Text n°3: Electrolysis

Definition and Basic principle of Electro Deposition Electro deposition is the process of coating a thin layer of one metal on top of different metal to modify its surface properties. It is done to achieve the desire electrical and corrosion resistance, reduce wear and friction, improve heat tolerance and for decoration. Paragraph1

Electroplating Basics The 'electro' part of the system includes the voltage/current source and the electrodes, anode and cathode, immersed in the 'chemical' part of the system, the electrolyte or plating bath, with the circuit being completed by the flow of ions from the plating bath to the electrodes. The metal to be deposited may be the anode and be ionized and go into solution in the electrolyte, or come from the composition of the plating bath. Copper, tin, silver and nickel metal usually comes from anodes, while gold salts are usually added to the plating bath in a controlled process to maintain the composition of the bath. The plating bath generally contains other ions to facilitate current flow between the electrodes. The deposition of metal takes place at the cathode. The overall plating process occurs in the following sequence:

1. Power supply pumps electrons into the cathode.
2. An electron from the cathode transfers to a positively charged metal ion in the solution and the reduced metal plates onto the cathode.
3. Ionic conduction through the plating bath completes the circuit to the anode.
4. At the anode two different processes take place depending on whether the anode material is soluble, the source of the metal to be plated, or insoluble, inert. If the anode material is soluble, a metal atom gives up an electron and goes into the solution as a positively charged metal ion replenishing the metal content of the plating bath. If the anode is inert a negatively charged ion from the plating bath gives up an electron to the anode.
5. The electron flows from the anode to the power supply completing the circuit. The deposition of metal at the cathode requires an electron so the rate of deposition depends on the flow of electrons, that is, the current flowing from the rectifier. The thickness of the deposit, therefore, depends on the current and the length of time the current is applied. This relationship is a result of Faraday's law which relates the weight of a substance produced by an anode or cathode electrode reaction during electrolysis as being directly proportional to the quantity of electricity passed through the cell.

Paragraph 2

Faraday's Laws of Electrolysis From his experiments, Faraday deduced two fundamental laws which govern the phenomenon of electrolysis. These are:
First Law. The mass of ions liberated at an electrode is directly proportional to the quantity of electricity i.e. charge which passes through the electrolyte.
Or The weight of a substance liberated from an electrolyte in a given time is proportional to the quantity of electricity passing through the electrolyte.
That is $W \alpha Q \alpha It$, where I is the current and t is the time. $W = Zit$ Where Z is a constant called electro-chemical equivalent.
If $I = 1$ ampere and $T=$ one second then, $Z = W$, which gives a definition of Z.
The electro-chemical equivalent of a substance is the amount of that substance by weight liberated in unit time by unit current.
Second Law. The masses of ions of different substances liberated by the same quantity of electricity are proportional to their chemical equivalent weights.
or, If the same current flows through several electrolytes, the weights of ions liberated are proportional to their chemical equivalents.
The chemical equivalent of a substance is the weight of the substance which can displace or combine with unit weight of hydrogen. Obviously, the chemical equivalent of hydrogen is 1 by definition.

Paragraph 3

Definitions

1. Current Efficiency: On account of the impurities which cause secondary reactions, the quantity of a substance liberated is less than that calculated from Faraday's Law. Current efficiency is the ratio of the actual mass of a substance liberated from an electrolyte by the passage of current to the theoretical mass liberated according to Faraday's law. Current efficiency can be used in measuring electro deposition thickness on materials in electrolysis. Current efficiency is also known as faradic efficiency, faradic yield and columbic efficiency.

2. Energy Efficiency: On account of secondary reactions, the voltage actually required for the deposition or liberation of metal is higher than the theoretical value which increases the actual energy required. Energy efficiency is defined as $= \frac{\text{theoritical energy}}{\text{actual energy required}}$

It is a process by which a metal is deposited over another metal or non-metal. Electro-plating is a very common example of such process.

Conditions have to be provided so that the deposit will be fine grained and will have a smooth appearance. The factors which affect the electro-deposition of metals are:

(i) Current Density, (ii) Electrolyte concentration, (iii) Temperature, (iv) Addition agents, (v) Nature of electrolyte; (vi) Nature of the metal on which the deposit is to be made, (vii) Throwing power of the electrolyte.

Current density: At low values of current density, the ions are released at a slow rate and the rate of growth of nuclei is more than the rate at which the new nuclei form themselves. Electro-deposition depends upon the rate at which crystals grow and the rate at which fresh nuclei are formed. Therefore, at low current densities the deposit will be coarse and crystalline in nature. At higher values of current density, the quality of deposit becomes more uniform and fine-grained on account of the greater rate of formation of nuclei. If the current density is so high that it exceeds the limiting value for the electrolyte hydrogen is released and spongy and porous deposit is obtained.

Electrolytic Concentration: This is more or less complementary to the first factor, i.e. current density, since by increasing the concentration of the electrolyte higher current density can be achieved. Increase of concentration tends to give better deposits and some people therefore favour it.

Temperature: The temperature of the electrolyte has two contradictory effects. One, at comparatively high temperature there is more diffusion and even at relatively high current density smooth deposits may be produced. Two, the rate of crystal growth increases the possibility of coarse deposits. At moderate temperatures the deposits are good. In chromium plating the temperature is maintained at 35°C, and in nickel between 50°C to 60°C.

Addition Agents: The quality of a deposit is improved by the presence of an addition agent which may be colloidal matter or an organic compound, otherwise the metal deposits in the form of large crystals and the surface becomes rough. Materials used as addition agents are gelatin, agar, glue, gums, rubber, alkaloids, sugar etc. The addition agents are supposed to be absorbed by crystal nuclei and prevent their growth into large crystals. The discharged ions start to build up new nuclei and the deposit of metal is fine-grained.

Nature of electrolyte: Smooth deposits are obtained from solutions having complex ions, e.g., cyanides. Silver from nitrate solution forms a coarse deposit while from cyanide solution it forms a smooth deposit. Therefore, the formation of smooth deposit largely depends upon the nature of electrolyte used.

Nature of the metal on which deposit is to be made: This factor influences the growth of crystals since it is believed that the operation of crystals is in continuation of these in the base metal.

Paragraph 4

Throwing Power The throwing power of an electrolyte may be regarded as the quality which produces a uniform deposit on a cathode having an irregular shape. Since the shape is irregular, the distance of the various parts of the cathode from the anode is not the same and therefore the conductance of the electrolyte is not the same for all parts of the cathode. The phenomenon of throwing power has not been clearly understood so far. In an electrolyte of low conductance, the current will concentrate on the parts of the cathode which are nearer the cathode resulting in poor throwing power. If the electrolyte has good conductance, the throwing power will also be good. One way to improve the throwing power is to keep a good distance between the cathode and the anode thereby providing more or less the same conductance for all parts of cathode. Presence of colloidal matter improves the throwing power but increase of temperature may produce the opposite effect.	
Extraction of Metals This is done in two ways: 1. The ore is treated with a strong acid to obtain a salt and the solution of such a salt is electrolyzed to liberate the metal. 2. When the ore in molten state is available it is electrolysed in a furnace. Extraction of Zinc The ore consisting of zinc is treated with concentrated sulphuric acid, roasted and passed through other processes to get rid of impurities by precipitation. The zinc-sulphate solution is then electrolysed. The cells consist of large lead-lined wooden boxes having aluminum cathodes and lead anodes. The current density is about 1000 amperes per square meter. Zinc is deposited on cathodes. Extraction of Aluminium Ores of aluminium are bauxite cryolite. Bauxite is treated chemically and reduced to aluminium oxide and then dissolved in fused cryolite and electrolysed. The furnace is lined with carbon. The temperature of the furnace is about 1000°C to keep the electrolyte in a fused state. Aluminium deposits at the cathode. Refining of Metals Electrolytic extraction gives about 98 to 99 percent pure metal. Further refining is done by electrolysis. The anodes are made of the impure metal extracted from its ores and the electrolyte is a solution of the salt of the metal. Pure metal is deposited on the cathode.	Paragraph 5

Exercise 1

Decide if the following statements are true or false.

N°	Sentence	True	False
	Paragraph 4		
1	At high values of current density, the ions are released at a slow rate		F
2	the rate of growth of nuclei is less than the rate at which the new nuclei form themselves		F
3	Conditions have to be provided so that the deposit will be fine grained and will have a rough appearance		F
4	Energy efficiency is defined as = (experimental energy)/ (actual energy required)		F
5	The throwing power of an electrolyte may be regarded as the quantity which produces a uniform deposit on a cathode having an irregular shape		F
6	the rate of growth of nuclei is more than the acceleration at which the new nuclei form themselves		F
7	At low values of current density, the electrons are released at a slow rate		F
8	the voltage actually required for the deposition or liberation of metal is lower than the theoretical value which increases the actual energy required		F
9	The throwing power of an electrolyte may be regarded as the quality which produces a uniform deposit on a anode having an irregular shape		F
10	Conditions have to be provided so that the deposit will be thick grained and will have a smooth appearance		F
11	The throwing power of an electrolyte may be regarded as the quality which produces a uniform deposit on a cathode having an irregular shape	T	
12	Energy efficiency is defined as = (theoretical current)/ (actual energy required)		F
13	the rate of growth of nuclei is more than the rate at which the new nuclei form themselves	T	
14	the voltage actually required for the deposition or liberation of metal is higher than the experimental value which increases the actual energy required		F
15	At low values of current density, the ions are released at a slow rate	T	
16	Conditions have to be provided so that the deposit will be fine grained and will have a smooth appearance	T	
17	Energy efficiency is defined as = (theoretical energy)/ (actual energy required)	T	
18	the voltage actually required for the deposition or liberation of metal is higher than the theoretical value which increases the actual energy required	T	

Paragraph 3	**Exercise 2:** Match a word in column A with a definition in column B
Column A	Column B
Faraday's first law	The masses of ions of different substances liberated by the same quantity of electricity are proportional to their chemical equivalent weights.
Faraday's second law	The mass of ions liberated at an electrode is directly proportional to the quantity of electricity i.e. charge which passes through the electrolyte.

Paragraph 4			**Exercise 3:** Match a word in column A with a definition in column B
Column A			Column B
Addition Agents			This is more or less complementary to the first factor, i.e. current density, since by increasing the concentration of the electrolyte higher current density can be achieved. Increase of concentration tends to give better deposits and some people therefore favour it.
Nature of electrolyte			The quality of a deposit is improved by the presence of an addition agent
Electrolytic Concentration			= (theoretical energy)/ (actual energy required)
Current efficiency			The throwing power of an electrolyte may be regarded as the quality which produces a uniform deposit on a cathode having an irregular shape
Energy efficiency is defined as			Therefore, the formation of smooth deposit largely depends upon the nature of electrolyte used
Throwing Power			Is the ratio of the actual mass of a substance liberated from an electrolyte by the passage of current to the theoretical mass liberated according to Faraday's law

Exercise 4: Fill in the blanks with an appropriate word from the box. The first letter is given.

sulphuric	zinc	electrolyte	grained	voltage	
hydrogen	proportional	smooth	throwing	equivalent	quantity
theoretical	extraction	bauxite	quality	weights	

N°	Sentence
1	Ores of aluminium are b a u x i t e cryolite.
2	The t h r o w i n g power of an electrolyte may be regarded as the q u a l i t y which produces a uniform deposit on a cathode having an irregular shape.
3	Electrolytic e x t r a c t i o n gives about 98 to 99% pure metal.
4	The ore consisting of z i n c is treated with concentrated s u l p h u r i c acid.
5	The chemical e q u i v a l e n t of a substance is the weight of the substance which can displace or

	combine with unit weight of h y d r o g e n
6	The masses of ions of different substances liberated by the same q u a n t i t y of electricity are proportional to their chemical equivalent w e i g h t s
7	The v o l t a g e actually, required for the deposition or liberation of metal is higher than the t h e o r i t i c a l value which increases the actual energy required.
8	Conditions have to be provided so that the deposit will be fine g r a i n e d and will have a s m o o t h appearance.
9	The weight of a substance liberated from an electrolyte in a given time is p r o p o r t i o n a l to the quantity of electricity passing through the e l e c t r o l y t e

Terminology	مصطلحات	Terminologie	Terminology	مصطلحات	Terminologie
Electrolysis			Corrosion resistance		Résistance à la corrosion
Corrosion		Corrosion	Plating bath		
Friction			Directly proportional		
Voltage			Fundamental laws		
Current			Electro-chemical equivalent		
Electrodes		Electrodes	Theoretical energy		
Anode		Anode	Fine-grained		
Cathode		Cathode	Soluble		Soluble
Electrolyte			Insoluble		Insoluble
Copper			Inert		Inerte
Tin			Thickness		
Silver			Colloidal		
Nickel					

Phrasal verbs

What are phrasal verbs? Phrasal verbs are phrases that indicate actions. They are generally used in spoken English and informal texts. Examples of such verbs include: *turn down*, *come across* and *run into*.

Phrasal verbs consist of a verb and a preposition or an adverb

Verb	Preposition/ adverb
get	up
go	through
write	down
take	after

Sometimes phrasal verbs consist of three elements:

Verb	Preposition / adverb 1	Preposition / adverb 2
look	forward	to
put	up	with
sit	in	for

When added to the verb the preposition or adverb may change completely the meaning of the verb. Here are some examples:

Phrasal verb	Meaning	Example
look for	search/seek	He is looking for his keys
look up to	have a great deal of respect for a person	His father is his model. He is the person he **looks up to**.
look forward to	await eagerly/anticipate with pleasure	She is **looking forward to** visiting Paris.
look up	to try to find a piece of information by looking in a book or on a computer:	She didn't understand the word. So she **looked** it **up** in her dictionary

The meaning of phrasal verbs:
Sometimes, it is difficult to understand the meaning of phrasal verbs. Before looking them up in a dictionary, it would be helpful to use the context to understand them.

Literal meaning: Some phrasal verbs have a literal meaning. They can be easily understood.
- She opened the door and ***looked outside***.
- She was ***walking across*** the street when she heard the sound of an explosion.

Idiomatic meaning: Phrasal verbs can also have a figurative or idiomatic meaning which makes them difficult to understand.
- Can you ***put*** me ***up*** for tonight?
The phrasal verb ***'put up'*** here does not mean to build (as in ***putting*** *a fence* ***up***). It has, however, an idiomatic/figurative meaning. It means to let someone stay in your house.

Separable or inseparable?	1. Sometimes, the preposition/adverb is placed either after the verb or after the object. Examples: Mary ***made up*** a really entertaining story/Mary ***made*** the story ***up***.	2. If the object is a pronoun, however, the preposition/adverb has to be placed after the pronoun (object). Examples: She **made** it **up**/Put it down/Take it off.	3. Some phrasal verbs are always inseparable. Example: I ***came across*** some old photos in a drawer. NOT: ~~I *came* some old photos *across* in a drawer.~~

Exercise 5
Translation

Definition and Basic principle of Electro Deposition: Electro deposition is the process of coating a thin layer of one metal on top of different metal to modify its surface properties. It is done to achieve the desire electrical and corrosion resistance, reduce wear and friction, improve heat tolerance and for decoration.

Electroplating Basics: The 'electro' part of the system includes the voltage/current source and the electrodes, anode and cathode, immersed in the 'chemical' part of the system, the electrolyte or plating bath, with the circuit being completed by the flow of ions from the plating bath to the electrodes. The metal to be deposited may be the anode and be ionized and go into solution in the electrolyte, or come from the composition of the plating bath. Copper, tin, silver and nickel metal usually comes from anodes, while gold salts are usually added to the plating bath in a controlled process to maintain the composition of the bath. The plating bath generally contains other ions to facilitate current flow between the electrodes. The deposition of metal takes place at the cathode. The overall plating process occurs in the following sequence:

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ترجمة

التعريف والمبدأ الأساسي للترسب الكهربائي:

الترسيب الكهربائي هو عملية طلاء طبقة رقيقة من معدن واحد فوق معدن مختلف لتعديل خصائصه السطحية. يتم ذلك لتحقيق الرغبة الكهربائية ومقاومة التآكل، وتقليل التآكل والاحتكاك، وتحسين تحمل الحرارة والديكور.

أساسيات الطلاء الكهربائي:

يشمل الجزء "الكهربائي" من النظام مصدر الجهد / التيار والأقطاب الكهربائية والأنود والكاثود، مغمورًا في الجزء "الكيميائي" من النظام، أو المنحل بالكهرباء أو الطلاء، مع استكمال الدائرة بتدفق الأيونات من حمام الطلاء إلى الأقطاب الكهربائية. قد يكون المعدن المراد ترسيبه هو الأنود ويتأين ويذهب إلى محلول في المنحل بالكهرباء، أو يأتي من تكوين حمام الطلاء. عادة ما يأتي النحاس والقصدير والفضة ومعدن النيكل من الأنودات، بينما تضاف أملاح الذهب عادة إلى حمام الطلاء في عملية خاضعة للرقابة للحفاظ على تكوين الحمام. يحتوي حوض الطلاء بشكل عام على أيونات أخرى لتسهيل تدفق التيار بين الأقطاب الكهربائية. يتم ترسب المعدن عند الكاثود. تحدث عملية الطلاء الإجمالية بالتسلسل التالي

1. يضخ التيار الكهربائي الإلكترونات في الكاثود.
2. ينتقل الإلكترون من الكاثود إلى أيون فلزي موجب الشحنة في المحلول والصفائح المعدنية المختزلة على الكاثود.
3. يكمل التوصيل الأيوني من خلال حوض الطلاء الدائرة إلى الأنود.
4. في الأنود ، تحدث عمليتان مختلفتان اعتمادًا على ما إذا كانت مادة الأنود قابلة للذوبان ، أو مصدر المعدن المراد طلاؤه ، أو غير قابل للذوبان ، خامل. إذا كانت مادة الأنود قابلة للذوبان، فإن ذرة معدنية تتخلى عن الإلكترون وتذهب إلى المحلول كأيونات معدنية مشحونة إيجابًا لتجديد المحتوى المعدني لحمام الطلاء. إذا كان الأنود خاملًا، فإن أيونًا مشحونًا سلبًا من حوض الطلاء يتخلى عن إلكترون إلى الأنود.
5. يتدفق الإلكترون من الأنود إلى مصدر الطاقة لإكمال الدائرة. يتطلب ترسب المعدن عند الكاثود إلكترونًا لذلك يعتمد معدل الترسب على تدفق الإلكترونات، أي التيار المتدفق من المقوم. وبالتالي، فإن سمك الرواسب يعتمد على التيار وطول الوقت الذي يتم فيه تطبيق التيار. هذه العلاقة هي نتيجة لقانون فاراداي الذي يربط وزن المادة التي ينتجها تفاعل قطب أنود أو كاثود أثناء التحليل الكهربائي بأنها تتناسب بشكل مباشر مع كمية الكهرباء التي تمر عبر الخلية.

Traduction

Définition et principe de base de l'électro-dépôt :

L'électrodéposition est le processus de revêtement d'une mince couche d'un métal sur un métal différent pour modifier ses propriétés de surface. Il est fait pour atteindre la résistance électrique et à la corrosion souhaitée, réduire l'usure et le frottement, améliorer la tolérance à la chaleur et pour la décoration.

Principes de base de la galvanoplastie :

La partie « électro » du système comprend la source de tension / courant et les électrodes, l'anode et la cathode, immergées dans la partie « chimique » du système, l'électrolyte ou bain de placage, le circuit étant complété par le flux d'ions du bain de placage aux électrodes. Le métal à déposer peut être l'anode et est ionisé et aller en solution dans l'électrolyte, ou provenir de la composition du bain de placage. Le cuivre, l'étain, l'argent et le nickel métallique proviennent généralement des anodes, tandis que les sels d'or sont généralement ajoutés au bain de placage dans un processus contrôlé pour maintenir la composition du bain. Le bain de placage contient généralement d'autres ions pour faciliter la circulation du courant entre les électrodes. Le dépôt de métal a lieu à la cathode.
Le processus de placage global se déroule dans l'ordre suivant :

1. L'alimentation pompe les électrons dans la cathode.
2. Un électron de la cathode se transfère à un ion métallique chargé positivement dans la solution et les plaques métalliques réduites sur la cathode.
3. La conduction ionique à travers le bain de placage complète le circuit vers l'anode.
4. À l'anode, deux processus différents ont lieu selon que le matériau de l'anode est soluble, la source du métal à plaquer ou insoluble, inerte. Si le matériau anodique est soluble, un atome de métal abandonne un électron et entre dans la solution sous la forme d'un ion métallique chargé positivement reconstituant la teneur en métal du bain de placage. Si l'anode est inerte, un ion chargé négativement du bain de placage cède un électron à l'anode.
5. L'électron circule de l'anode à l'alimentation électrique complétant le circuit. Le dépôt de métal à la cathode nécessite un électron, de sorte que la vitesse de dépôt dépend du flux d'électrons, c'est-à-dire du courant provenant du redresseur. L'épaisseur du dépôt dépend donc du courant et de la durée d'application du courant. Cette relation est le résultat de la loi de Faraday qui établit que le poids d'une substance produite par une réaction d'électrode anodique ou cathodique pendant l'électrolyse est directement proportionnel à la quantité d'électricité traversant la cellule.

Exercise 6 : Translation

English

Definitions

1. Current Efficiency:

On account of the impurities which cause secondary reactions, the quantity of a substance liberated is less than that calculated from Faraday's Law. Current efficiency is the ratio of the actual mass of a substance liberated from an electrolyte by the passage of current to the theoretical mass liberated according to Faraday's law. Current efficiency can be used in measuring electro deposition thickness on materials in electrolysis. Current efficiency is also known as faradic efficiency, faradic yield and columbic efficiency.

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(ii) Electrolyte concentration,
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(iv) Addition agents,
(v) Nature of electrolyte;
(vi) Nature of the metal on which the deposit is to be made,
(vii) Throwing power of the electrolyte.

3. Temperature:

The temperature of the electrolyte has two contradictory effects. One, at comparatively high temperature there is more diffusion and even at relatively high current density smooth deposits may be produced. Two, the rate of crystal growth increases the possibility of coarse deposits. At moderate temperatures the deposits are good. In chromium plating the temperature is maintained at 35°C, and in nickel between 50°C to 60°C.

Français

عربية