Task ID: 425.028
Task title: Lowering the Environmental Impact of High-k and Metal Gate-Stack Surface Preparation Processes
Deliverable title: Report on the low-water single wafer novel "staged rinse" methods for high-k metal fabrication application

Abstract:
We have combined experiments and simulation to investigate the post high-k clean rinse processes. Experiments are planned for getting the modeling parameters for the model. The experiments involve the Electro-Chemical Residue Sensor (ECRS) technology. The sensor wafers were manufactured, and a two-nanometer-thick HfO_2 film was deposited conformally on the sensor wafer to form the high-k ECRS wafer. Rinse of this high-k ECRS wafer after high-k clean is under investigation. Rinse mechanisms and adsorption/desorption rate constants will be found. The current status is calibration of the high-k ECRS and post NH_4OH rinse.

Technical Results:
Another experimental research is performed in parallel. A two-nanometer-thick HfO_2 film was also deposited on the crystals for the quartz crystal microbalance (QCM). Using this technology we hope that the adsorption/desorption rate constants can be extracted from the temporal mass monitoring. After finishing the post APM rinse research, we continued our research on post SPM rinse. The SPM solution consists of sulfuric acid (97%) and hydrogen peroxide (30%) with volume ratio of the chemicals 4:1. The solution was heated to 130 ± 3°C. The resistivity of the Ultra-Pure Water (UPW) for post SPM rinse was 18.18 MΩ-cm (measured at the point of use). Both heated UPW and room temperature UPW were used. The heated UPW was measured to be 55 ± 2°C. The experiment setup is shown in Fig.1. A high profile 25-wafer cassette was used as carrier. Twenty four silicon wafers (150 mm diameter) and one sensor wafer were inserted into the carrier. Low-Temperature Oxide (LTO) was grown on the twenty four silicon dummy wafers. The sensor wafer was placed in the center slot of the cassette. The cassette with wafers was immersed in SPM for 10 min and then manually transferred into the rinse tank for rinsing. The UPW flow rates used in this research are 3.46 gallons per minute (GPM) and 1.73 GPM. If using 3.46 GPM, it takes 52 sec to fill the rinse tank.

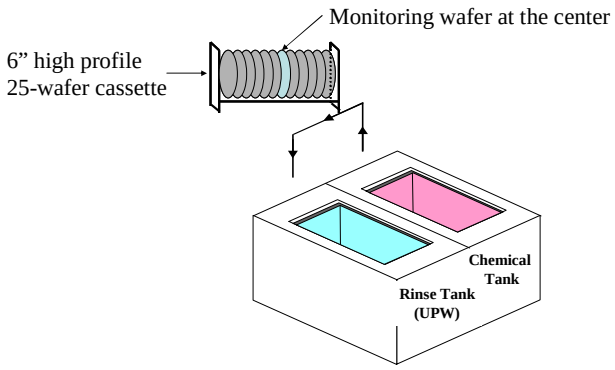

Figure 1: Post SPM rinse experiment setup

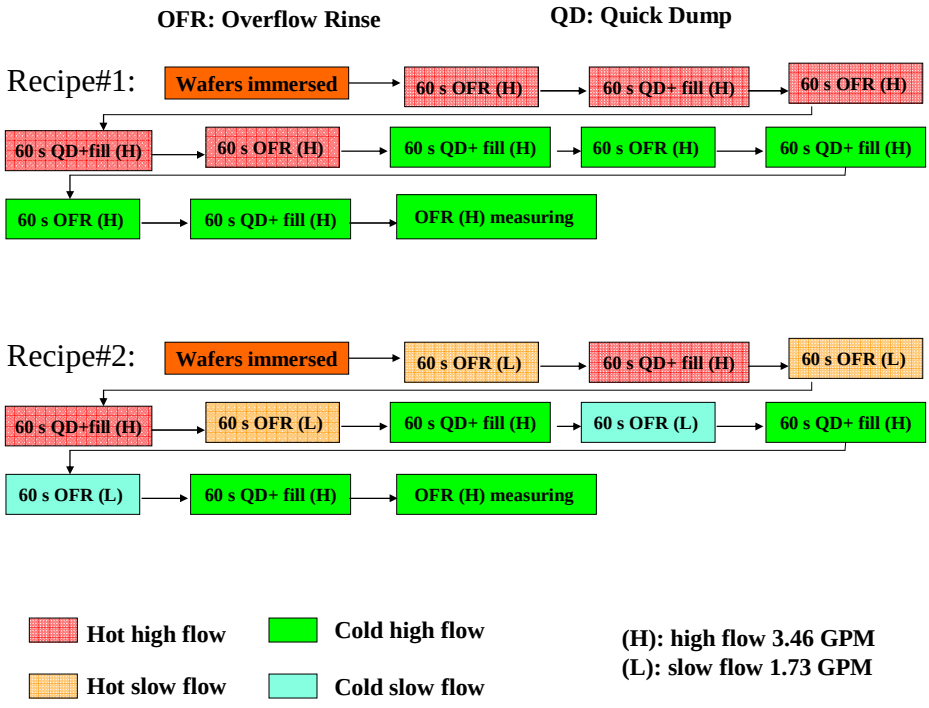

Figure 2: Post SPM rinse recipes

Two different rinse recipes were investigated in this research as seen in Fig. 2.
The higher temperatures significantly enhance rinsing; also for hot water rinse, the chemical removal mechanism is dominated by desorption after a couple of quick dumps. Therefore, we should be able to use slow flow in hot water rinse to decrease UPW

consumption. As shown in Fig. 3, recipe #2 actually delivers the same cleanliness as recipe#1, but saves a lot of water and energy. The experiment results confirmed our strategy.

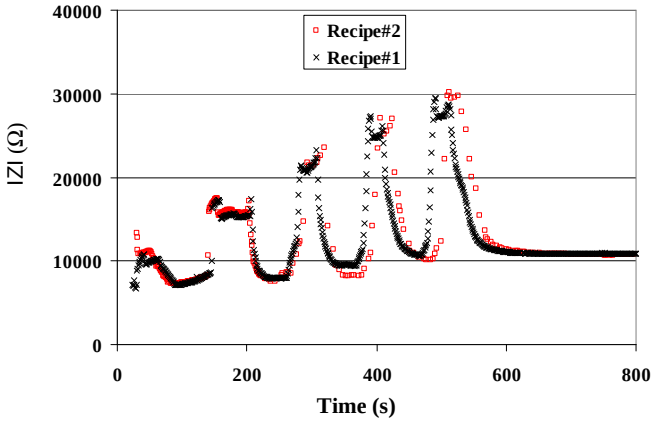

Figure 3: Comparison of different staged rinse recipes