Course content
1. Process Steps (75 minutes)
2. Properties, Defects, and Evaluation (60 minutes)
3. Coating Uses (25 minutes)
4. Coating Selection, Coating Specification, and Supplier Evaluation (25 minutes)
5. Final exam (15-30 minutes)

Do not need to complete a module in one sitting
- If you exit a module before completion, the software will bookmark your place.
  When you return, click YES to "Would you like to resume where you left off?"
Module learning objectives
At the end of this module students will be able to do the following:
1. Describe the purpose and procedure for the process steps associated with electroplating.
2. Explain the primary process variables for each step of the electroplating process.
3. Identify the electroplating process format to use based on component shape and size.

Electroplating
Deposit metal on substrate surface
- Metal
- Metallized plastic
- Metallized glass and ceramic

Focus on metal substrates

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<tbody>
<tr>
<td>Au</td>
<td>Ni</td>
<td>Brass</td>
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0.050 mm
Electroplating line

Substrates

Individual components

Metal coil, wire, tube, pipe

Electronic circuit boards, leadframes, and connector pins

Jewelry
**Electroplated metals**

**Pure metals**
- Cu, Ni, Cr, Zn, Sn, Au, Pd, Ag, Cd, Pb

**Alloys**
- Zn-Ni, Sn-Pb, Cu-Zn, Pd-Ni, Ni-Co

**Single layer**
- Clean surface
- Strip (for replating)
- Pre-bake
- Roughen surface
- Electroplate layer 1
- Strike or Zincate
- Dry
- Electroplate layer 2
- Water rinse
- Water rinse
- Dry
- Remove mask
- Buffing, grinding, or machining
- Post-plating coating
- Hydrogen bake
- Water rinse
- Activation
- Mechanical surface preparation
- Apply masking

**Multiple layers**
- Clean surface
- Strip (for replating)
- Pre-bake
- Roughen surface
- Electroplate layer 1
- Strike or Zincate
- Dry
- Electroplate layer 2
- Water rinse
- Water rinse
- Dry
- Remove mask
- Buffing, grinding, or machining
- Post-plating coating
- Hydrogen bake
- Water rinse
- Activation
- Mechanical surface preparation
- Apply masking
Mechanical surface preparation

Purpose:
\[ \delta \] Smooth surface prior to plating - Cosmetic
\[ \delta \] Prevent contaminating cleaning and plating baths with loose metal particles

- Remove burrs
- Remove flash from castings
- Smooth welds
- Remove parting lines on castings

Clean surface

Purpose: Remove soil from substrate surface, preparing it for subsequent operations

- Soils are materials left on substrate’s surface from previous operations
- Surface contamination prevents good adhesion of plated layer to substrate

Three categories of soils
\[ \delta \] Organic: Lubricants used in metal forming, rolling, and machining operations. Soaps, lard oils, and wax bases are also encountered.
\[ \delta \] Inorganic: Rust, heat and weld scale, smuts, and oxides (tarnish).
\[ \delta \] Miscellaneous: Shop dirt, glove prints from handling parts, flux from brazing operations, and burned-on soils from quenching operations.
Cleaning steps
1. Pre-clean + water rinse
2. Alkaline clean + water rinse
3. Remove oxide scale and electroclean
   - Oxide scale is heavy corrosion or heat treating scale
   - Processes used and order depends on substrate alloy and amount of scale
   - Water rinse between each step

Alkaline clean
Remove soil residue remaining from the pre-clean
Immersion or spray
Example: Trisodium phosphate + Sodium carbonate at 80 to 90°C (176 – 194 °F)
Agitation to improve cleaning efficiency and effectiveness
**Electrocleaning**
Remove soils that are strongly adherent to parts
  - Pass electricity through part and cleaning bath
  - Hydrogen or oxygen bubbles formed by electrolytic decomposition of water
  - Bubbles move upward over parts, removing soil

**Remove oxide scale**
May be necessary to remove oxide scale
  - Acid etch (pickle) or alkaline etch
  - Sand or bead blast
Activation
Immerse parts in acid

Purpose
- Remove thin oxide from surface
- Neutralize residual alkaline film from alkaline cleaning

Acid used depends on compatibility with substrate material

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Strike
Thin layer of pure metal deposited on substrate surface

Purpose: Provide good adhesion between deposit and substrate

Additives in electroplating chemicals have negative impact on adhesion to substrate

Strike chemicals do not include additives used in subsequent plating steps

Strike thickness negligible compared to subsequent layers
**Zincate**
Deposit thin Zn layer on active metals, for which an oxide grows very fast
- Al and Mg substrates
- Does not involve use of electricity to deposit Zn

Immersion process
- Al or Mg oxide dissolves
- Underlying metal dissolves and is replaced by Zn

**Electroplate**
Immerse substrate in plating bath
Deposit metal on substrate surface
Electroplating physics
Power supply connected to substrate and anode
Electricity flows through anode, substrate, and plating chemicals
Metal deposits on substrate surface

Inputs
- Plating chemicals
- Current density
- Plating time
- Plating bath temperature
- Agitation

Outputs
- Thickness
- Appearance
- Composition (for alloys)
- Hardness
- Ductility
- Porosity
- Residual stress
- Solderability
- Wirebonding

Click each process input to learn more
Click Next after reviewing each input
Maintaining proper bath chemistry

Plating chemicals must be maintained within certain limits to ensure efficient operation and good quality deposits.

Bath constituent concentrations will deviate from optimum values due to:

- Drag-out – solution carried with components during removal from tank
- Solution evaporation
- Chemical decomposition
- Soluble anode consumption
- Additive depletion due to co-deposition in deposits and breakdown
- Impurities introduced by extraneous objects falling into plating tank

Current density

Current density = \( \frac{\text{Current}}{\text{Substrate surface area}} \)

Amps/inch\(^2\) or Amps/dm\(^2\)

\[ \begin{align*}
\text{Width} & = 5.0 \text{ cm (2 in)} \\
\text{Height} & = 2.5 \text{ cm (1 in)} \\
\text{Thickness} & = 0.625 \text{ cm (0.25 in)}
\end{align*} \]
Hydrogen bake
130 to 220 °C (266 to 428 °F) for up to 24 hours (for most applications)
Allow outgassing of hydrogen absorbed during acid cleaning and electroplating
  δ Prevent hydrogen embrittlement of high strength steel
Must be performed within a few hours after plating
ASTM B850 Standard Guide for Post-Coating Treatments of Steel for Reducing the Risk of Hydrogen Embrittlement

Post-plating coating: Chromate conversion
Used for corrosion protection, identification, and as a primer for paint
Treatment with chemicals containing hexavalent or trivalent chromium
  δ Convert metal surface to a thin layer containing chromium compounds
Several metals and their alloys can be treated, including Al, Cd, Cu, Mg, Ag, Zn
  δ Metal being chromated can be substrate or coating
Appearance depends on bath formulation, chromated metal, and chromate thickness
  δ Clear-bright and blue-bright
  δ Yellow iridescent
  δ Brown, olive drab, and black
Rack Plating

Components placed inside a barrel that rotates when immersed in process tank. Used for small, sturdy components. More plated thickness variation compared to rack plating.

Barrel plating

Components placed inside a barrel that rotates when immersed in process tank. Used for small, sturdy components. More plated thickness variation compared to rack plating.
Barrel plating line

Reel-to-reel plating

Wire  Coil  Leadframes