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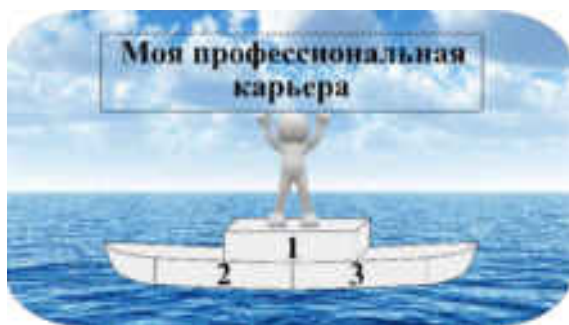


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**Международный научно-образовательный электронный журнал
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Название публикации: «TECHNOLOGY FOR OBTAINING COPPER COATINGS VIA THE GALVANIC PROCESS»

Abstract

Copper electroplating, a widely utilized galvanic process, plays a critical role in modern industry due to its excellent electrical conductivity, corrosion resistance, and aesthetic qualities. This paper presents a comprehensive analysis of the technological principles underlying copper coating via electrochemical deposition. Emphasis is placed on electrolyte composition, process parameters, substrate preparation, and coating performance. The study also evaluates recent advancements in environmentally sustainable plating technologies.

1. Introduction

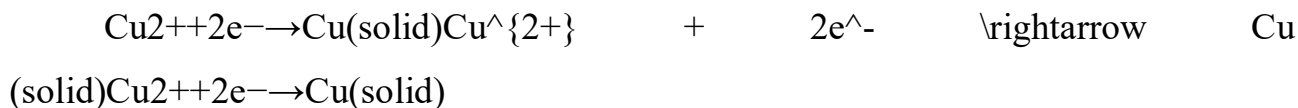
Copper coatings are extensively applied in electronics, automotive engineering, and decorative finishing. The galvanic process, based on electrochemical reduction, allows for precise control of coating thickness, microstructure, and adhesion. Compared to other coating methods such as thermal spraying or physical vapor deposition, electroplating offers superior uniformity and cost-efficiency.

The process involves the reduction of copper ions from an electrolyte solution onto a conductive substrate under the influence of an external electric field. This method is essential for printed circuit boards (PCBs), corrosion-resistant layers, and conductive coatings.

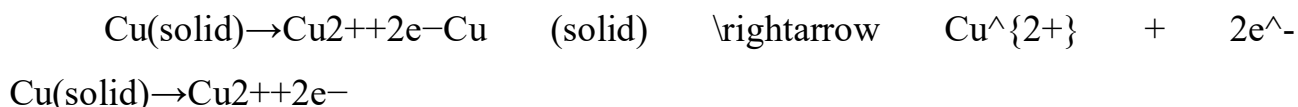
2. Theoretical Background of Copper Electroplating

2.1 Electrochemical Principles

Copper electroplating is governed by Faraday's laws of electrolysis. At the cathode, copper ions are reduced:



At the anode, typically composed of pure copper:



The deposition rate is directly proportional to the current density and time.

2.2 Electrolyte Composition

The most commonly used electrolytes include:

- **Acidic sulfate baths** ($\text{CuSO}_4 + \text{H}_2\text{SO}_4$)
- **Alkaline cyanide baths**
- **Pyrophosphate baths**

Among these, sulfate electrolytes dominate industrial applications due to their simplicity, high efficiency, and lower toxicity compared to cyanide systems.

3. Materials and Methods

3.1 Substrate Preparation

Proper surface preparation is essential for coating adhesion. The process typically includes:

1. Degreasing (organic solvents or alkaline cleaners)
 2. Acid pickling (removal of oxides)
 3. Rinsing with deionized water
 4. Activation (mild acid treatment)
-

3.2 Electroplating Setup

A standard electroplating system consists of:

- Power supply (DC source)
 - Electrolytic bath
 - Copper anodes
 - Cathode (workpiece)
 - Agitation system
 - Temperature control unit
-

3.3 Process Parameters

Critical parameters influencing coating quality include:

Parameter	Typical Range
Current density	1–10 A/dm ²
Temperature	20–60 °C
pH	0.5–2 (acid baths)
Plating time	5–60 minutes

Control of these parameters determines grain size, uniformity, and mechanical properties of the coating.

4. Results and Discussion

4.1 Coating Characteristics

Copper coatings obtained via galvanic processes exhibit:

- High electrical conductivity
- Good ductility
- Uniform thickness distribution
- Strong adhesion to substrate

However, defects such as porosity, roughness, and internal stress may arise if parameters are not optimized.

4.2 Influence of Additives

Organic additives (levelers, brighteners, suppressors) significantly influence coating morphology. For instance:

- **Brighteners** improve surface smoothness
 - **Levelers** enhance uniform deposition
 - **Wetting agents** reduce surface tension
-

4.3 Environmental Considerations

Traditional electroplating processes pose environmental challenges due to toxic waste (especially cyanides). Recent trends focus on:

- Cyanide-free electrolytes
 - Wastewater treatment technologies
 - Recycling of metal ions
-

5. Conclusion

The galvanic deposition of copper remains a fundamental technology in industrial surface engineering. Its versatility, cost-effectiveness, and scalability make it indispensable in numerous applications. Advances in electrolyte formulation and environmental management continue to improve process sustainability and coating performance.

6. Suggestions

- Implementation of pulse electroplating to improve coating structure
 - Development of eco-friendly electrolyte systems
 - Integration of automation and real-time monitoring
 - Further research on nanostructured copper coatings
-

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