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Research Article

Effect of $NaBH_4$ concentration on hardness and microstructural properties of electroless deposited St-37 steel

Y. Yılmaz[*], H. Akbulut[2] and M. Uysal[3]

[1*] Sivas University of Science and Technology, Faculty of aeronautics and astronautics, Department of Aeronautical Engineering, Sivas, Turkey, (ORCID: 0000-0003-0690-8004), yyilmaz@sivas.edu.tr

[2] Sakarya University, Faculty of Engineering, Departmant of Metallurgical and Materials Engineering, Sakarya, Turkey, (ORCID: 0000-0002-2984-347X), akbulut@sakarya.edu.tr

[3] Sakarya University, Faculty of Engineering, Departmant of Metallurgical and Materials Engineering, Sakarya, Turkey, (ORCID: 0000-0002-9396-7450), mehmetu@sakarya.edu.tr

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Abstract

In this study, electroless Ni-B depositions were achieved on the St-37 steel substrates at different $NaBH_4$ concentrations and 950 ºC and 1 hour. Electroless Ni-B deposited samples had a cauliflower-like surface texture that makes the electroless Ni-B deposited surface lubricating naturally and as the $NaBH_4$ concentration increased, the grain size decreases in the microstructure. XRD spectra of the sample showed partial amorph region together with the crystalline region. Microhardness testing of the deposited samples were performed with a microhardness tester under a load of 25 g and an indentation time of 10 s. The highest hardness value was obtained in the sample prepared with 1.4 g/l $NaBH_4$ concentration.

Keywords: Deposition, Microhardness, Ni-B, Microstructure, St-37, Surfaces.

1. Introduction

A great number of hard depositing techniques have been developed to improve the surface of the materials. Generally, these techniques are applied on substrate materials to control their wear and friction behavior. Among the deposition processes, electroless deposition allows the production of wear resistant hard coatings without the use of special equipment [1]. The principle of electroless deposition is relatively simple: It is based on the reduction of metal ions placed in aqueous solution with a chemical substance without the need for an external current source [2]. The electroless deposition process has gained widespread acceptance in the market due to the excellent corrosion and wear resistance properties of the coatings [3]. The electroless deposition method can provide a thin and uniform deposition layer regardless of the size, shape and nature of the substrate material provided that the surface of the material to be deposited is properly treated. Since no external current source is used, the reaction rate during deposition can be controlled and adjusted relatively easily compared to the electrical deposition process. Among the different types of electroless metal deposition, nickel has proven its importance in applications due to its excellent wear and corrosion resistance [4]. There are many of study of the electroless nickel deposition [1-10] but within the framework of this study, the effect of NaBH4 concentration used as a reduging agent on hardness and microstructure properties of electroless nickel boron depositionss was investigated.

2. Material and Method

In this electroless Ni-B deposition process, 25x35x5 mm St-37 steel samples was used. For the surface cleanliness of steels, they were polished, ground with SiC paper, cleaned ultrasonically with acetone, immersed in vol.30% HNO3 solution and cleaned with distilled water respectively. The electroless deposition process were performed at solutions having 0.8 g/l, 1.4 g/l, 2.0 g/l and 2.6 g/l NaBH4 concentrations respectively at 95 ^{o}C and 1 hour. The component and their functions used in the electroless deposition prosess were given Table 1. After the deposition process, the samples were cut and mounted in a resin and prepared for metallographic observation by polishing and etching %2 nital. A Field Emission Scanning Electron Microscopy (FESEM, QUANTA FEG 450) is used to observe the surface characteristics of deposited samples. The microstructure of the deposited samples were analyzed by X- Ray Diffractometer (XRD, Rigaku) using CuKα radiation with wave length of 0.1542 nm The sample was scanned between 20° and 90° at a rate of 3°/min. Hardness testings for the deposited samples were achieved with a microhardness tester (Microhardness Tester, LEICA VMHT MOT) under a load of 25 g and indentation time of 10 s.

Table 1. Components and functions and concentration of the electroless deposition bath

Coating Bath Components	Concentration	Function
Metallic ion source ($NiCl_2.6H_2O$)	30 g/l	Supplying the metal atoms to the material deposited on the surface
Reducing agent ($NaBH_4$)	0.8 g/l	Providing to reduce the metallic ions
Complexing agent (EDA)	90 g/l	Complexing with metal ions, and increases bath stability.
Stabilizer (TlAs)	16 mg/l	Preventing decomposition of the bathroom spontaneously.
Alkalinity Element (NaOH)	90 g/l	Adjusting the alkalinity of coating solution.

3. Results and Discussion

Fig.1 illustrates the XRD spectra of samples deposited by electroless Ni-B deposition process under different $NaBH_4$ concentrations. Here, it is obvious that at approximately 2θ=45^{o}, there is a partial wide peak with distinct crystalline nickel peaks. This wide peak indicates the amorph region in the microstructure. This result is some more different than the other literature studies [5, 6, 7]. Theoretically, a disturbance in the arrangement of atoms manifests itself as a broad peak in the XRD pattern, the degree of segregation of the metalloid alloys in the electroless deposition process determines the crystallinity of the deposited layer [3]. Since boron segregation was relatively high, it resulted the amorph region.

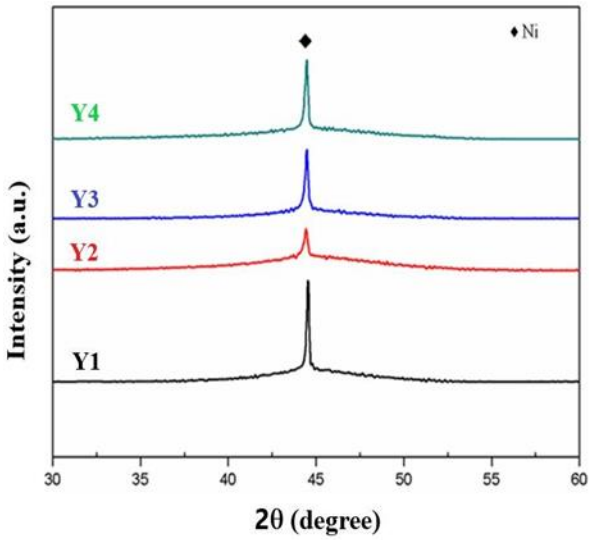

Fig.1. XRD patterns of electroless Ni-B deposited samples produced at different $NaBH_4$ concentrations (black line: 0.8 g/l (Y1), red line:1.4 g/l (Y2), blue line:2.0 g/l (Y3) and green line: 2.6 g/l (Y4) NaBH4 respectively).

The surface morphology of electroless Ni–B deposited samples are illustrated in Fig. 2. FESEM micrograph of deposited surface exhibited cauliflower type structure which ensures the electroless deposited samples are naturaly lubricating that shows the nature of electroless nickel deposition that this point is consistent with other previous scientific studies [11, 12]. It is obvious that, depending on the increasing NaBH4 concentration, grain sizes in the microstructure decreases and grains are distributed more tightly and homogenously. This may be explained the Hall- Petch effect of the increasing boron atom in the microstructure [6]. Table 2. summarizes the microharness data of the electroless deposited samples. According to the table, the maximum hardness was obtained the sample with 1.4 g/l $NaBH_4$ concentration, in higher $NaBH_4$ concentrations, hardness values decreased due to may be decomposition of the deposition baths spontaneously during the process.

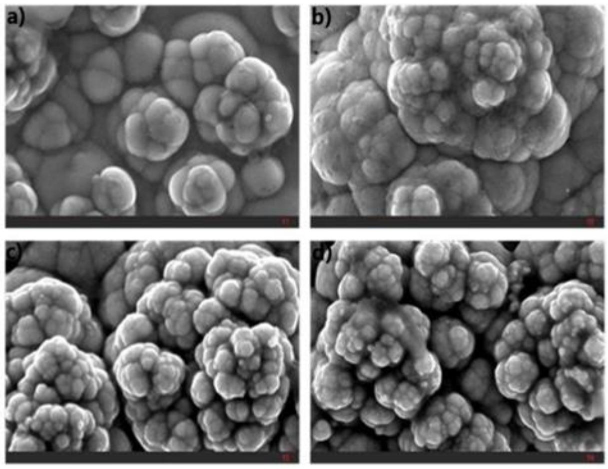

Fig 2. FESEM images of the electroless Ni-B deposited samples obtained at different NaBH4 concentration (a) Y1:0.8 g/L, b) Y2:1.4 g/l, c) Y3:2.0 g/l and d) Y4:2.6 g/l NaBH4 concentration respectively.)

Table 2. The average microhardness data of electroless Ni- B deposited samples prepared with different $NaBH_4$ concentrations. (Y1:0.8 g/l, Y2:1.4 g/l, Y3:2.0 g/l and Y4:2.6 g/l $NaBH_4$ respectively.)

Electroless Ni-B coated samples	**Average Hardness Data ($HV_{0.25}$)**
Y1	706
Y2	814
Y3	725
Y4	505

4. Conclusions and Recommendations

In this study, effect of the $NaBH_4$ concentration on the Ni-B electroless deposited St-37 steel samples' microstructural and mechanical properties was studied. As a result, some findings were reached that in the deposited case, the layer miscrostructure shows crystalline regions with together some partial amorph regions due to irregular distribution of atoms in the microstructure resulting a broad peak. The surface microstructure of the electroless deposited samples show that depending on increasing the $NaBH_4$ concentration, the grain size decrease in the microstructure that is an evidence of the Hall-Petch's Law. The hardness value incresed as the $NaBH_4$ concentration increase but after a certain $NaBH_4$ concentration upwards a certain concentration value, hardness value started to decrease due to spontaneous decomposition of the deposition baths.

5. Acknowledge

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