Bulletin of Electrochemistry 6 (1) January 1990, pp 44-45

Characteristics of fluoborate solutions with titanium for cadmium electrodeposition

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Experiments were carried out for identifying the deposition characteristics of titanium-containing fluoborate cadmium plating solutions making use of cold rolled and spring steel substrates. Electrochemical studies on permeation of hydrogen during cadmium plating showed a titanium content of 0.5 g dm^{-3} to be of advantage.

Key words: Cadmium plating, hydrogen permeation, fluoborate bath

INTRODUCTION

There are areas of use such as aerospace and defence where electroplated cadmium is unlikely to be replaced. The fluoborate bath is of great importance for electroplating of high strength steels with no or only minimal hydrogen embrittlement. This paper reports the results of investigations performed with cold rolled and 165 $kg.mm^{-2}$ UTS spring steel substrates and solutions composed of cadmium fluoborate (222.0 $g.dm^{-3}$) and, apart from other ingredients, tetravalent titanium (0.5–2.5 $g.dm^{-3}$), because of the experimentally observed reduction in hydrogen pick-up due to titanium addition [1].

EXPERIMENTAL

Cadmium was electroplated on anodically alkaline-cleaned specimens of cold rolled steel (8.0 × 2.5 × 0.02 cm) and of spring steel (8.0 × 2.5 × 0.015 cm), from 250 ml fluoborate cadmium plating solutions containing 222.0 $g.dm^{-3}$ cadmium fluoborate, 5.5 $g.dm^{-3}$ ammonium fluoborate, 20.0 $g.dm^{-3}$ boric acid, and 0.5, 1.5 or 2.5 $g.dm^{-3}$ tetravalent titanium, of pH 3.0 and prepared as for earlier work [1]. Tetravalent titanium was introduced in the form of a solution prepared by dissolving freshly precipitated titanium from potassium titanium oxalate in fluoboric acid. Plating was carried out at current densities of 100, 200 and 300 $A.m^{-2}$ and at room temperature. Pure cadmium anodes were employed. The anode-to-cathode distance was maintained at 6.0 cm. The cathode current efficiency was determined in each case from the deposit mass and the quantity of electricity passed through the solution. An almost AC-ripple-free direct current was used.

Hydrogen permeation studies were performed by the electro-permeation technique making use of 0.015 cm thick spring steel specimens flashed on one side with palladium from a tetramminopalladium bath [2], and the same experimental set- up as in earlier experiments [1].

RESULTS AND DISCUSSION

The results of experiments of electrodeposition characteristics of the solutions show that, on both the substrates, matt white, smooth deposits can be obtained at current densities

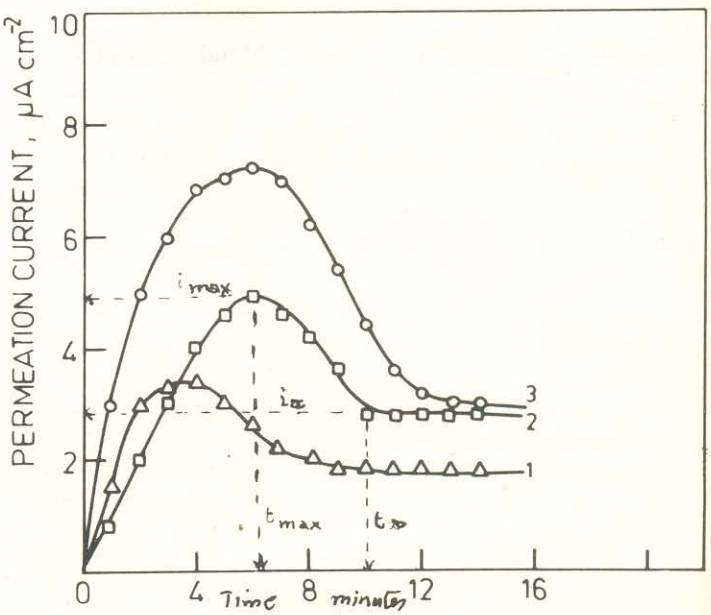

Fig. 1: Typical plots of permeation current and time for different current densities

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of 100-300 $A.m^{-2}$ with current efficiencies of 98,93 and 90 per cent respectively for titanium concentrations of 0.5, 1.5 and 2.5 $g.dm^{-3}$ in the solutions.

Table I and Fig. 1 present data in regard to hydrogen permeation during cadmium deposition. Whereas the permeation current increases with plating current density, an increase in titanium concentration, while giving rise to a lower efficiency, is generally associated with a lower permeation current. A titanium concentration of 0.5 $g.dm^{-3}$ therefore appears to be adequate.

TABLE–I: Influence of tetravalent titanium concentration on hydrogen permeation in spring steel

Current density (Am^{-2})	Titanium concentration ($g.dm^{-3}$)	i_{max} (μAcm^{-2})	t_{max} (min)	i_{∞} (μAcm^{-2})	t_{∞} (min)
100	0	4.3	3.0	2.5	8.0
	0.5	3.4	3.5	1.8	9.0
	1.5	3.0	4.0	1.6	9.0
200	0	6.5	5.0	3.8	10.0
	0.5	5.0	6.0	2.8	10.0
	1.5	5.5	6.0	2.5	12.0
300	0	8.0	5.0	4.0	12.0
	0.5	7.2	6.0	3.0	13.0
	1.5	7.6	5.0	3.3	13.0

It is of great practical significance that the hydrogen pick-up by spring steel, also a high strength steel, gets reduced if tetravalent titanium is present in an acidic plating solution.

CONCLUSION

Presence of 0.5 $g.dm^{-3}$ tetravalent titanium in a fluoborate cadmium solution appears to be advantageous for cadmium plating of high strength steels with minimum hydrogen pick-up.

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