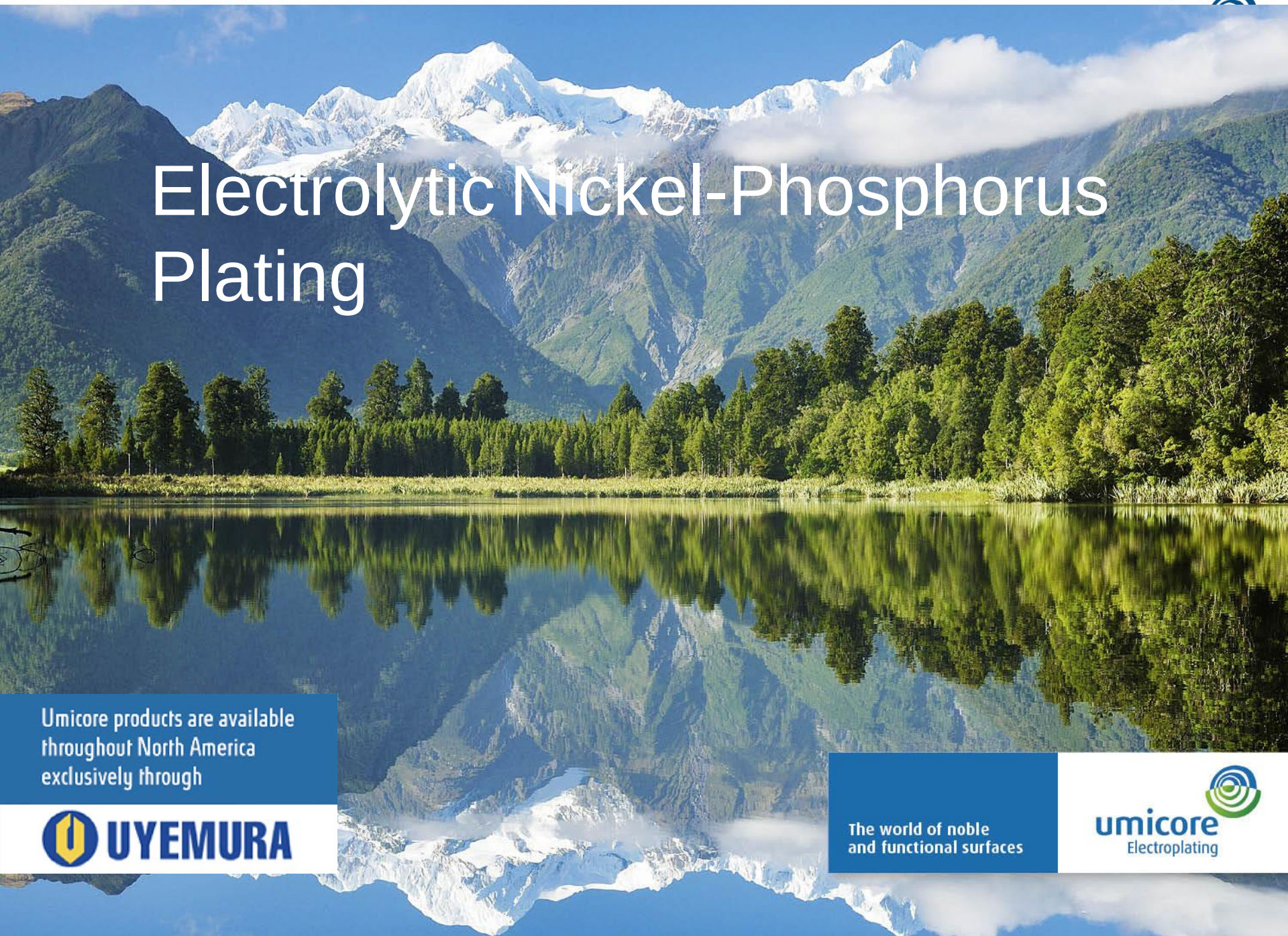
Electrolytic Nickel-Phosphorus Plating



Umicore products are available throughout North America exclusively through

UYEMURA

The world of noble and functional surfaces

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“Electrolytic Nickel-Phosphorus Plating“

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Discussion

- NIPHOS® E-Plated Nickel Phos: Characteristics
- E-Plated Nickel Phos: Advantages
  Reasons for Interest
- E-Plated Nickel Phos: Electrolyte Specifications
- E-Plated Nickel Phos: Layer Properties
- E-Plated Nickel: Applications / Markets
- Summary Future Outlook

E-Plated Niphos®

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Coating Characteristics

Electroplated Alloy composition	Nickel 88 - 94 %
	Phosphorus 6 - 12 %
	Diamagnetic (P > 11 %)
Hardness	550 - 600 HV, without heat treatment
Abrasion	2 mg/1000 strokes (Bosch-Weinmann)
Ductility and Color	Same as bright nickel
Corrosion resistance	Very good – Excellent

Advantages of E- Plated Nickel Phosphorus

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- **Highly Competitive Processing Cost -** bath is simple to maintain, lasts a long time and has no heavy metals
- **Robust Electrolyte -** wide processing window, tolerence to metal contamination
- **Fast processing speed -** including Connector and reel to reel applications
- **Corrosion Properties -** superior to Bright Nickel and Equal to Electroless Nickel
- **Ultimate corrosion and diffusion barrier layer -** (e.g. AuCo , Ag, gradient % P layers and numerous electronic applications)
- **Diamagnetic properties -** will expand use in High Frequency Applications
- Ideally Suited to **Improve the Current Chromium** plating Process of Record (POR)

E- Plated Nickel Phos: Advantages / Considerations
Why Interest over Electroless Nickel ?

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Electrolytic Nickel Phosphorus

- **Easy to maintain**... insol / soluable anodes
- **Lower Cost: operation and make-up**
- **Lasts a long time, stable bath**
- Velocity ..fast plating time, reel to reel
- No heavy metals, halogenates or sulphur
- No plate out or tank passivation req
- Lower operating temperatures
- Wide window for metal contamination
- Improved throwing power
- **Gradient Layers by adjusting Phos content to achieve enhanced performance in the same bath**

Electroless Nickel

- Difficult to maintain
- Higher Cost: for operation and make-up
- Low MTO, freq dumps
- Slower plating time
- Heavy metals, halogenates
- Requires tank passivation
- Higher operating temperatures
- Susceptible to metal contamination
- **Excellent throwing power all E-plated Nickel baths**
- Fixed Phos content high or low

NIPHOS® - E-Plated Nickel Phos

Basic Electrolyte Solution

NIPHOS® - Electrolyte

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Characteristics

Nickel	80 g/l (70-90 g/l)
Phosphorus	25 g/l (20-30 g/l
pH-value	2.5 - 2.7
Temperature	60 °C
Current density	4.0 A/dm² Rack 1.5 A/dm² Barrel
Plating speed	0.4 µm/min 1.5 um/min
Soluble or insoluble	(Pt/Ti) anodes can be used
Rack or Barrel	both plating options are available

Electrolyte Plating Characteristics

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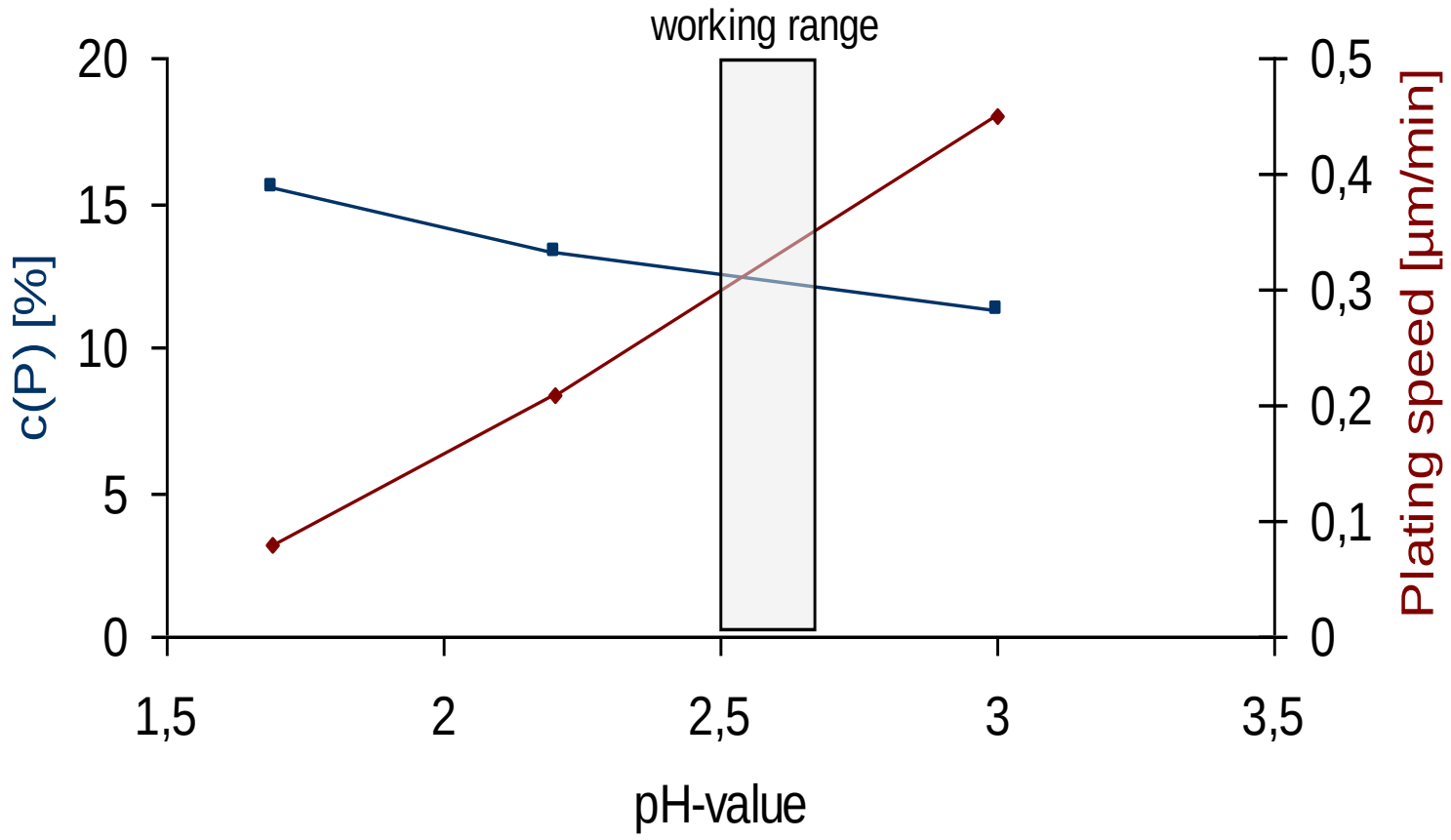
pH - Dependancy on P – content in the Layer (Rack, 4 A/dm²)



Thickness Distribution / Throwing Power

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Standard Connectors – Thickness Distribution in µm

Connector used	White Bronze	Nickel-Phosphorus	Bright Nickel	Bright Tin	Gold on NiP
	3,13	5,82	5,26	3,64	0,24
	2,88	3,92	3,34	3,06	0,23
	2,76	2,74	2,07	1,94	0,21
	2,56	2,76	1,52	2,52	0,21
	2,60	2,86	1,52	1,85	0,20
	2,91	3,21	1,48	2,28	0,21
	3,12	4,05	2,72	2,81	0,22
	3,41	6,42	9,75	4,06	0,20

Electrolyte Tolerance to Impurities

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2X - 4X Improvement

Electrolyte Type	*Tolerance to Impurities*
Nickel-Phosphorus	*Zn and Cu up to 200 mg/l*
Bright Nickel	*Zn und Cu up to 50 -100 mg/l*
Electroless Nickel	*Zn und Cu up to 25 - 50 mg/l*

NIPHOS®

Deposit Layer Properties

NIPHOS® - Layer Properties

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Base Characteristics E-Plated NiP

Phosphorus content:	11 – 13%
Hardness:	appr. 550 HV Heat Treat to 1300 HV
Corrosion and Wear Resistance	Excellent
Color :	Stainless Steel like appearance
Leveling Power:	Retains Brightness

Hardness Comparison

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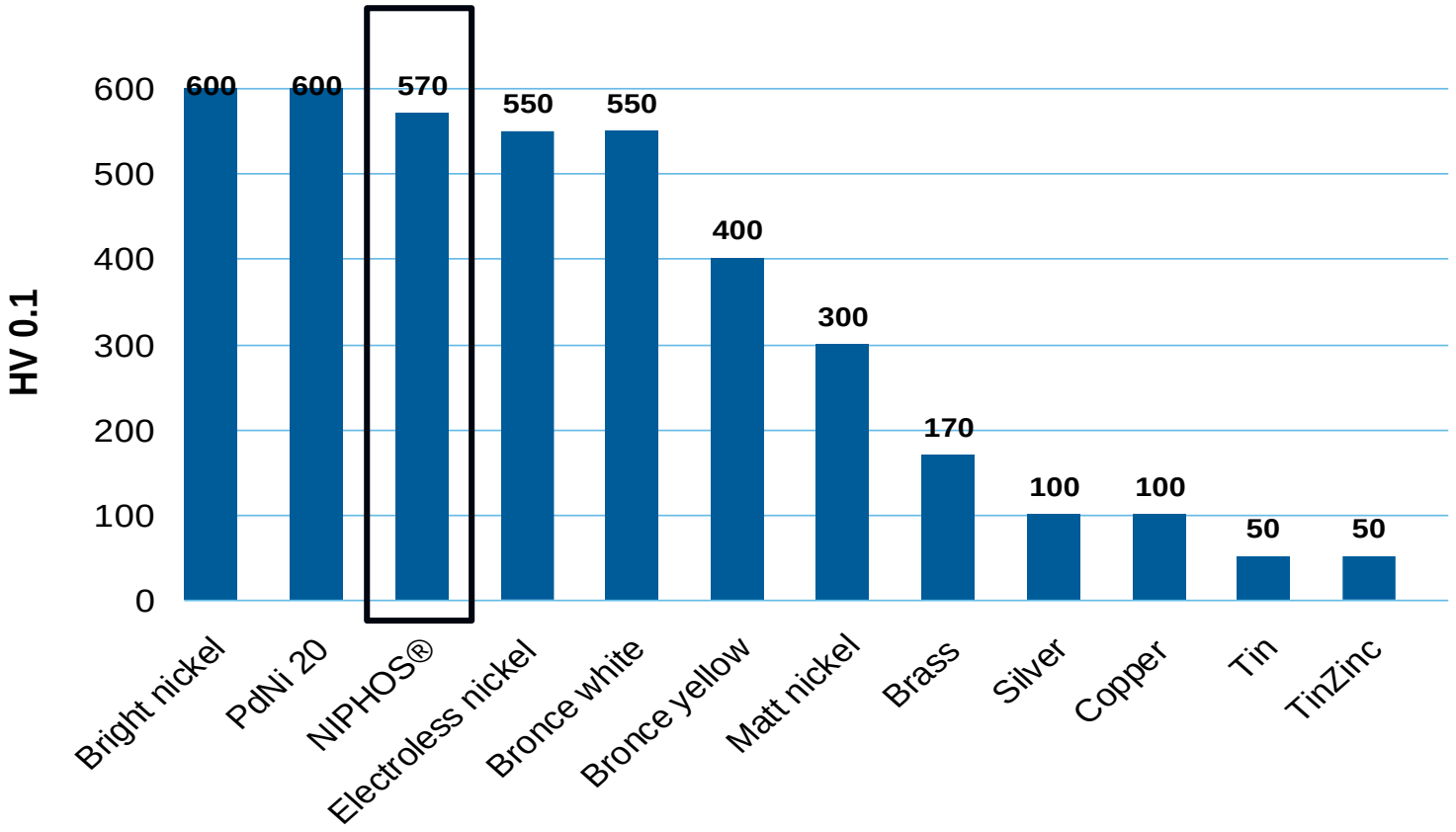
Hardness of Different Coatings



Superior Wear Resistance

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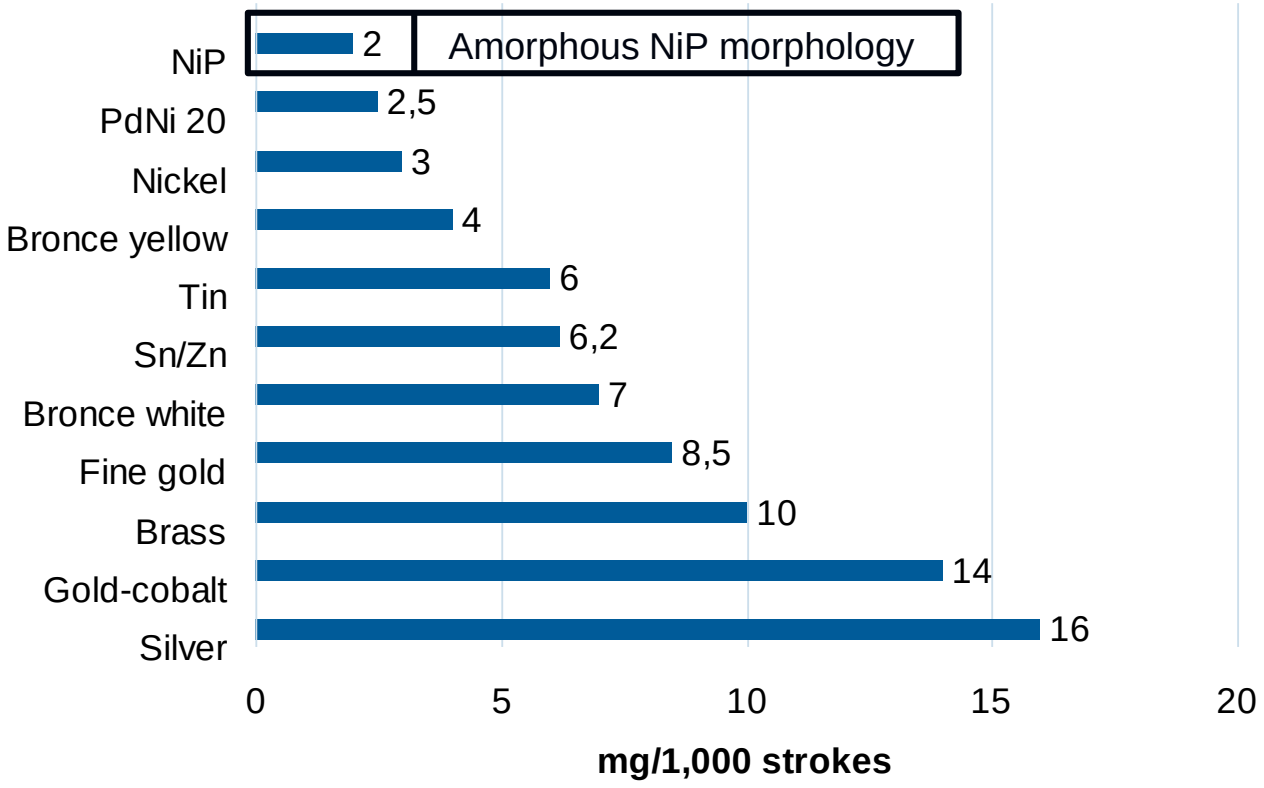
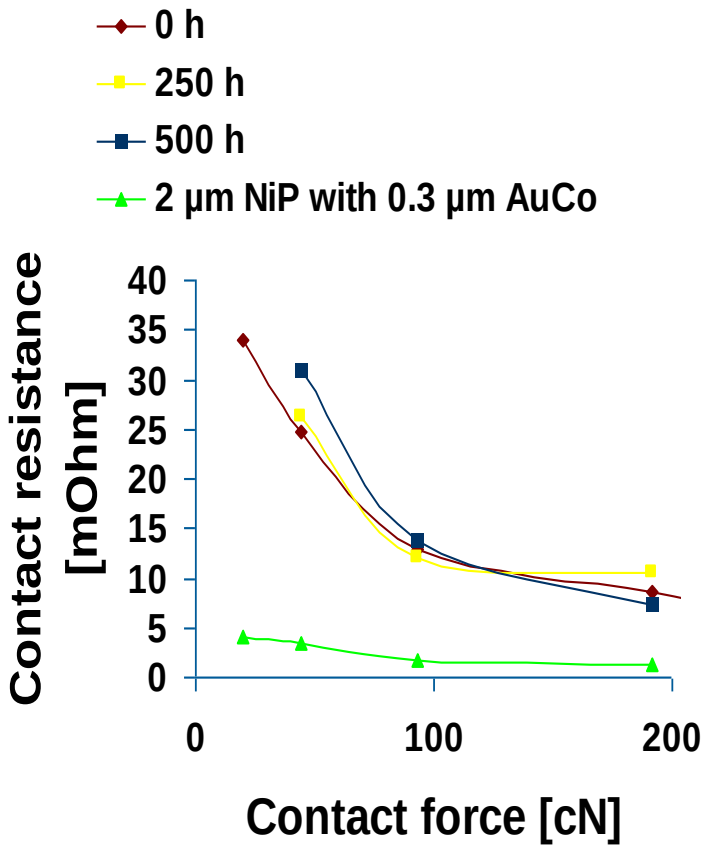
Wear - Bosch-Weinmann

Emery paper (Swiss standard 6/0), 300 g weight



Contact Resistance



- Substrate Brass
- Layer thickness 2 µm NiP
- Exposure testing 125 °C for 250 h, 500 h
- Test tip Platinum
- Test force See diagram
- Limit for practical use
  < 10 mOhm at 200 cN for non-ferrous metals

- NiP / AuCo suitable as contact material!

Solderability / Welding

Solderability

Exposure testing: 16 hours at 155 °C

Flux: Type 2542, Alpha-Metals

Solder: SnPb (60/40), 230 °C

Results

ZCT (Zero Crossing Time in (sec) 2.1 s (NiP)
2.0 s (NiP + AuCo)

Welding

Results

- NIPHOS® very good
- Bright Nickel poor, due to high carbon content of the layers

Corrosion Resistance

Layer thickness NiP 2 - 3 µm, substrate: brass

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Salt Spray Test (DIN 50021, 120 h)

- No corrosive attack
- Iridescent discoloration of the surface

Kesternich Test (DIN 50018, 5 cycles)

- No attack
- Discoloration of the surface

Pollution Gas Test (EN 60068-2-60, method 4, 10 days)

- Minimal attack on the layer
- Loss of brightness

Rapid T Change (IEC 68-2-14, -30 °C/125 °C, 1 h each, 10 cycles)

- No visible changes

Salt Spray Test
(DIN 50021, 120 h)

"Standard connectors"

The connectors were exposure-tested in inserted form and individually

Top

- 2 - 3 µm NIPHOS® 966

Bottom

- 2 - 3 µm NIPHOS® 966
- 0.2 µm AURUNA® 526

Kesternich Test (DIN 50018, 5 cycles)

"Standard connectors"

The connectors were exposure-tested in inserted form and individually

Top

- 2 - 3 µm NIPHOS® 966

Bottom

- 2 - 3 µm NIPHOS® 966
- 0.2 µm AURUNA® 526

Pollution Gas Test (EN 60068-2-60, method 4, 10 days)

"Standard connectors"

The connectors were exposure-tested in inserted form and individually

Top

- 2 - 3 µm NIPHOS® 966

Bottom

- 2 - 3 µm NIPHOS® 966
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Rapid Temperature Change

(IEC 68-2-14, -30 °C/125 °C, 1 h each, 10 cycles)

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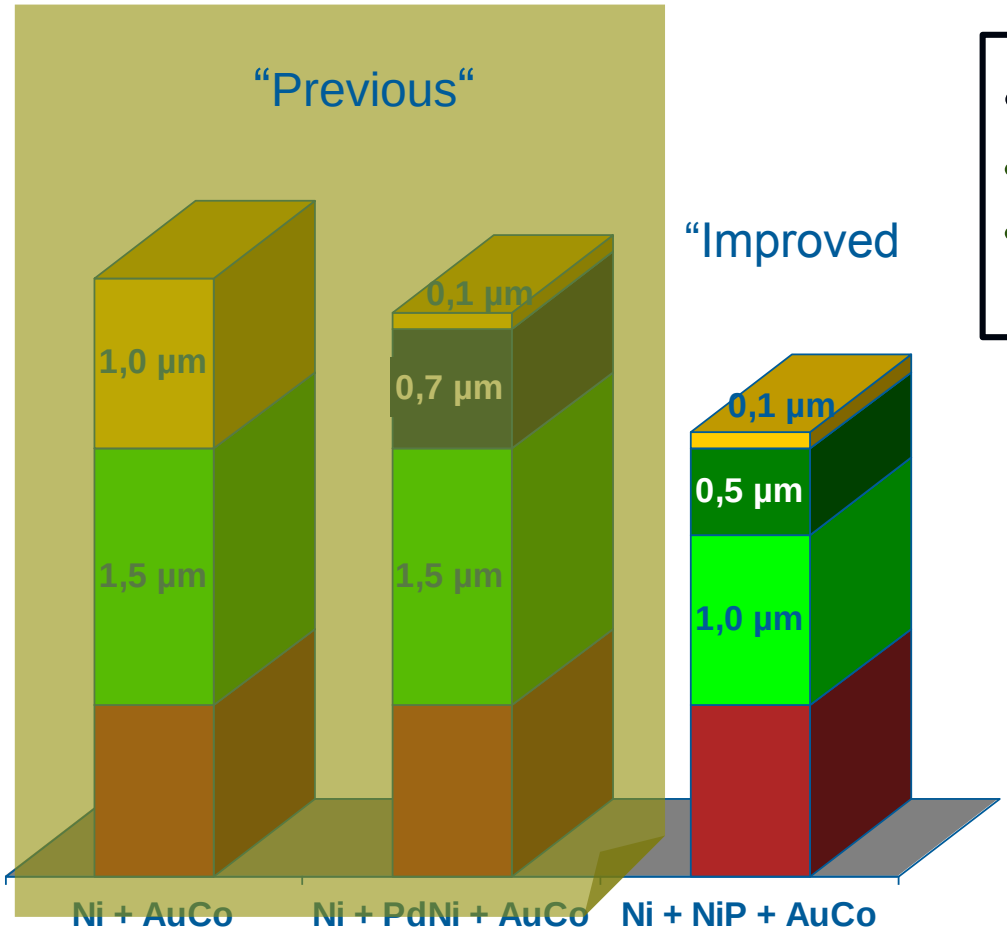
Bottom

- 2 - 3 µm NIPHOS® 966
- 0.2 µm AURUNA® 526

Contact / Connector System Applications



Benefits

- Reduced Gold thickness
- Replace Palladium Nickel
- Reduce Nickel Thickness

Summary / Comparison of different layer sequences for Connectors

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Gold

- Very expensive

Palladium or Palladium-Nickel / Goldflash (Gold acts as a type of lubricant)

- Great variation of the Palladium-price
- Often smell of ammonia
- Extremely sensitive to cyanide
- “Brown powder” effect

Nickel-Phosphorus / Goldflash

- Inexpensive
- Easy to maintain
- No ammonia odor

Electroplated Nickel Phosporus Applications

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- Improved corrosion resistant and diffusion layer under e. g.
  - Gold
  - Chromium (Cr3+ or Cr 6+)
  - Palladium / Nickel
  - Ruthenium
- Substitution and Elimination of electrolytic nickel (completely or partly) especially Marine and Sea climate applications
- Substitution of electroless nickel (if parts are "simple") especially hydraulics
- Lead-frames /Connectors (with AuCo as final layer)
- Solar-cell carriers (corrosion resistance)

Stainless Steel Finish after 6 Month Field Test

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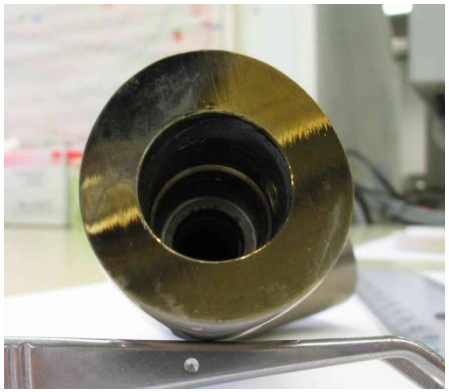
Zirconium - PVD

NIPHOS® 966



Shock Absorber & Piston Rod Applications

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Old demand: 120 h Salt Spray

- Plated with 20 – 30 µm Cr

New demand: 480 h Salt Spray

- 10 – 20 µm NiP + 20 – 30 µm Cr or
- 10 – 20 µm NiP + 5 µm Cr or
- 10 – 20 µm NiP

Plating on Plastics

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- In the POP field, NIPHOS® is used in the sequence:
  ABS / Cu or Ni / Ni (bright or matt + bright) / NiP / Cr
  The NIPHOS®-layer replaces strange combinations of up to 4 different Nickel-layers.

- The advantage is, that NIPHOS® dramatically improves the corrosion resistance of the whole system; this is important in automotive applications, when the CASS-test has to be passed.

- In traditional Systems, Cr was plated on top of bright Nickel. Cracks in the Cr-layer caused localized corrosion and attack of the Ni-layer.

- The use of NiP before Cr-plating will stop this corrosion.

NIPHOS® under Chromium

after 5 cycles
kesternichtest

triple nickel / chromium double nickel / NIPHOS® / chromium

CASS Testing for Chrome

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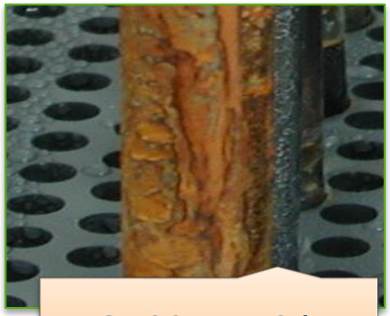
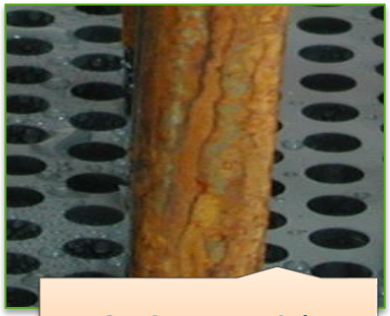


Cr 20 µm, 6 h



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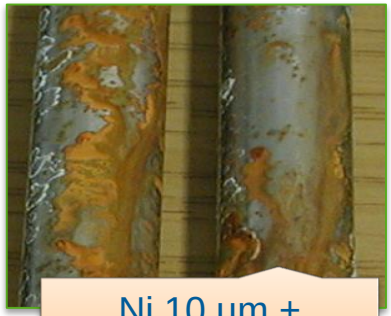

Ni 10 µm +
Cr 10 µm, 72 h

EN 10 µm +
Cr 10 µm, 240 h

Niphos 10 µm +
Cr 10 µm, 240 h

Niphos 20 µm,
168 h

Niphos heat
treated 20 µm,
48 h

Summary of Corrosion and Aging Tests

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	NSS	CASS	Corrodkote
Chromium (20 µm)	16	6	1
Chromium (35 µm)	24	6	1
Nickel (10 µm) + Chromium (10 µm)	> 336	72	2
Electroless Ni (10 µm) + Chromium (10 µm)	**> 336**	**slightly after 96 h**	**10**
Electrolytic NiP (10 µm) + Chromium (10 µm)	**> 336**	**slightly after 168 h**	**10**
Electrolytic NiP (20 µm)	> 336	slightly after 168 h	7
Electrolytic NiP (20 µm) Heat treated 400 °C, 1 hour	240	48	1

Credentials of E-Plated NiP for Connectors

The combination NIPHOS® and Au/Co (0,2 µm) has passed the measure-ments of the contact resistance after storage at different conditions according to

- **IEC 1076-4-104** and

- **Bellcore GR-1217-CORE** (125 mating cycles // 10 days storage in
  mixed gas conditions // 125 mating cycles)

Summary: Advantages of E- Plated Nickel Phosphorus

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- **Diamagnetic properties -** will expand use in High Frequency Applications

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