SURFACE METAL CHARACTERIZATION BY TIME-OF-FLIGHT SIMS

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The paper will discuss process-induced surface metal contamination analysis of wafers by Time-of-Flight Secondary Ion Mass Spectrometry (TOF-SIMS). In contrast to Vapor Phase Decomposition (VPD) based measurements, TOF-SIMS can provide comparable metal detection limits (between 10^7 and 10^9 atoms/cm^2) for all elements from analysis areas $\leq$ 40µm x 40µm in a single analysis without the need for any chemical processing. The relatively small analysis area makes TOF-SIMS applicable to monitoring surface contamination from selected areas of processed wafers. TOF-SIMS surface metal measurements can be performed across a whole wafer as close as 0.5mm to the wafer edge, with the ability to provide surface metal concentration maps. Surface metal contamination on the backside of wafers can also be analyzed because the technique is relatively insensitive to surface topography. The TOF-SIMS measurement result represents the average surface concentration for all elements within the analyzed area to an analysis depth of ~1nm.

Figure 1 shows a comparison of surface metal contamination measured by TOF-SIMS on a prime Si wafer with 0.25µm SiO_2 and a duplicate wafer that was processed in a P5000 plasma etcher. The etcher had previously processed ZrO_2 wafers (30mTorr, BCl_3 40sccm, Cl_2 10sccm, no magnetic field, ~0.7nm/s ZrO_2). The wafer marked "post etch" was processed for 180s using the same recipe. The wet oxidized prime wafer shows an Al surface concentration of $3x10^9$ atoms/cm^2, increasing to ~10^{12} atoms/cm^2 after etching. It should be noted that the strong increase in Al after etching was not observed on a control wafer which was etched using the same etch recipe but before processing of ZrO_2 wafers. It is observed that Zr, which is at the detection limit for this analysis before etching, increases by a factor ~10 after etching. A related study showed that the Zr transfer to etched wafers (SiO_2) increases linearly with the etch time of ZrO_2 wafers. The correlation to changes in Fe and Cu surface concentrations is much weaker. The Cu surface concentration is increased and Fe is decreased after etch processing.

Other elemental contaminants are observed on the wafers, including Na, Mg, K and Ca. Figure 2 shows how the distribution of these elements changes moving from the edge of the wafer into an area 30mm in from the edge. The Fe concentration varies across the 30mm distance, but it generally decreases approaching the wafer edge. In contrast, the Na and K concentrations increase near the wafer edge.

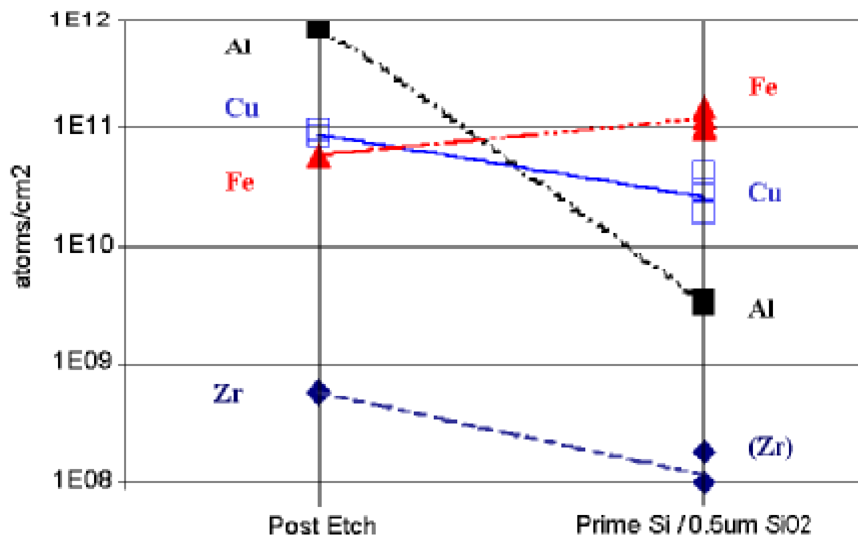

Fig.1: TOF-SIMS analysis of surface metal concentrations on a prime silicon wafer that was pre-diffusion cleaned and wet oxidized to grow 0.25µm SiO_2, and a duplicate wafer that was processed in a P5000 plasma etcher. The etcher had previously processed ZrO_2 wafers. The "post etch" wafer was processed for 180s, using the same recipe. The transfer of Zr to the etched wafer is evident.

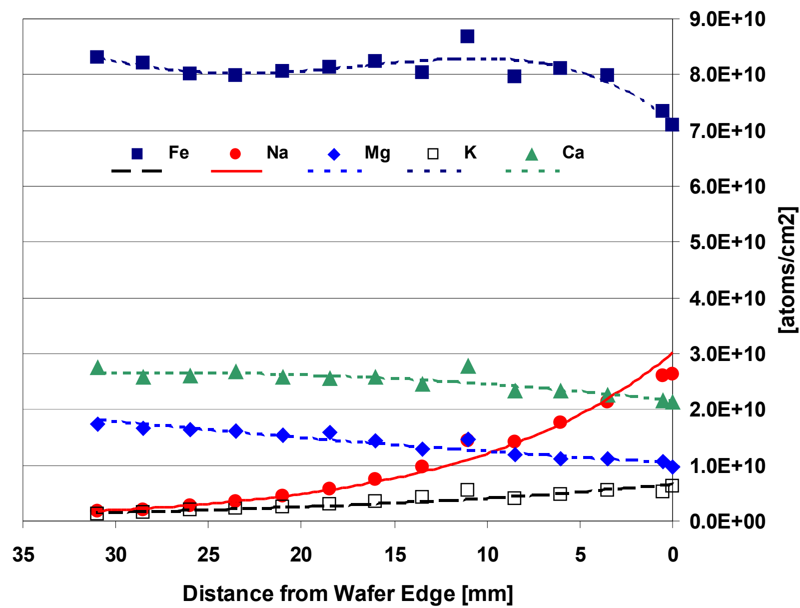

Fig. 2: Contamination Map in the vicinity of the wafer edge of the "post etch" wafer showing the presence and distribution of other elemental contaminants. Fe, Na, Mg, K and Ca were detected.