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Specialty Chemicals

Surface Finishing Equipment

Engineered Powders

Analytical Controls

Customer Requirements for Nickel Plating

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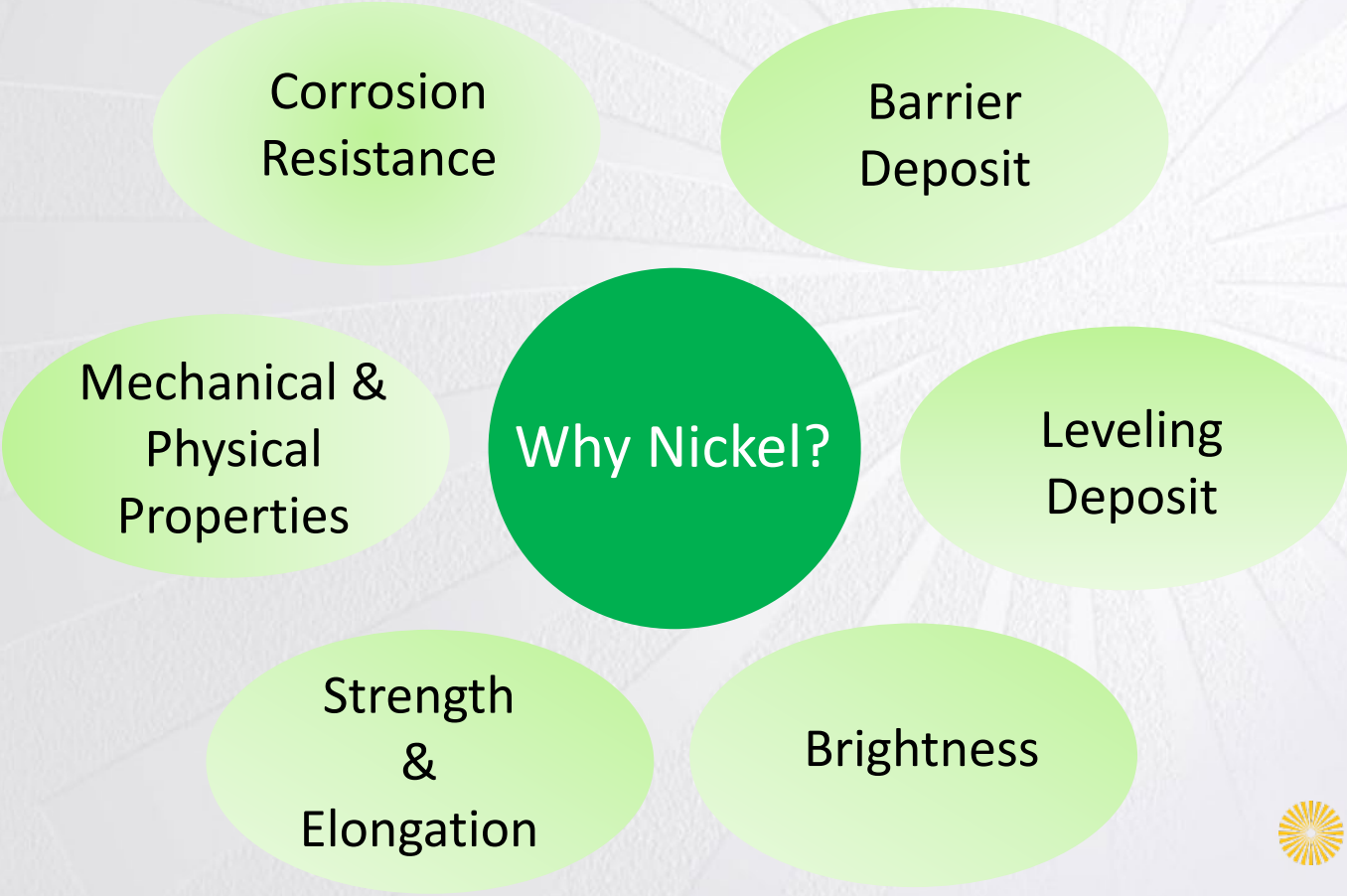
Introduction



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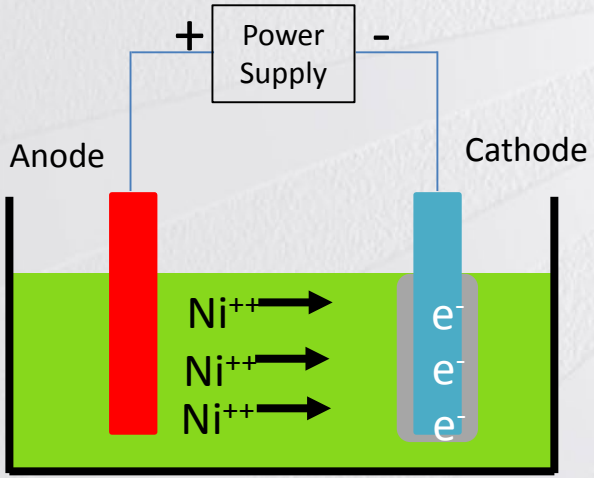
Nickel Deposition

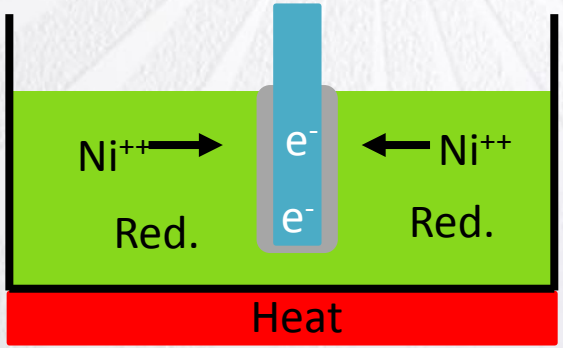
Electroplating = Current Source

- ✓ Overall Faster Deposition
- ✓ Highest Throughput



Electroless = Chemical Rxns

- ✓ Can plate electrically isolated and non-conductive parts
- ✓ Can achieve greater uniformity



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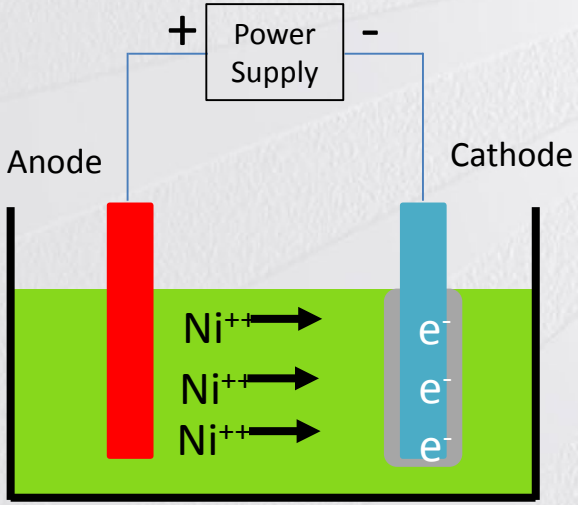
Nickel Electrodeposition

With Current Flow:

- Ni metal anode dissociates into Ni^{++}
- $Ni^{++} + 2\ e^{-}$ = Ni metal at cathode
- Ni^{++} replenished by anode



Cathode Current Efficiency = (Exp't wt. gain / theor. wt.)*100

Anode Current Efficiency = (Anode wt. loss / theor. loss)*100

Cathode Eff. < Anode Eff.

- Increasing Ni^{++}
- Increasing pH

Ni^{++} offset by drag out

pH requires constant adjustment

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Anodes

Function:

- Conduct & Distribute Current Uniformly
- Soluble anode replaces Ni ions

Types : Inert vs. Soluble

- Soluble = Pure Grade & Activated Sulfur

  Activated sulfur required in chloride & bromide free solutions
- Inert = mixed metal oxide, platinum

Position :

- Anodes should be a little shorter and positioned away from the edge of the plating rack.
- Soluble anode bars dissolve bottom up, giving poor thickness distribution from top to bottom.

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Typical bath components for Ni Electroplating

- **Nickel ion source** : Nickel Sulfate, Nickel Sulfamate
- **Sol'n Conductivity & anode dissolution** : NiCl, NiBr
- **Buffer / pH control** : Boric Acid*
- **Grain Refiner / stress reducer** : Carriers (aromatic organic sulfur compounds)
- **Ductility & Leveling** : Brighteners (low conc. Consumed by electrolysis)
- **Anti-Pitting Agents** : Wetting Agents that lower surface tension

* Boric acid is on the candidate list for substance of very high concern (SVHC) so new formulations are being developed to eliminate boric acid.

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Types of Ni Electroplating

Barrel Plating

- Components tumble freely without nesting or locking together
- Barrel loading should be <50% of barrel volume
- Carrier = high, Brightener/Leveler = low
- Mesh size of barrel as large as possible

Rack Plating

- Parts are loaded into racks and held in place
- Rack makes electrical contact with part – design of contact points is critical
- Quality of plating impacted by arrangement of rack in plating tank; i.e. anode to cathode spacing, solution flow, etc.

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Application of Different Ni Baths

Decorative

Watts Nickel : Nickel Sulfate, Nickel Chloride, Boric Acid

Electroless Nickel : Nickel Sulfate, Hypophosphite

http://winstarchemhk.com/wp-content/uploads/2016/11/Decorative-Bright-Nickel.jpg

Functional

Sulfamate Nickel: Nickel Sulfamate, Nickel Bromide, Boric Acid

Electroforming

https://www.shimifrez.com/services/electro-forming/

Activation

Wood's Nickel Strike: NiCl, HCl

https://www.finishing.com/563/18.shtml

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Watts Nickel Bath Formulation

By Professor Oliver P. Watts in 1916

Operating Parameters	
Nickel Sulfate	35.0 to 45.0 oz./gal
Nickel Chloride	6.0 to 12.0 oz./gal
Boric Acid	4.0 to 6.0 oz./gal
pH	3.5 to 4.5
Temp.	40° - 60° C
Current Density	20 to 70 ASF

Decorative & Functional Products

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Wood's Nickel Strike Formulation

Operating Parameters	
Nickel Chloride	10.0 to 20.0 oz./gal
Hydrochloric Acid	5.0% to 15.0% by volume
Temp.	RT
Current Density	voltage enough to cause gassing

Activation of nickel and nickel alloys such as Inconel and stainless steel

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Sulfamate Nickel Formulation

Operating Parameters	
Nickel Sulfamate	8.0 to 12.0 oz./gal
Nickel Bromide	1.0 to 1.5 oz./gal
Boric Acid	3.0 to 5.0 oz./gal
pH	3.0 to 4.5

Functional and electroforming due to low stress

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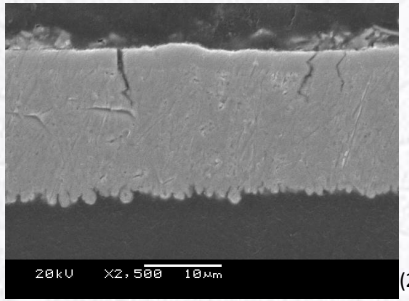
Stress

Develops from electro crystallization and/or the co-deposition of impurities


(1)

Compressive Stress
Blisters: Deposit expands



(2)

Tensile Stress
Cracking : Deposit tries to contract

Watts Nickel Solution w/o additives = 125 to 185 MPa Tensile
(Sulfamate Ni Solutions can have lower stress)

Sulfur-containing organic additives (saccharin), carriers, & secondary's help form compressively stressed Ni deposits

(1) https://vacaero.com/information-resources/vacuum-brazing-with-dan-kay/146644-be-sure-to-blister-test-your-nickel-plating-before-brazing.html
(2) Y. Oda et al, IPC 2009, p.4

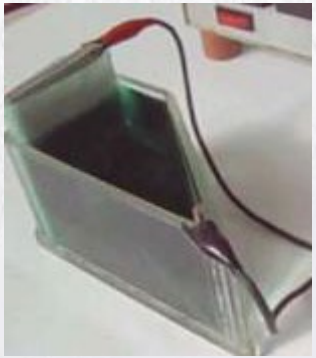
Impurities Introduced into Plating Baths

- Insoluble : Dust abrasives and anode fines that cause roughness
- Metallic: Parts dropped into the tanks, drag in from chemistries upstream, leaching agents from resist and rack coatings

  Can be observed on hull cell panels as a dark cloudy haze starting from the low current density areas

- Organic: Oil and grease dragged in from the cleaner or not cleaned off in the first place

  Can be observed on hull cell panels as a cloudy light colored haze starting from the low current density areas.



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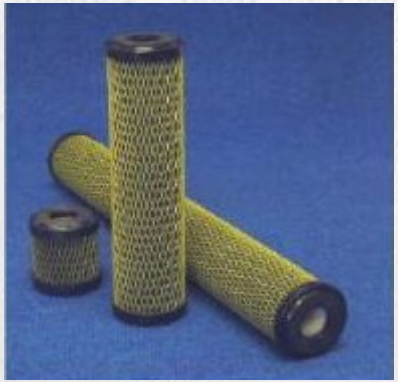
Purification Procedures

- Continuous filtration to minimize roughness.
- Low current density electrolysis.
- High pH treatments to help precipitate iron, aluminum and silicon at a pH of 5.0 to 5.5.
- Removal of organics by using activated carbon.
- Hydrogen peroxide or potassium permanganate can be used to help with the carbon treatment.



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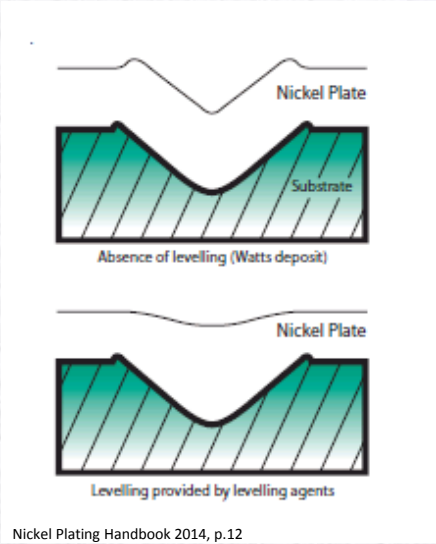
Leveling & Brightness

Leveling:

What? plated metal preferentially fills in defects & scratches on the surface

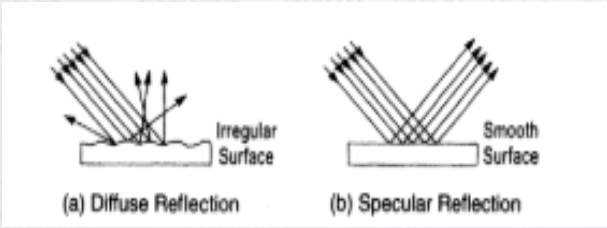
How? Organic additives in plating sol'n adsorb on micropeaks limiting current flow while increasing current density in microgrooves



Nickel Plating Handbook 2014, p.12

Brightness:

Combination of leveling, grain refining, and crystal growth.



Modern Electroplating, p.13

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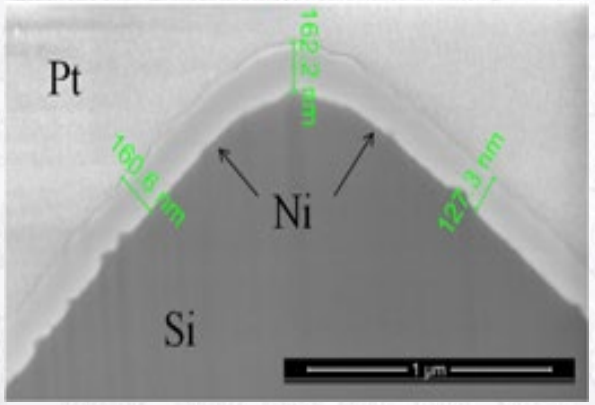
Engineering & Functional Testing

Thickness testing:

- Microscopic examination of cross sections.
- Kocour de-plate
- Beta Backscatter
- XRF – X-ray Fluorescence
- Weight gain per the measured surface area



Adhesion testing:

- Bending, twisting, and tape testing.
- Thermal shock, for steel 300° C and zinc alloys 150° C and quench.

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Engineering Properties

Ductility: *Ability of a plated deposit to undergo deformation without cracking*

Test: 1 mil Ni deposit on Cu foil. Bend 180° over a 12 um mandrel and look for cracks down to base material

- Additive free deposits have elongation ~30%
- Semi bright deposit have elongation ~8%

Corrosion: *Corrosion resistance may depend on deposit thickness*

Test: Salt Spray box, Fuming Nitric Test in Desiccator

- > 5 um for use under gold & other coatings
- ~125 um for severe applications; i.e. bumpers & auto wheels

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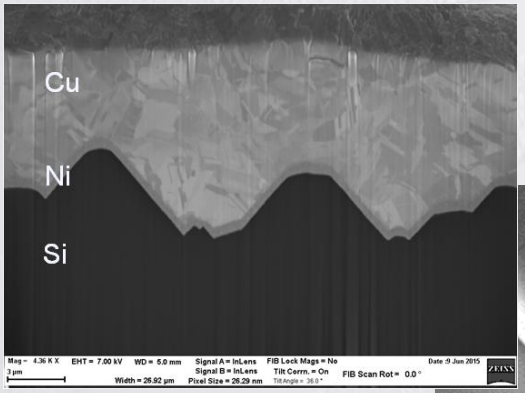
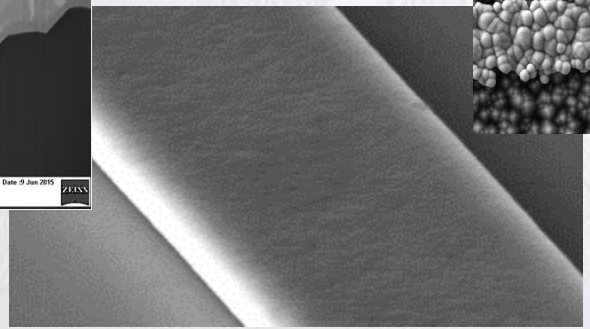
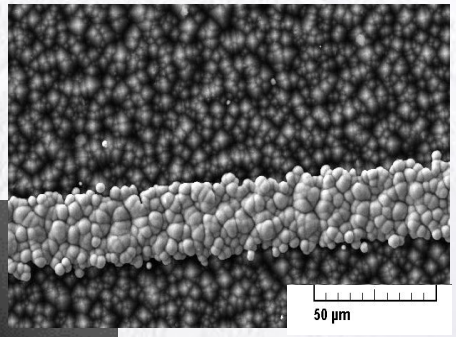
Thank you







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