# Entegris-Jetalon Sales Channel Partner Training

Jetalon Solutions, Inc.

Pleasant Hill, CA

# Agenda

- Introduction to Jetalon
- Entegris-Jetalon Technology Review
- Product Introduction
- CMP Process variables
- Applications for Entegris-Jetalon Technology
- Appendix I – post CMP processes

# Entegris-Jetalon Technology Review for CMP Applications

# Entegris-Jetalon Technology Overview

**SRS Chemical Sensor:**

**The core Optical Sensor that is packaged into each product**

**CR-288**

**Concentration Analyzers**

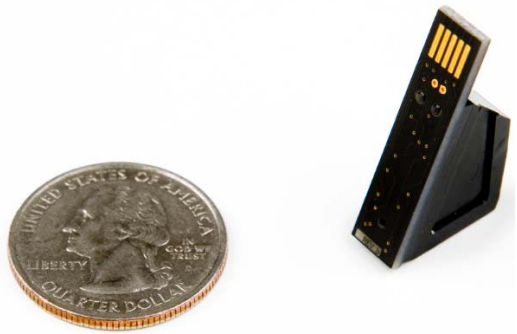

**Plastic NX-148**

**Concentration Analyzer**

**Stainless Steel NX-148**

**Concentration Analyzer**

# SR Sensor: Chemical Sensor ™ Technology




- SRS Chemical Sensor is a miniaturized, optical sensor based on the refractive index principle of operation.
- SRS Sensor is the key hardware component in Entegris-Jetalon's disposable bag, liquid controller, and chemical analyzer products
- Entegris- Jetalon's products key differentiators:
  - Miniaturized sensor = agile packaging for analysis systems
  - Superior Accuracy and Response Times
  - Most convenient on-site calibration of all analyzers on the market
  - Large dynamic range for concentration measurements
  - Long Lifetime Components



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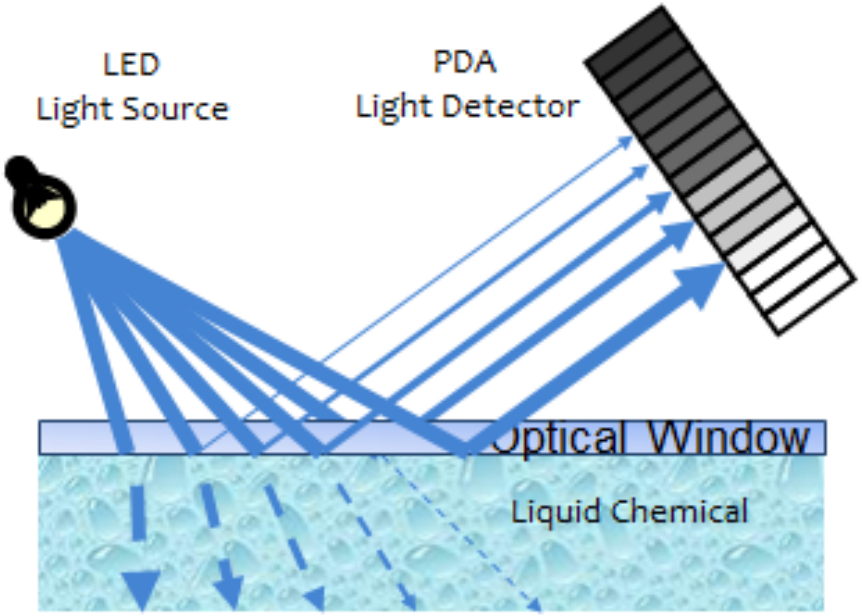
# Refractive Index Chemical Analyzer: How it works



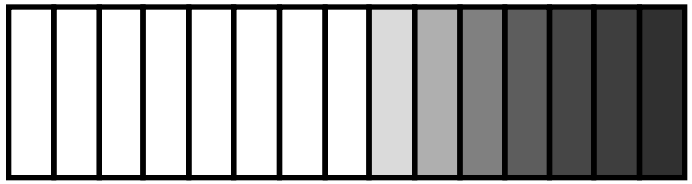

**Miniaturized Liquid Chemical sensor**

**Refractive index**

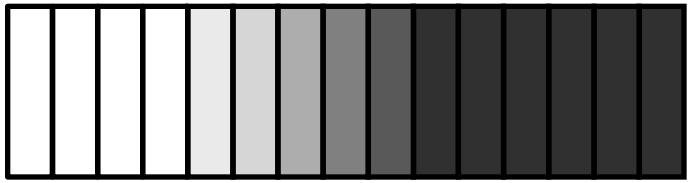
**Reflection geometry**

- Light reflects off window/liquid interface into the PDA
- Angle of reflection determined by refractive index ratio between liquid and window
- Entegris- Jetalon algorithm measures small changes in reflected light intensity really fast (100 milliseconds) and highly accurately (0.01 wt% and better).
- Reflection geometry and miniaturization enable unique concentration monitoring performance.

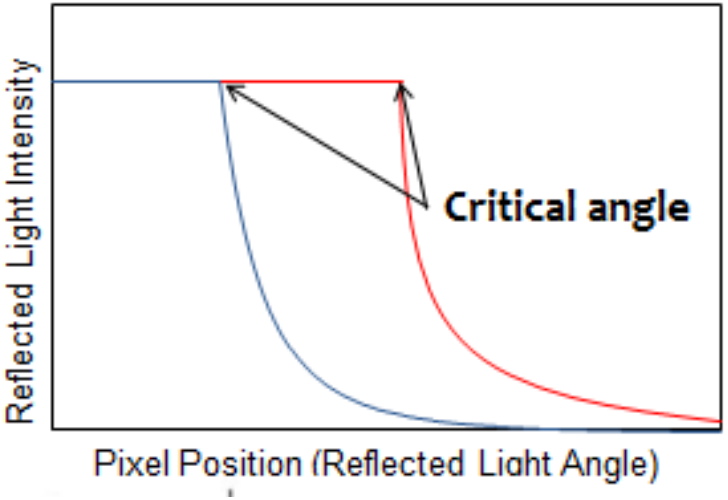
# Refractive Index Chemical Analyzer: How it works



**Lower Concentration**



**Higher Concentration**




1. As liquid concentration changes, critical angle moves, and pixels on PDA “light up” and “go dark”
2. Reflected light intensity changes are used to determine critical angle
3. Critical angle determines index of refraction (IoR)
4. Simple calibration of (IoR) determines chemical concentration output in wt% or ppm.



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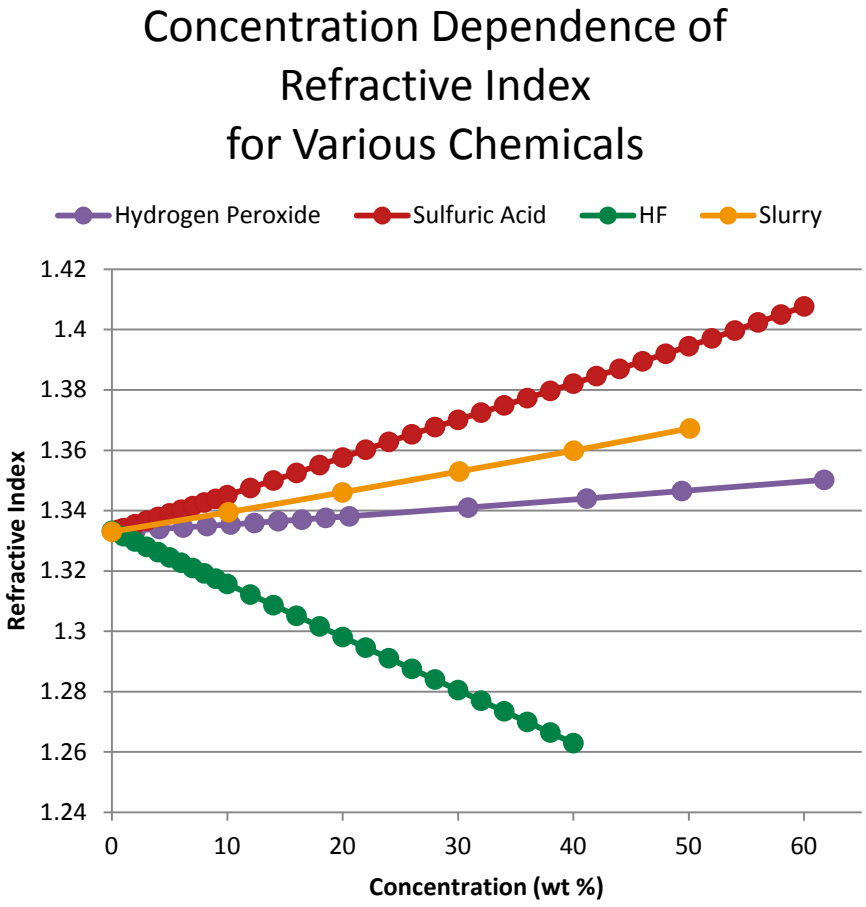
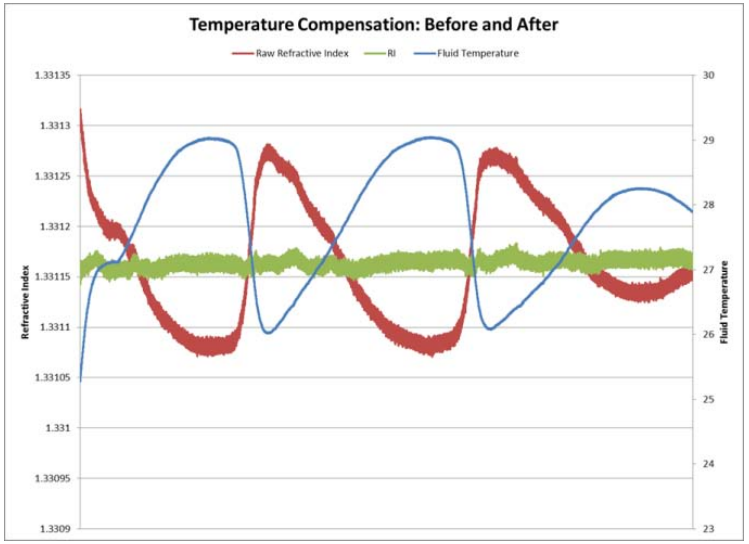
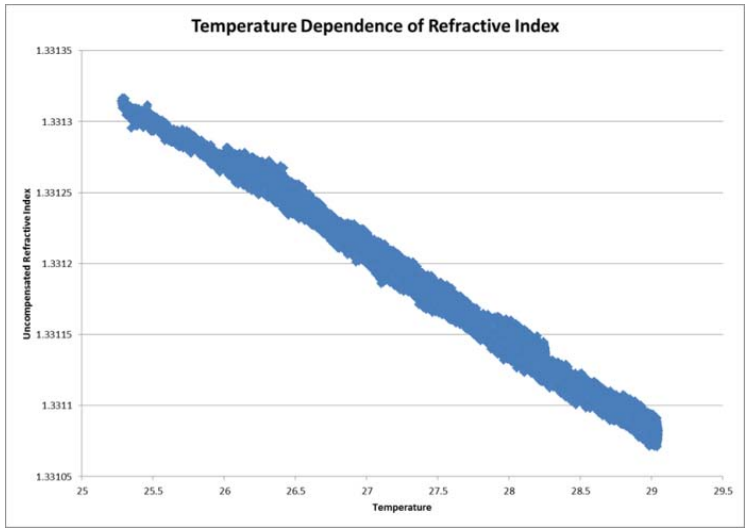
# Refractive Index Sensor Calibration




- Calibration to a wide range of chemicals is possible.
- Sensors have extremely high dynamic range.
- Most chemical calibrations are linear over very wide ranges.
- Calibration can be performed once, and calibration files can be shared between sensors.

# Refractive Index Sensor Real-time Temperature Compensation




- Every sensor features an integrated thermistor.
- Refractive index is temperature-dependent.
- Temperature compensation is performed automatically and in real time

# Entegris-Jetalon Product Review

# Entegris-Jetalon Liquid Chemical Concentration Analyzers


## The CR-288 Liquid Chemical Concentration Analyzer:

- Single electronics box operates 1, 2, 3, or 4 sensor heads
- LCD display for chemical concentration and temperature
- Eight 4-20 mA analog and RS-232 outputs
- Full software suite for data acquisition and sensor settings
- Ultrahigh purity chemical compatibility


## The NX-148 Concentration Analyzer:

- Single sensor head
- Electronics integrated with sensor into a single package
- Outputs concentration and fluid temperature
- Two 4-20 mA analog and a RS-485 outputs
- Ultrahigh purity chemical compatibility
- Price competitive for OEMs

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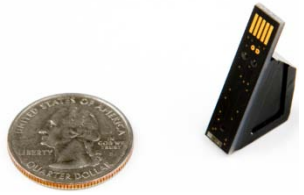
# The CR-288 Family's Components

- SRS Chemical Sensor
  - Optical-electronic refractive index sensor
  - Measures concentration and temperature of any liquid chemical



- CR-288 Sensor Head
  - Available in SS and plastic, bench top and any end connection
  - Ultrahigh purity single crystal synthetic sapphire window


- Digital Display Unit (DDU)
  - Stand-alone electronics brain with LCD readout
  - Operates up to 4 independent sensor heads via a 3 M (max) Cable
  - Interface to computer, PLCs, etc.
  - 8 analog 4-20 mA outputs for conc. and temperature of each Sensor Head
- 288-connect software
  - Graphical user interface (GUI) software
  - Calibrations, initialization, diagnostics, data logging/analysis.

- Typical sold as kits containing above components : "Kit-X"
  - Example Kit-1 is 1 Sensor Head and 1 DDU
  - Example Kit-2 is 2 Sensor Heads and 1 DDU



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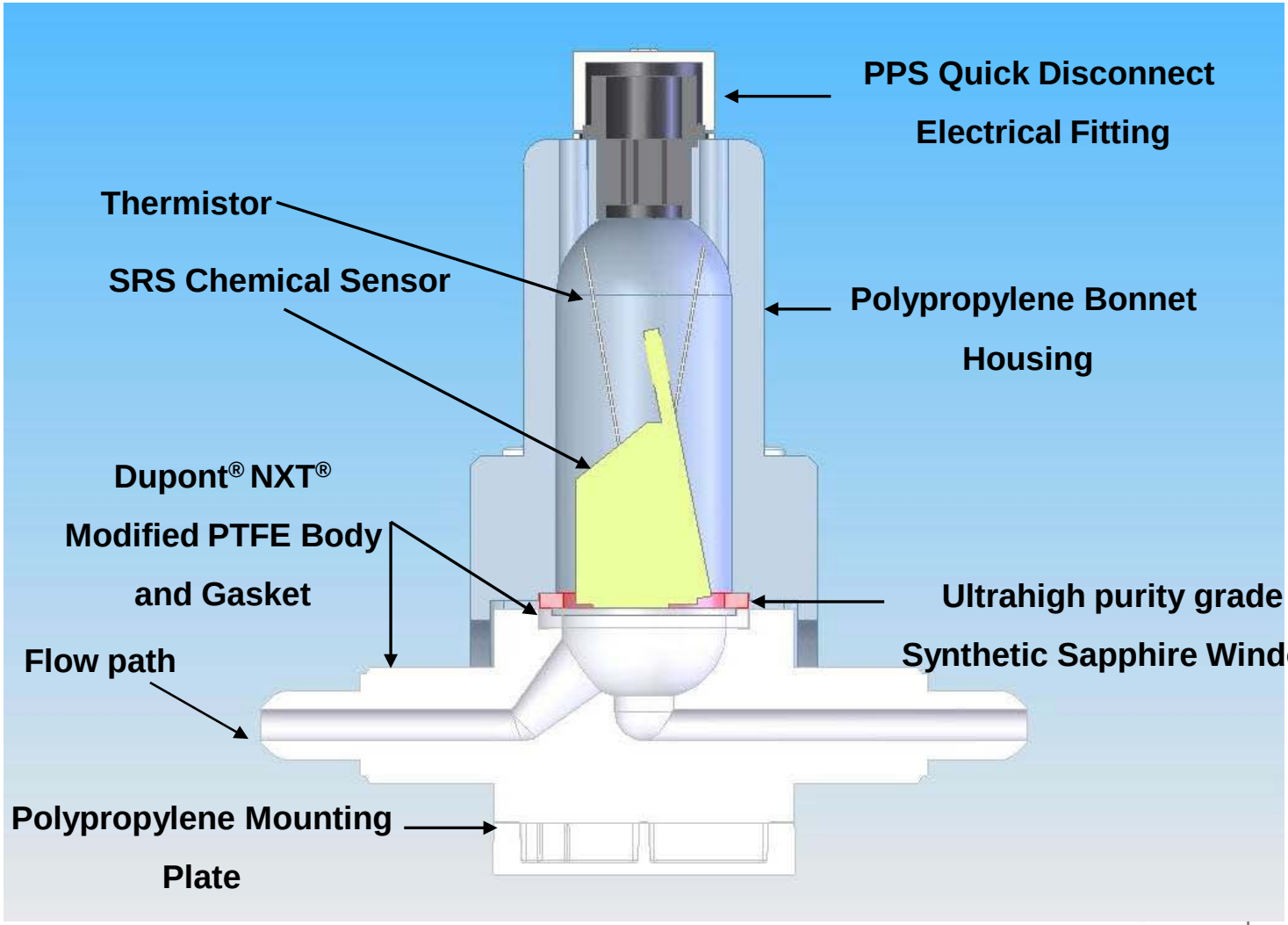
# CR-288 Sensor Head Cross-Section



# NX-148
## Integrated Sensor Head and Electronics

## NX-148 Features:

- Single channel monitoring system
- Integrated electronics board stack design
- Long cable (>30 meters)
- Standard RS485, 4-20 mA communication
- 148-connect software
  - Graphical user interface (GUI) software
  - Calibrations, initialization, diagnostics, data logging/analysis.

# Entegris Jetalon's Product Differentiation

- Highest Cost Savings and Performance of any analyzer
- Agile Packaging and Interface
  - Fluidic cells come in any material (plastic, metal), and any end connection type and size
  - Upcoming Derivative Products:
    - Tank Sensor
    - Table Top/Benchtop Sensor
    - High Temperature Sensor
- CR-288/NX-148 are Factory calibrated by Jetalon.
- 88-connect software enables on site re-calibrations in minutes
  - Diagnostics, data logging, sensor tuning, calibration
- No maintenance or replacement parts

# CR-288 vs. Auto-Titration for H2O2 in CMP Slurries

| Auto-Titration Typical 200MM Wafer Fab | Data | Cost Per Month | Cost Per Year | CR-288® Comparison |
|---|---|---|---|---|
| Frequency of titrations | Every 8 hours | | | Real time monitoring |
| Time for complete titration | ~45 minutes | | | Real time Data point every 1.2 seconds |
| Frequency per day | 3 times | | | Real time monitoring |
| Number of values per each titration | 2 | | | Real time monitoring |
| Amount of slurry used for each titration | 1kg per titration value<br><br>For each titration cycle, 2 values are taken. The result will be the average of these 2 values and each value will require 1kg of slurry at a cost of ~$13 per kg. | | | 0 |
| Cost of slurry used per value | Cost $13 per titration value<br><br>(2 samples = $26) x 3 per day = $78 per day. Average 30 days. | ~$2,340 | ~$28,080 | 0 |
| Re-agent used for each titration | Re-agent is needed for chemical reaction to get titration. Re-agent is needed for each titration. | ~$4,300 | ~$51,600 | 0 |
| O-ring replacement | Change every 3 months @ $10.00 per month | ~$10 | ~$120 | 0 |
| Probe | Change probe average of once every 6 mos. | ~$105.00 | ~$1,260 | 0 |
| Maintenance | Time to replace O-rings, probes, and other misc. items @ ½ day @ $150 per hour (estimate) | ~$600 | ~$7,200 | Re-zero<br>1 per month<br>1 hour @ $150 |
| **TOTAL** | | **~$7,355** | **~$88,260** | **$150** |

## Application:

*$H_2O_2$ spiking in CMP slurries*

Results Published by Chartered Semiconductor

"CMP Slurry Blending Process Optimization and Cost Improvements using Real-time Concentration Monitoring"

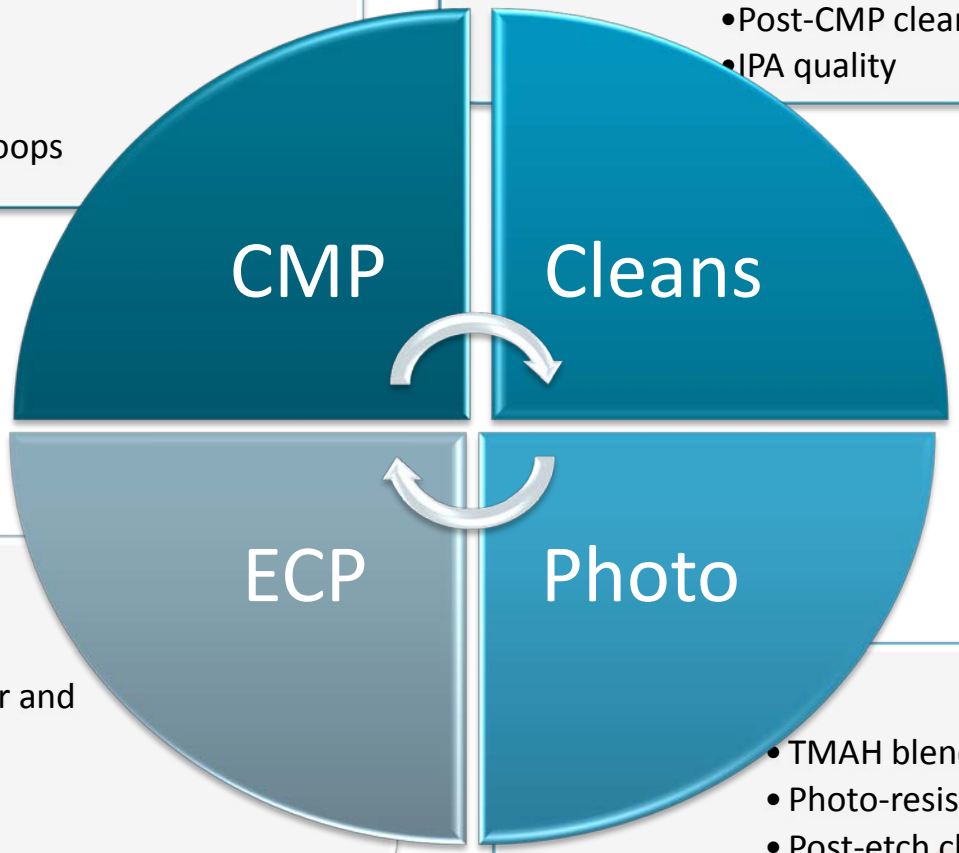
Aparece, C.D.; Wacinski, C.; Rajan, S. Advanced Semiconductor Manufacturing Conference, 2007. ASMC 2007. IEEE/SEMI Volume , Issue , 11-12 June 2007 Page(s):320 – 325

# Semiconductor Applications – CMP Focused

# Microelectronics applications for NX-148/CR-288

- $H_2O_2$ spiking in slurries
- Incoming slurries batch-to-batch quality
- Slurry dilutions
- Proprietary additives
- Monitor global and local loops

- Single wafer on demand blending monitor and control
- Batch tool chemical blending
- Endpoint detection
- Batch bath monitor
- Post-CMP clean chemical blending
- IPA quality

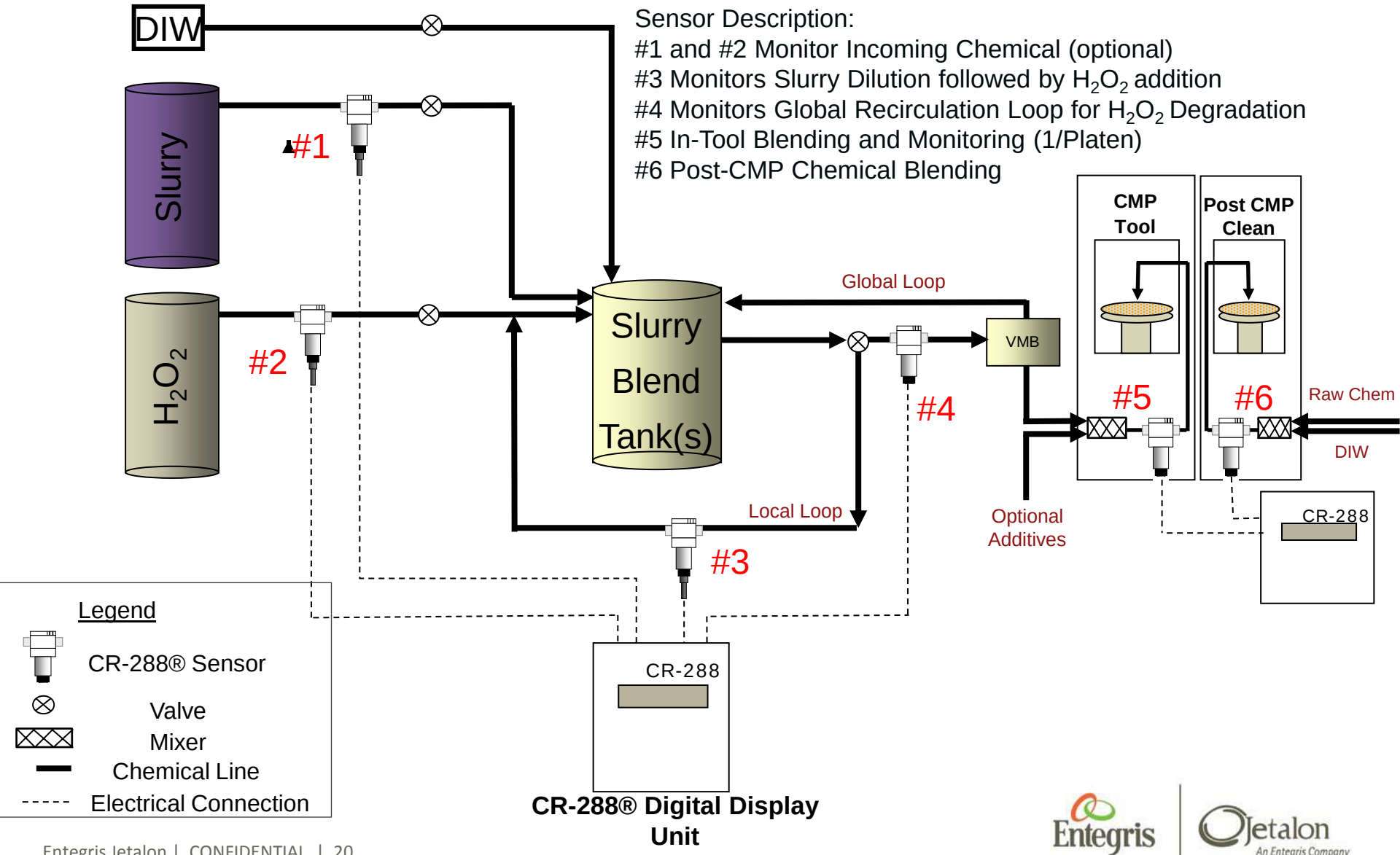



- Dissolved oxygen monitor
- Chemical blending monitor and control
- Plating bath monitor

- TMAH blending and additives
- Photo-resist verification
- Post-etch cleans
- Track system HMDS and solvent concentration monitor

# CMP Slurry Applications: Hydrogen Peroxide and Slurry Monitoring

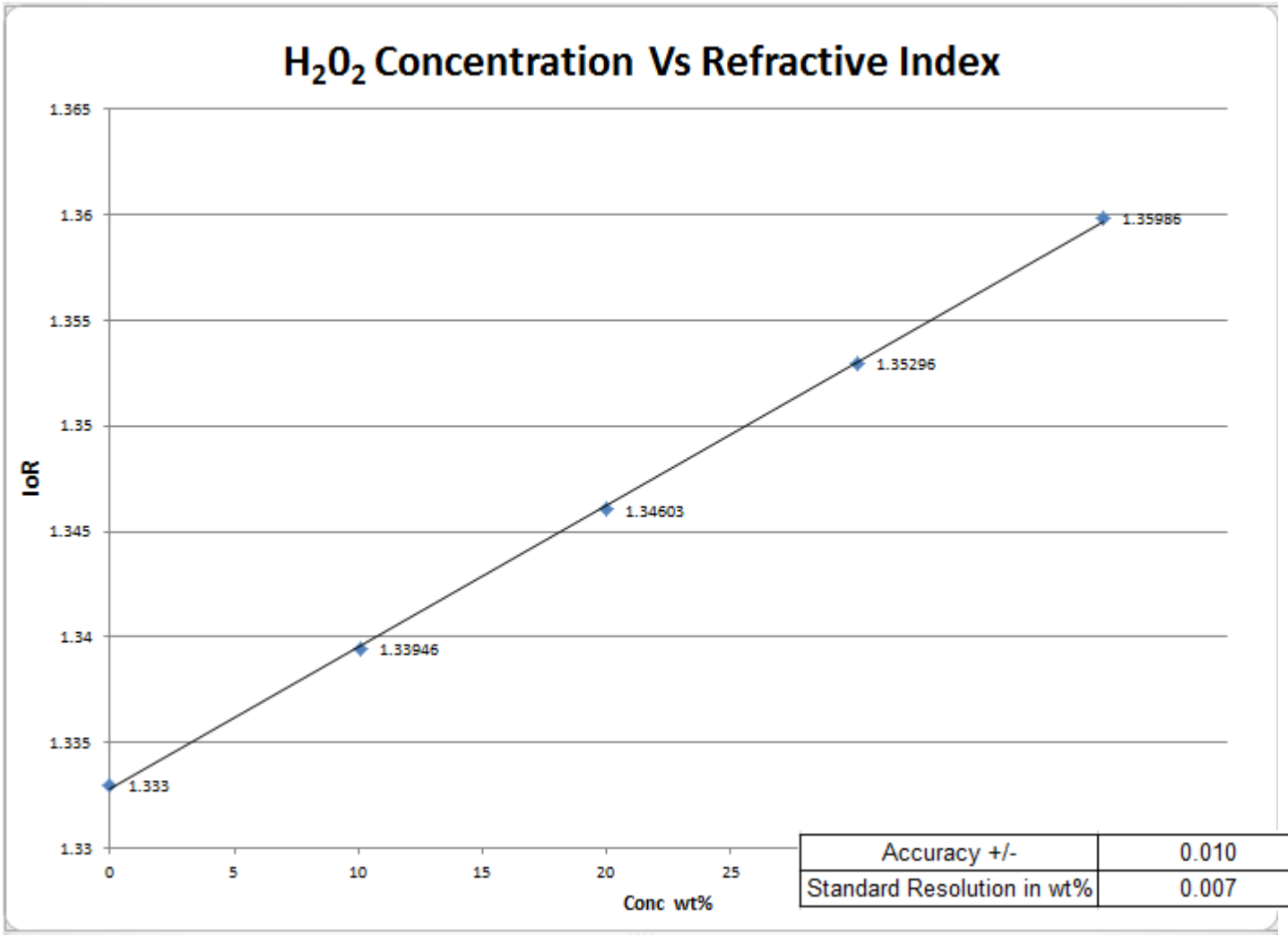
# CR-288 Total Monitoring Solution for Slurry Blending




Sensor Description:
#1 and #2 Monitor Incoming Chemical (optional)
#3 Monitors Slurry Dilution followed by $H_2O_2$ addition
#4 Monitors Global Recirculation Loop for $H_2O_2$ Degradation
#5 In-Tool Blending and Monitoring (1/Platen)
#6 Post-CMP Chemical Blending

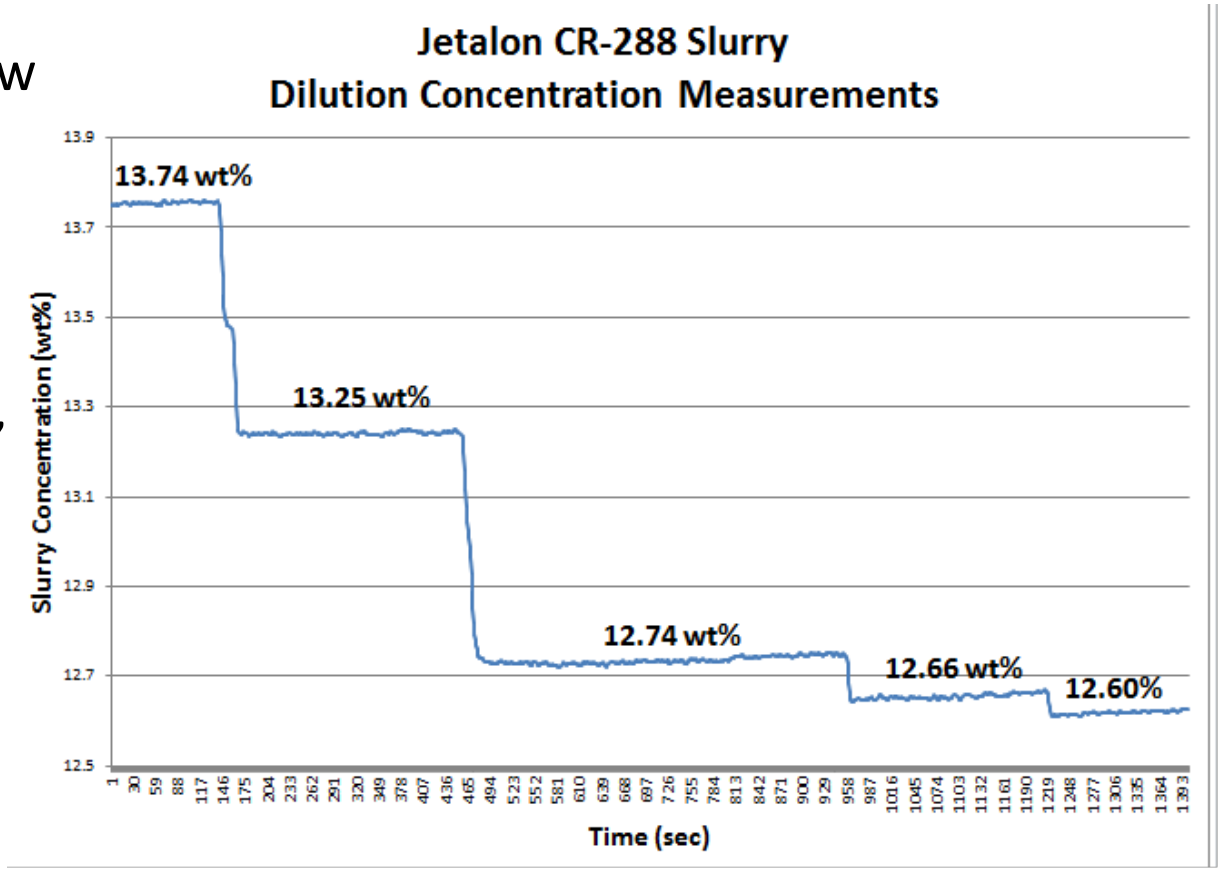
**CR-288® Digital Display Unit**

# Monitoring Incoming H2O2



# Slurry DIW Dilutions

- Purification and blending Ammonia and DiW with raw silica based slurry, and achieve 13.7 wt% slurry +/-0.2 wt% accuracy
- Using staircase steps in concentration calculations, CR-288 measurement accuracy was +/-0.02 wt %
- Easily resolved down to customer requirement of 0.06 wt % steps in dilution (30x our resolution)

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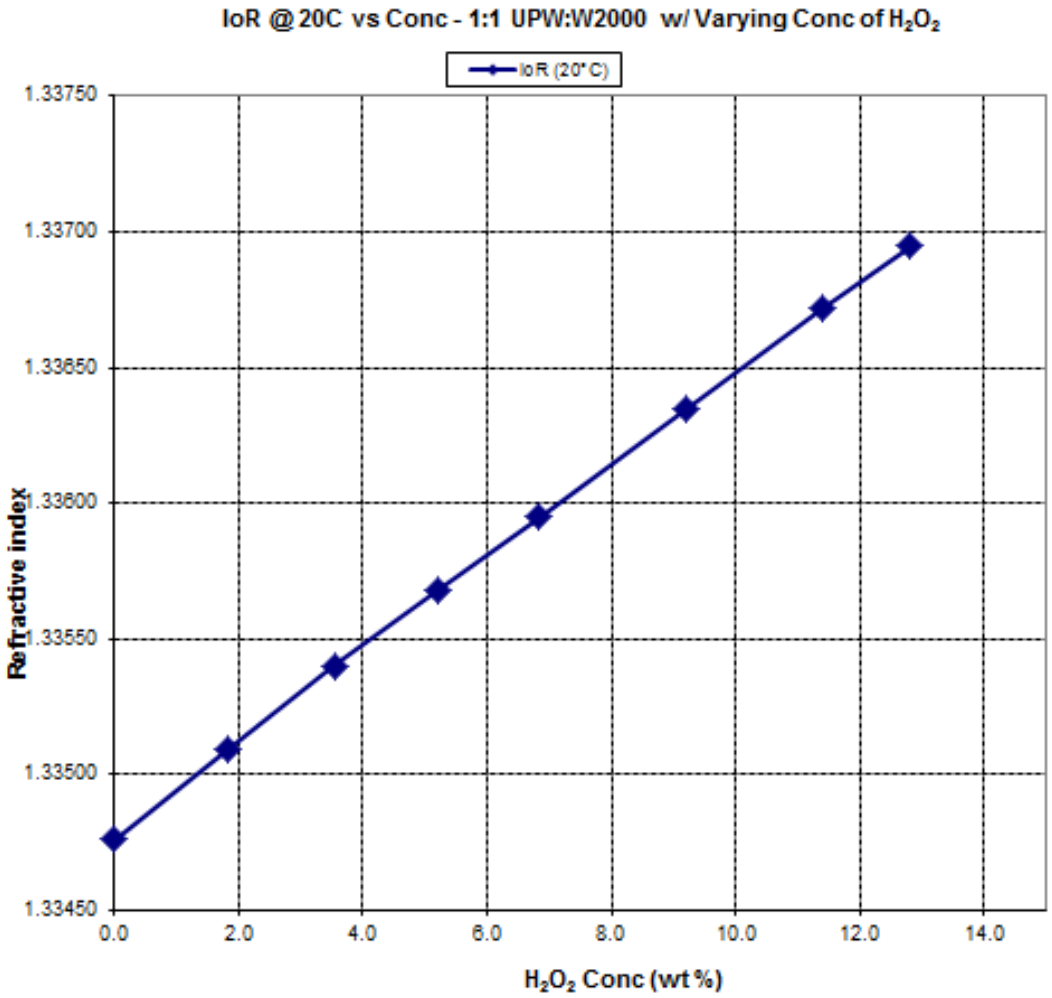
# Monitoring H202 Spiking

- Monitoring the $H_20_2$ Spiking post raw slurry Dilutions.
- For most slurries changes can be accurately resolved down to customer requirement of 0.01wt %

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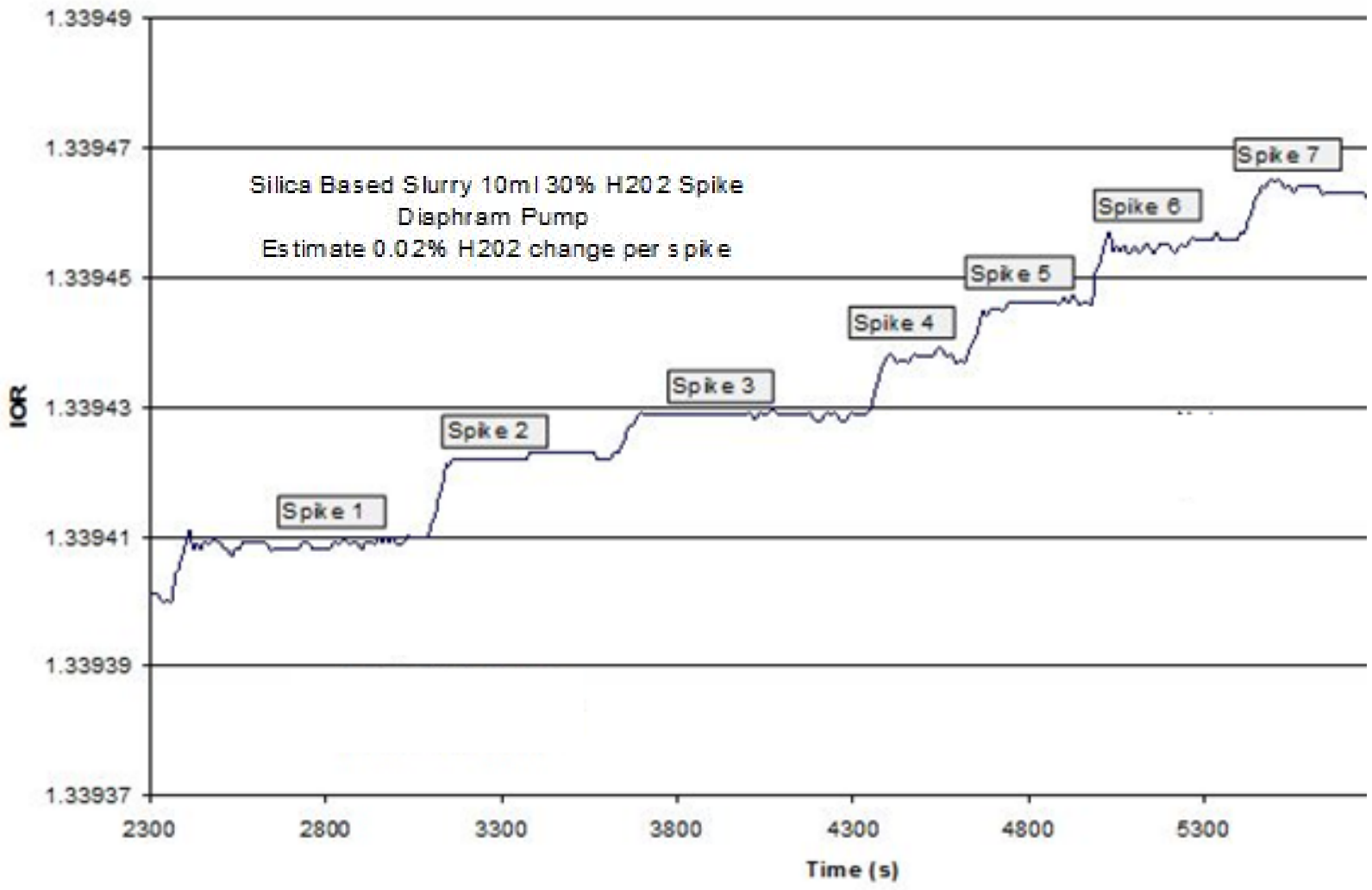
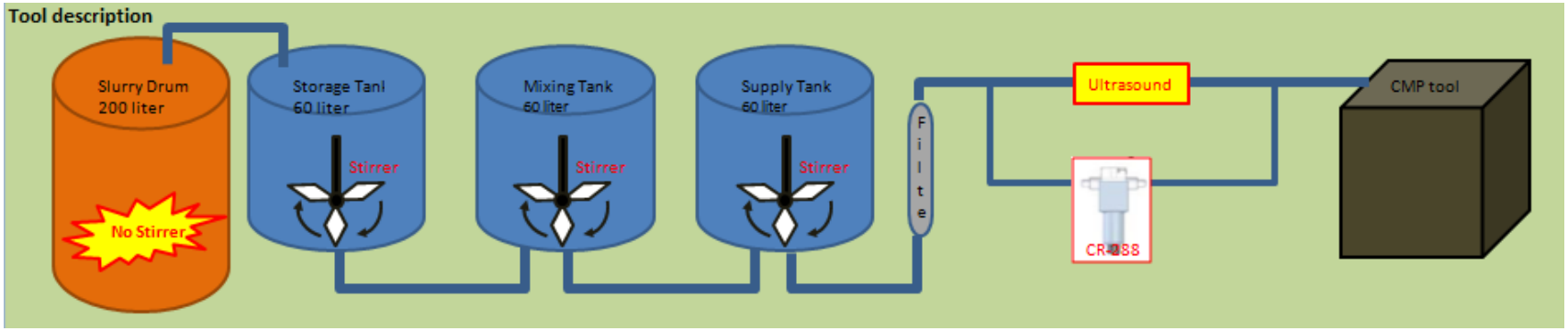
# Monitoring H2O2 Spiking In W2000



# Supply Strategies and Complementary Issues

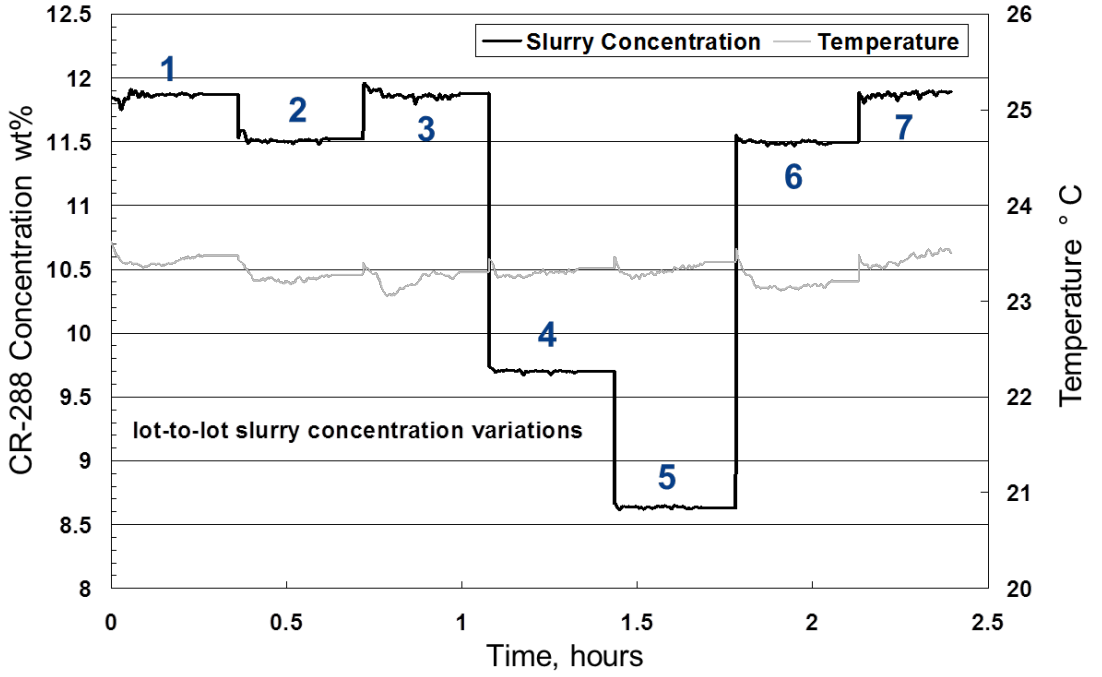
# Mixing Tank Strategy and Discovery




- Found Variation after Filter change
- Discovered Incoming Slurry variation

# Inconsistencies Incoming Slurry

* CR-288-slurry Monitors barrel-to-barrel incoming slurry concentration variation for 7 barrels of slurry in sub-fab CMP slurry delivery tools
* The CR-288 is able to measure lot-to-lot concentrations of slurries in real-time. With this capability, each lot is monitored in real time as the concentration can be brought to the desired range.

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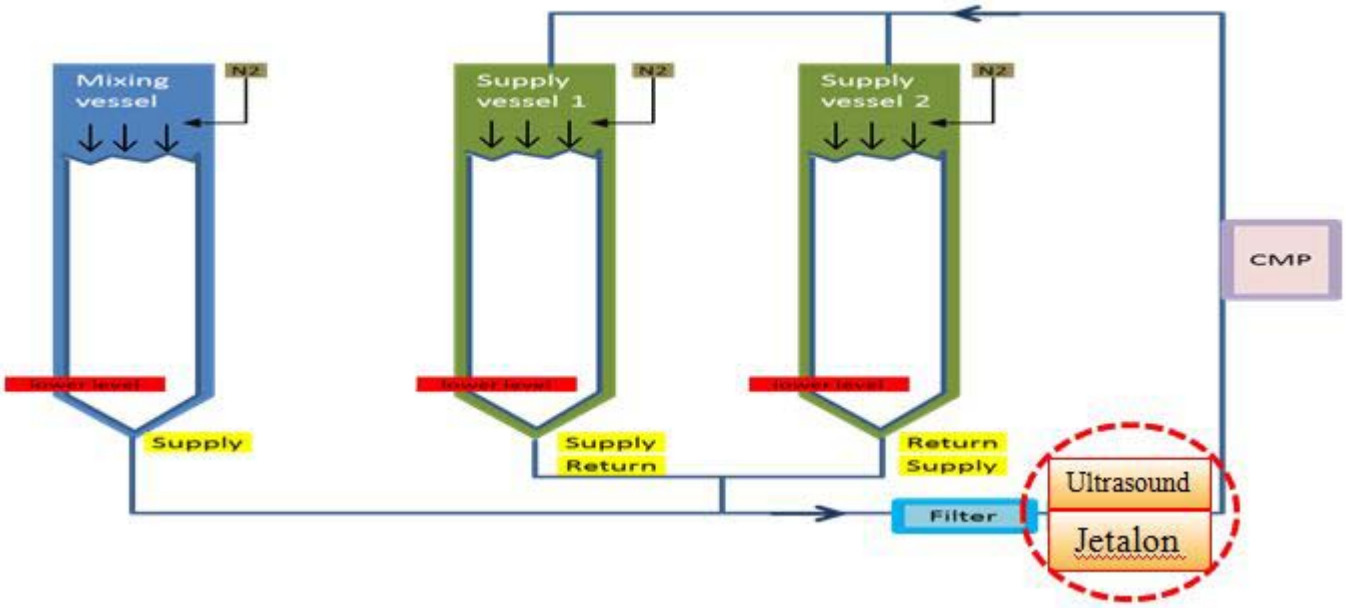
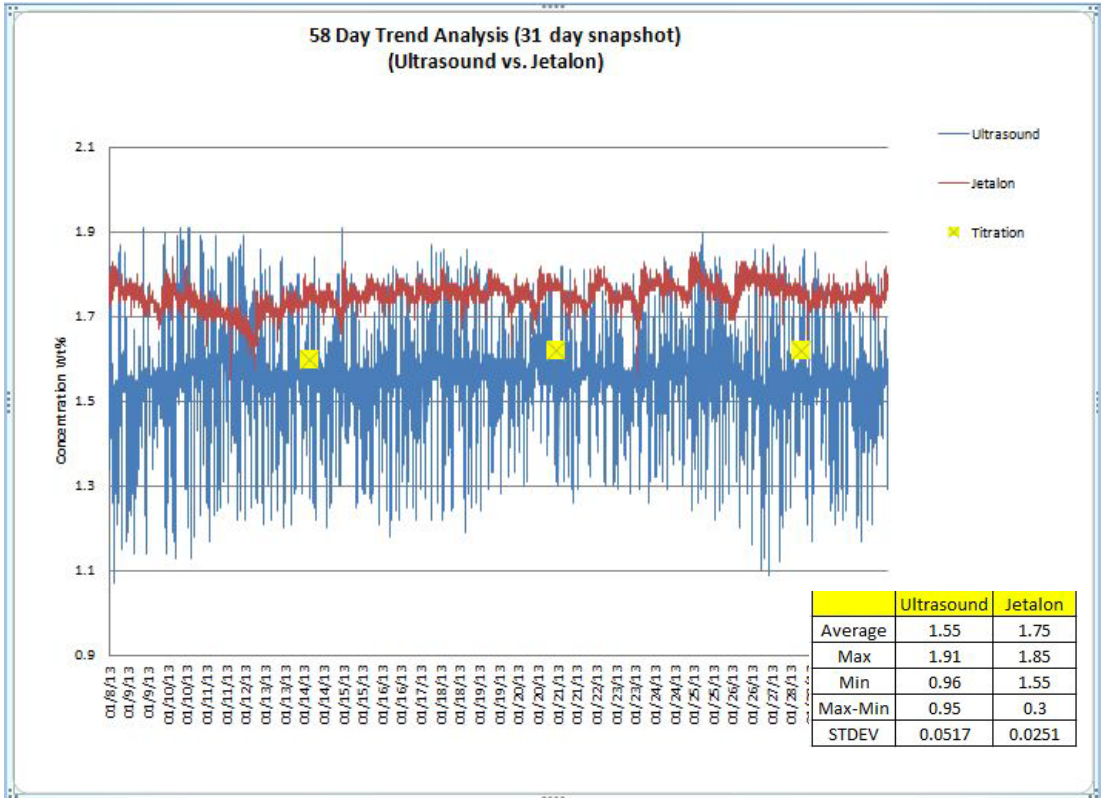
# P&ID of Vessel System



# H2O2 Spiking in CMP Slurry Global Loop

- Retrofit for existing Slurry Delivery tool.
- Accuracy for H2O2 can be ± 0.05 wt% (or better).
- Silica Based Slurry




| | Ultrasound | Jetalon |
|---|---|---|
| Average | 1.55 | 1.75 |
| Max | 1.91 | 1.85 |
| Min | 0.96 | 1.55 |
| Max-Min | 0.95 | 0.3 |
| STDEV | 0.0517 | 0.0251 |

# Current Entegris-Jetalon Technical Resources

- Outside of your normal Entegris GPS and Customer Service avenues, Entegris-Jetalon has the following technical specialists to assist with:
  - Technical Presentations
  - Customer On-Site Testing
  - Customer Training
  - Technical Customer Application Review

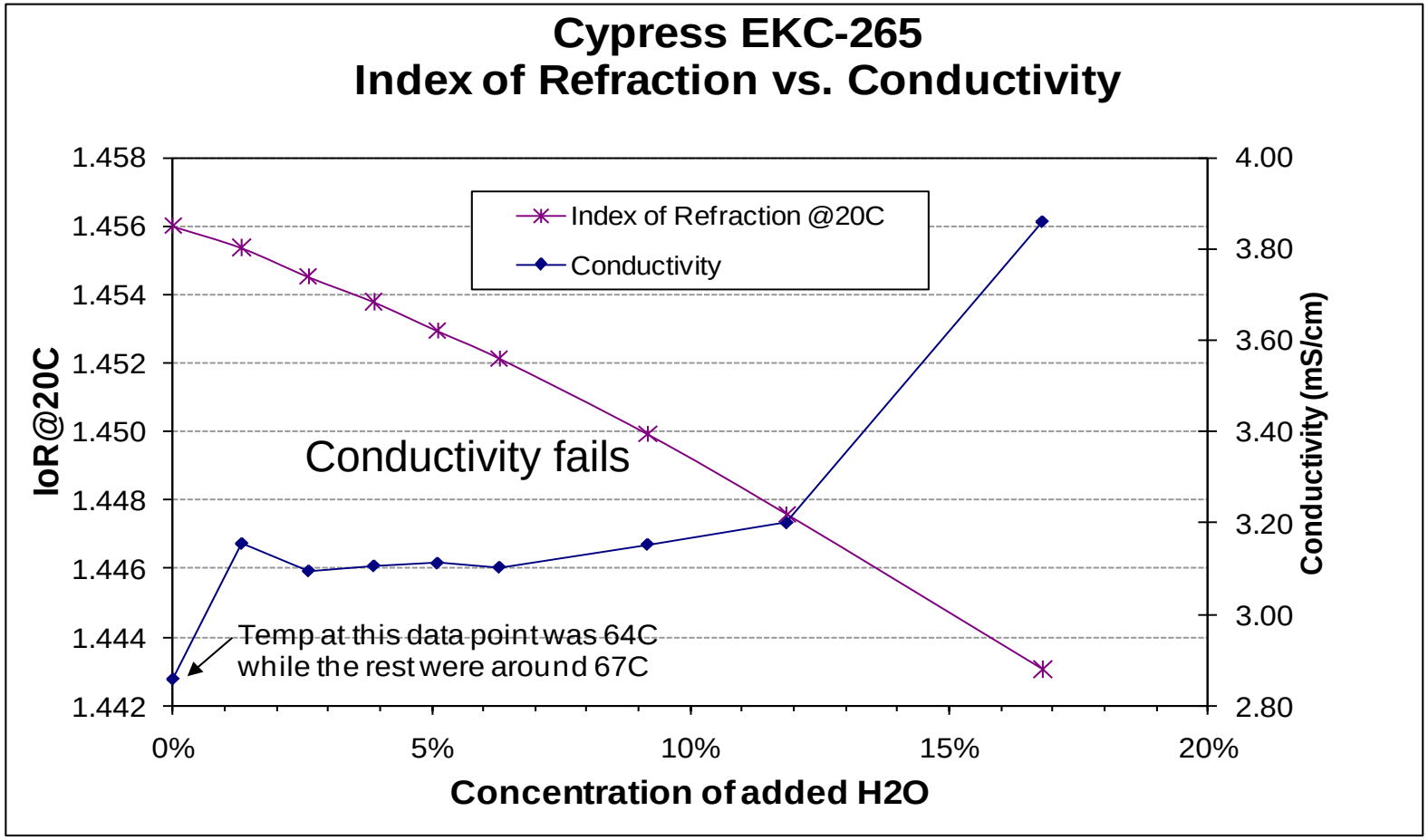
| Name | Purpose | Territory | Contact Info |
|---|---|---|---|
| Chris Wacinski | GPS | U.S. and Europe | Chris_Wacinski@entegris.com<br>+1-408-460-3599 |
| Chris Farmer | GPS | U.S. and Asia | Chris_Farmer@entegris.com<br>+1-925-357-0730 |

# Thank You

# Appendix

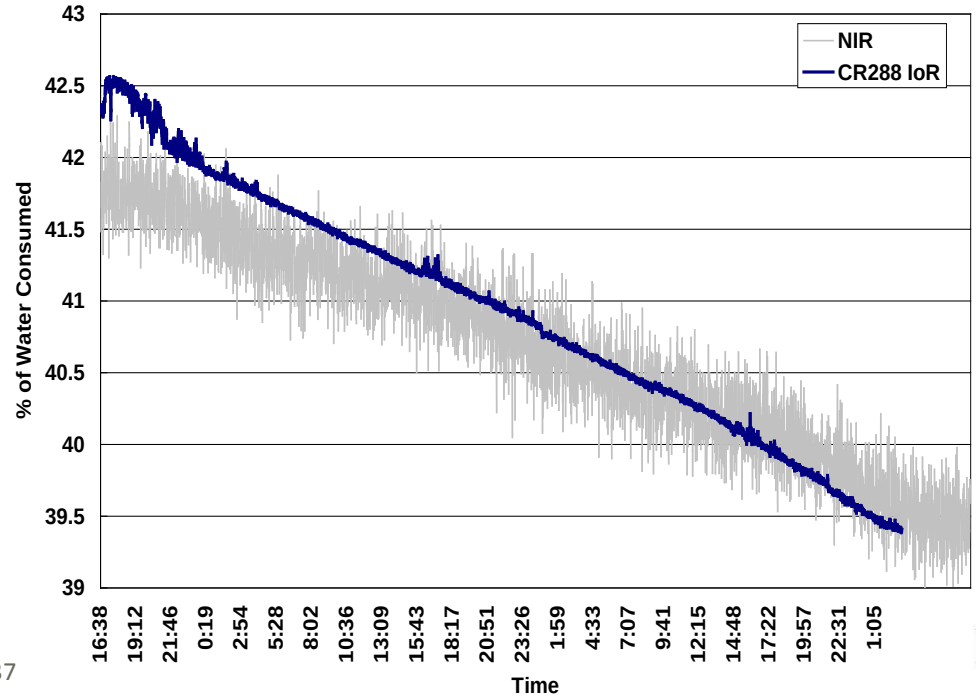
## Additional related CMP and Post CMP monitoring

# CR-288/NX-148 in EKC-265 Post Al etch

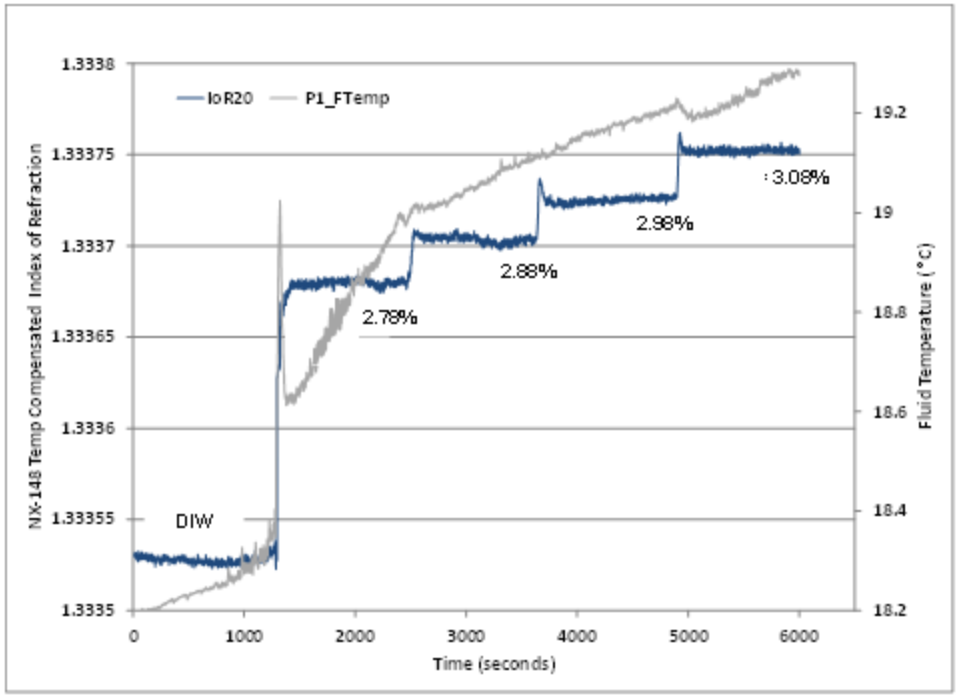


# CR-288/NX-148 Replaces NIR to Monitor Water Consumption in post-CMP Clean Chemistry

- Measurement of a Post-CMP chemical and the percentage of water consumed during wafer processing. Batch wafer process and customer wants to re-fill water as it is evaporated or consumed.
- NX-148/CR-288 has 10X better signal to noise and faster response time (1 sec as compared to >3 sec) than either ABB or Horiba Near-Infrared (NIR) Spectrometers.
- CR-288/NX-148 outperforms NIR



# ESC-784 NX-148 Concentrations for Post-CMP Cu Cleans




- Japan OEM post-CMP Cu cleaning chemistry blended POU in CMP tool.
- Incoming Chemical is high concentration and diluted to target concentration of 2.78 wt%.
- CR-288 monitors POU Blend to insure target concentration of 2.78wt% is met before wafer cleaning.
- CR-288 kit2 is used, one sensor head for each cleaning tank.

# Example of Chemicals Measured by NX-148/CR-288 in Microelectronics

| Process Area | Process Chemicals |
|---|---|
| CMP Slurry Delivery | $H_20_2$, Slurries, KOH |
| FEOL Surface Prep | HF, SC1, SC2, BOE, SPM, $NH_3$, HCl, IPA, $H_3PO_4$, $H_2SO_4$, $HNO_3$, $H_2SO_4$, $NH_4OH$ |
| Post-CMP cleans | DHF, Citric acid, Ammonia, Surface Preparation Chemicals |
| BEOL Surface Prep | Post-etch residue cleansers, solvents, organic acids, DSP+ |
| Photolithography | TMAH, photoresist |
| Electroplating | $Cu^{2+}$, electroplating bath chemistry |
| Thin Film Solar | $Cu^{2+}$, Thiourea, $CdSO_4$, $NH_4OH$ |

# CR-288/NX-148 Performance

## Baseline Performance

- Index of Refraction accuracy (refractive index units) ± 1 x 10-5
- Concentration accuracy:± 0.01%
- Temperature accuracy: 0.01° C
- Temperature resolution: 0.01° C
- Response time: 1.2 sec
- Improvements in baseline performance realized to an extent on environmental conditions, e.g. pressure, temperature and magnetic field fluctuations

## Realized Performance

| Chemical | Resolution |
|---|---|
| $H_2O_2$ | ± 0.01% |
| TMAH | ± 0.005% |
| SC1 | ± 0.004% |
| SC2 | ± 0.004% |
| Slurries | ± 0.01% |
| BTA | ± 0.01% |
| Solvents | ± 0.01% |
| HF | ± 0.005% |