COMPOSITION DISTRIBUTION IN Zn-Ni ALLOY PLATING

C. Shankar[a] and Malathy Pushpavanam[b]

[a]Government College of Technology, Coimbatore - 641 013, Tamil Nadu, India
[b]Central Electrochemical Research Institute, Karaikudi - 630 006, Tamil Nadu, India

Composition dispersion during zinc-nickel alloy plating from a chloride bath has been studied using a bent cathode. The effect of bath composition, operating conditions and the effect of having shields of different configurations, have been studied and the best condition for producing deposits with minimum composition dispersion has been identified.

INTRODUCTION

Zinc-nickel alloy has been in commercial use especially in the automotive industry for components such as fuel, break and transmission components and in pre-fabricated steel components in Japan and other European countries to provide good corrosion resistance and also with a view to replace toxic cadmium (Pushpavanam, 2001).

In any deposition, thickness distribution plays an important role to decide properties like porosity and corrosion resistance. In alloy deposition, besides this, the composition of the deposit also decides the property of the coating and any appreciable variation in the composition over an irregularly shaped component will result in difference in colour, strength, corrosion resistance and other physical properties from point to point. The extent of variation in alloy composition in an object is known as 'Composition Dispersion' (Brenner, 1963) and minimum dispersion is anticipated to get the best performance. The variation in composition is mostly decided by the current distribution on the object and its influence on the alloy composition. Obviously, deposition from a complex bath results in less dispersion.

This alloy has been electrodeposited from both acidic and alkaline solutions and both have their own merits and demerits (Pushpavanam, 2001). The alkaline baths invariably are dependant on organic complexes causing disposal problems in one way or the other. Also, the cathode current efficiency from these systems is very low, leading to the embrittlement of steel components. But, they have the unique advantage of yielding deposits having almost uniform composition over a wide spectrum of current densities due to the complex nature of the bath. The acidic baths offer white deposits with high rate of deposition and ensure less embrittlement of the components. However, the composition dispersion is more than that in alkaline baths and hence more attention is to be given for reducing it or increasing the current distribution. With this in mind, the authors have tried various methods such as introducing conformal anodes, shields, reducing the cell dimension, inter-electrode distance(IED), etc., in zinc-nickel alloy deposition from a chloride bath and the results are summarised in this paper.

EXPERIMENTAL

A purified bath of the following composition

Zinc as chloride	40 g/L
Nickel as chloride	28 g/L
Total chloride	150 g/L
H_3BO_3	30 g/L
pH	4.0

was used:

Polished, degreased and electro-cleaned stainless steel cathodes of 3 x 16.5 cm. bent as shown in Fig. 1 were used for composition

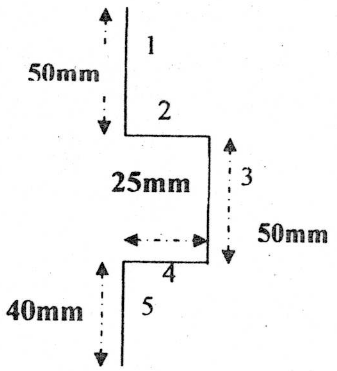

Fig. 1 - Bent cathode structure

determination at the points 1, 2, 3, 4 and 5. The deposits at these points were stripped in dilute nitric acid and then estimated for their nickel content volumetrically. Dual anodes

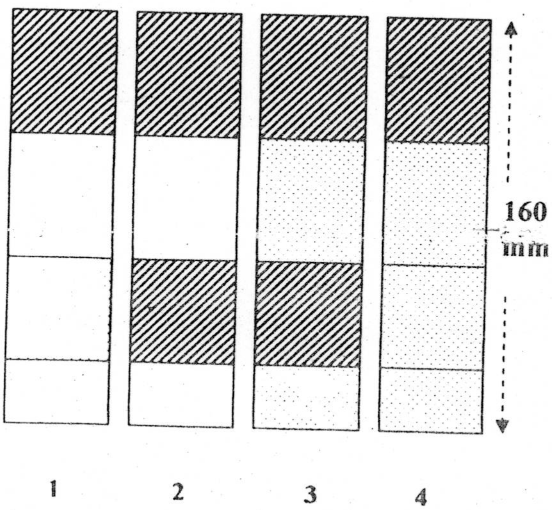

Fig. 2 - Different shields used for the study

were used. Shields of various shapes as given in Fig. 2. were used to enable uniform current distribution. Experiments were conducted in a 7 x 24 x 24 cm. PVC cell. Effect of using a conformal anode, reducing the breadth of the cell to 3.5 cm. and changing the inter electrode distance etc., on the composition dispersion of the alloy was also studied.

RESULTS AND DISCUSSION

In a rectangular cell in which the electrodes completely cover the walls, the current distribution at the cathode is supposed to be uniform. The electric field between the electrodes is parallel. A deposit obtained with such a cell configuration should have uniform current distribution and hence the composition over the entire cathode surface. But, in the zinc-nickel alloy system, the nickel content of the deposit decreases with current density. Any variation in the current distribution will be indicated by a change in the nickel content of the alloy increasing the composition dispersion. The current density differences between the electrode edges and the centre will be greater, the smaller the distance between the electrodes and hence, it is normally maintained at 15 cm in regular metal deposition.

Fig. 3 depicts the change in nickel content at five different points on the bent cathode keeping the IED as 15, 23 and 30 cm. It is observed

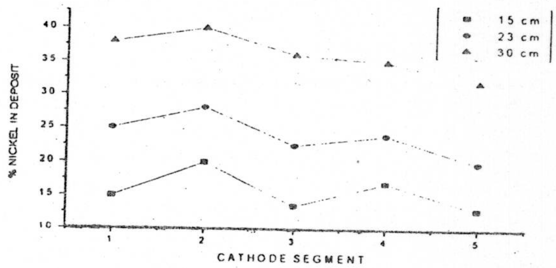

Fig. 3 - Effect of inter-electrode distance on the alloy composition

that more uniform alloy composition is obtained with increase in IED. Generally, the nickel content at all points were on the higher side with increase in IED to 30 cm, probably due to increase in the solution resistance. Due to practical difficulties, a distance of 23 cm was selected for other experiments.

Figs. 4 and 5 show the effect of introducing shields during plating with 15 cm and 23 cm IED. Shields 2 and 3 showed more improvement in the uniformity of alloy composition compared to 1 and 2.

Fig. 6 shows the effect of chloride ion concentration on the nickel content at all points.

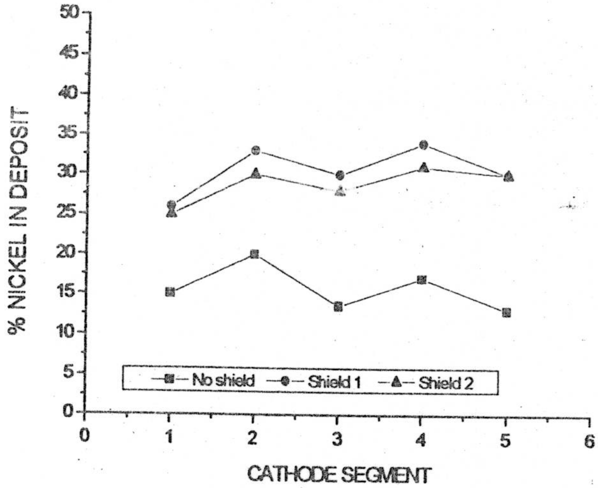

Fig. 4 - Effects of shields on the alloy deposition (15cm IED)

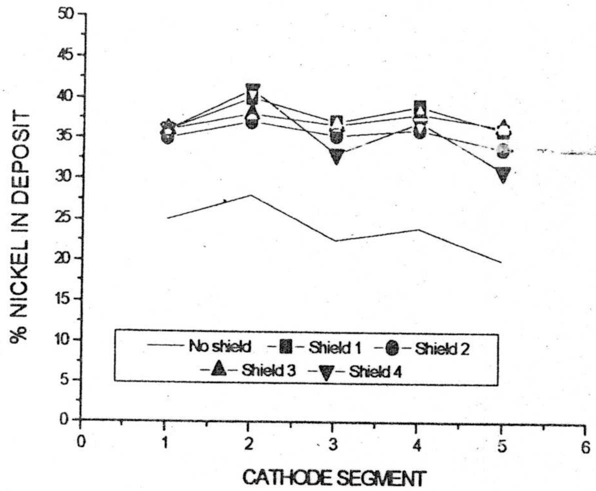

Fig. 5 - Effect of shields on the alloy composition (23cm IED)

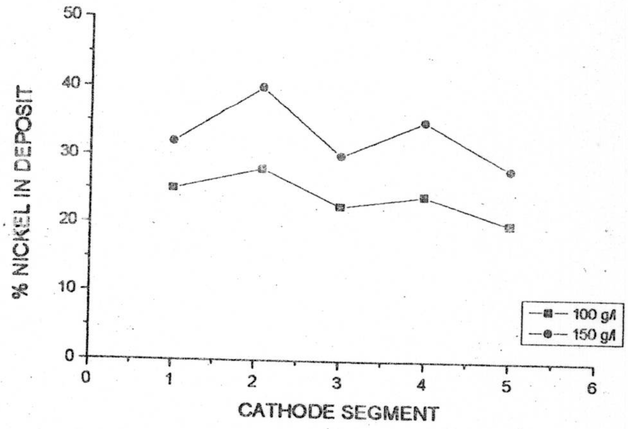

Fig. 6 - Effect of chloride ion concn. on the alloy composition (23cm IED)

Generally in plating baths, increase in chloride ion concentration increases the throwing power due to increased electrolyte conductivity. But, the results indicate that composition dispersion is adversely affected by increased chloride concentration. Moreover, increase in conductivity should result in increase in current density at the points, which will have the tendency to reduce nickel content. It could, therefore, be concluded that increased chloride concentration has favoured more of nickel co-deposition in the alloy.

It was observed that use of conformal anode, as shown in Fig. 7, which is normally adopted to get uniform deposition even in the inaccessible portions, has increased the composition dispersion. Also, halving the cell width shows a beneficial influence of unifying the composition at all points.

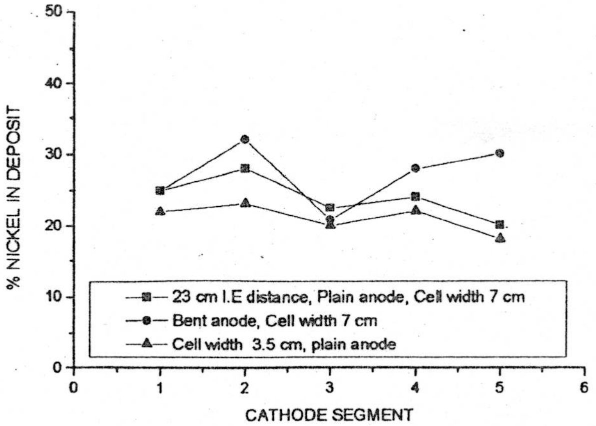

Fig. 7 - Effect of bent anode and reducing the cell width on the alloy composition (23cm IED)

CONCLUSION

With proper adjustment of the cell dimensions, inter electrode distance and shields, it is possible to improve the composition dispersion and current distribution on the cathode during Zn-Ni alloy deposition.

ACKNOWLEDGEMENT

The authors wish to express their sincere thanks to the Director, Central Electrochemical Research Institute, Karaikudi for permission to publish this paper.

REFERENCES

1. A. Brenner (1963) Electrodeposition Of Alloys, Academic Press, NY.
2. Malathy Pushpavanam (2001), B. Electrochem., Vol. 16, 539.

(Cont. from page 165)

- Micrographs have a clear scale bar on the photograph with the magnification given in the legend
- Tables and figures are self-explanatory with key details of procedures given in the legend or foot notes
- Values in tables and text do not exaggerate the accuracy of the methods used
- References agree between text and list
- Non-standard abbreviations are defined at first use