ELECTROCHEMICAL PLATING WITH NICKEL AND CHROMIUM METALS FOR CORROSION PROTECTION

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ABSTRACT:

Electrochemical plating method has been used for plating Nickel and Chromium onto Copper substrates.

In this work $NiSo_4$ and CrO_3 are used as a basic salts for preparing Nickel and Chromium electrolytes respectively. X-Ray diffraction, microscopical and composition examinations have been used to study surface and crystal structures for Ni and Cr plating layers.

Results have shown that the crystal structure of Ni plating is in the (FCC) with lattice constant of 3.5238Å and for Cr plating is in the (BCC) with lattice constant of 2.8845Å. Mechanical properties examination on these plating layers have been investigated. It was found that the hardness for Ni plating is 800HV and for Cr plating is 750HV.

The corrosion rates have been measured for both Ni and Cr platings. They are 0.00011mpy for Ni plating and 0.00009mpy for Cr plating.

الطلاء الكهروكيمياوي بمعادن النيكل و الكروم للوقاية من التآكل

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الخلاصة

أستخدمت طريقة الطلاء الكهروكيمياوي لعملية التغطية بطلاءات النيكل والكروم على قواعد من معـدن النحاس وباستخدام الخلايا الكهروكيمياوية حيث تم تحضير محاليل الطلاء (الالكتروليت) بالاعتماد على ملـح كبريتات النيكل ($NiSO_4$) كملح أساسي لترسـيب طلاء النيكل مع اسـتخدام بعض المواد الإضـافية، أما محلول طلاء الكروم فقد تم تحضيره باسـتخدام ثلاثي اوكسـيد الكروم (CrO_3) كمـادة أساسـية مـع استخدام بعض المواد الإضافية أيضاً. أجريت فحوصات حيود الأشعة السينية (X-Ray Diffraction) لدراسة التركيب البلوري لكل من طلاء النيكل و الكروم، كما أجريـت الفحوصـات المجهريـة و قياسـات الصلادة و عمليات تحليل التركيب الكيمياوي لهذه الطلاءات، كذلك أجريت قياسات معدلات التآكل لكـل من الطلاءات المحضرة و المعدن الأساس. لقد بينت النتائج أن التركيب البلوري لطلاء النيكل هـو المكعـب المتمركز الأوجه (F.C.C) و لطلاء الكروم المكعب المتمركز الجسم (B.C.C) . أما معدل التآكل باستخدام محلول (NaOH) كوسط أكل و بتركيز (50%) فلقد بلغ (0.00011 mpy) لطلاء النيكل و (0.00009 mpy) لطلاء الكروم.

INTRODUCTION:

Modern technology has at its disposal a wide range of constructional materials-metals and alloys, plastic, rubber etc. and the selection of an appropriate material for a given application is the important responsibility of the design engineer [1].

The interaction of a metal or alloy with its environment is clearly of vital importance in the performance of materials of construction, and the fact that the present work is largely confined to a detailed consideration of such interaction could create the importance that this was the sole factor of importance in materials selection. Nickel and Chromium metals have been selected as the coating metals on the Copper substrates using electrochemical plating method for corrosion protection of copper.

Copper substrates are good electron conductors can be electroplated with adherent coatings. Nickel coatings have long been applied to metallic substrates in order to provide a surface that is resistant to corrosion, erosion and abrasion. Electrodeposited chromium is one of the most widely used metallic coatings, both decorative and "hard", is produced with the use of a solution of chromic acid containing a small amount of catalyst may be used.[2]

THEORITICAL:

The processing of electrochemical plating is not easy but it depends on many factors such as current density through the metals, electrolyte concentration, temperature of electrolyte, (pH) and the deposition time. Current enters through the metal-electrolyte interface of the anode, which is usually made from the same metal as is plated on the cathode. The anode dissolves replacing the metal lost at the cathode:

$$M = M^{n+} + ne^{-} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

The weight (W) of the deposited material on the electrode can be expressed by Farady law:[3]

$$W = It\, W_{eq} / nF$$

$$W = \frac{ItW_{eq}}{96500} \quad \ldots\ldots\ldots\ldots (2)$$

where: (n) Equivalent number, (F) Farady constant, (I) Current Density, (t) Deposition Time, (W_{eq}) Equivalent Weight.

For electrochemical plating, the current efficiency (η) can be determined from this equation:[4]

$$\eta = \frac{W_{ex}}{W_{th}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where (W_{th}) the calculated weight of deposited material and (W_{ex}) the weight of deposited material from the experiment.

As the time of plating and the current through electrolyte will be known , the deposited material can be calculated from this equation:[5]

$$W = \frac{ItW_{eq} * \eta}{96500} \quad \text{……..(4)}$$

From the following equation , the Corrosion Rate (R_{mpy}) can be calculated by measuring the losses of weight of metals.[6]

$$R_{mpy} = \frac{W_L * 22.273}{\rho A t} \quad \text{…. ...(5)}$$

where :R_{mpy}: corrosion rate (mpy) , W_L : losses of weight (gm) , ρ : metal density (gm/cm^3), A : sample area ($inch^2$) ,t : time (year)

EXPERIMENTAL:

Figure (1) shows the electrochemical plating cell. The copper substrates are connected as cathodes where the Nickel or Chromium was deposited on Copper as coating films.[7,8]

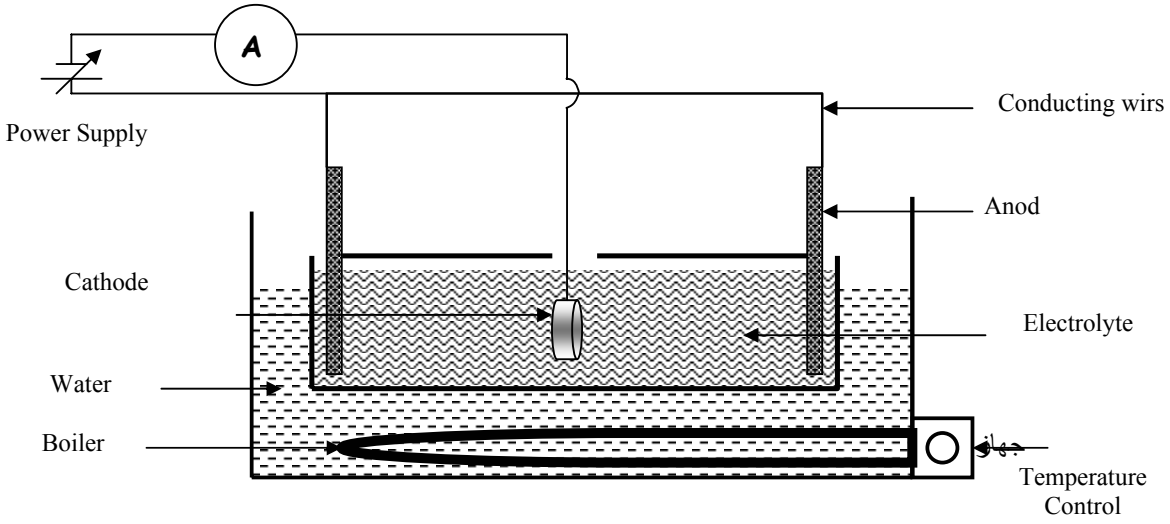


Fig (1): The Electrochemical Plating Method

The Composition of electrolyte for electroplating Nickel is: Nickel sulphate ($NiSO_4$) 180g/l , Ammonium chloride (NH_4Cl) 25g/l and Boric acid (H_3BO_3). Chromium Plate can be obtained from the electrolyte with composition of Chromic acid (CrO_3) 250g/l and Sulphuric acid (H_2SO_4) 2.5g/l.

Nickel or Chromium plate on Copper substrates have been prepared by changing the current density to obtain a variable thickness of plating at constant deposition time of 3min and electrolyte temperature of 55 ^{0}C.

X-ray diffraction have been investigated to study the crystal structure of Nickel and Chromium plates. Lattice constant of these coating layers are calculated. Mechanicl

examination on these plating layers have been investigated by measuring the hardness using Vickers test method.

Microscopicl examinations have been obtained to study the surface structure of these platings using OLYMPUS optical microscope.

Corrosion rates of these samples have been measured using Sodium Hydroxide (NaOH) as corrosive environment medium with different concentrations of 10% and 50%. The corrosion rates are measured on losses in weight of coating layers with time (Days).

RESULTS:

The variation of plating thickness with current density for Nickel and Chromium shows in Fig. (2).

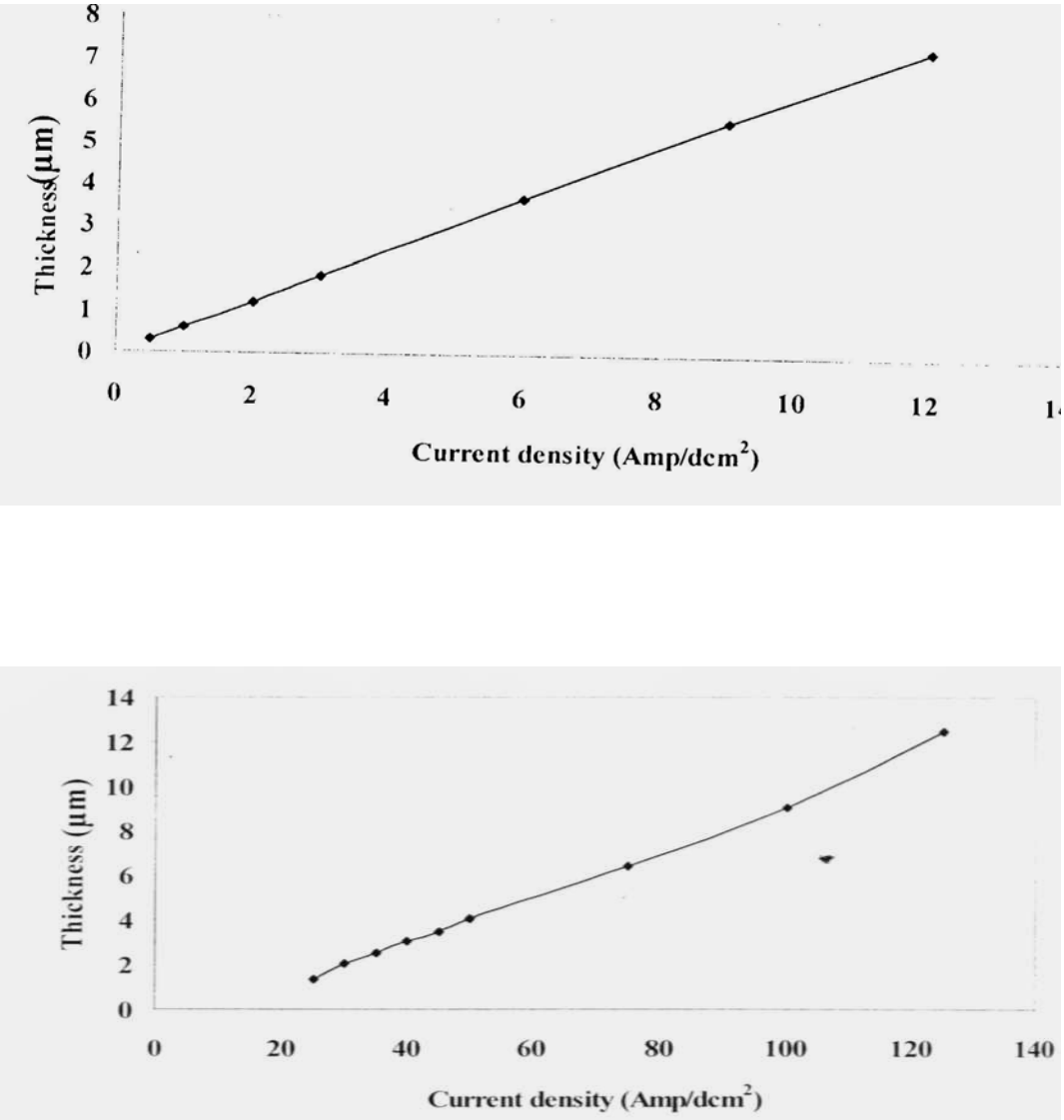


Fig (2): Variation of plating Thickness with Current density for: (above) Ni and (below) Cr

Results have shown that the crystal structure of Ni plating is in the (FCC) structure with lattice constant of 3.5238Å and for Cr plating is in the (BCC) structure with lattice constant of 2.8845Å. Mechanical properties examination on these plating layers have been investigated. It was found that the hardness for Ni plating is 800HV and for Cr plating is 750HV.

Microscopical examinations for Ni and Cr plating to study the surface structure shows in figure (3) at magnification of 400X .

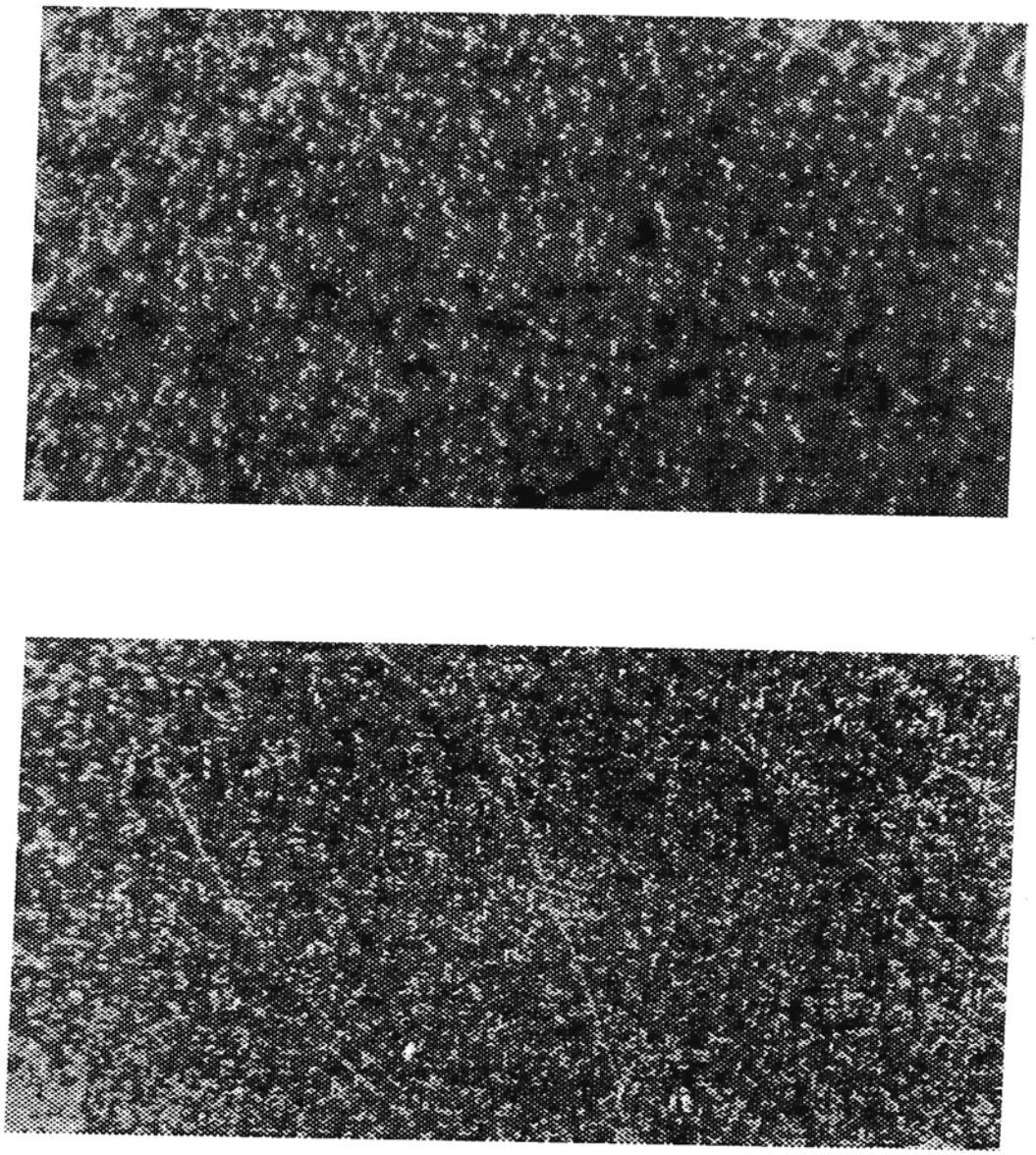
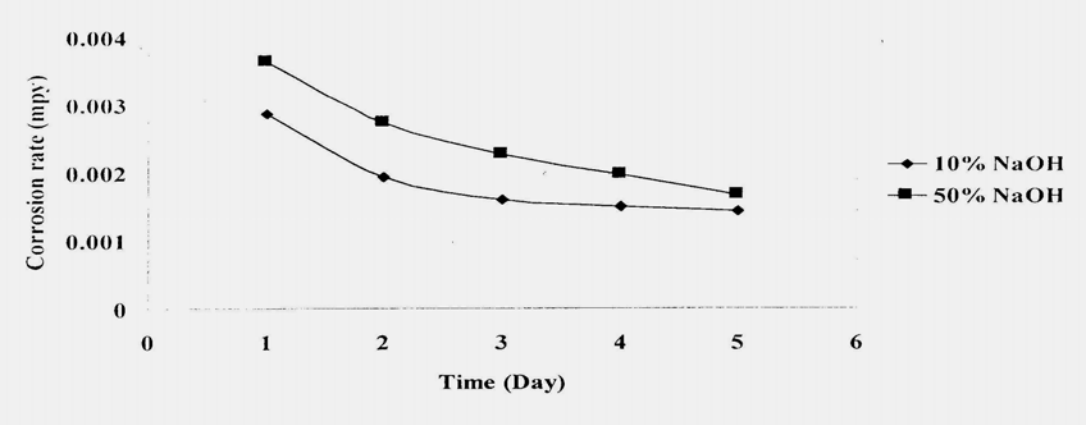
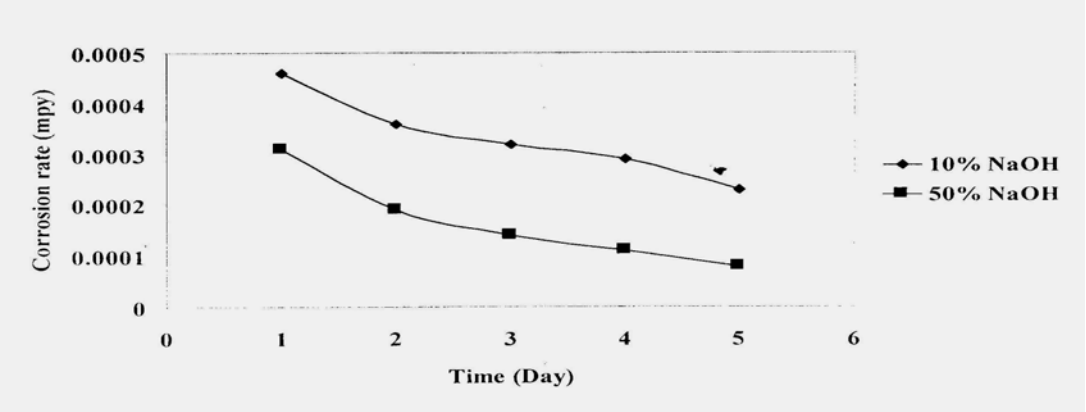


Fig (3): Micrograph using optical microscope at Mag. Of 400X for: (above) Ni and (below) Cr

Corrosion rates have measured for Copper substrates, Ni and Cr plating layers using NaOH as corrosive medium within 5 days. The results demonstrated in figure (4).





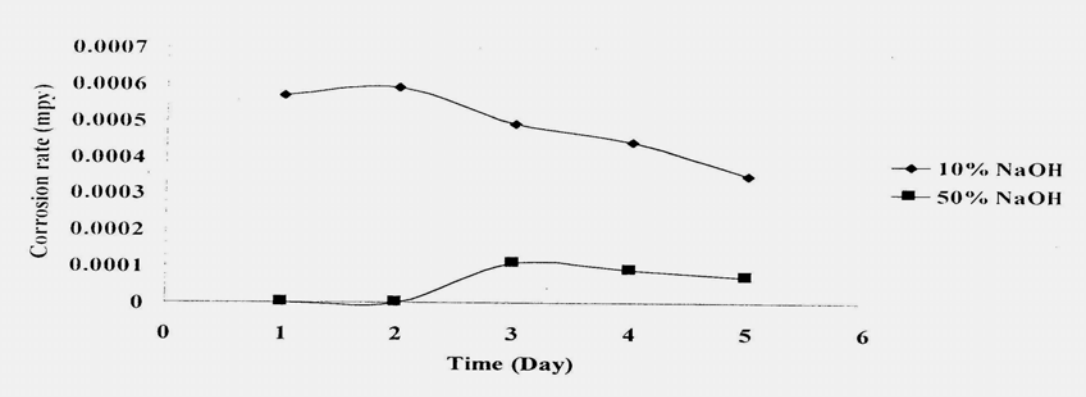


Fig (4): Variation of Corrosion rates with Time for:
(above) Cu , (Middle) Ni and (below) Cr

DISCUSSION:

Electrochemical plating method has been used for plating Nickel and Chromium onto Copper substrates. Different thicknesses of plating have been obtained. X-ray diffraction has shown polycrystalline struture of Ni and Cr layers are grown on Cu substrates. Good results of hardness have been obtained for Ni plating of 800HV and for Cr plating of 750HV.

Figure (2) shows the increasing of the deposition of plating layers thickness with the increasing of current density duo to acceleration of metalice ions to be deposited at the electrode.

Microscopical examinations of these platings are shown in fig.(3) confirmed the surface structure of these platings layers are smooth and homogenous. The corrosion rates have been measured for both Ni and Cr platings demonstrated in fig.(4). They are 0.00011mpy for Ni plating and 0.00009mpy for Cr plating[9].

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