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Preparation and Study on Nickel Coated Aluminium through Electroless Deposition Technique

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Abstract:*In this study we made an attempt to prepare nickel (Ni) coated aluminium (Al)via electroless deposition technique for the formation of a thin metallic nickel film coating on pure sintered aluminium substrate which was developed by powder metallurgy route.The metal film of nickel was deposited on the metal surface of aluminium from an aqueous electrolytic solution of nickel chloride as a source ofnickel. This electroless deposition process involves without additional external electrode or any electric current passingthrough it.The surface structure of sintered aluminium is changed as a consequence of several interactions between sintered aluminium and aqueous electrolytic solution of nickel chloride carried on room temperature. In this experiment the influence of process parameter like temperature was also observed. The prepared nickel coated aluminium samplewas analyzed for their phases by XRD analysis. Changes of surface morphology after electroless deposition on aluminium substrateis studied by SEM analysis.*

Keywords: *Sintered aluminium, Electrolesscoating, XRD, SEM, Porosity, Vickers micro-hardness.*

I. Introduction

The requirementfor new magnetic materials are increased in modern electrical and electronic industry for generating current or produce magnetic fields.During past few decades silicon steel and ferrites dominate magneticmaterials are considered as a reliable source and widely used as magnetic materials in electromagnetic machinery like transformers, motors and generators etc. These available magnetic materials have high density and hence made the electrical equipment so bulky, hence costly. These materials are not so suitable for small electronic circuits.

On the other hand, aluminium is one of the most plentiful metallic element on earth and it is preferable for the engineering applications due to its low density, light weight, corrosion resistance, and easy of fabrication.These aluminium has no inherent magnetic property. Powder metallurgy is an art and science by which density, hence weight of the material is decreased after fabrication from its original without so much compromise its properties [1- 2].

Electroless nickel coating is anautocatalytic plating process whichinvolves the presence of a chemical reducing agent in solution to reduce metallic ions to the metal state. This reduction takes placewithout the presence of any external electrodes, but electric current (charge transfer) occurs naturally without any external field/current.Inelectroless technique, the aqueous electrolytic solution is considered as anode and acts as a source of metal ions. Similarly, instead of a cathode, the metal which will be coated is serving as the cathode. This makes a loop for electric current (charge transfer) between anode to cathode [3].Electroless nickel plating process can be applied on both metal and some nonmetal substrates such as thermoplastic [4-5], glass [6], silicon [7] which must have less efficiency than anode (aqueous electrolytic solution) [3].

This paper investigates electroless nickel coating on sintered aluminium at different temperatures. According to authors' knowledge, there is not so much literature available to perform electroless nickel coating on sintered aluminium developed by powder metallurgy route. Coating a layer of nickel on sintered aluminium can improve its properties like porosity and hardness and expands its applications due to magnetic property.

II. Materials And Methods

2.1 Development of sintered Aluminium by Powder Metallurgy Route

The base material used in the present experiment was sintered aluminium, developed from commercially available aluminium powder (99.7 %) purchased from LOBA Chemie, India and used without any pretreatment. The compactaluminium powder was uniaxially pressed and sintered simultaneously using a steel mold having an internal diameter of 10 mm at a pressure of 2 ton with a 10- ton hydraulic hot-pressmade by NascorTechnologies Private Limited, West Bengal, India at temperature 600 ºC for one hour at a constant heating rate of 5ºC/min. After sintering, the sample was cooled slowly in the same machine.

2.2 Preparation of nickel chloride solution

Electrolytic solution of nickel chloride (20 N)was prepared by dissolving the reagent into distilled water, and stirred few minutes with the help of a magnetic stirrer.

2.3 Testing and Characterization

2.3.1 XRD Analysis

X-ray diffraction patterns were recorded for Ni coated Al sample by employing RigakuUltima III analytical difractometer (with Cu-Kα radiation, $\lambda = 1.54059$ Å) at 40 kV and 30 mA. Intensity data were recorded by the step-counting method with scan rate 5^0/min between 10˚ and 80˚ (2θ). The phases were identified by comparing with standard JCPDS files.

2.3.2 Microstructure

Before observing microstructure, sintered aluminium was mirror polished and etched with keller's solution and then microstructure was taken by LEICA Optical Microscopy model no DM-2700M Image Analyzer.

2.3.3 SEM and EDX Analysis

SEM and EDX analysis were carried out by using JEOL MAKE SEM model JSM 6360, operated by PCSEM software.

2.3.4 Density and Apparent Porosity Measurement

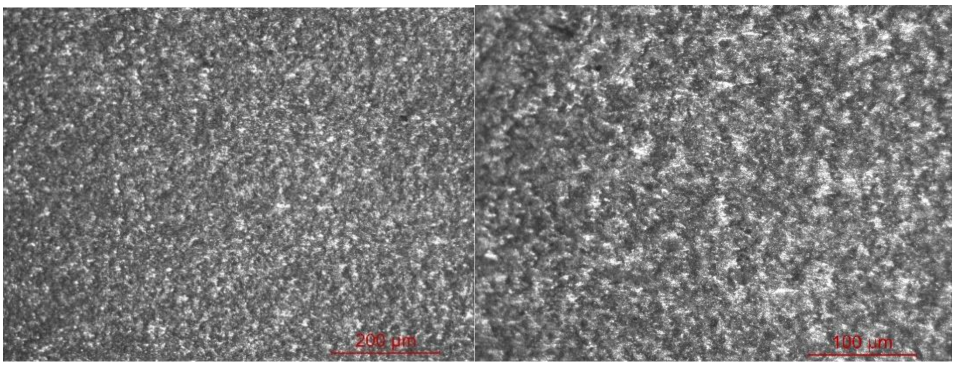
Weight and dimension were measured for pure aluminium sample before and after sintering. From the dimension measurement both green and sintered densitieswere calculated. Apparent Porosity was measured with the help of universal porosity measurement technique.

2.3.5 Micro-hardness Survey

Micro-hardness survey was performed for the sample before and after coating by using 100 gf loads with 15 sec dwell time. For precise measurement, hardness was taken in three different positions for each sample and finally average the hardness numbers by using Leco Micro Hardness tester (Model LM248SAT).

III. Results And Discussion

3.1 Microstructure



(a) (b)

Figure 1: Microstructure of sintered Al at (a) 100 X and (b) 200 X magnification

Fig. 1 shows the microstructure of sintered Al. Figure implies that fine grain structure is developed after sintering.

3.2 EDX Analysis of sintered Al

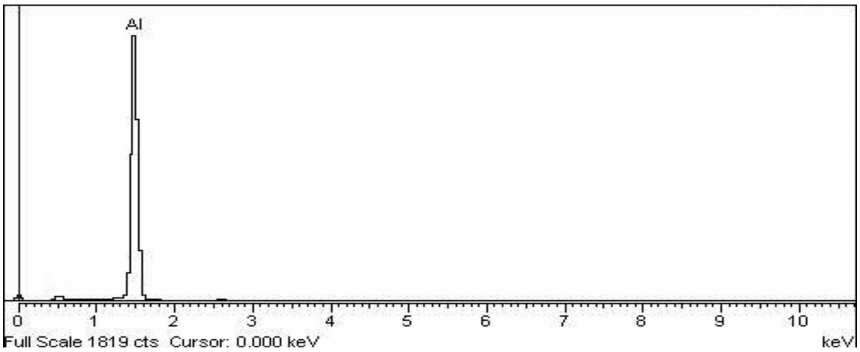


Figure 2: EDX analysis of sintered Al

Fig. 2 shows the EDX data for sintered Al. EDX analysis after sintering was done for observing the elemental composition of the developed material after sintering, more accurately about the reaction between aluminium and furnace environment. Result shows that no reaction occurs in this sintering environment and as a result pure Al was developed.

3.3 Density Measurement

Table 1 shows the densities of Al before and after sintering. Density is increased significantly after sintering which implies the formation of bonding.

Table 1: Density of Aluminium

Sample	Green Density (gm/cc)	Theoretical Density (gm/cc)	Sintered Density (gm/cc)
Sintered Al	1.87	2.7	2.6

3.4 XRD Analysis

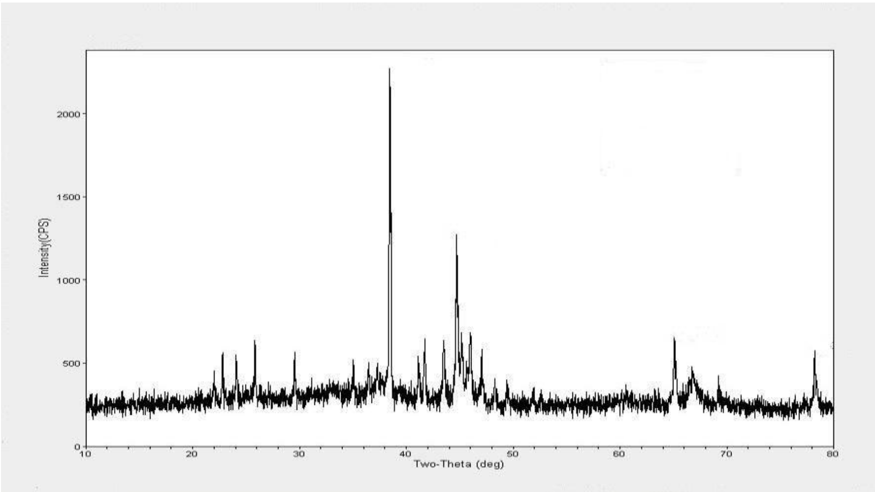


Figure 3: XRD pattern of sintered Al

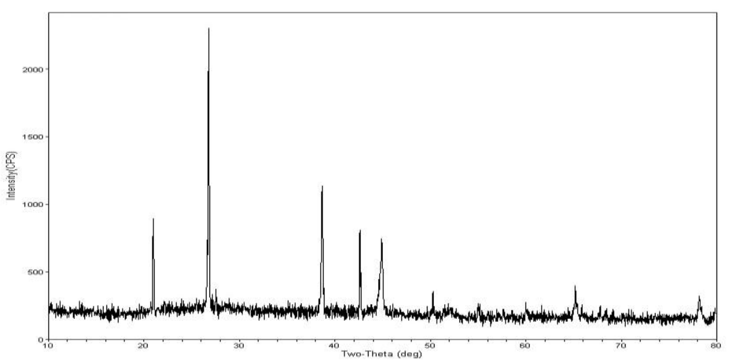


Figure 4: XRD pattern of Ni coated Al

XRD pattern of sintered Al and Ni coated Al are shown in fig. 1 and 2 respectively. From fig. 1, sintered Al shows the characteristic peaks at 2θ angle of ~ 38.493 (111), 44.739 (200), 65.012 (220) and 78.019 (311). From fig. 2, it is clear that Ni coated Al show same peak for Al with the addition of the peaks for Ni at 2θ angle of ~ 20.4 (001), 27.447 (110), 44.57 (111) and 51.81 (200). As Ni shows individual peaks, the Ni coated Al has magnetic property and hence, attracted by an external magnet.

3.5 SEM Analysis

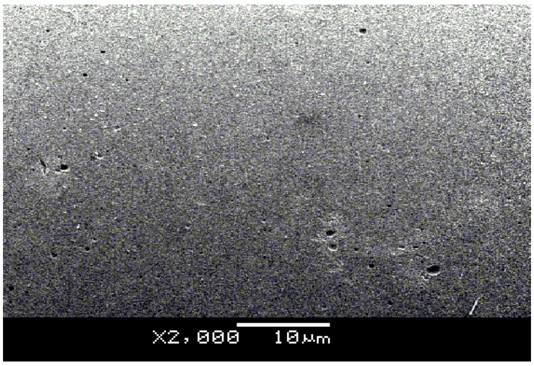


Figure 5: SEM image of sintered Al

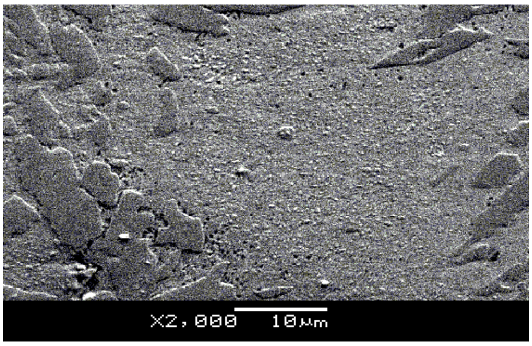
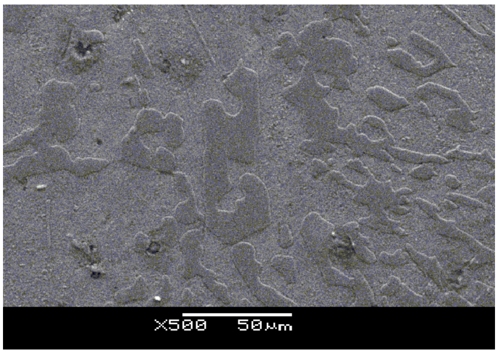
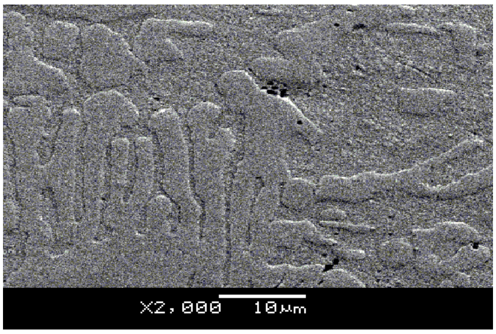


Figure 6:SEM image of Ni coated Al (heated during coating)



(a)



(b)

Figure 7:SEM image ofNi coated Al(without heating) at (a) 500 X and (b) 2000X magnification

Fig. 5- 7 shows the surface morphology of sintered Al and Ni coated Al where coating process is carried out at different environment based on temperature. Temperature has significant role on this coating process and hence coating was done very rapidly with temperature; but the distribution of Ni is not uniform throughout the surface as shown in fig. 6. On the other, Ni is uniformly distributed throughout the whole surface where coating was done on room temperature as shown in fig. 7. The formation of pore is reduced, indicates better bonding between substrate (sintered Al) and coating (Ni) and improves surface morphology where coating is carried out at room temperature.

3.6 Apparent Porosity Measurement

Table 2 shows the apparent porosity of sintered Al before and after Ni coating. Apparent porosity is decreased after Ni coating, indicates the improvement of properties.

Table 2: Apparent Porosity

Apparent Porosity of Sintered Al	Apparent Porosity of Ni coated Al
0.98 %	0.56 %

3.7 Hardness Measurement

Table 3 shows the hardness values of both sintered Al and Ni coated Al. Hardness is increased after coating.

Table 3: Vickers micro-hardness

Sintered Al	Ni coated Al
345.2MPa	382.5 MPa

IV. Conclusion

The significant conclusions of this experiment are as follows:

- Pure sintered aluminium was developed successfully through powder metallurgy technique.
- Electroless plating is employed successfully to coat a layer of nickel on the surface of the sintered aluminium without any additional temperature.
- Temperature has a significant role on electroless process. The surface morphology is not so good for the sample coated with nickel where temperature is given during the coating process.
- The XRD pattern of the coating sample shows the presence of both nickel and aluminium. As no intermetallic compound formed, this material shows magnetic property and attracted by an external magnet.
- Furthermore, nickel coating improves the surface properties of the material. As a result, porosity is decreased and a consequence, hardness value is improved after coating where coating process is carried out on room temperature.

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