Journal of Industrial and Engineering Chemistry 18 (2012) 888–897

Contents lists available at SciVerse ScienceDirect

Journal of Industrial and Engineering Chemistry

journal homepage: www.elsevier.com/locate/jiec

Barrel plating process specification for undercoating with copper cyanate

Kyong Ho Han [b], Seung Bum Lee [a], In Kwon Hong [a,*]

[a] Department of Chemical Engineering, Dankook University, 448-701, Republic of Korea
[b] Department of Electronics and Electrical Engineering, Dankook University, 448-701, Republic of Korea

ARTICLE INFO

Article history:
Received 17 April 2011
Accepted 25 June 2011
Available online 7 November 2011

Keywords:
Barrel plating
Copper cyanate
Undercoating
Coating thickness
Open pore ratio

ABSTRACT

Barrel plating is a method of coating small parts using a horizontal type barrel, which can be operated automatically. Nevertheless, barrel plating for a plating material with a complex geometry has a problem with deviations in the coating thickness due to the supply of the plating solution through the barrel and irregular contact of the plating material and cathode. Therefore, this study examined the relationship between the barrel pore size, number of pores and open pore ratio in copper cyanide barrel plating as well as the plating characteristics in accordance with the process variables, such as the barrel rotation speed, plating temperature, plating voltage and plating time. An automobile wheel nut was selected as the plating material and barrel plating was carried out in a 4.7 L sized barrel. The optimal part charging quantity was found to be 40 ea., and the plating characteristics of the best quality for the optimal plating conditions of the barrel plating process were a plating temperature, plating voltage and rotation speed of 323 K, 1 V and 1.5 rpm in a barrel with 22.5% of open pore ratio.

1. Introduction

The size of plating materials is decreasing with the increasing compactness of the shape of finished goods. As various small parts are being localized in cases of electronic parts or automobile parts, the automation of a plating process for a large quantity of plating materials is essential and barrel plating has attracted considerable attention. Barrel plating is a plating method that involves the charging of small plating materials (500 g or less by weight) in a barrel, which has the advantage of automation without manual racking or unracking. Plating in a barrel involves the rotation of small plating materials that are contact with each other. This is different from general electroplating because there is less variation in the plating thickness between low current and high current areas and the plating materials may have the luster of an incidental grinding effect. Barrel plating is used mostly as an undercoat for strike plating rather than for thickness plating [1–3].

Barrel plating equipment is divided into a horizontal type and a sloping type barrel. The horizontal type barrel rotates horizontally in a small plating bath, and the material is plated as metal ions are supplied to the barrel through the pores on the barrel surface. The rotating speed of the horizontal type barrel is in the range of 6–15 rpm according to the size of the plating material or barrel. The voltage is up to 10–15 V because the resistance increases when a voltage flows though many pores on the barrel surface between the anode and cathode. The sloping type barrel, which is used to plate small quantities or small parts, such as electronic components, does not submerge the barrel in the plating bath but the barrel is rotating for plating after placing the plating solution in a barrel inclined by 1/3 of its volume. Plating is usually worked in a 30–40° sloping barrel, and it is operated at a rotation speed of 5–20 rpm and a voltage of 6–8 V. The barrels used for barrel plating are divided into rectangular and cylindrical types, and various types of barrels, such as hexangular, octangular and circular types, are used according to the shape and size of the plating materials. The dimensions of the barrel are generally ID = 300–350 mm, L = 600–650 mm, and V = 30–75 L, and vinyl chloride or polyethylene are used as the barrel material because they have outstanding chemical and thermal resistance [4–7].

The barrel plating of parts with complex geometries can lead to plating failure or peeling-off of the plated layer because of a deficiency of metal ions from the anode to the barrel inside, and a deviation of the plating thickness can also occur on account of the change in current density due to the irregular contact between the cathode busbar and plating materials. The situation seriously requires an understanding of the plating characteristics according to the plating variables in barrel plating because barrel plating in industry depends only on the engineer's experience, and its application to new plating materials is solved by a trial-and-error method [8–10]. This study examined the relationships between the barrel pore size, number of pores, and open pore ratio in copper

* Corresponding author. Tel.: +82 31 8005 3544; fax: +82 31 8005 3536.
E-mail address: khong@dankook.ac.kr (I.K. Hong).

1226-086X/$ – see front matter
doi:10.1016/j.jiec.2011.11.066

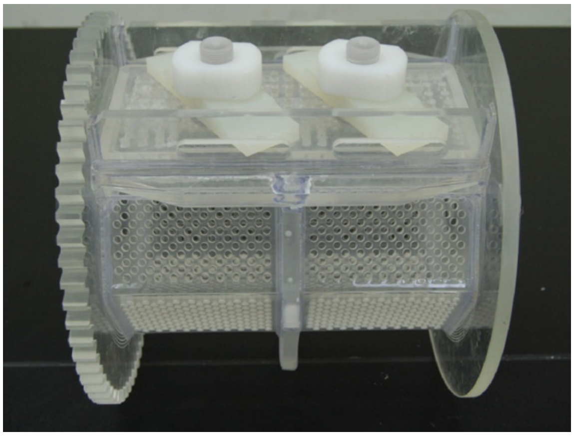

Fig. 1. The photograph of barrel in pilot plating plant.

cyanide barrel plating as an undercoating process to produce a database after observing the plating characteristics in accordance with the process variables, such as the barrel rotation speed, plating temperature, plating voltage and plating time.

Table 1
Specifications of the barrel in this study.

Pore size, *d* (mm)	Number of pore, *P* (ea.)	Area of pore, *C* (mm^2)	Open pore ratio, *H* (%)
3	2533	17,904.7	14.5
5	1417	27,822.7	22.5
8	680	34,180.5	27.6

2. Experimental

2.1. Making of copper cyanide solution

Copper cyanide itself cannot be dissolved in water but dissolves in the form of $Cu(CN)_3^{2-}$ complex ions in water when added with sodium cyanide or potassium cyanide. On the other hand, it makes a complex ion with a too high coordination number in the form of $Na_3Cu(CN)_4$ when excess sodium cyanide is supplied, and NaCN is extricated off after dissociation if the amount of NaCN is too little or the temperature is too high [11,12]. This experiment examined copper cyanide barrel plating with constant copper cyanide (CuCN) and sodium cyanide (NaCN) concentration at 50.0 g/L and 70.0 g/L, respectively, which is an intermediate concentration plating solution.

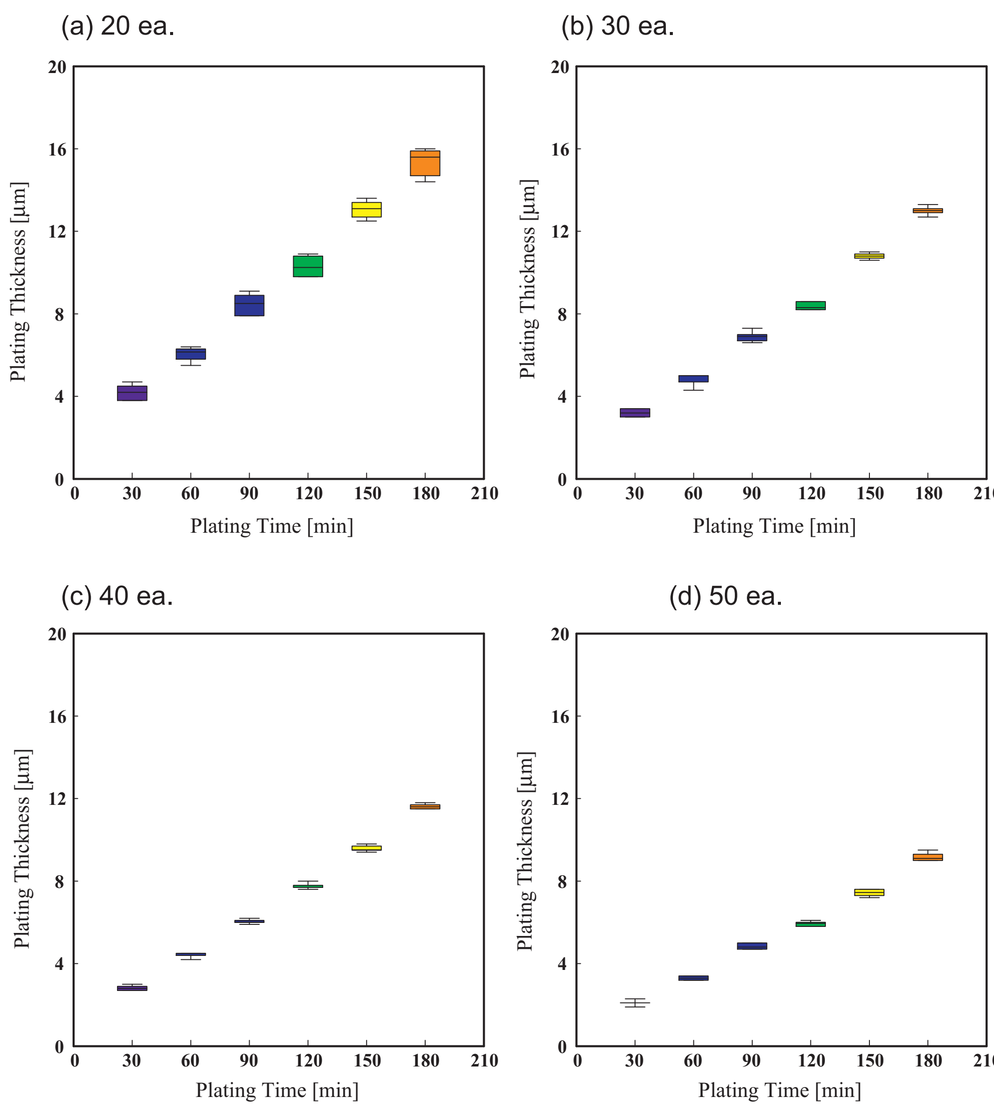

Fig. 2. Variation of the plating thickness as a function of the number of wheel nuts at 323 K (*H* = 22.5%, rotating speed = 1.5 rpm, voltage = 1.0 V).