MIXING AND HANDLING CHALLENGES WITH NEXT GEN SLURRIES

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MEGA KINETICS FLUID SYSTEMS

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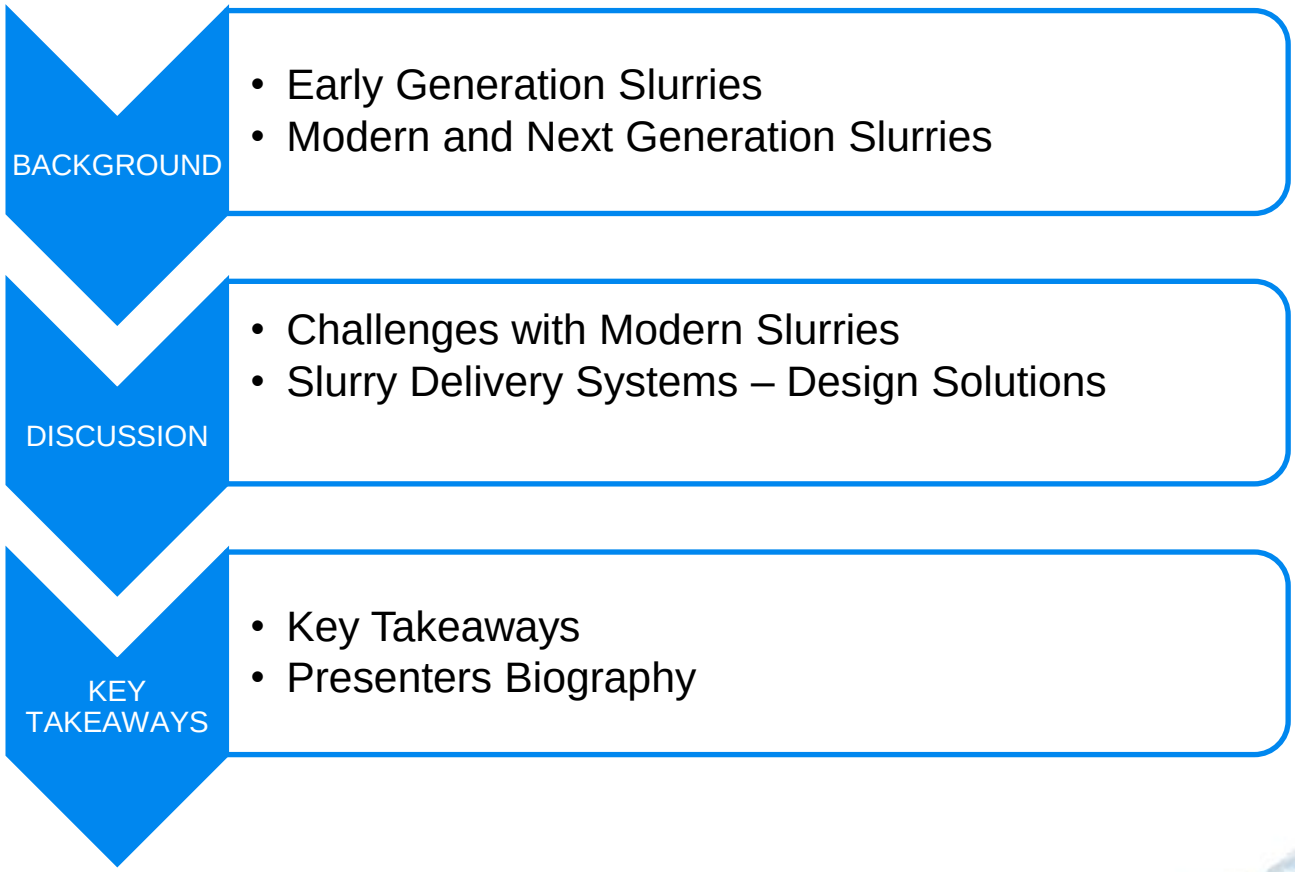
AGENDA



EARLY GENERATION SLURRIES

Early CMP slurries were typically characterized by fairly simple formulations
- ILD slurries used either precipitated or fumed silica
- Tungsten slurries were either alumina and ferric nitrate or later silica and peroxide

Early slurry formulations were typically comprised of 4-5 different components
- Abrasive, pH adjust and DI water for ILD applications
- Abrasive, pH adjust, rate promoter, (inhibitor), and DI water for W applications

With the addition of copper polishing in the early 2000s, organic components were added to alumina abrasives which introduced additional mixing and handling and pot life concerns
- Organic components react with both the abrasive and with any oxidizer
- Organic components provide a viable food source for bio-growth

Most early slurry formulas contained higher solids concentrations compared to their chemical components (more mechanical than chemical)

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MODERN AND NEXT GENERATION SLURRIES

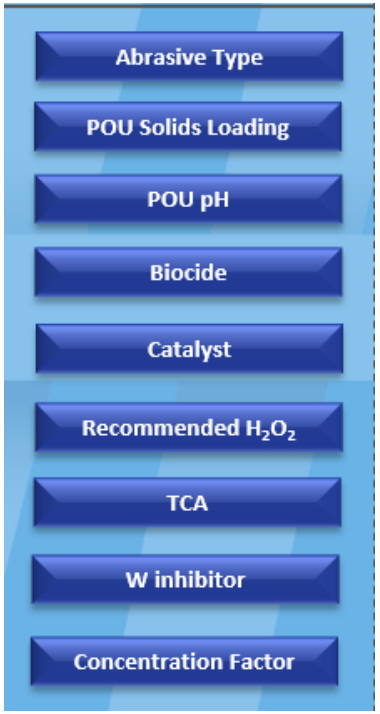
With advances in IC design, the requirements for CMP slurries have led to increasingly complex formulations

- Abrasives have generally become both smaller in size and lower in concentration at POU
- Organic components have increased in number and comprise a wider range of compounds
- More chemical than mechanical

Modern slurry formulations are typically much more complicated

- Multiple rate promoters *and* inhibitors
- Additional abrasive component complexity
- Some new slurry formulations have 12+ different components

Some slurries require 2 pack solutions to provide sufficient shelf-life stability as well as required polishing performance



Semi-Sperse WIN iDIEL EPOCH SiLECT SiCeed

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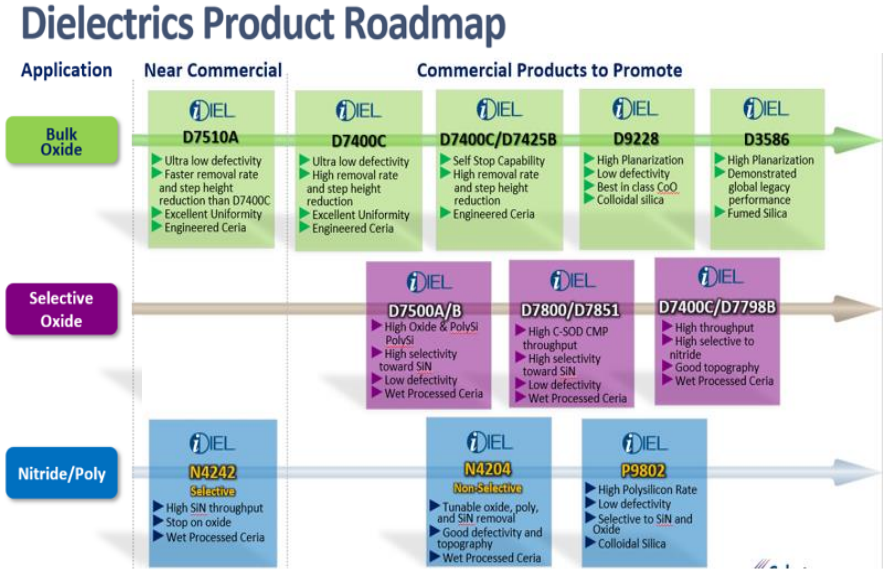
CHALLENGES WITH MODERN SLURRIES - APPLICATION

The proliferation of new CMP polishing applications has increased both the number and types of CMP slurries

- New applications require novel slurry formulations
- Slurry manufacturing is now a boutique industry, as opposed to previous “one size fits all” formulation paradigm
- CMP Applications are growing which introduce new abrasives and chemistries outside of those traditionally used in the IC industry



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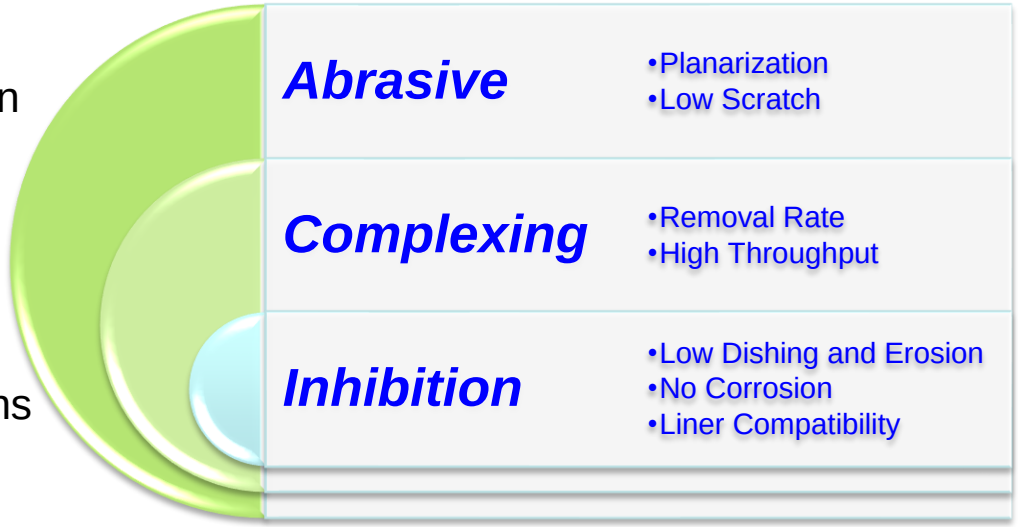
CHALLENGES WITH MODERN SLURRIES - FAMILIES

Different Customer Applications can be similar, but have very different polishing requirements

- Different film types and configurations
- Different film deposition types
- Polisher and Process Limitations



To address this, “families” of slurries are developed that provide a range of performance characteristics

- Formulations are similar, but distinct
- May be specially modified for unique customer applications

Characteristics	C8902	C8908-02	C8910	C8917
Dilution	10 X	10 X	10 X	10 X
pH	~4	~4	~4	~4
Abrasive Type	Colloidal Silica	Colloidal Silica	Colloidal Silica	Colloidal Silica
Abrasive Size	<30nm	<30nm	<30nm	<30nm
POU Abrasive%	0.25%	0.25%	0.125%	0.25%
H_2O_2 Addition	1.5%	1.5%	1.5%	1.5%
Cu Rate (D100, 2.5psi, 70rpm)	9500 (A/min)	8000 (A/min)	6500 (A/min)	5500 (A/min)
Cu Rate (D100, 1.5psi, 70rpm)	7500 (A/min)	6000 (A/min)	4500 (A/mini)	4000 (A/min)
Selectivity Cu:TaN	>1000:1	>1000:1	>1000:1	>1000:1
Dishing (100um)	450 A	350 A	600 A	300 A
Erosion (9um 90%)	60 A	60 A	180 A	60 A
Pot Life (Days)	> 7	> 7	> 7	> 7

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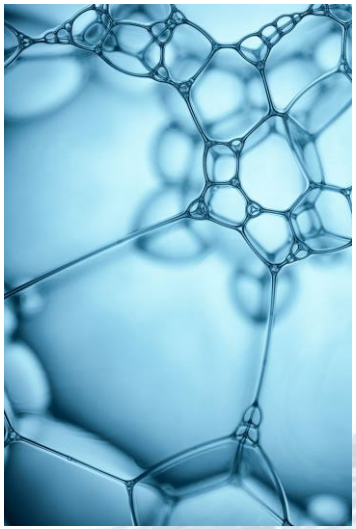
CHALLENGES WITH MODERN SLURRIES - FORMULATION

To complicate matters, increasing focus on cost performance have driven a trend towards increasing concentration of the slurry as supplied

- Higher slurry concentrations require special Mixing and Handling procedures
- Higher solids concentrations can result in higher levels of stratification and additional pre-mixing requirements
- Higher solids and chemical concentrations may impact the shelf life of the slurry
- Increased dilution ratios require more accurate SDS mixing equipment

New organic components may introduce other issues like foaming, light sensitivity and even shear issues

- Polymers and surfactants are added to the slurry formulation to address polishing requirements
- Slurry foaming can be addressed to a large degree with special handling considerations
- Light sensitivity issues are normally associated with ambient UV



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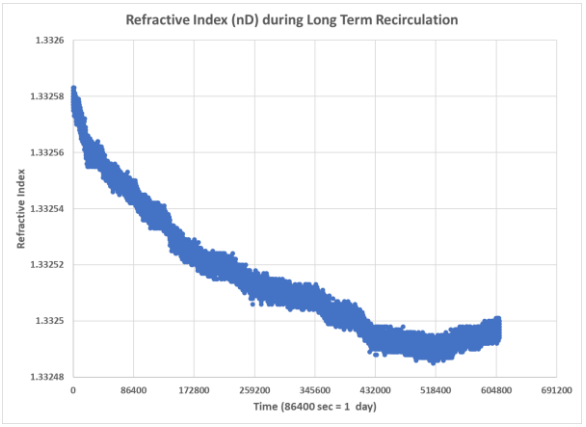
CHALLENGES WITH MODERN SLURRIES - METROLOGY

As the slurry formulations increase in complexity, it is harder to find appropriate analytical methods to track the different components

- Similar yet distinct components like surfactants or polymers can be difficult to isolate
- Changes in chemistry which occur over time, or after oxidizer addition can result in by-products which may, or may not, interfere in polishing performance
- Particle sizing can be difficult because of different chemistries in solution



There are limited on-line sensor types available to monitor slurry health

- Traditional pH and conductivity sensors
- Ultrasonic flow meters and densitometers
- Refractive index sensors

ADVANCES IN SLURRY HANDLING

In recent years, the introduction of new slurry handling equipment has greatly improved the ease of use with modern slurries

- Centrifugal pumps provide controllable high, pulsation-less flow for slurry distribution
- New valves and fittings more optimized for shear sensitive abrasives have been developed
- Additional development of online sensors for flow rate, density and particle sizing have been integrated into new slurry distribution system designs
- Alternate mixing and handling procedures which utilize drum rolling and tumbling have been developed for customers who require them

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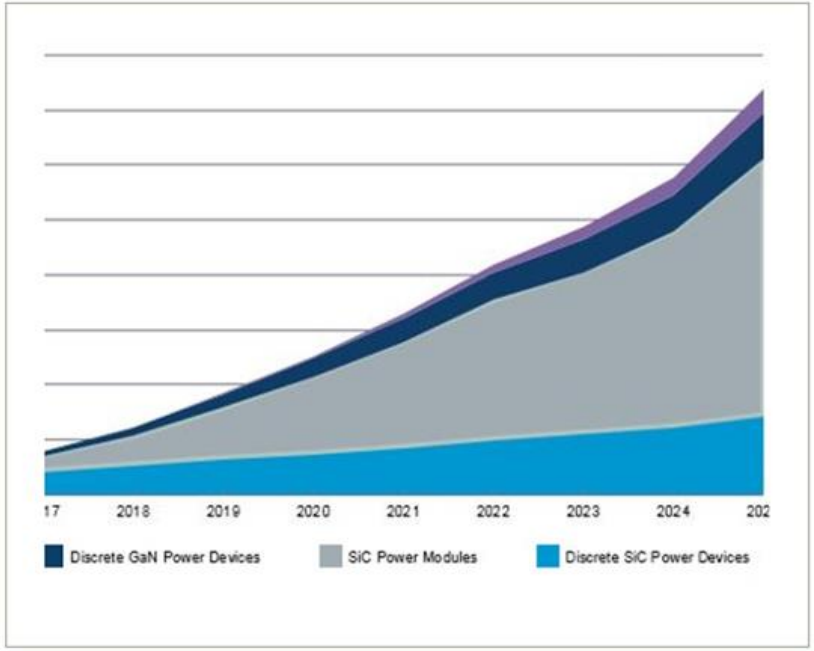
EMERGING SLURRY TECHNOLOGY

Silicon Carbide Wafer Polishing Slurries

New Development of SiC slurries is being driven by the rapidly increasing market for SiC devices

- New abrasive types
- New oxidizers
- Significant handling concerns
  - Pre-mixing and distribution
  - Materials of Construction
  - Sensor types



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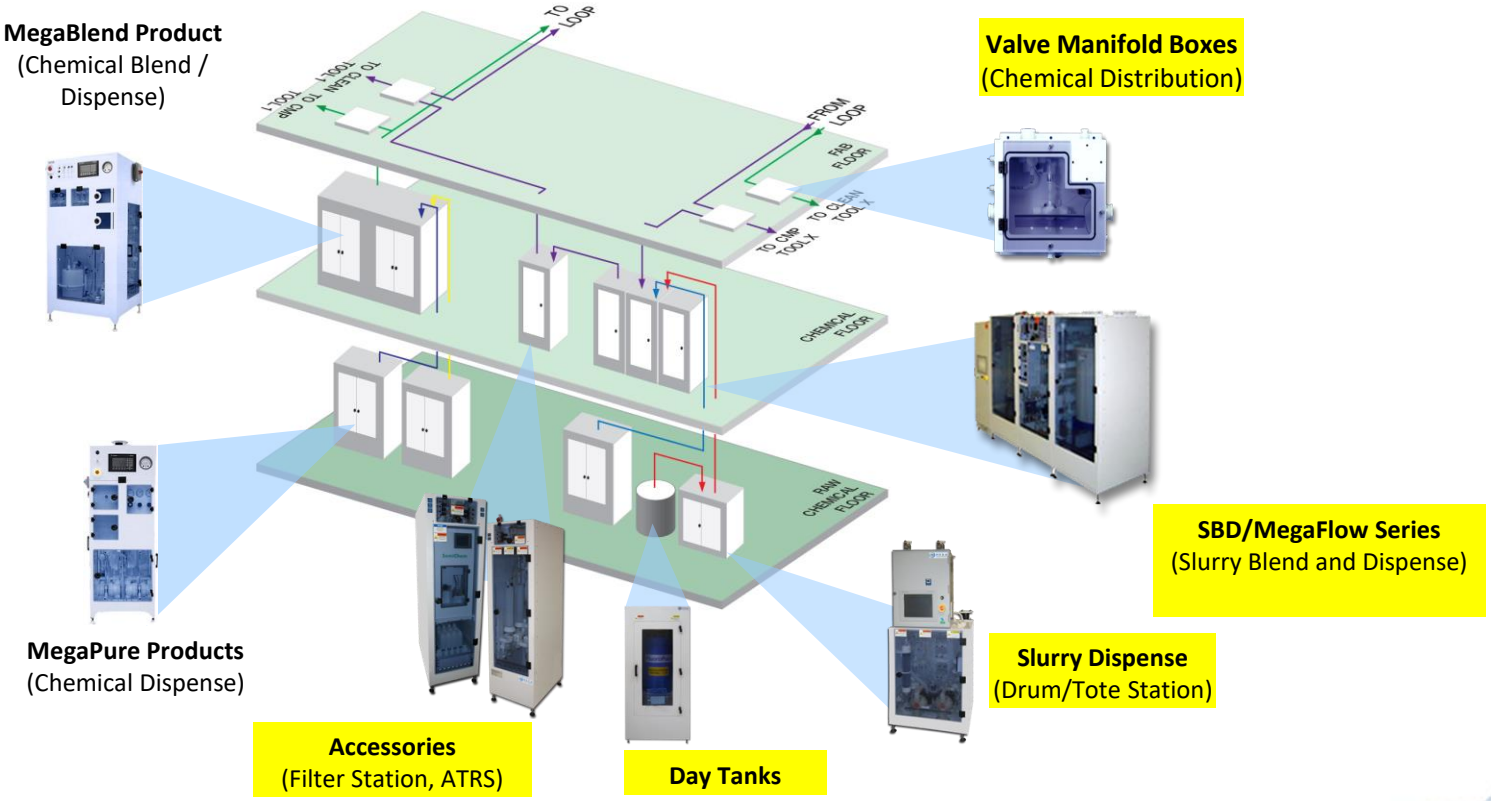
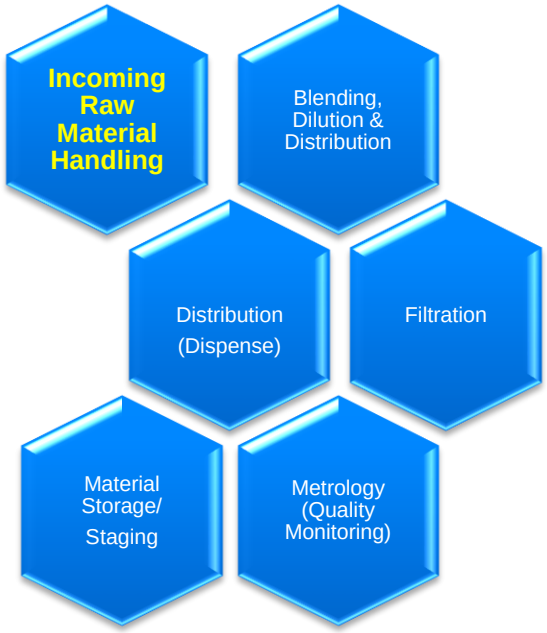
SLURRY DISTRIBUTION SYSTEMS OVERVIEW



A typical Fab layout incorporating the various Mega Fluid Systems product lines supporting the CMP Process.

INCOMING RAW MATERIAL HANDLING: CMP SLURRY



Slurry Carts

SD50

SD100

SD100
Full Height

SD200

Key Process Design Requirements:

- Homogenize incoming raw material at source container before material transfer.
  - *Which method to employ to ensure complete material homogeneity?*
- Facilitate material transfer from source container to Distribution System
- Supplementary functions:
  - Incoming Material Filtration
  - Incoming Material Quality Monitoring

BLENDING, DILUTION & DISTRIBUTION: CMP SLURRY

SBD35

ESSEX

SBD100

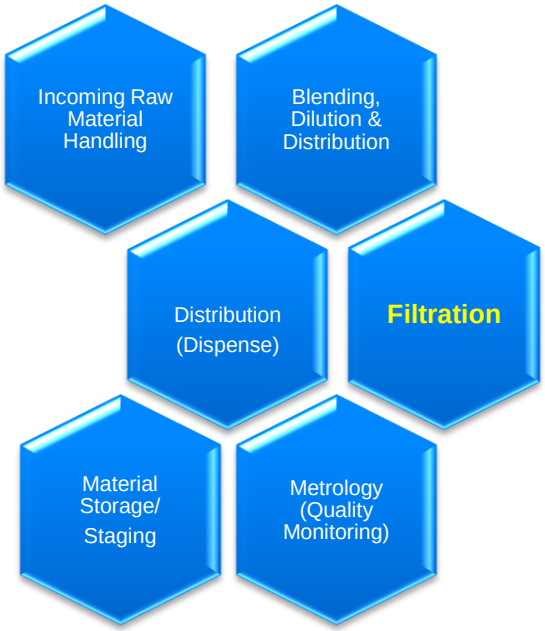
SBD25

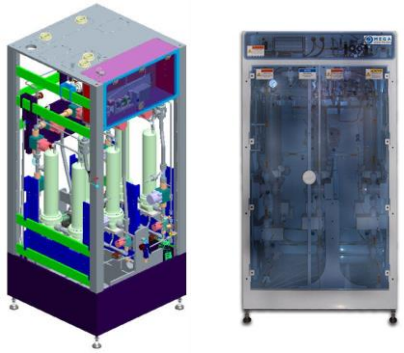
MegaFlow Trio

Key Process Design Requirements:

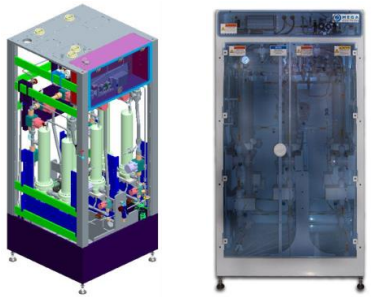
- Accurate addition of required raw material components as per set blend specifications
- Homogenization of added components in Blend/Day Tank before delivery to Point-of-Use (POU).
- Delivery of blended/diluted slurry to POU.
  - *What type of dispense system to employ?*
  - *What is the required Blend Make up Rate?*
  - *What is the POU flow and pressure requirements?*
- Supplementary functions:
  - Filtration of blended/diluted slurry
  - Quality Monitoring of Mixed/blended slurry

FILTRATION: CMP SLURRY

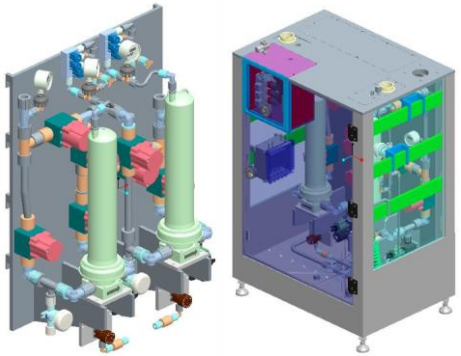




SF100



SF200



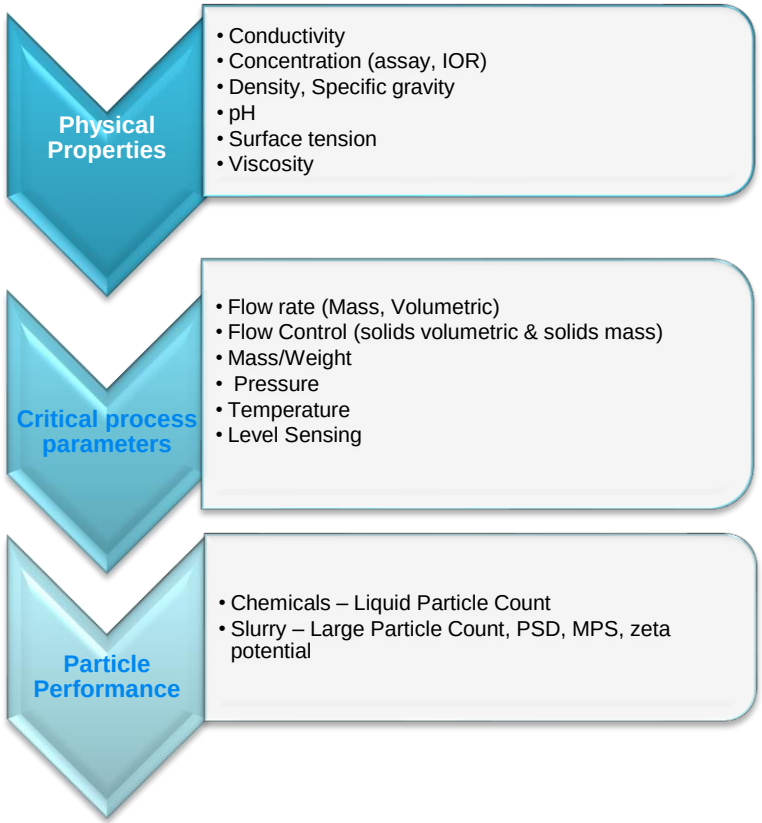
SF300

Filter Carts

Key Process Design Requirements:

- Effective filtration of large particles (LPC) and agglomerates without affecting the required abrasive particles necessary for the CMP polishing step
- Maximize filter media contact with slurry material
- Ability to change filter media without affecting the quality of CMP slurry material
- Ensure continuous supply of CMP slurry material to POU

METROLOGY – QUALITY MONITORING



Key Process Design Requirements:

- Quality monitoring of critical material parameters
  - Sampling (offline analysis)
  - Inline metrology
  - Online metrology
- Monitoring of critical process parameters
  - Delivery Flow, pressure
  - Flow control – component addition
  - Weight, Level
- Metrology accuracy and sensitivity to process or POU requirements

KEY TAKEWAY

CMC Materials is committed to deliver high performing and innovative solutions that solve our customers' challenges. Our due diligence in providing the most complete and comprehensive recommendations in slurry handling coupled with compelling data is key in providing value to our customers.

Mega's Slurry Blend and Distribution Systems are designed and manufactured to deliver quality slurry materials at the point-of-use while maintaining good slurry dispersion and slurry particle health.

The CMP Operation benefits from the low Facilities Equipment Cost of Ownership and the reduced quality defects from the supplied slurry which is maintained and monitored at optimum conditions.

PRESENTERS BIOGRAPHY

Carlo Aparece

Carlo Aparece is the Director of Process Integration for Mega Fluid Systems, a chemical and slurry delivery equipment subsidiary of Kinetics that serves the semiconductor, LED, pharmaceutical, specialty chemicals and solar/PV industries.
Prior to joining Mega, he has spent over 20 years in the semiconductor industry in Asia and the US in varying roles as Process Engineer, Facilities Chemical Engineer and Member of Technical Staff for chemical and slurry distribution systems and Quality Materials Lead for CMP Materials and Processes.

Marc Maxim

Marc Maxim is the Global Lead for Slurry Mixing and Handling for CMC Materials, a prime supplier of CMP slurries and other chemistries to the semiconductor, optics, media storage and power device market.
Marc has been with CMC Materials Inc. (formerly Cabot Microelectronics Corporation/Cabot MMD) since 1997 working in all the various types of mixing and handling activities associated with slurries. His role also includes on-site technical support and troubleshooting at customer sites around the world.