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EFFECT OF ELECTROLESS PLATING TIME ON HARDNESS AND BRITTLENESS FORCE OF ELECTROLESS NI-B COATINGS ON GCR15 SURFACE*

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Аннотация. Electroless Ni-B coatings were deposited on GCr15 steels by electroless deposition method. In this study，the effect of electroless plating time on hardness and brittleness of the deposits were analyzed. The surface morphology was observed with an OLYMPUS DSX510 metallographic microscope; the hardness of the plating layer was measured with an HV-1000 microhardness tester; and the brittleness of the plating layer was tested with a Rockwell hardness tester. The results show that the electroless plating time increases, the surface of Ni-B plating becomes more dense, the hardness increases, the brittleness increases, and cracks easily appear.

Ключевые слова: electroless Ni-B plating time; GCr15 steel; hardness; brittleness

化学镀时间对 GCR15 表面化学镀 NI-B 镀层硬度及脆性的影响**

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摘要: 采用化学沉积法在 GCr15 钢上沉积了 Ni-B 镀层. 本研究分析了化学镀时间对镀层硬度和脆性的影响. 用 OLYMPUS DSX510 金相显微镜观察表面形貌;

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用 HV-1000 显微硬度计测出镀层硬度; 用洛氏硬度计测试镀层脆性. 结果表明: 化学镀时间增加, Ni-B 镀层表面更加密集, 硬度增加, 脆性增大, 易出现裂痕.

关键词: 化学镀 Ni-B 时间; GCr15 钢; 硬度; 脆性

0 引言

GCr15 钢广泛应用于纺织, 航空航天, 汽车, 轮船等领域, 主要用于制造旋转运动核心部件, 如传动轴上的钢球, 滚子和轴套等 [1]. 化学镀 Ni-B 厚度均匀, 具有良好的耐磨性, 润滑性, 良好的延展性和耐腐蚀性, 优异的可焊性等优点 [2], 是一种广泛应用于金属表面处理的新型技术 [3]. Barati Q [4] 介绍了镍硼化学镀层并给出了化学镀 Ni-B 及复合镀层未来趋势. Barman M [5] 研究硼氢化物浓度对化学镀镍硼镀层摩擦性能和机械性能的影响.

本研究中, 采用化学沉积法在 GCr15 钢表面, 控制变量化学镀时间, 分别镀 1h 和 4h 的 Ni-B 镀层. 本文主要研究了化学镀时间对 Ni-B 镀层硬度及脆性的影响. 采用 OLYMPUS DSX510 金相显微镜, HV-1000 显微硬度计, 洛氏硬度计分析对比不同化学镀时间下, Ni-B 镀层表面形貌及性能改变.

1 实验材料及方法

1.1 基体材料

采用退火处理的 GCr15 钢板为化学镀 Ni-B 的基体, 基体标准块尺寸为 20mm×15mm×5mm, 表面硬度约为 180HV. 详细化学成分见表 1 [6].

表 1 GCr15 钢化学成分表 (wt%)
Table 1. GCr15 steel chemical composition table (wt%)

C	Cr	Mn	Si	Ni	Cu	P	S	O	Fe
0.95	1.44	0.36	0.27	0.06	0.07	0.13	0.004	0.0004	Bal.

1.2 预处理

首先, 将 GCr15 标准块按 160#, 320#, 600#, 1000# 的碳化硅砂纸依次进行打磨, 然后, 用 W2.5, W0.5 粒度的金刚石喷雾抛光剂抛光, 抛至表面成镜面效后用清水和酒精冲去表面杂质, 风干 [7]. 随后, 基体浸泡在 60℃恒温 (Na_2CO_3, 20～30g/L, NaOH, 10g/L, $Na_3PO_4 \cdot 12H_2O$, 50g/L) 碱性溶液中碱洗 15min, 取出热, 冷水洗, 再浸泡在 30% 盐酸中酸洗活化 1 min [8], 取出热, 冷水洗. 最后将样品立即浸入镀液中.

1.3 化学镀Ni-B镀液成分

化学镀 Ni-B 的镀液组成和工艺参数如表 2 所示. 选择六水合氯化镍作为主盐, 硼氢化钠作为还原剂, 乙二胺作为络合剂, 硝酸铅作为稳定剂, 氢氧化钠作为 PH 调节剂. PH 保证在 13 以上, 镀液放置于 90℃ 恒温水浴锅, 分别镀 1h (记作试样 1) 和 4h (记作试样 2).

表 2 Ni-B 化学镀液组成及工艺参数
Table 2.
Ni-B electroless plating bath composition and process parameters

化学成分及工艺条件	浓度(g/L)及参数
NiCl2·6H2O	30
NaBH4	1
C2H8N2	60
Pb(NO3)2	0.03
NaOH	40
PH	>13
时间 (h)	1,4
温度 (℃)	90

2 测试结果与分析

2.1 化学镀时间对表面形貌影响

通过 OLYMPUS DSX510 金相显微镜观察试样 1,2 表面形貌 (标尺: 50μm), 如图 1,2 所示.

镀 1h 的 Ni-B 镀层表面为分布较多类似颗粒的表面形态, 而经过 4h 更多的镍和硼沉积并且聚集一起, Ni-B 镀层表面 «生长» 成更大更密集的山丘状.

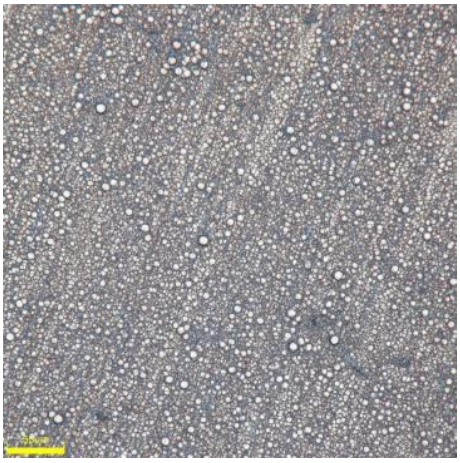

图 1 Ni-B 镀层表面形貌 (1h)
Fig. 1. Surface morphology of Ni-B coating (1h)

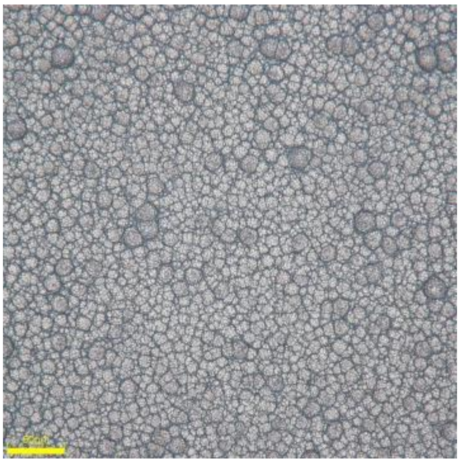

图 2 Ni-B 镀层表面形貌(4h)
Fig. 2. Surface morphology of Ni-B coating (4h)

2.2 化学镀时间对硬度的影响

通过 HV-1000 显微硬度计在试样 1,2 表面正反各测五次硬度, 如图 3,4 所示, 去掉每组最高值和最低值, 取平均值 [9]. 得到试样 1 的平均硬度为 681HV, 试样 2 的平均硬度为 728HV.

镀 4 小时的镀层相对镀 1 小时的镀层因沉积时间更久, 镀层中硼元素更多; 并且镀层 1h 表面形貌所展示的晶粒之间较大空隙, 可通过更多沉积的镍硼元素填充而减小, 这样可以阻碍位错运动来提高流变应力, 从而导致硬度相对提高.

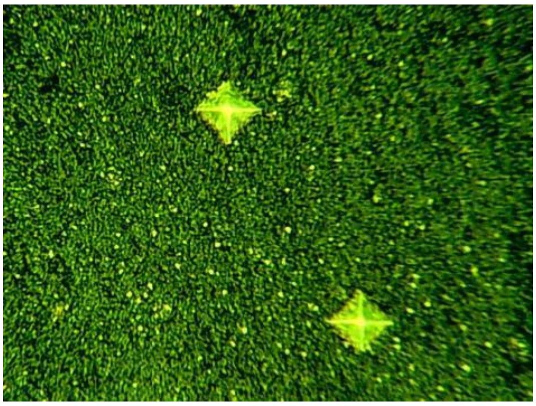

图 3 Ni-B 镀层表面硬度 (1h)
Fig. 3. Surface hardness of Ni-B coating (1h)

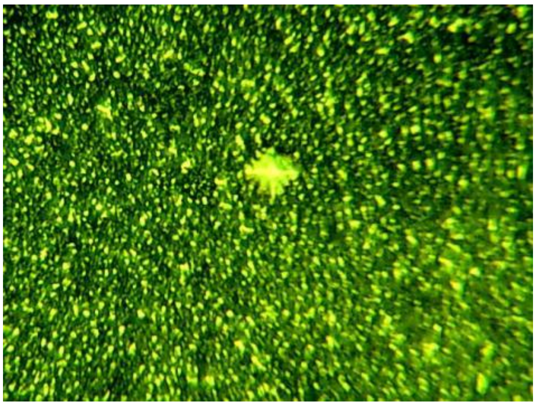

图 4 Ni-B 镀层表面硬度 (4h)
Fig. 4. Surface hardness of Ni-B coating (4h)

2.3 化学镀时间对脆性的影响

通过洛氏硬度计, 用金刚石圆锥压头在试样镀层表面垂直施加 150g 的压力, 压力保持 30s 后卸力. 再使用 OLYMPUS DSX510 金相显微镜观察压痕周围的裂痕情况 (标尺: 400μm). 如图 5,6 所示.

镀 1h 的 Ni-B 镀层压痕周围无明显裂痕, 但镀 4h 的 Ni-B 镀层周围有较大且明显裂痕. 首先, 由于随着镀层厚度的增加, 沉积过程基体或最新镀层的活性逐渐降低, 导致对镀液中游离的镍, 硼离子吸引更差, 镀层之间由内向外结合能力越差; 其次, 高含量的硼元素导致化合物之间, 化学键之间的结合力更差; 最后, 镀层的硬度相对基体硬度差值更大, 承载能力降低, 导致镀层更容易从基体脱落.

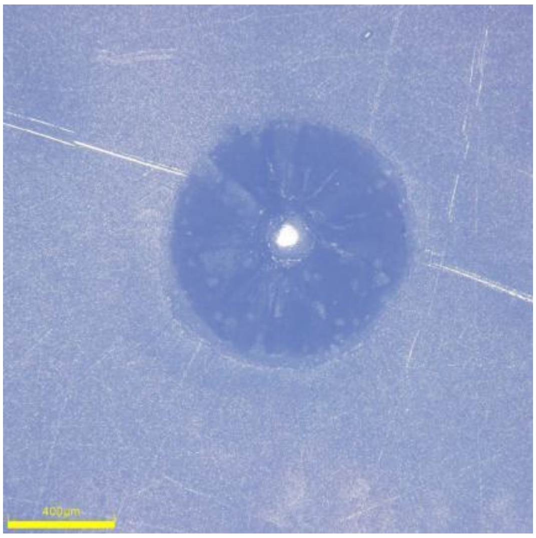

图 5 Ni-B 镀层压痕 (1h)
Fig. 5. Surface indentation of Ni-B coating (1h)

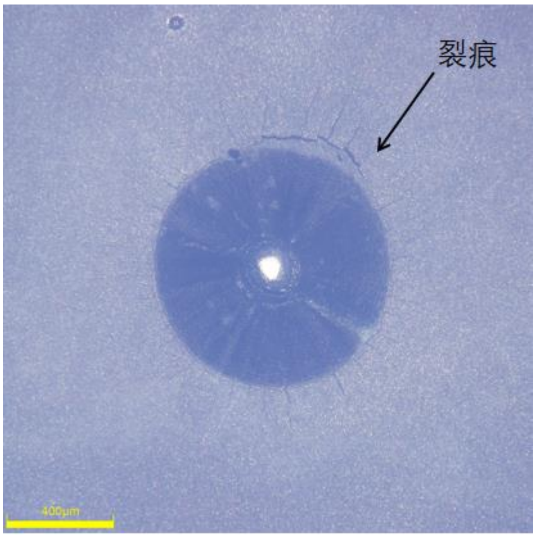

图 6 Ni-B 镀层压痕 (4h)
Fig. 6. Surface indentation of Ni-B coating(4h)

3 结束语

本研究得出, 相同条件下在 GCr15 钢上分别化学镀镍硼 1 小时和 4 小时, 镀层表面由较分散圆颗粒状逐步形成更密集的山丘状, 且硬度随之少量增加, 由于更久的沉积与基体结合能力和承载能力变弱, 导致脆性增加, 更易出现裂痕.

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