Properties of Electrodeposited Zn-Fe-SiO_2 Composite Material

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Abstract: Electrodeposited Zn and Zn-Fe alloy has been applied widely to protect steel from corrosion, but there are still some problems need to be solved, such as pollution of passivation, low corrosion resistance, high hydrogen embrittlement, etc. In this paper, Zn-Fe-SiO_2 composite materials have been synthesized from sulfate bath by non-cyanogen plating technology. Corrosion resistance, porosity and hydrogen embrittlement of Zn-Fe-SiO_2 composite materials have been tested and these data have been compared with the properties of Zn and Zn-Fe alloy. The results show that corrosion resistance and all other properties of Zn-Fe-SiO_2 composite materials are superior to Zn and Zn-Fe alloy, and this kind of non-passivation environmentally benign materials has a great future in application.

Key words: plating technology; Zn-Fe-SiO_2 composite material; environmentally benign materials
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Enormous economic lost and social hazard are caused by metal corrosion[1]. Electrodeposited Zn and Zn-Fe alloy has been applied widely to protect steel from corrosion, but there are still some problems need to be solved, such as pollution of passivation, low corrosion resistance, high hydrogen embrittlement, etc[2-5].

Zn-Fe-SiO_2 composite materials have been synthesized from sulfate bath by non-cyanogen plating technology. Corrosion resistance, adhesion, porosity and hydrogen embrittlement of Zn-Fe-SiO_2 composite materials have been tested systematically, and these data have been compared with the properties of Zn and Zn-Fe alloy.

1 Experiments

The Zn-Fe-SiO_2 composite materials with Fe 2.5% and SiO_2 0.5% are electrodeposited from sulfate bath: $FeSO_4 \cdot 7H_2O$ 30 g/L, $ZnSO_4 \cdot 7H_2O$ 50 g/L, $(NH_4)_2SO_4$ 60 g/L, $C_6H_8O_7 \cdot H_2O$ 30 g/L, $Al_2(SO_4)_3 \cdot 12H_2O$ 6 g/L, ascorbic acid 2 g/L, SiO_2 30 g/L, pH 2.5~3, current density 2.5 A/dm², temperature 20~30℃.

2 Results and Discussion

Component and properties of Zn, Zn-Fe alloy and Zn-Fe-SiO_2 composite coatings with the same thickness (21 μm) are listed in table 1.

Tab. 1 Component and properties of Zn, Zn-Fe alloy and Zn-Fe-SiO_2 composite material (21 μm)

Tested item	Zn	Zn-Fe	Zn-Fe-SiO_2
Component /%		2.5 (Fe)	2.5 (Fe) 0.5 (SiO_2)
Red rust time under neutral salt spray /h	200	180	300
Corrosion rate of coatings dipped in neutral salt solution / ($\mu m \cdot a^{-1}$)	30~40	20~24	12~16
Corrosion rate of coatings in atmosphere / ($\mu m \cdot a^{-1}$)	1	0.5	<0.2
Porosity / ($N \cdot cm^{-2}$)	5~20	1~3	0~1
Hydrogen content /%	0.00128	0.00457	0.00091

From table 1, it can be seen that:

(1) The corrosion resistance of Zn-Fe-SiO_2 composite materials under neutral salt spray is approximately 1.7 times as Zn-Fe alloy, and 1.5 times as Zn coating.

(2) The corrosion resistance of Zn-Fe-SiO_2 composite materials dipped in neutral salt solution is approximately 1.6 times as Zn-Fe alloy, and 2.5 times as

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Zn coating.

(3) The corrosion resistance of $Zn-Fe-SiO_2$ composite materials exposed in atmosphere is more than 2 times as Zn-Fe alloy, and more than 5 times as Zn coating.

(4) $Zn-Fe-SiO_2$ composite materials have lower porosity and hydrogen content than Zn and Zn-Fe alloy.

Morphologies of Zn, Zn-Fe alloy and $Zn-Fe-SiO_2$ composite coating are shown in Fig. 1.

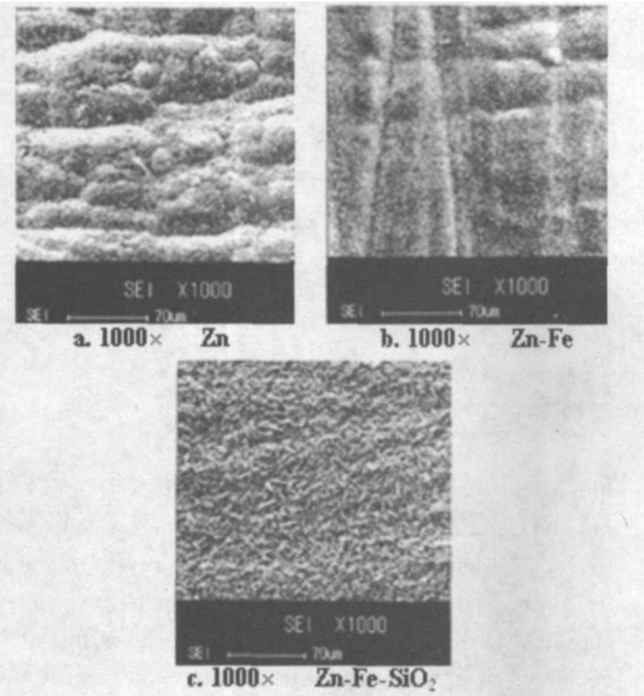

Fig. 1 Morphologies of Zn, Zn-Fe alloy and $Zn-Fe-SiO_2$ composite coating (SEI)

As seen from Fig. 1, $Zn-Fe-SiO_2$ composite coating has the most uniform and finest crystal, so it shows the best property.

3 Conclusions

Properties of $Zn-Fe-SiO_2$ composite materials are superior to Zn and Zn-Fe alloy, and this kind of non-passivation environmentally benign materials has a great future in application.

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电镀 $Zn-Fe-SiO_2$ 复合材料的性能研究

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摘 要：镀锌与 Zn-Fe合金广泛用于钢铁零件的防护，但是仍存在钝化液毒性大、环境污染严重、耐蚀性低、氢脆高等不足。本文采用无氰电镀技术制备了 $Zn-Fe-SiO_2$ 复合材料，并测试了 $Zn-Fe-SiO_2$ 复合材料的耐蚀性、孔隙率和氢脆性等综合性能，同时与电镀 Zn及 Zn-Fe合金进行了对比。实验结果表明：电镀 $Zn-Fe-SiO_2$ 复合材料的耐蚀性及其它综合性能均优于镀锌与 Zn-Fe合金，无需钝化处理，环境友好，应用前景广阔。

关键词：电镀技术；$Zn-Fe-SiO_2$ 复合材料；环境友好材料

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