Hydrogen

Opportunities

Rohen Bhatnagar
OEM & New Fields Manager

mks | Atotech

mks

Atotech, a global, leading brand in surface-finishing solutions

Founded in **1993**

$1.5bn in sales (2021)

Almost **2,400** total patents in our portfolio as of today

Present in more than **40** countries, serving over **8,000** customers worldwide

48% of our R&D projects are devoted to sustainable goals

3 regional HQ
15 TechCenters
17 production sites

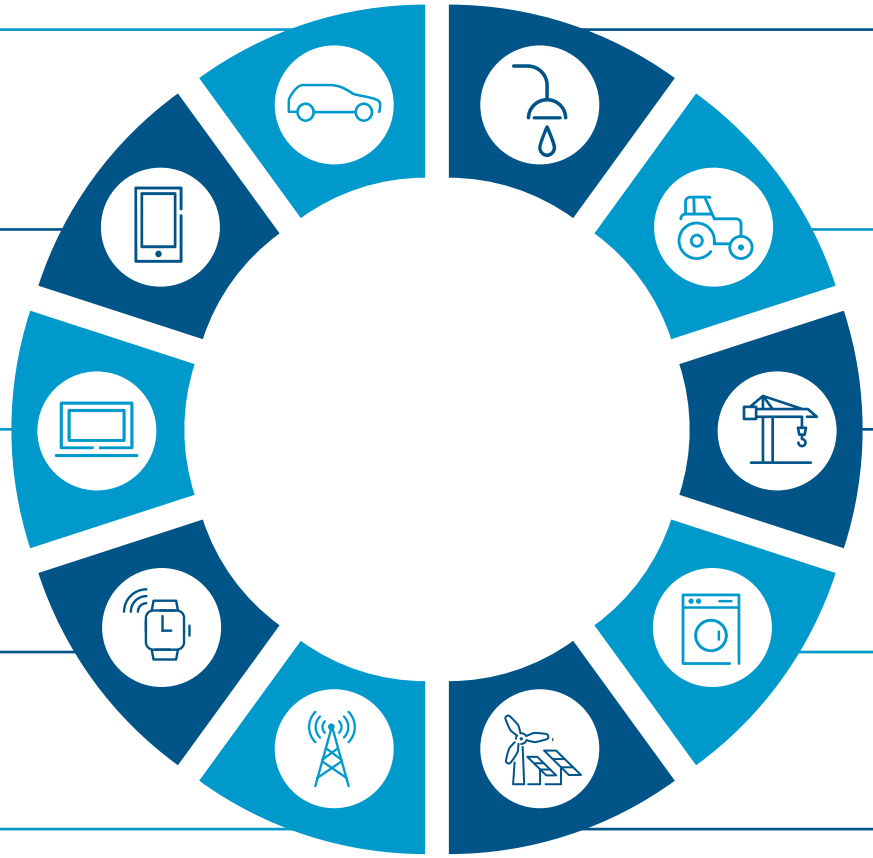
Over **4,000** experts

230 kt/year production capacity

As of December 2021

We serve multiple end markets and industries

- Automotive
- Smartphone
- Computing
- Consumer electronics
- Communication infrastructure



- Sanitary
- Heavy machinery
- Construction
- Household appliances
- Energy

Company overview

EMPLOYEES WORLDWIDE

~10,000

TOTAL CUSTOMERS ACROSS THE GLOBE

33K+

2021 PRO FORMA REVENUE(3)

$4.4B

2021 PRO FORMA R&D INVESTMENT(3)

$253M

LEADING POSITION IN 24 CATEGORIES(1)

24

SEMI CHIPS MADE w/ MKS PRODUCTS(2)

~100%

2021 PATENTS WORLDWIDE(3)

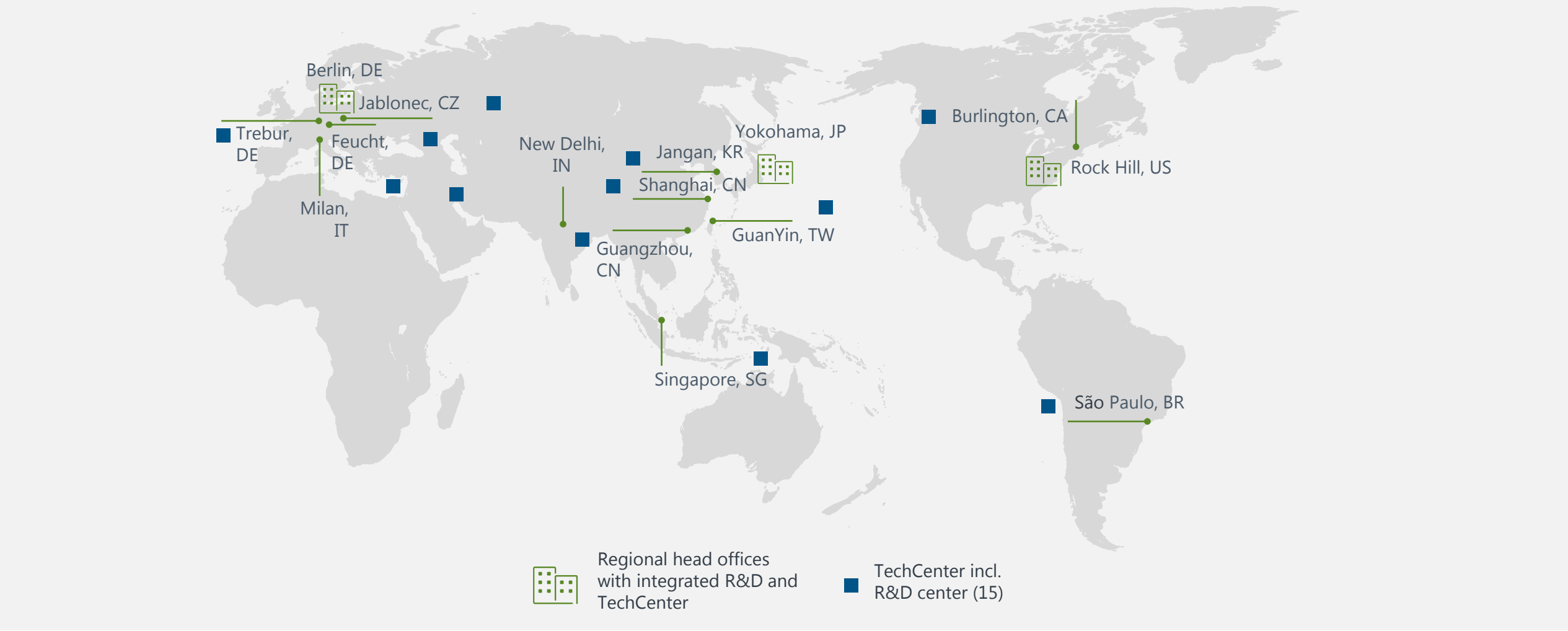
3,800+

ENGINEERS AND SCIENTISTS

2,000+

(1) Product categories where Company estimates it is #1 or #2;
(2) Internal Company estimate;
(3) Pro forma revenue consists of revenue for 2021 for MKS and Atotech and R&D investments consists of R&D expenses for 2021 for MKS and Atotech. Patents consist of issued patents for MKS and Atotech as of December 31, 2021

Our TechCenters



as of April 2022

Atotech Development Center (ADC) in Manesar

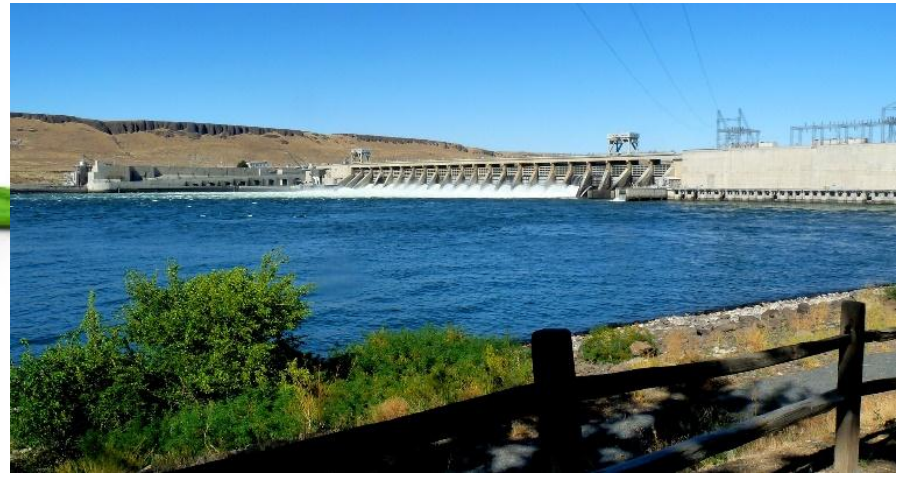
Key facts	
20,000 square meters	
140	employees + 50 support
17	plating lines
39	labs
3	customer support pilot lines

ADC

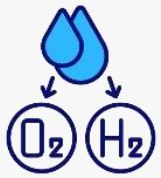
ADDS SPEED TO OUR R&D PROGRAMS!

Green energy

Green energy is a tight resource

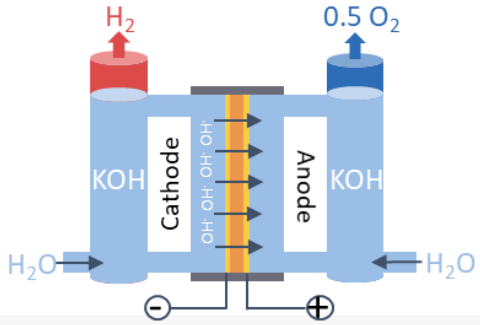
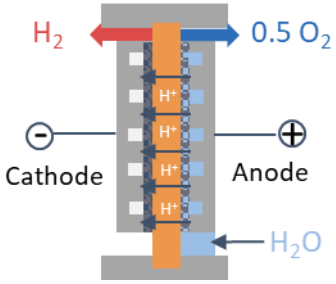
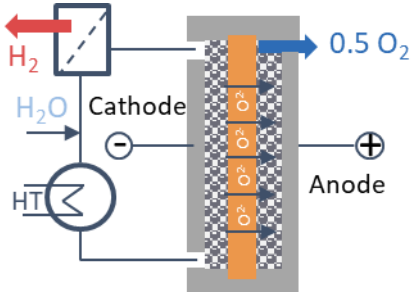


Hydrogen Economy

	Generation	Storage and Transport	Use
			
Examples	• Alkaline Electrolysis (AEL) • Polymer Electrolyte Membrane (PEM) • Solid Oxide Electrolyser Cell (SOEC)	• Tanks and pipes • Compressed H2 • Cryo-compressed H2	• Polymer Electrolyte Fuel Cell (PEFC) • Solid Oxide Fuel Cell (SOFC)
Atotech Solutions Supports	• **Electrolysers** • Purification 	• Valves • Seals 	• **Fuel Cells** 

Atotech is contributing to reduce CO_2 emissions and supporting the H_2-industry in technical challenges

Electrolyser

	AEL	PEM	SOEC
			
Electrolyte and Charge Carrier	• Liquid electrolyte • Alkaline • KOH/OH-	• Polymer membrane Electrolyte • Acidic • H^+	• Solid Electrolyte • Ceramic Oxide • O^{2-}
Electrode & Bipolar-plate	• Raney Nickel • Stainless steel / EN or Ni • Cast Iron / EN or Ni	• Precious metals (Platinum/Iridium) • New concepts like Pt/Ni alloy	• Ni-Cermet, Perovskite
Atotech Solution	• ELeVEN® LP 350 (Low P EN) • Nichem MP 1188 (Mid P EN) • Ni/Fe	• Nichem® HP 1170 (high P EN) • Platinor®	• Atotech are looking for opportunities in this field to develop suitable processes

Atotech's metallisation processes to increase efficiency and long term stability

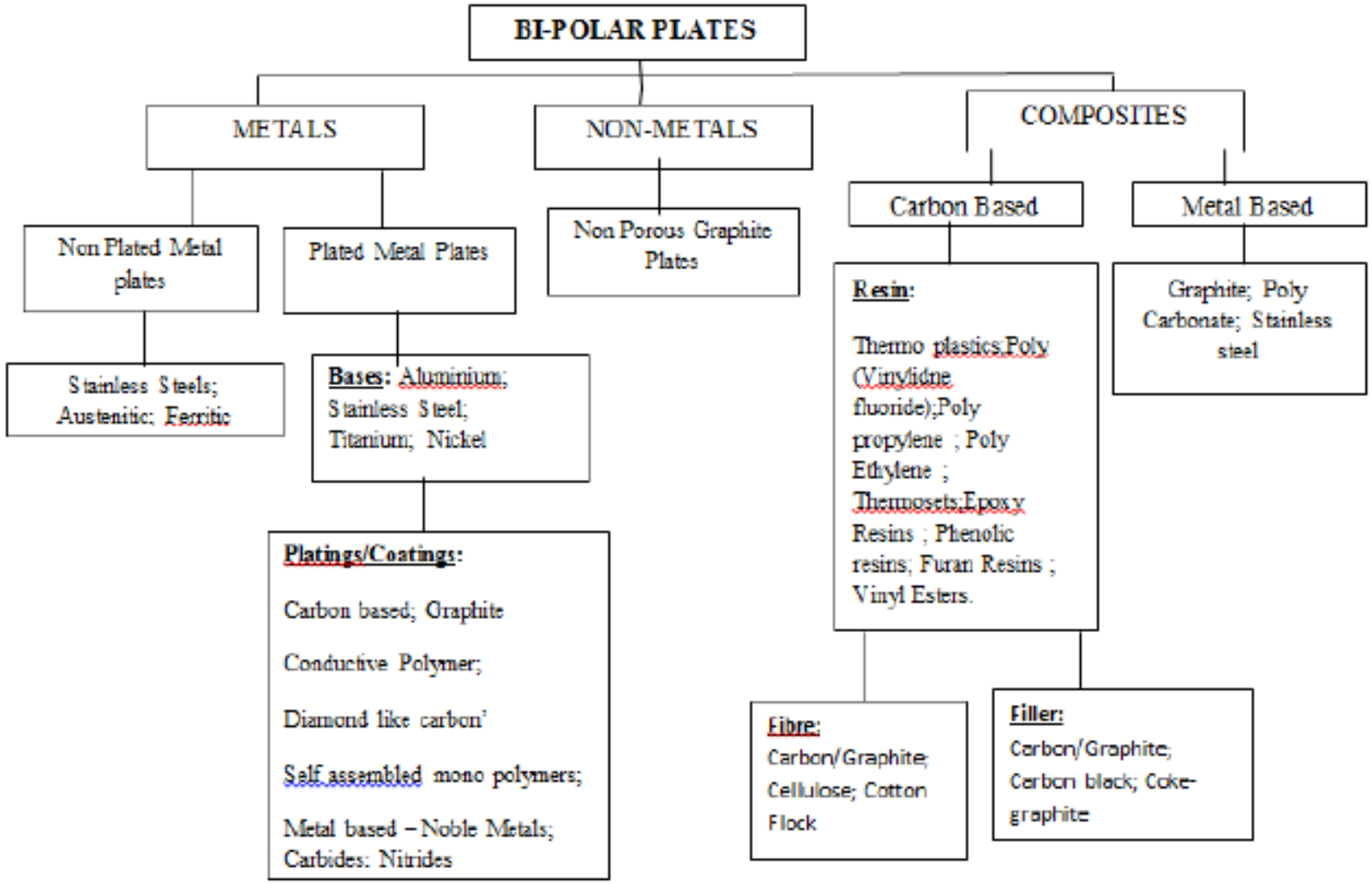

The Missing Piece

Bipolar Plate a Key Component

- **Metallic Plates**

- **Advantage**
  - High electrical conductivity, formability and manufacturability, low gas permeability & superior mechanical properties
  - Higher strength, toughness and shock resistance than graphite plates

- **Disadvantage**
  - Corrosion: Leading to formation of a thin oxide layer on their surface.



Electroplating – A Multi Faceted Solution

Criteria

- Strong adhesion
- Impermeable to fuel cell reactant gases
- Chemically stable or inert
- Conductive

Why Electroless Nickel

- Plated as a NiP alloy
- Electroless as a process forms an uniform coating
- Versatile – ranging from Low P to High P
- Stable across range of pH
- Balance of hardness and corrosion resistance

Surfacing Finishing Solutions

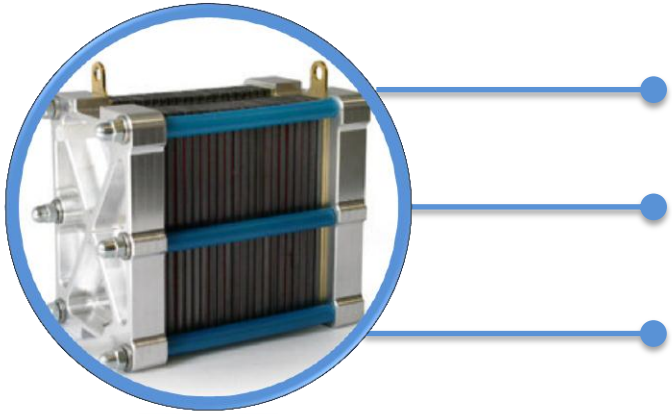
Electroless Nickel for AEL

Plating processes

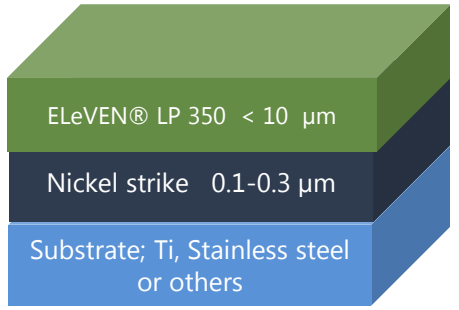
ELeVEN® LP 350

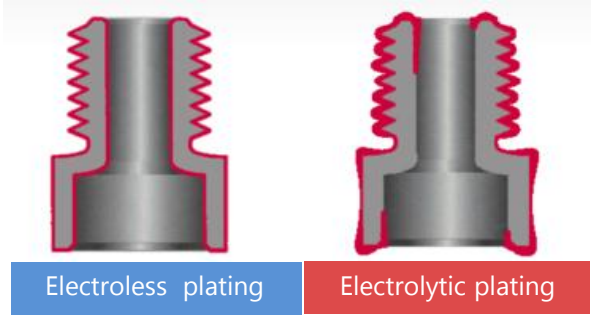
Low Phosphorus electroless nickel process

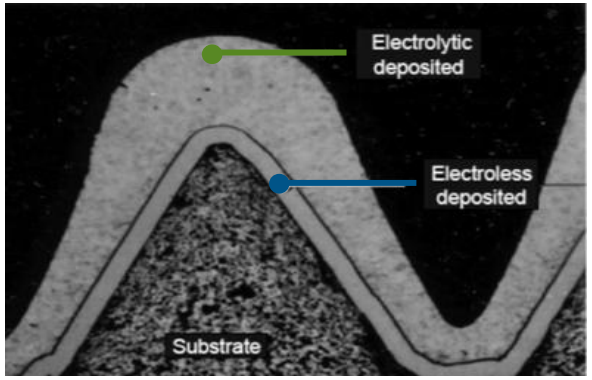
High corrosion resistant in Alkaline environments



- Bipolar Plates
- Cathode
- Anode







Electrolytic Ni = >99.5% Ni
EN = Ni & P alloy (1-12% P)

- High corrosion resistance to alkaline conditions
- Uniform coating thickness distribution for complex shaped parts with deep recesses compared to electroplating processes
  - Chemical process which does not require external power supply, thus not affected by current distribution
- Phosphorus content: 1-4% w/w
- Plating speed: 14-20 µm
- Internal stress: Compressive

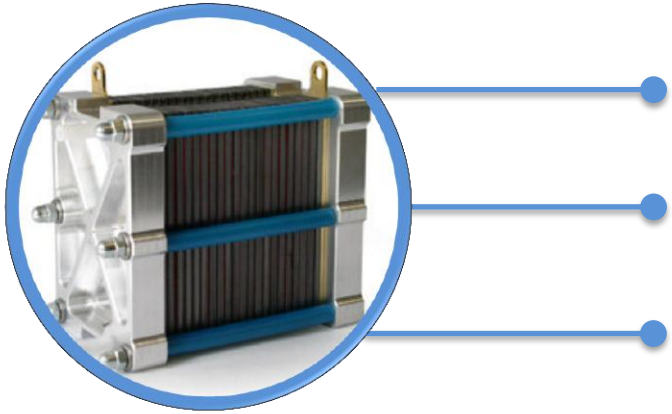
Surfacing Finishing Solutions

Electroless Nickel for PEM

Plating processes

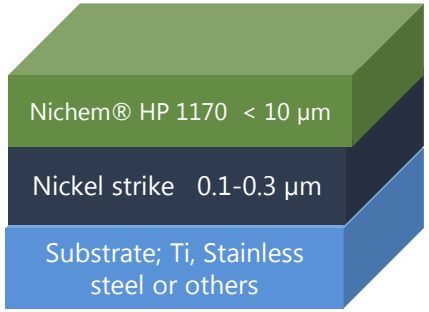
Nichem® HP 1170

High Phosphorus electroless Nickel process with high corrosion resistance to acidic environments



- Bipolar Plates
- Cathode
- Anodes?

- Exceptionally high level of corrosion resistance in acidic conditions
- Ideal coating for cathodes and Bipolar plates
- Uniform thickness distribution
- Phosphorus content: 10-12% w/w
- Plating speed: 8-12 µm
- Internal stress: Compressive



- Immersion in HCl 15% v/v for each cycle
- Temperature: 82°C [180 F] maintained using water bath
- Time: 4 hours / cycle
- Panels coated with 60-65 µm EN rinsed, dried, examined, and weighed after each cycle
- Application of multiple cycles allowing comparison

Mid-P EN (after 1 cycle)

Pb based high-P EN (after 1 cycle)

High-P EN (Pb free) (after 1 cycle)

Nichem® HP 1170 (after 4 cycles)

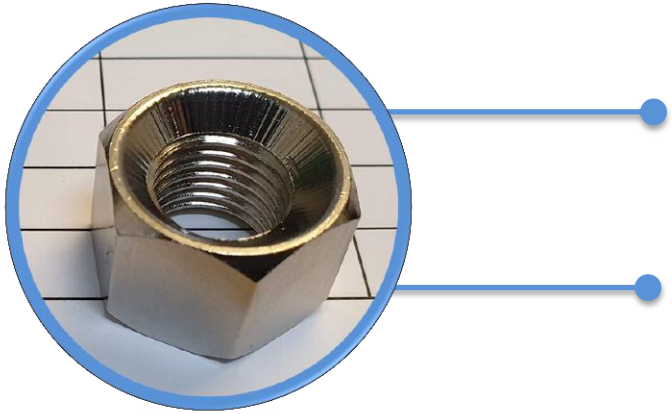
Surface Finishing Solutions

Fastener plating for electrolysers

Plating processes

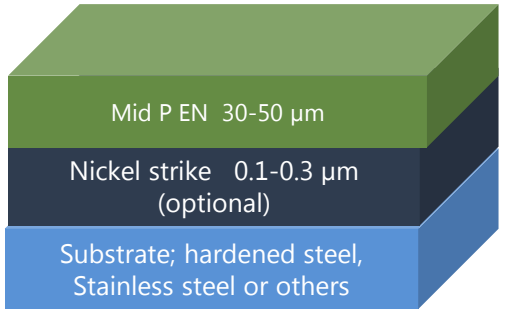
Nichem® MP 400
Or
EDEN® 113 Bright

Bright Mid P electroless for corrosion protection and bright appearance



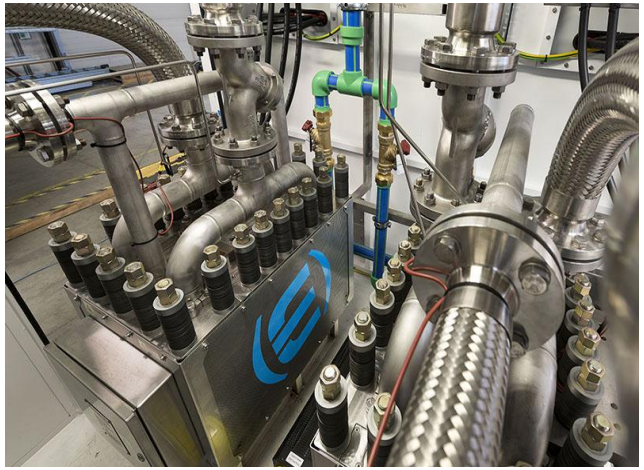
Fasteners for pipes

High corrosion requirement



The metal stack of choice for the electrolyser periphery component:

- Fasteners other periphery equipment used on the electrolyser stack & pipework
- High corrosion requirements
- Uniform thickness (25-50µm)
- Coating should be cosmetically appealing



Curtsey of Cummins

Surfacing Finishing Solutions

Electrolytic

Pd/Ni	Ni/W	Fe/P	Zn/Ni	Ni/Fe
Ag	Au	Pd	Pt	Ru/Rh
Cu	Ni	Sn	Zn	

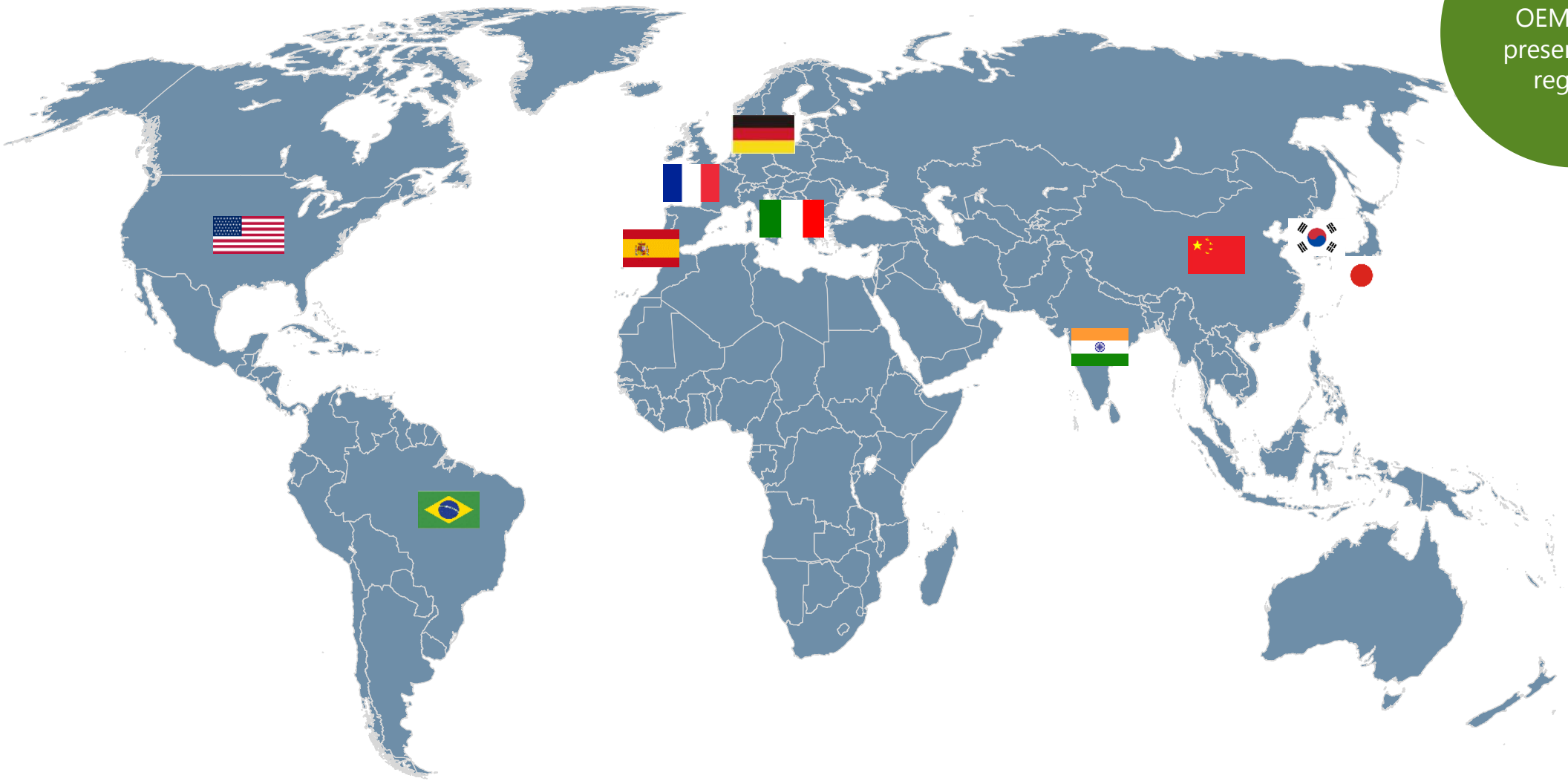
Electroless

Ni/P (1-4% P)	Ni/P (10-12% P)	Ni - Composite (PTFE/SiC/Diamond)
Ni/P/ Mo	Ni/P/ Mo/W	
ENIG		

Contact us to find the best process matching your needs to increase efficiency and long term stability

Surfacing Finishing Solutions

The worldwide OEM team present in all regions



Thank You
Contact Info:

Rohen Bhatnagar
OEM & New Fields Manager , India
Materials Solutions Division
MKS Instruments

Atotech India Private Limited
Plot No. 446 - G & H, Sector-8, IMT Manesar Gurugram – 122050
Main: +91 124 6447900, Mobile: +91 9899890174
Rohen.bhatnagar@atotech.com
www.atotech.com
www.mksinst.com