Influence of Ni-Mn Coating on Steel-A Review

M.Senthil Kumar, M.Anbazhagan, R.Chandra Mouli, R.Chandru, M.Deva

Department of Mechanical Engineering, Sona College of Technology. Salem-5.

msksona@gmail.com,
anbazhagsn.m1996@gmail.com,
chandramoulirams@gmail.com,
chandru5mouse@gmail.com,
kdeva977@gmail.com

ABSTRACT

In this paper, effects of coating material on steel are investigated. By considering conditions and constraints Nickel (Ni) based multilayer alloy coatings is possible and advantages such as good resistance to wear, corrosion and fatigue are obtained. Various methods denoted to increase the fatigue life of steel used in different application by various authors are studied in this paper. Ni-Mn coating on AISI 4340 steel increases the Hardness and Corrosion properties. Electro deposition by pulse plating produces less porosity and fine grains compared to DC plating. Effect of sulphate bath, temperature, pulse current, frequency and duty cycle of electroplating was studied. Sulphate bath produced fine grains and smooth surface finish. By increasing the percentage of Ni content in coating the hardness increases.

Keywords: Electro deposition, EN8 steel, pulse plating, sulphate bath, Ni-Mn alloy, SEM

I.INTRODUCTION

Components in automobiles such as crankshafts, rear axle shafts, aircraft crankshafts, connecting rods, gears, propeller shafts, drive shafts, landing gear and rock drills etc. are made of EN8 steel. All these parts involved in applications could be subjected to wear and tear, corrosion and tensile strength. Corrosion, wear and Fatigue are the most important parameters to consider for the failure of rotating elements. These are typically subjected to dynamic loads (fluctuating loads). Hard coatings are done to improve the surface properties of components.

There are numerous parameters that affect the fatigue life are listed: Cyclic stress state, incorrect geometry (stress concentration), material type, surface quality, size and distribution of internal defects, residual stresses, manufacturing process, direction of loading , grain size, shaft misalignment, vibration caused by bearings application, improper lubrication, overloading and pressure acting on piston.[1]

A. Nickel-Manganese Coating

Nickel electroplating on low carbon steel are used in many industrial application due to its improving corrosion fatigue life. Coating thickness improvement provides good protection against corrosion but in other hand reduces fatigue life.6 μ m thickness of electroplated Nickel improved fatigue life of low carbon steel specimen in corrosive environment and exposed to cyclic load.[2]

Nickel coatings are most attractive due to their low porosity content and high corrosion resistance. However, improving these properties seems to be necessary for special purposes which can be achieved through pulse plating.[3]

Composition of Plating Bath				
Nickel sulfate	280g/1 (liter)			
Nickel chloride	30g/1 (liter)			
Manganese sulfate	10g/1	25g/1		
Formic acid	50g/1			
Boric acid	45g/1			
(additive for high hardness plating 28cc/1)				
Added only for high hardness plating				
Content of Mn	0.023%	0.047%	0.053%	0.078%
Plating condition				
Bath temperature: 60℃	Ph: 4.2	Current density: 40A/dm²		

Figure.1.Bath Composition

The optimized parameters of Ni-Mn corrosion resistance coating are: the concentration of nickel sulfate of 280g/l, the interaction between niclel ion and manganese ion is 280g/l & 10g/l and the interaction between nickel ion and brightener 30g/l & 50g/l.

Ni in coating has a strong effect on the morphology and micro hardness of coatings. Increasing composition of Ni_2+Mn_2+ ratio, temperature and current density Ni in the coating also increased. The optimum properties were electrodeposited at 30A/dm^2 , 60°C from the bath with Ni_2+Mn_2+ ratio equals. [4]

B. Current Density

The relationship between the amounts of included manganese and current density during mechanical electrodeposition are discussed. Bath ratio has been varied in experiments by changing the Mn-sulphamate content in solution. The manganese inclusion in the deposits increases with increasing Mn-sulphamate concentration. It is evident that the increasing current density results in higher levels of Mn in the deposits independent of what bath ratio is applied. Considering the decreasing trend of abrasion marks on the surface and the coarse trend of grain, the change of microstructure in attributes to the combined action of particle polishing and manganese codeposition. It is likely that the fine grain effect of particle polishing is more prominent than Mn additive. [5]

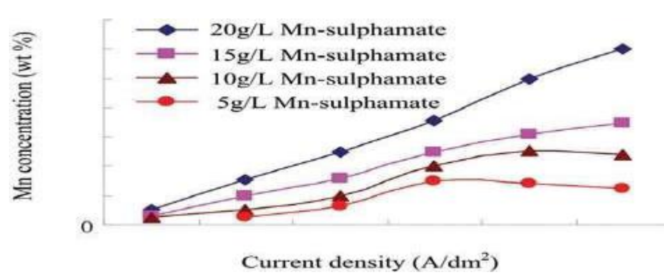

Figure.2.Current density Vs Mn concentration

C. Pulse electrodeposition

Electrodeposition is one of the most interesting technologies to deposit metal layers for MEMS. Electrodepositon has important advantages over alternative techniques, such as the higher rate of deposition, which allows the growth of thicker layers, the easy control of the thickness and decomposition of the layer, the possibility to process complex surfaces with non-planar morphology and the low cost of the experimental set-up. Besides, electrodeposition is fully compatible with standard Si micromachining Technology. The ability to selectively deposit metal layers on the window regions from a mask layout makes the post processing of CMOS processed wafers easier. [6]

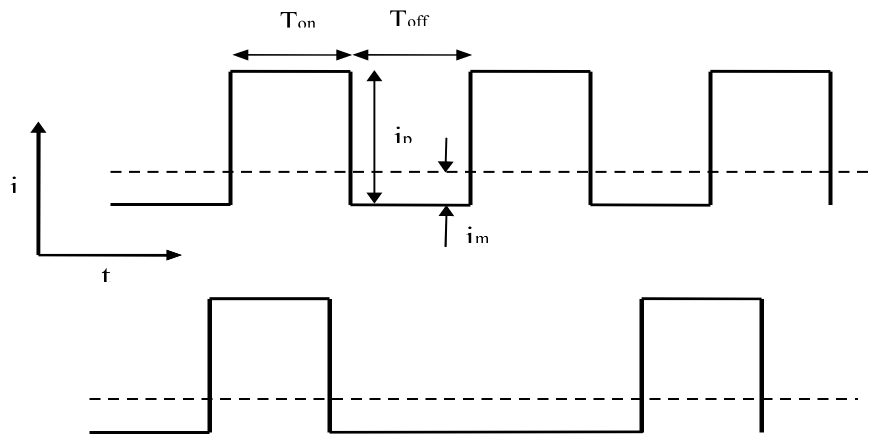

Figure.3.Scheme for investigating changes in PC density with constant pulse time and constant average current density.

D. SEM Analysis

The SEM micrograph displays the coating thickness approximately100µm produced by the pulse current metal deposition. The figure.4 exhibit the SEM microstructure of the nickel coating at current densities of 30A/dm^2 and 50A/dm^2. The microstructures shown reveal that the coating consists of polyhedral grain of nickel. Further, there is presence of prominent cracks in the coating done at current density 50 A/dm^2, but the tendency of cracking of less when pulse coated at current density of 30 A/dm^2, although a very few fine cracks are visible. This suggests that pulse current electro-deposition using a proper and appropriate current density will results in producing submicron and or nano-structure nickel deposit on steel substrate. [7]

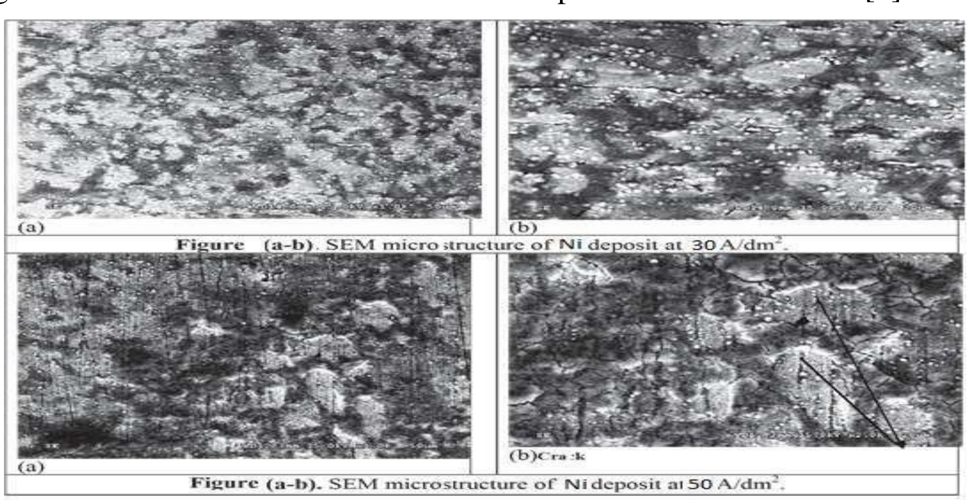

Figure.4.SEM images of Ni deposits

E. XRD Analysis

In order to determine the crystalline structure of Ni-Mn electrodeposits, XRD analysis was carried out. As a reference, the Ni-Mn alloy, which was electroplated with 200mA/cm^2 for 1hr, was analyzed. Fig. 5 shows XRD patterns of the deposited alloys and an amorphous structure appeared at a Mn content of about 1.2 atomic %. The peak position in an X-ray diffraction pattern is related to the elements that compose the material. Besides size of the crystallite, non-uniform distortion of the crystallite is another factor that causes broadening of the peak width. The average size of the crystallite can be determined by measuring the peak width. Scherrer's equation is often used for calculations of the crystallite size. [8]

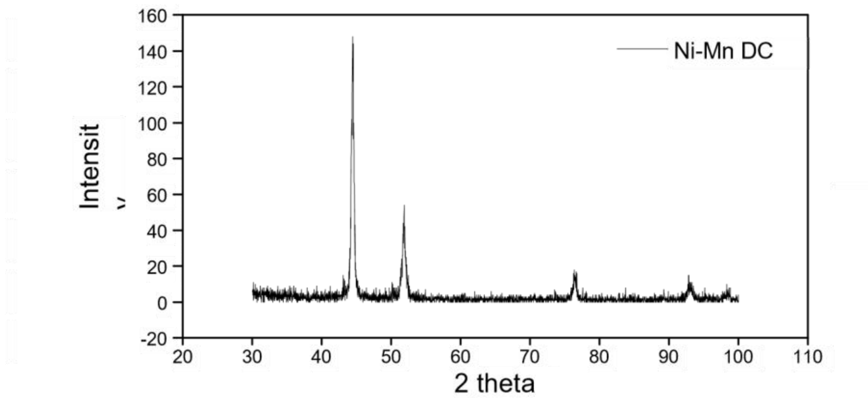

Figure.5.XRD analysis of DC electroplated film.

F. Micro Hardness

Microhardness was measured using Vickers hardness number (VHN) for a 100-g load on metallographically polished cross-sections. The hardnesses reported here are an average value from ten locations across the thickness. Pulse conditions significantly affected the hardness. A clear trend was observed in the microhardness, ranged from 190 to 280 VHN, with various conditions. Applied current density, pulse time, and duty ratios are found to affect the microhardness. The highest microhardness was found with 200mA/cm^2, 10ms on time /30ms off time. [9]

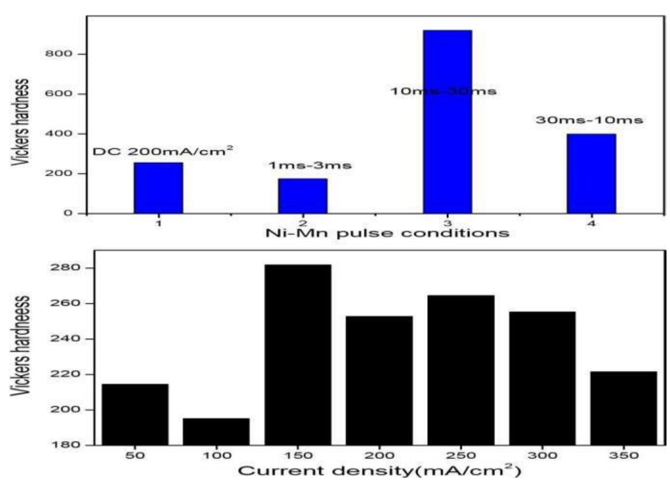

Figure.6.Vickers hardness of electroplated film.

II.Conclusions

In this work, DC and PC Ni-Mn electrodepositions were performed to deposit the Ni-Mn alloy. There is no significant difference in Micro hardness as a function of Mn contents. In pulse electrodeposition, film composition and properties are strongly influenced by the current density and the current off-time. Higher Mn contents were observed with pulse current condition. Ni-Mn alloy was successfully electrodeposited without pH adjustment. The selection of anode material was very important. Mn content of electrodeposits was not correlated with hardness, but varying pulse conditions resulted in a great difference in hardness. From the literature survey we observed that Wear resistance, Tensile strength, Corrosion property, Hardness and fatigue life of steel can be increased by pulse electroplating.

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