Concentrate Copper Waste Treatment

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emewCorporation

Minimizing Copper Concentrate Waste

- Overview of Copper waste generation from the Chemical Mechanical Planarization (CMP) and Electroplating
- Current process and proposed process
- Technology overview
- Design and performance data
- Expected savings and benefits

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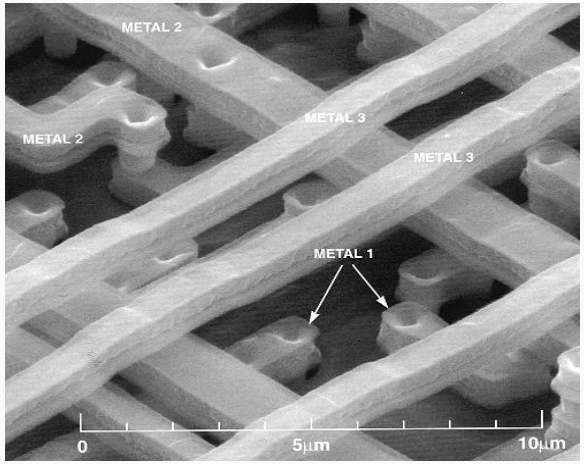
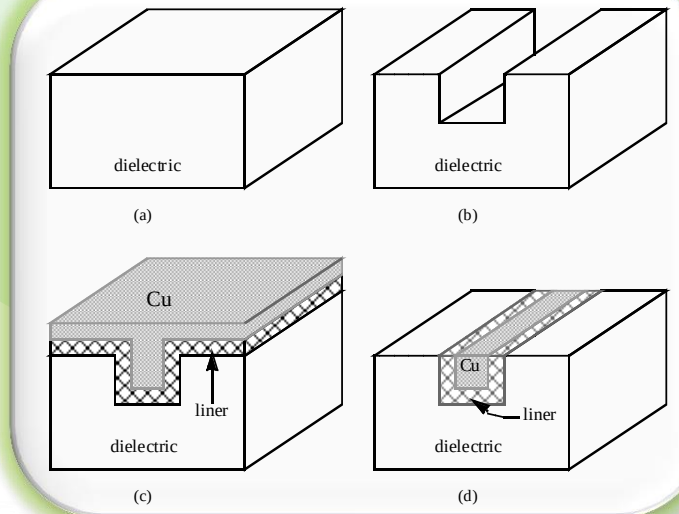
Copper Interconnect

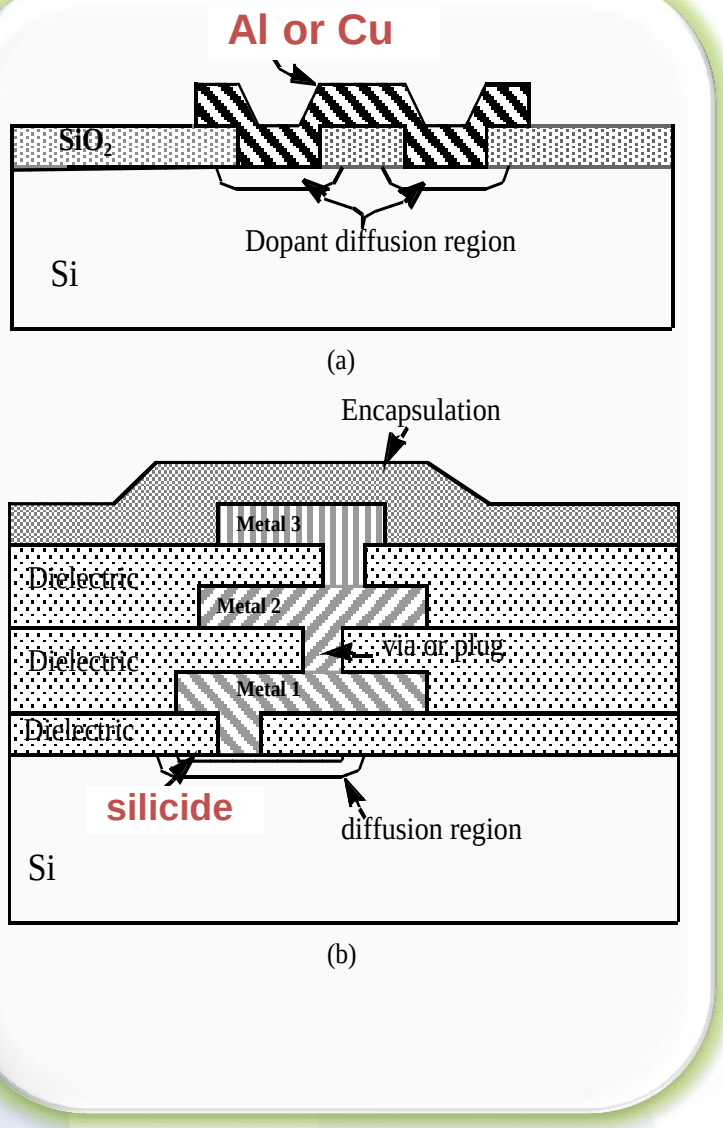
If we had twitter 10 years ago Copper would have been trending….

- About 10 years ago the semiconductor industry transitioned to using copper instead of aluminum for Back End of Line (BEOL) Interconnects
  - Transitioned from Aluminum to Copper conductors
  - Copper is deposited on wafer using CVD, PVD, or Electroplating
  - Copper is removed using Chemical Mechanical Planarization (CMP)

Interconnect – The Back-end Process







Modern Semiconductor Devices for Integrated Circuits (C. Hu)

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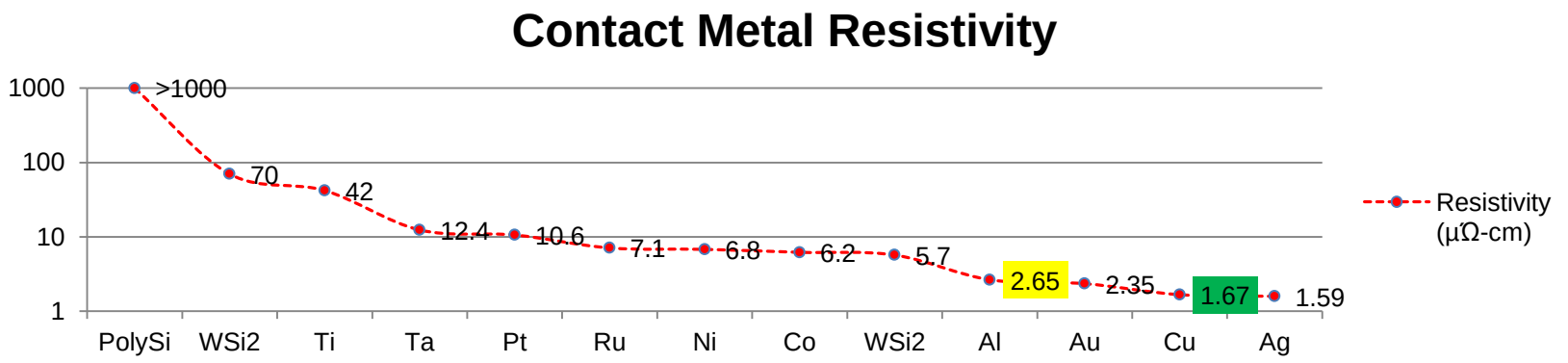
Why Copper?

- Copper Advantages
  - Much lower resistance than aluminum lower power consumption
  - Better alternative for smaller structures
  - Less need for W interconnect eliminates process steps
  - Improved thermal properties at the interface with other materials
  - Cu has excellent electro-migration reliability and 40% lower resistance than Al.



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Why Copper?

- Copper Disadvantage
  - Cross Contamination requires fab separation logistics
  - Copper is susceptible for corrosion needs passivation layer
  - Can not be structured as easy as Al in dry etch processes
    - Copper patterns requires damascene process.
  - Creates Hazardous Waste

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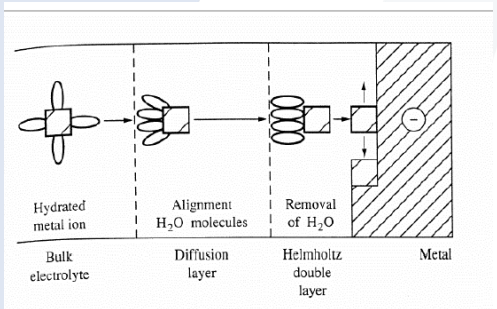
BEOL - The Back-end Process

Electroplating Chemicals

- Copper Electroplating creates concentrated liquid Copper Waste
  - Contains Copper Sulfate
    - 5,000 – 10,000ppm as $CuSO_4$
  - Sulfuric Acid
    - 50,000 – 100,000ppm as H_2SO_4
  - Hydrogen Peroxide
    - 30,000 – 80,000ppm as H_2O_2

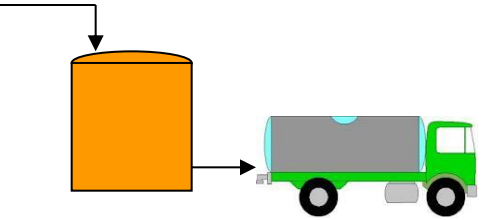


From Roy Magnusun, Endicott Interconnect (IBM)

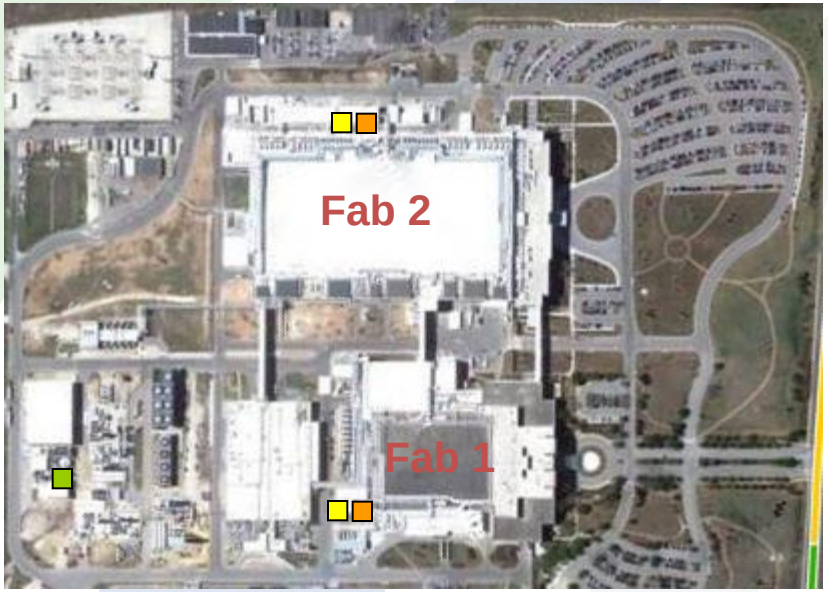
Component	Role	Example
Metal Salt	Source of plating metal	Copper sulfate
Acid Base additive	Provides ionic conductivity	Sulphuric acid
Carriers	Helps increase conductivity into small feature areas	Polyethers or polyoxyethers
Levelers	Improves uniformity of plating thickness	Organic nitrogen compounds, amines, amide, surfactants
Brighteners	Controls brightness and hardness	Sulphur containing compounds
Wetters	Decrease surface tension	Surfactants

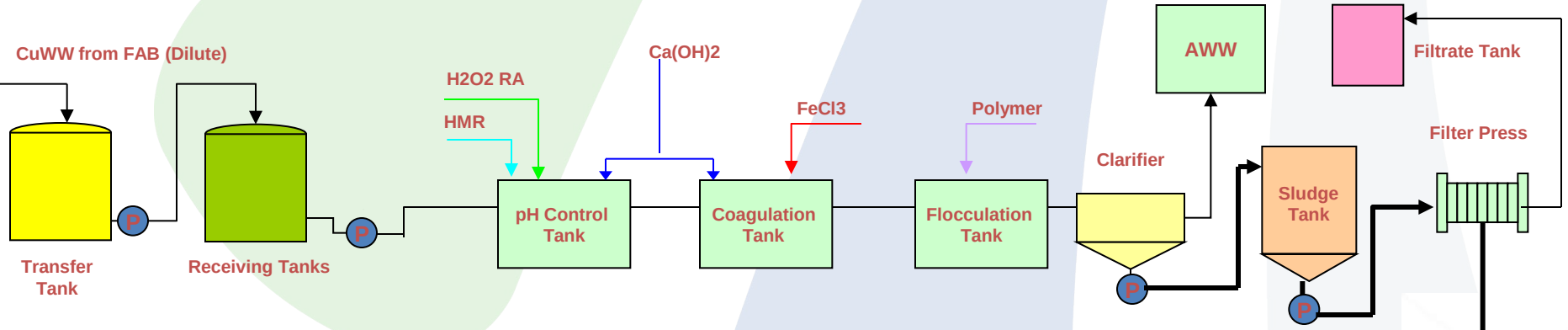
SAS - Copper Treatment (Current)

CuW from FAB (Concentrated)



CuW Composition	Range
Peroxide (ppm)	18,000- 20,000
Cu (ppm)	4,000 – 7,000
Sulfate (ppm)	40,000 - 50,000
Sulfuric Acid (ppm)	36,000 – 50,000





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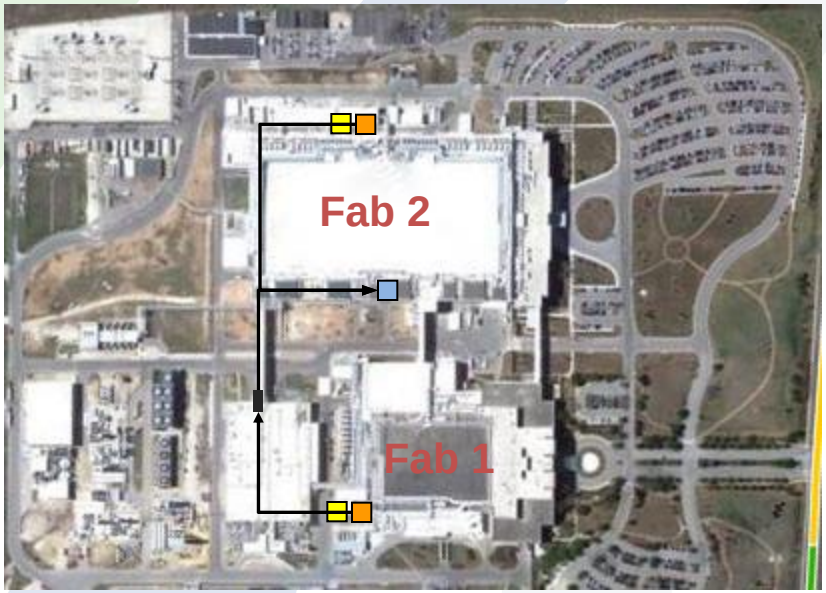
SAS - Electrowin Copper Treatment

CuW from FAB (Concentrated)

CuSO4 – Transport/Disposal
0 gal/year

Cu Harvesting
Up to 60,000lbs/yr



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electro-winner

-ve
+ve

Design includes H_2O_2 destruction as part of the polishing array

CuWW
from FAB
(12ppm)

Cu(<10ppm)

H2O2 RA

HMR

Ca(OH)2

FeCl3

Polymer

AWW

Filtrate Tank

Filter Press

Clarifier

Transfer Tank

Receiving Tanks

pH Control Tank

Coagulation Tank

Flocculation Tank

Sludge Tank

- No Significant change in final CuWW

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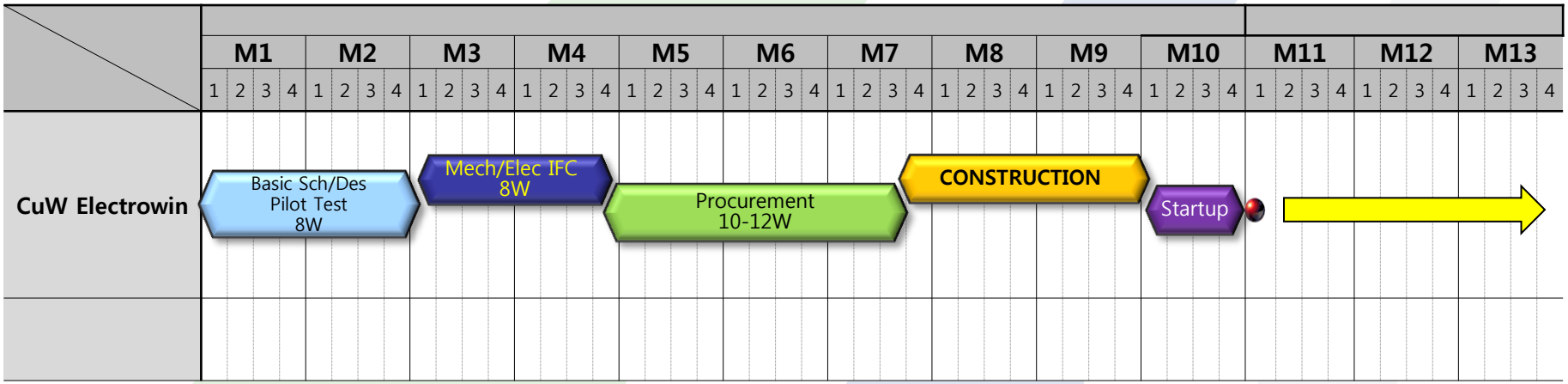
SAS - Electrowin Install Schedule



- Pilot testing part of initial design development
- Visited similar installation after pilot test completed
- Electro winner lead time 12 weeks
- Construction start 8 weeks after design complete and finished in 10 weeks
- OEM team on-site for 6 weeks for startup/training
- Site Operations will monitor system and perform maintenance
- Copper harvesting will be 2 times per week (30-60 minutes per harvest)
- Challenges:
    - Space for electro-winner equipment
    - Distribution of CuW to electro-winner
    - Pumping systems/controls

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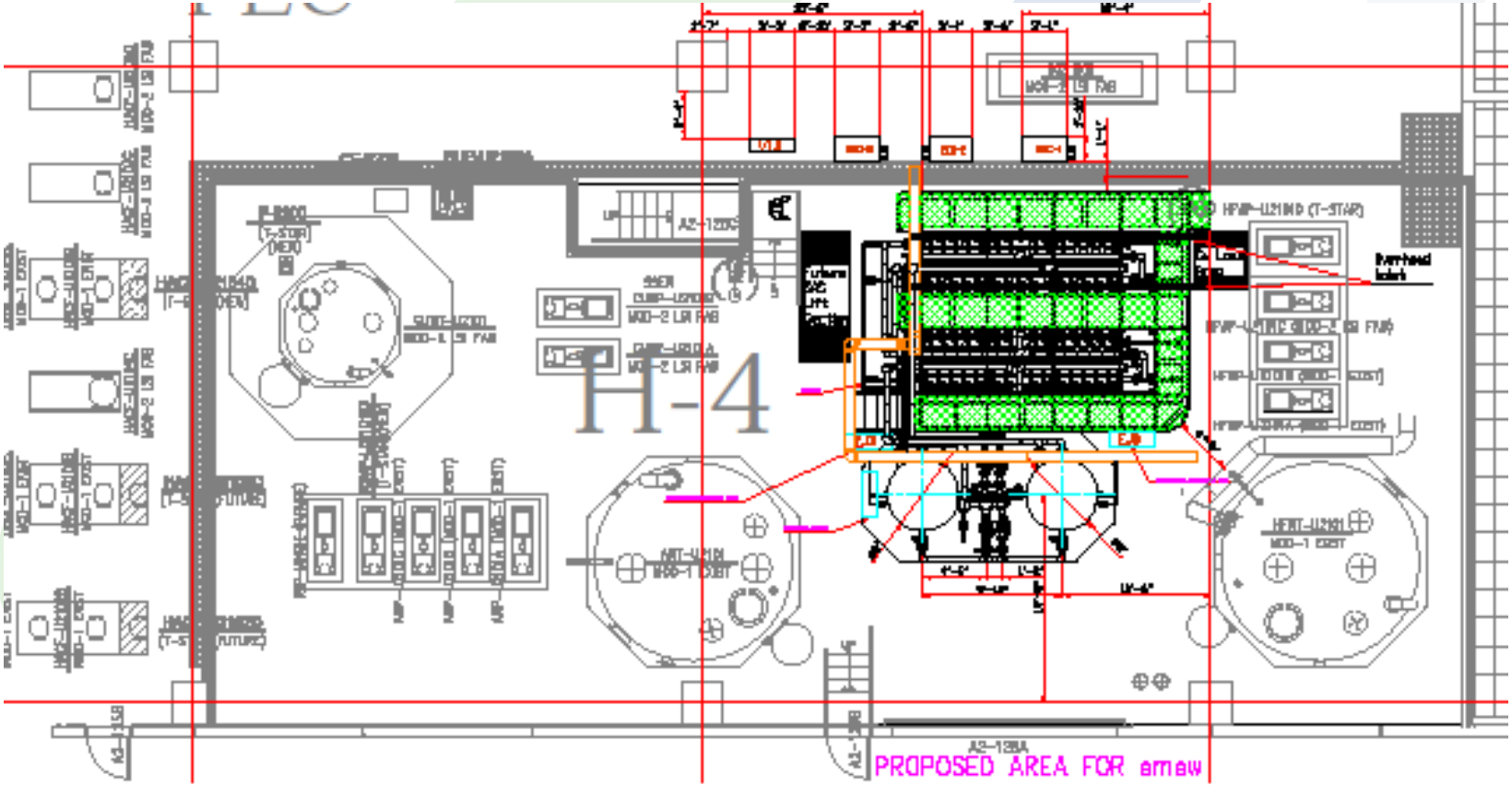
60 Cell Cu Plant Layout



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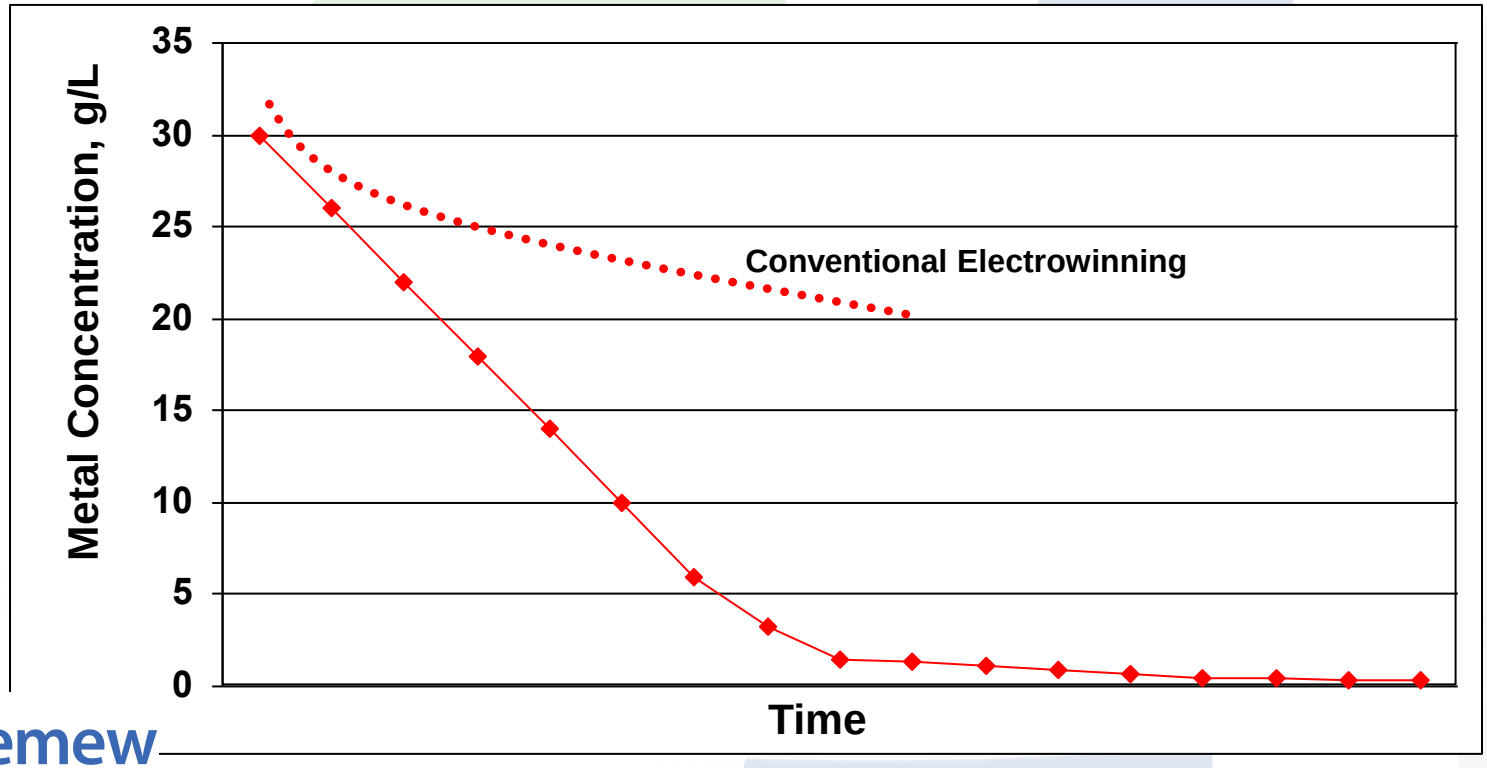
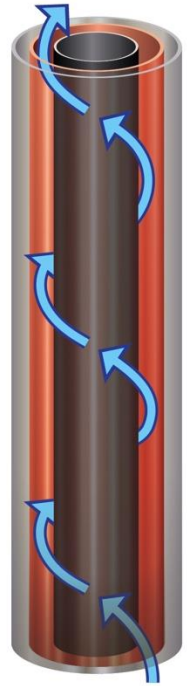
Fundamentals of high mass transfer EW (emew)

- High current efficiency by accelerating the rate which metal ions are presented to the cathode surface.
- Eliminates problems with depletion zones
- Lower feed concentrations, larger ‘bite’





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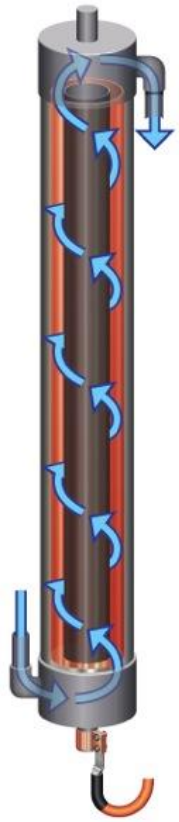
Unique cell design

Starter Sheet, usually SS, is slid inside the body of the emew cell

The metal being recovered is plated onto this removable/reusable starter sheet when current is passed between ANODE and CATHODE.

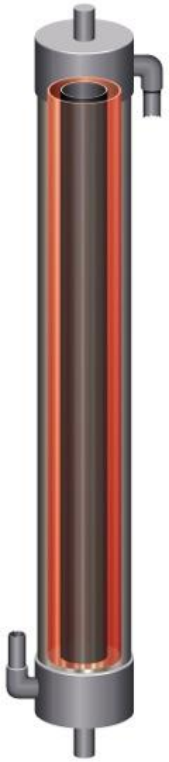


SS pipe with GFABS end caps.

The ANODE runs through the center of the cell.

The inside surface of the pipe is the CATHODE.

SS mesh inserts used for polishing applications



Electrolyte is pumped through the cell from the bottom.

Power is applied to the cell between the ANODE & CATHODE.

Metal begins to plate on the CATHODE

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Bench Scale Kit

1. SAS bench scale trials completed during initial design
2. Demonstrated proof of concept
3. Generated design data

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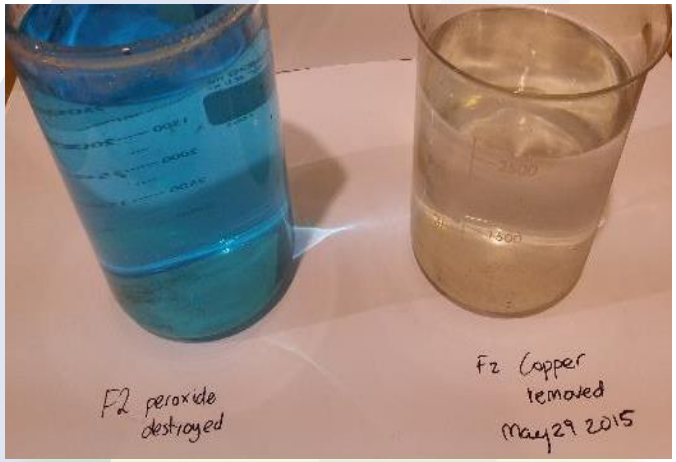
Process steps



1. H_2O_2 **destruction (within emew cell)**

2. Copper recovery (as saleable cathode)

3. Copper depletion (to below 10ppm)

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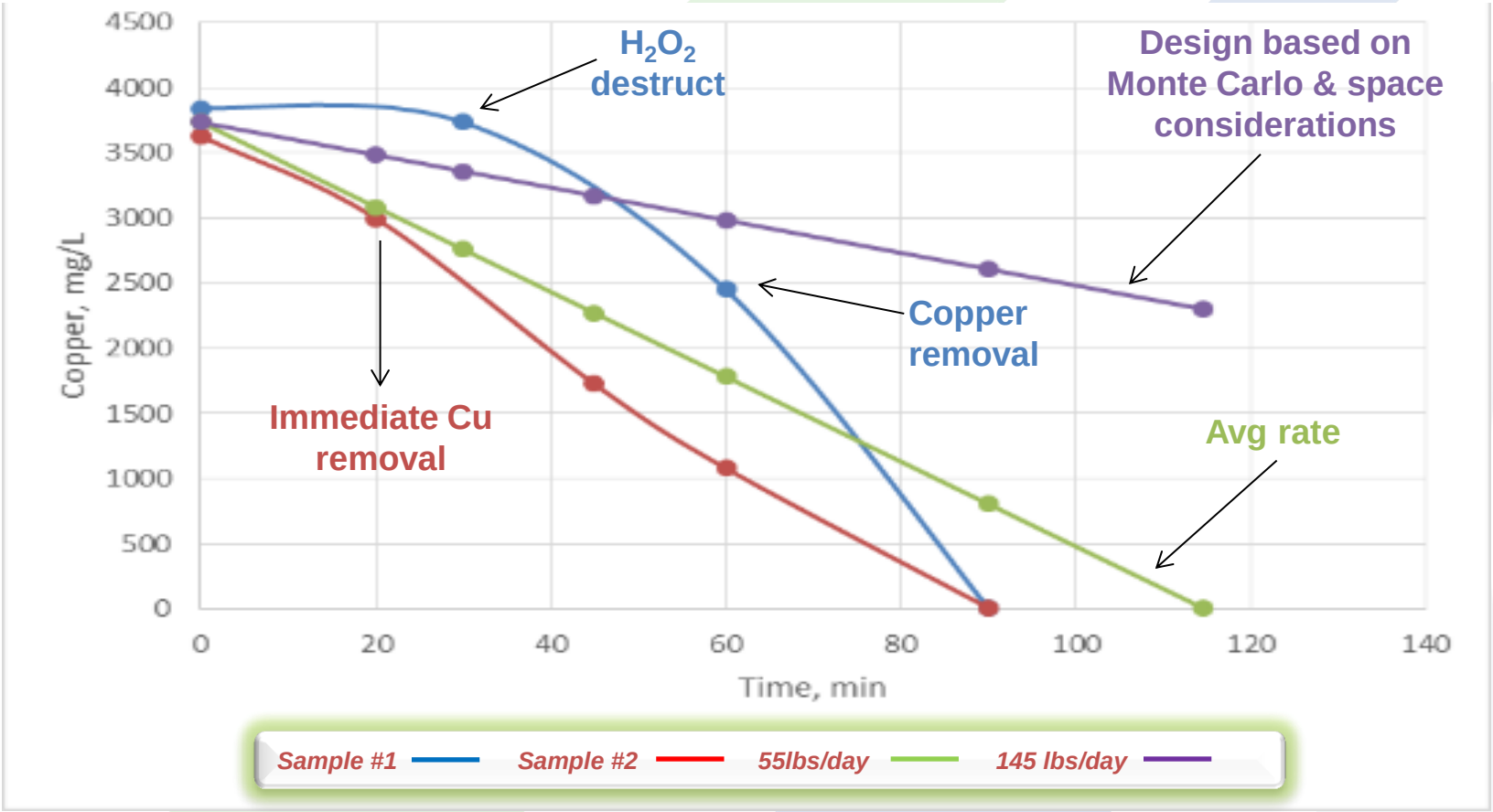
Copper removal from solution



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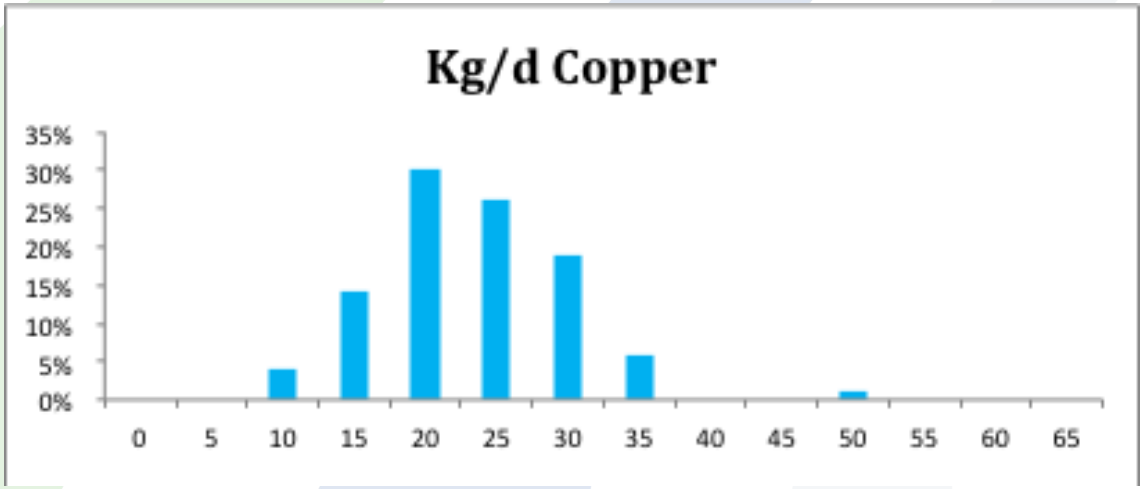
Design and plant sizing using Monte Carlo simulation and actual plant data

	Histogram	Frequency	
0	0	0	0%
0	5	0	0%
0	10	3	3%
0	15	20	20%
1	20	33	33%
0	25	28	28%
0	30	11	11%
0	35	3	3%
0	40	2	2%
0	45	0	0%
0	50	0	0%
0	55	0	0%
0	60	0	0%
0	65	0	0%
0	70	0	0%
0	75	0	0%



Simulation results	
Ave kg/d	25
Min, kg/d	14
Max, kg/d	41
Std Dev, kg/	5

- 100 iterations of Sample1 and Sample2 (volume & Cu conc)
- 99.7% less than 42 kg/d (92.4 lbs/d)
- Design capacity (145 lbs/d) should be adequate

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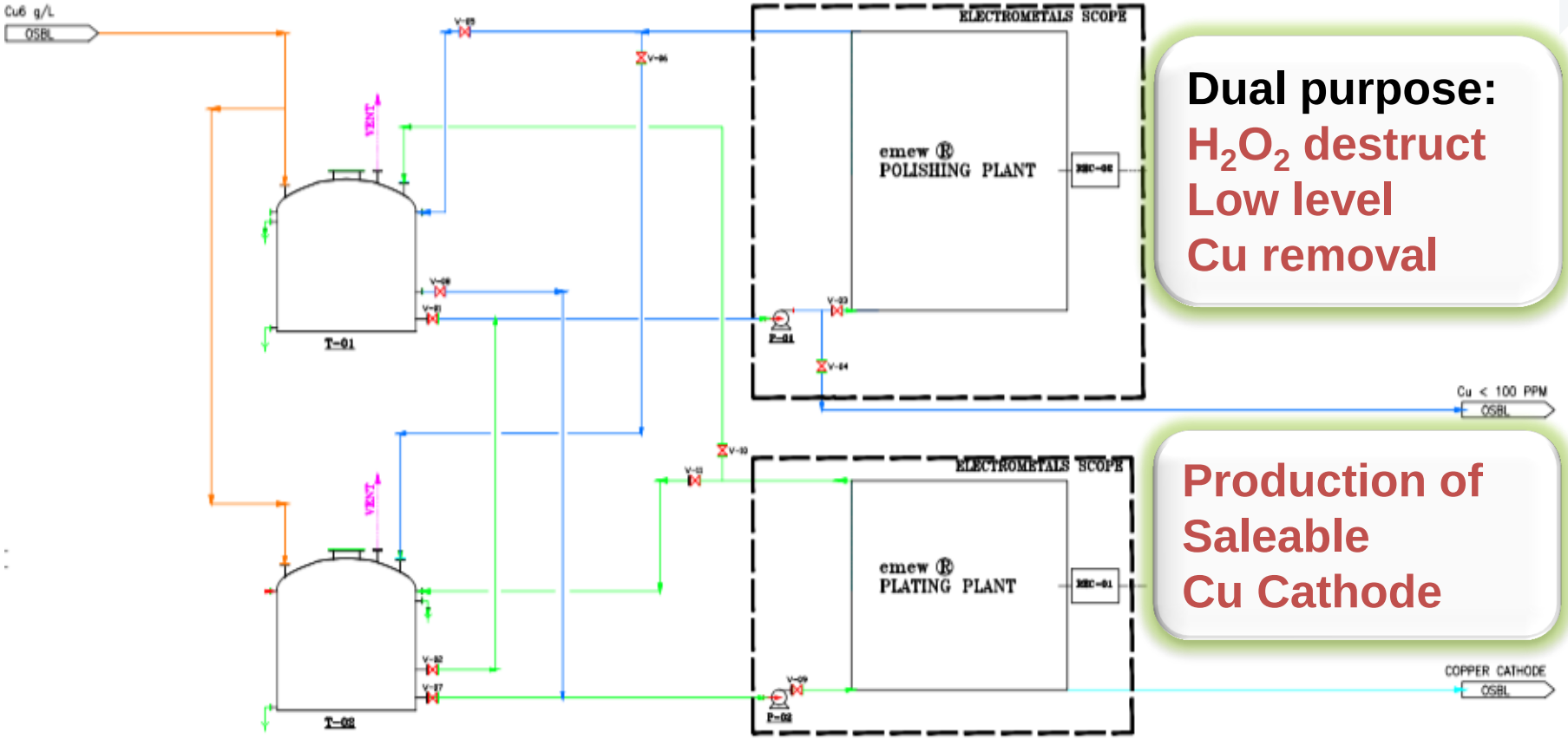
Conceptual Process Flow



Dual purpose:

H_2O_2 destruct

Low level

Cu removal

Production of Saleable Cu Cathode

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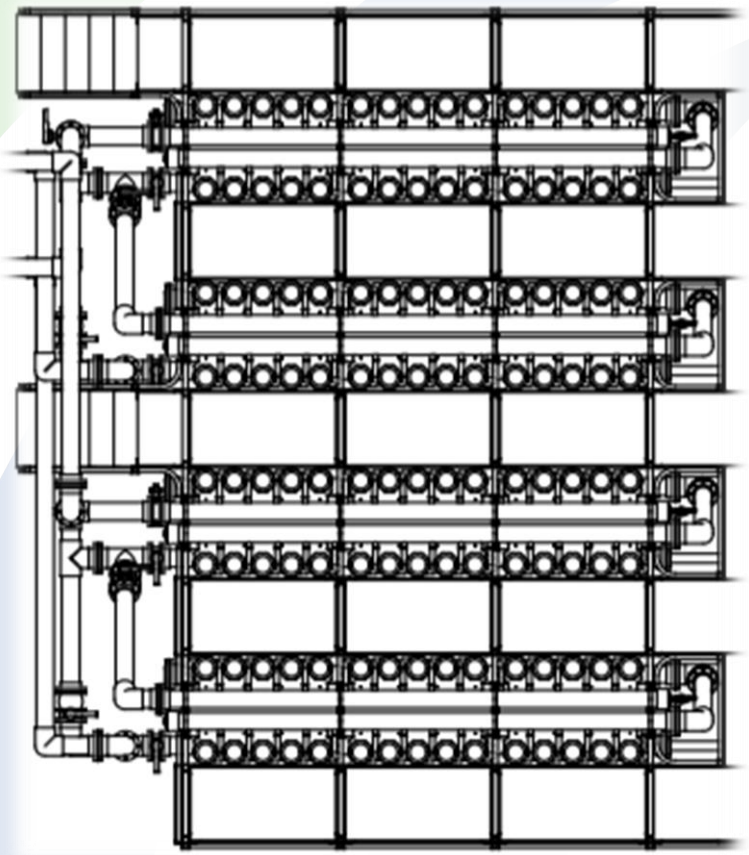
Modular Skid Design



- Compact footprint
- Easy to install
- Accommodates range of throughputs

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Copper cathode produced

- Easy to handle
- Easy to harvest (30-60 seconds each)
- Easy to sell (LME grade Cu)

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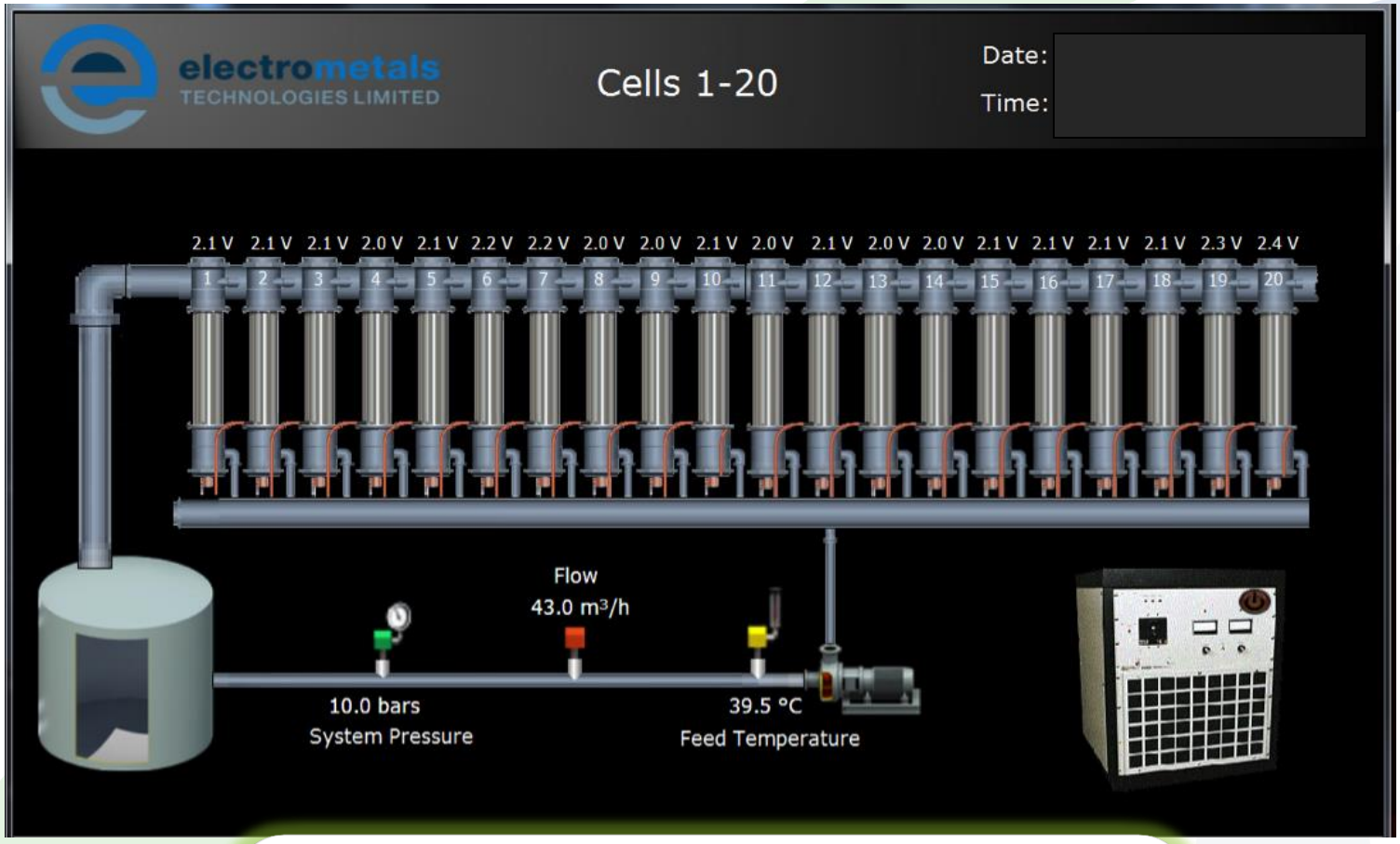
Customizable HMI (process control / voltage monitoring)



- Good operator interface
- Transfer to plant DCS / HMI
- Full access to all data
- Full integration into existing systems

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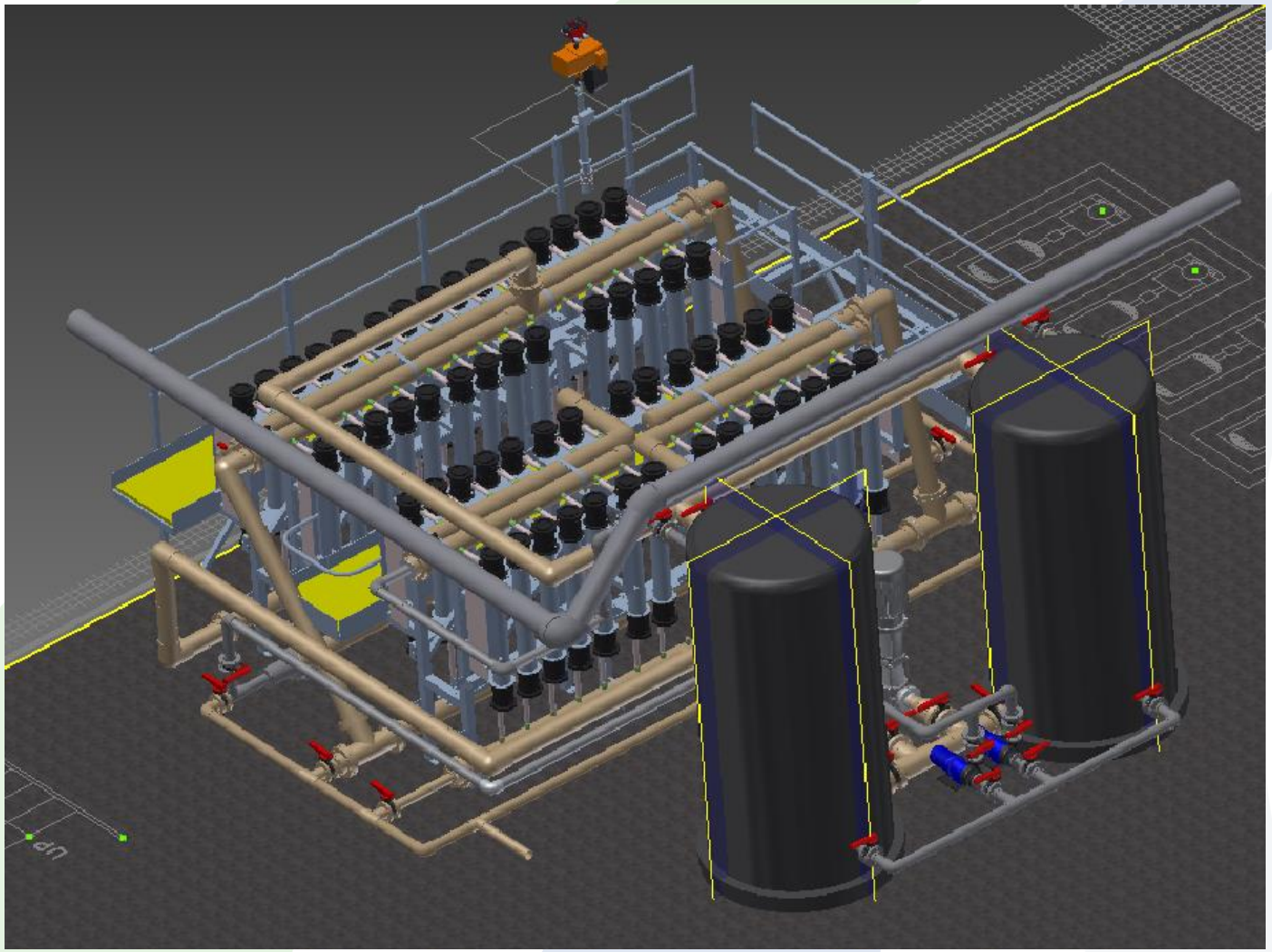
60 Cell Cu Plant Layout

3 Dimensional Rendering



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Electrowin Copper Waste Treatment

Pros

- Eliminates shipments CuW liquid waste
- Produces up to 60k lbs/yr Cu as revenue
- Proof of concept lab scale pilot
- Reduces RECRA reportable hazardous waste shipments
- Good Environmental Stewardship
- 12 month ROI

Cons

- Capital investment
- Install CuW distribution from waste collection points
- Utility Cost
  - Electrical cost is 3kWh/Kg Cu produced
  - Wastewater cost
- Maintenance costs for anode recoating
- Labor to operate
  - 2 techs for 30 minutes every 4-5 days to harvest Cu

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Electrowin Copper Waste Treatment

- ✓**Ideal solution for copper waste treatment in semiconductor plants**
- ✓**Economical, effective method that takes Cu waste and converts it into a saleable product**
- ✓**Promotes Environmental Stewardship for the Semiconductor Industry**

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