Synthesis of Ni-P/Ni-P-W Nanocomposite Coating and its Tribological Resistance

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Abstract: ***The synthesized tungsten nanoparticles (0.5 g/l, range 40 to 150 nm) are dispersed randomly into electroless Ni-P matrix for Ni-P-W nanocompositeplatings on an AISI1040 grade steel substrate (MS). The thickness of these deposits is in range of 15 to 25 micrometer. The scanning electron microscope attached in permutation of energy dispersive spectroscopy furthermore X-ray diffraction techniques were exploited to analyze surface morphology, elemental symphony and phases of platings correspondingly. The results of these studies reveal successful fusion of tungsten nanoparticles as white globules into electroless Ni-P matrix and with those as-deposited platings have amorphous structure and heated platings (400°C) have crystalline structure. Further Ni-P/Ni-P-W platings are investigated for microhardness by respective technique. The results of the studies corroborate that inclusion of tungsten nanoparticles into electroless Ni-P plating enhances the microhardness. The phase transformation initiation of amorphous nickel is headed toward nickel phosphide and crystalline nickel completely at 400°C which improved microhardness of nanocomposite Ni-P-W electrolessplatings.***

Keywords: Electroless plating, Ni-P-W, characterization, microhardness.

I. INTRODUCTION

The electro less plating has accomplished extensive significance because of its uniform deposition, superior corrosion and tribological resistance. It is a proscribed chemical reduction method where copious chemical reactions occur concomitantly, in aqueous middling with no stream of electricity [1-3]. The dirt free metallic Ni, binary alloys as Ni-P, Co-P, Ni-B and Co-B furthermore ternary alloys Ni-P-B, Ni-Co-P, Ni-W-P etc were plated effectively moreover premeditated for their tribological properties. In last decade, extensive research has been done for codeposition of second segment nanoparticles into EL Ni-P medium and known as electro less nano composite platings. The particles such as Si_3N_4, SiC, WC, W, ZnO, ZrO_2, TiO_2, and Al_2O_3 etc., are preferred for code position [4-15] for high hardness, corrosion and wear resistance. Furthermore, soft particles as MoS_2, WS_2, PTFE, BN (h)) also graphite (C) afford super lubrication whilst built-in in EL Ni-P medium [16-24] because of having knack to avert connection between two buddy surfaces under un-lubricated environment. Elsewhere of Ni-P-X (X = stiff particles) platings, the Ni-P-W platings illustrated very towering hardness furthermore wear conflict of substituting accessible hard chromium plating in automobile, aerospace and defense industries. Therefore in current investigation codeposition of synthesized W nanoparticles in EL Ni-P medium moreover its microhardness has been carried out.

II. EXPERIMENTAL METHODS

The electrolessplating (Figure 1) was done for two and half hour duration on mild steel (MS) specimens (20 mm × 20 mm × 03 mm) which have chemical composition as C = 0.082%, Si = 0.034%, Mn = 0.33%, P = 0.006%, S = 0.024%, Cu = 0.05% and Fe = balance. Before depositions, the specimens were degreased with a solvent named acetone furthermore sluiced with deionized solvent. For sensitization and activations, specimens were dipped in 1% $SnCl_2$ solution for 120 seconds and in 0.05 % $PdCl_2$ solution for 60 seconds respectively. Bath symphony along with working surroundings for platings is specified in Table 1. Heating of Ni-P/Ni-P-W platings were conceded out in Argon ambiance at 400 ^{0}C for 01hour time. The configuration of W fine particles, Ni-P/Ni-P-W platings were deliberated via X-ray method with CuKα radiation (λ = 0.154 nanometer). Surface morphology of platings was scrutinized by SEM technique and qualitative elemental analysis of platings was done by EDAX/FESEMequipments. The crystallite middling extent of fine particles was premeditated via Scherer rule ($d = 0.9\lambda/\beta\cos\theta$) wherever, $d_{hkl}$is crystallite bulk upright to (*hkl*) plane, λ (nanometer) is wavelength of X-ray beam used (i.e., λ = 1.51 Å), β (radiun) is breadth of diffraction crest moreover θ is crest location. The FWHM is taken in support of β. The microhardness of platings was calculated by a microhardness tester.

TableA.1 Components of EL bath and their utility

Salt/ chemical formulae	Quantity (g for 100 ml)	Functions
Nickel sulphate	04.17 g	source of Ni^{2+} ions
Tri sodium citrate	04.73 g	complexing driving force, put off wild release of Ni^{2+} ions
Sodium acetate	02.54 g	exertion as acidic buffer to maintain pH

Revised Manuscript Received on August 10, 2019.

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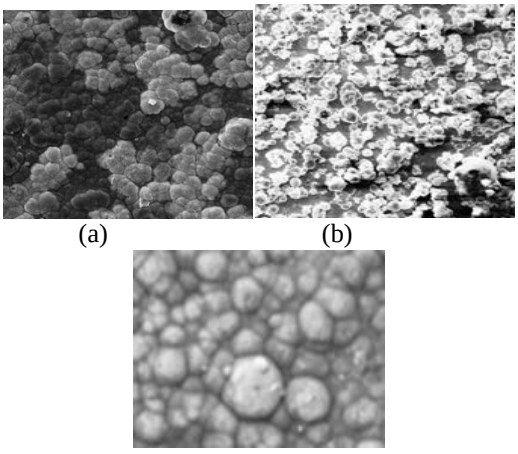
NaOH/acetic acid10% solution	added in drops	keep up pH of solution ~5.6
Sodium hypophosphite	02.43g	reducing chemical, tender electrons to Ni^{2+} ions which on accommodating electrons get reduced toward Ni^{0} furthermore deposited at catalytic exterior
Sodium dodecyl sulphate	00.01g	increase wettability in addition to surface charge
Lead acetate	00.10 mg	pour as a stabilizer
Synthesized W nano particles 40-150 nm range	00.05g	work as reinforcement into the Ni-P matrix
Bath operating conditions	-	temperature 86-88 ^{o}C; pH 5.6; steady stirring
Annealing temperature	400 ^{0}C, Ar atmosphere, 1hour time	comprehend significance of heat treatment on tribological and corrosion resistance

Fig. A.1: Deposition of W nanoparticles into EL Ni-P matrix

III. RESULTS AND DISCUSSIONS

The SEM images (WD 12.5mm, EHT 20kV) of as-plated moreover heated Ni-P/Ni-P-W platings are given away Figures 2.



(a) (b)

(c)

Fig.B.1: SEM micrographs of (a) Ni-P as-plated (b) Ni-P-W as-plated platings (c) Ni-P-W heated platings

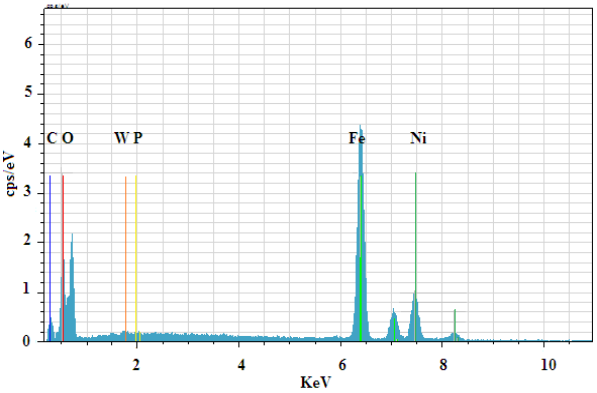


Fig. C.1: EDAX micrographs of Ni-P-W as-plated platings

Table B.1: EDAX values of EL Ni-P-W as-plated and heated specimens

Elements	% Weight As-Plated specimens	% Weight Heated specimens
Ni	80.64	79.54
P	11.52	11.29
W	03.73	03.89
Fe	04.11	05.28
Total	100.00	100.00

Table C.1:Microhardness of different test specimens

Specimens	Hardness (HV_{25}) scale
MS	398.7
Ni-P as-plated	493.2
Ni-P heated at 400˚C	580.6
Ni-P-W as-plated	697.9
Ni-P-W heated at 400˚C	944.5

After heating no noteworthy transformation in topography of platings are observed. The microstructure of Ni-P platings has rotund globular configuration excluding morphology of complex Ni-P-W plating is diverse commencing Ni-P platings. In Ni-P-W platings, W nanoparticles are glowing discrete into Ni-P medium nevertheless at various spaces heavy coagulation of W nanoparticles which may be due to deposition of surfeit W nanoparticles on the surface of platings. The stoicheometric fraction of rudimentary analysis (wt. %) dogged by EDAX (Figure 3) method is prearranged in Table 2. By EDAX method, in heated Ni-P-W platings dwindle in absorption of Ni on accumulation of W (0.5gpl) and P % vestiges nearly alike and an curious boost of Fe has been also observed.It has been also reported in [25-33] that elemental allocation in plating affects plating properties furthermore outlined an inter-diffusion stratum. The occurrence of momentous quantity and consistent allocation of Fe bared via EDAX scrutiny, credited to dispersion of plating elements towards edge of plating along with mild steel [34-40]. The XRD spectra of as-plated Ni-P platings set apart with diffraction Ni (111) and iron peaks, which match up to amorphous phases of alloys (JCPDS000031044).

The amorphousness of platings is too justified by presence of phosphorous about 11% weight (Table2). The max out of iron is for reason of mild steel. The analogous spectrum of as-plated Ni-P-W platings bared amorphousness of Ni-P medium alongside very diminutive attribute diffraction climax of W nanoparticles due to presence of lower amounts of W (0.5gpl) nanoparticles in composite platings. Annealing on 400 ^{o}C for 01hour time in Argon milieu is naked a shrink in streak expansion and intensity of crests which indicate transformation of amorphous nickel and Ni_xP_y segments in crystalline Ni, Ni_3P and W phases. The microhardness of Ni-P/Ni-P-W platings in as-plated and heated environments was determined by a microhardness tester with residence time of 20 seconds under a 25 gf load. The hardness of mild steel substrate and Ni-P/Ni-P-W plated specimens are in succeeding sort Ni-P-W (heated)>Ni-P-W (as-plated)> Ni-P > MS. The results of microhardness put forward that addition of W nanoparticles into Ni-P platings put in drastically to microhardness of specimens as W nanoparticles are the hardest nanoparticles.

IV. CONCLUSIONS

A dull grimy nanocomposite plating of Ni-P-W on mild steel substrates is experienced. Electroless Ni-P/Ni-P-W platings illustrate evidence of good adherence on mild steel. The microhardness values of Ni-P-W platings are enhanced significantly on incorporation of W nanoparticles into electroless Ni-P matrix.

ACKNOWLEDGEMENT

Authors acknowledge for GEU, GEHU, IITR, THDCIHET and Wadia Institute Dehradun for providing support and experimental support in finishing of current experimental study.

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