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# Slurry Delivery Systems Defining Incoming CMP Slurry Density and Achieving Target Process Concentration Driven by Inline Metrology Unify CMP Engineers

The chemical mechanical planarization CMP community has found a need for defining new industry standards for stakeholders with respect to reporting technical properties and functionality of CMP related materials and consumables in typical process conditions. CMP slurry density is one of the critical objectives. In serving complex CMP slurry feed to point-of-use, the presented slurry delivery system has validated inline refractive index unit RIU liquid measurements in combination with other proprietary measurement techniques in defining and achieving target set-points of both slurry density and H2O2 concentration.

Simultaneously semiconductor fabs set increasingly tight upper and lower control limits UCL, LCL on slurry density and H2O2 additions. The technology of defining incoming slurry density and achieving target UPW dilutions is enabled by a closed-loop real-time control and liquid monitoring in the slurry delivery system. Data from the process characterization of the industry relevant slurry shows the system meets a UPW:slurry density dilution target in a +/-0.000025 g/cm3 control limit range. Addition of H2O2 to a multi-constituent solution presented consistent blending to within +/-0.004%wt of target.

## 1 Introduction

The CMP community has called for standards when employing offline methods for reporting CMP slurry density g/cm3 as delivered by the slurry manufacturer.

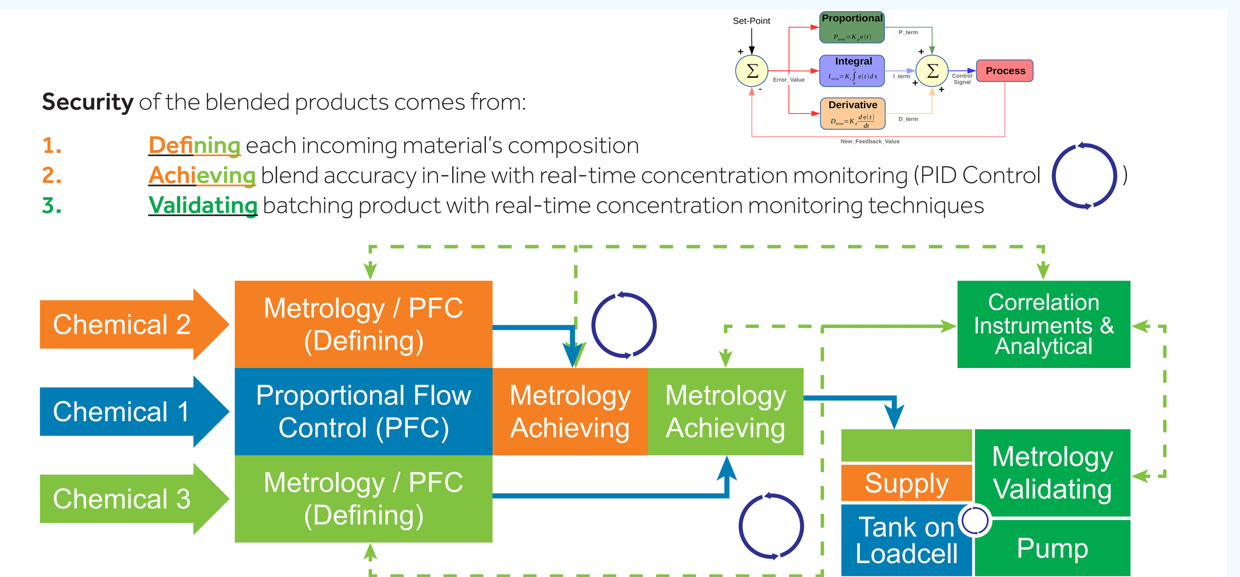
The entailing challenge is to meet tight UCL and LCL requirements in process conditions by characterizing CMP slurries and finding limitations of inline methods for the same CMP slurry density g/cm3 monitoring.

Inline refractive index unit metrology has been successfully employed in characterization of tungsten, copper, and interlayer dielectric ILD oxide slurries. In addition, the same technology is used in monitoring H2O2 concentration.

## 2 Methods

DFS blend and distribution technology is designed for characterizing CMP slurries by employing a defined system process. The system is naturally purposed for defining incoming chemical by using metrology measures for detecting variation in the chemical feed and adjusting for the shifts in lot-to-lot feeds in order to maintain the blend consistency and achieve the target chemistry concentration within the tightest requirements. Inline metrology approaches in the incoming supply, blend and distribution processes provide the ability to define, achieve and validate precise chemical volume in the supply loops in real time. Automatic closed-loop adjustment for any degradation, shift or other changes in a component within the chemical mixtures ensures that the chemistry remain constant to the tightest required values.

This gives the freedom to optimize onsite, in real-time, and maintain the proprietary process secrets as internal intellectual property IP. Offering a benefit of in-house development, while enabling a user chemical source independence or incoming supplier coordination for product development joint efforts.




## 3 Results

Profiling was conducted in distinct phases to characterize all relevant portions of the mixing process including:

- Defining the incoming solutions and diluting them to various concentrations
- Achieving the same target CMP slurry density and H2O2 concentration repeatably
- And lastly, letting the system provide to the points-of-use in an automatic mode of operation unhindered

The slurry dilution samples were measured with an offline densito-meter (upper blue line) following the set requirements in SEMI standard C96. Simultaneously within the system the inline RIU monitor detected the corresponding slurry density dilutions (lower yellow line). In the next phases, the mixing system was in full operation automatic mode, while introduced with other slurry dilutions to prove the robustness of the system. Data shows the system meets an extreme accuracy within UCL, LCL of +/- 0.000025 g/cm3. The precision having the purpose to operate within +/- 0.000015 g/ml (corrected to 20C) on the same solution.

The SDS diluted the slurry to achieve center point density and then H2O2 added to seven (7) concentrations setpoints to demonstrate the accuracy. Against the analytical results, the system's calculated concentration demonstrated an accuracy within 0.004%wt in the range 0.10-3.00%wt H2O2 in slurry under test and a precision within 0.0027%wt of respective repeated setpoint blend.