, such as polyback, have been extensively studied and reported in the last twenty years (1-2). The changing requirements of sub-0.20um device technologies, however, force a re-examination of the traditional approaches to both internal and external gettering. The local site flatness requirements of the advanced device technologies are driving wafer technology towards double side polishing of wafers on both 200mm and 300mm wafer diameters. The integration of polyback external gettering with double side polishing is not a practical solution. Even more importantly, the advanced device technologies are moving to lower thermal budget processes, reducing the process temperatures and times at temperature as compared with prior CMOS device generations. A key consideration with respect to internal gettering using oxygen precipitates will be the thermal conditions under which the oxygen precipitates become large enough in size and high enough in density to be effective gettering sites.

The purpose of these experiments was to determine the minimum oxygen precipitate growth conditions necessary to getter very high levels of Cu and Ni contamination intentionally introduced at the sample backsurface and diffused into a wafer.

Experimental

200mm p- wafers with MDZ® (3-4) were processed through varying bake conditions between 800C and 950C, and then through epitaxial growth. The wafers were then intentionally contaminated with spots of Ni and Cu in the 1E14-1E15at/cm^2 range on the backsurface. The metal contamination was diffused into the wafer using either the "Graff test" (5) or a CMOS Pad Oxidation. The samples were Secco etched in order to highlight metal precipitates on the polished surface. Gettering efficiency was judged by optical examination for surface haze associated with shallow etch pits from the metal precipitates. Separately, an identical set of samples were processed through an oxygen precipitate growth cycle of 4 hours at 800C + 16 hours at 1000C in order to grow the oxygen precipitates large enough for a measurement of their density.

Results

The measurement of oxygen precipitate density following the growth cycle showed all sample groups, except for the non-baked control, to be in the range of 1.5E9 to 6E9def/cm3. The control sample oxygen precipitate density was below detection limit. Estimates of oxygen precipitate radius for the various bake conditions were made using Ham's model (6).

In the case of the Graff test with its rapid cooling rate, a transition in Ni haze intensity was observed over an oxygen precipitate radius range up to around 7nm. At a calculated radius of >8.5nm Ni haze was completely suppressed. This corresponds to complete Ni gettering for oxygen precipitate growth conditions of > 2 hours at 900C or > 1 hour at 950C. Figure 1 shows Ni haze intensity with calculated oxygen precipitate radius. In the same test, Cu underwent a more abrupt transition than Ni from high haze to no haze at an estimated oxygen precipitate radius of around 5nm. This corresponds to complete Cu gettering for oxygen precipitate growth of > 4 hours at 850C, > 1 hour at 900C, and > 0.5 hours at 950C.

Conclusions

Complete gettering of very high levels of Cu and Ni intentional contamination is achieved with an oxygen precipitate radius of less than 10nm for an oxygen precipitate density in the 1.5-6E9def/cm3 range. Oxygen precipitate nuclei formed by MDZ® or by long conventional furnace annealing processes, can grow to the 5-10nm size range early in a CMOS process or by wafer supplier annealing, and getter effectively. These data provide additional evidence that large oxygen precipitates are not required for effective gettering of fast diffusing transition metals such as Cu and Ni.

References

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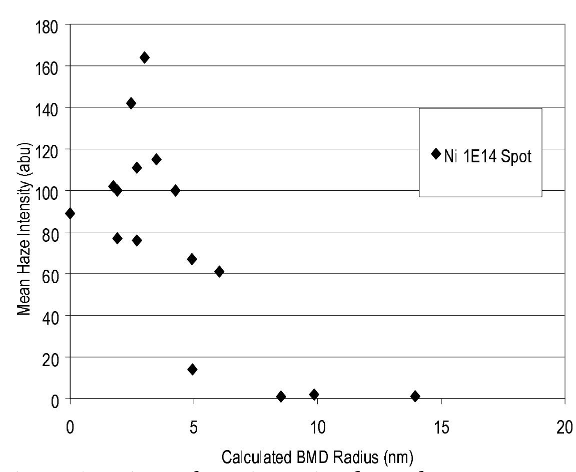

Figure 1: Ni spot haze intensity dependence on oxygen precipitate radius in Graff test.