

Production and Investigation of Ceramic-Metal Composite from Electroless Ni Plated AlN and Al Powders

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ABSTRACT: Al metal matrix composites reinforced with AlN have been fabricated by Tube furnace sintering at various temperatures. A uniform nickel layer on Al(%1AlN)%19Ni, Al(%2AlN)%18Ni, Al(%3AlN)%17Ni, Al(%4AlN)%16Ni, Al(%5AlN)%15Ni powders were deposited prior to sintering using electroless plating technique, allowing closer surface contact than can be achieved using conventional methods such as mechanical alloying. A composite consisting of quaternary additions, a ceramic phase, AlN, within a matrix of Al, AlN, Ni has been prepared at the temperature range between 550°C and 650°C under Ar shroud. X-Ray diffraction, SEM (Scanning Electron Microscope) density, and hardness measurements were employed to characterize the properties of the specimens. Experimental results carried out for 650°C suggest that the best properties as comprehension strength σ_{max} and hardness 681.51(HV) were obtained at 650°C and the tube furnace sintering of electroless Al plated (%5AlN)%15Ni powders is a promising technique to produce ceramic reinforced Al (%5AlN)%15Ni composites..

KEYWORDS: Electroless Nickel plating, Ceramic-Metal composites, Powder metallurgy, Sintering.

I. INTRODUCTION

Highly thermally conductive aluminum nitride ceramics were metalized by an electroless plated Ni depositions for the purpose of utilizing them in practical electronic circuit substrates. Aluminum nitride substrates were effectively etched by Formula solution, and the adhesion strength between Formula and the Ni was found to increase with an increase in surface roughness. Platings play an important role in industry for improving tool lifetime and performance. Transition metal nitrides, such as TiN and HfN have received considerable attention as wear-resistant coatings because of their high mechanical hardness, wear resistance and chemical inertness. Nowadays, a great deal of attention has been paid to compositionally modulated multilayer films, especially transition metal nitride ceramic/ceramic multilayers with each layer on the nanometer scale because of their possibility to achieve best hardness [1]; [2]; [3]. Besides, the enhanced tribological properties of metal/metal nitride have attracted interest in a group of investigations [4]; [5]; [6]; [7]. The mechanical properties of the multilayered films were found to be affected greatly by the modulation period, and a conventional Hall-Petch type relationship [4]; [6] or Koehler's model [5] was applied to explain the mechanism of hardness enhancement. In recently study, Kasano et al. examined Ti/TiN multilayered films with smooth compositional transition at interfaces that were fabricated with computer controlled gas flow rate. It was shown that the interfaces as well as the modulation period of the multilayers might play an important role in improving mechanical properties [7]; [8]. Metallic materials with small grains exhibiting a high strength are interesting from both theoretical and experimental point of view. Further enhancement of their mechanical properties is possible due to reinforcement by ceramic particles [9].

In this study, the ceramic-metal composites were obtained by using electroless nickel (Ni) plating with Aluminium Nitride (AlN) and Aluminium(Al) powders.

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Ceramic materials, which include monolithic ceramics and ceramic-matrix composites, have been identified as potential candidates for high-temperature structural applications because of their high-temperature strength, light weight, and excellent corrosion and wear resistance.

II. EXPERIMENTAL PROCEDURE

In this study, specimens were prepared using two different techniques. Initially, Aluminium Nitride (AlN), Aluminium (Al) at certain rates were mixed homogenously. powders plated with electroless nickel. Nickel chloride (NiCl₂.6H₂O) was used for plating. Chemicals used in nickel plating bath and their ratios are shown in Table 1. The general flowchart of the study is given in Figure 1. Ceramic-metal composite was fabricated by tube furnace sintering specimens prepared in different ways. Sintering was performed at the temperature range 550°C-600°C and 650°C under argon atmosphere in micro-wave oven for one hour.

Table 1. Chemicals of nickel plating bath and their ratios

Chemicals	Weight(%)
Aluminium Nitride (AlN)	% 1-% 2-% 3-% 4-% 5
Aluminium (Al)	% 80
Nickel Chloride (NiCl ₂ .6H ₂ O)	% 19-% 18-% 17-% 16-% 15
Hydrazine Hydrate (N ₂ H ₄ .H ₂ O)	20%
Distile Water	80%
Temperature(°C)	90-95 °C
pH Value	9-10

III. EXPERIMENTAL FINDINGS

In this chapter, the properties of the composite as sintered specimens were characterized by the physical, mechanical and metallographic examination. The densities of the specimens before and after sintering were determined. The density graphics of Ni plated AlN-Al powder before and after sintering are shown in Fig 1. It can be observed that the density after sintering changed depending on the temperature. The highest density of 2,943 gr/cm³ in plated powders was reached at 650 °C.

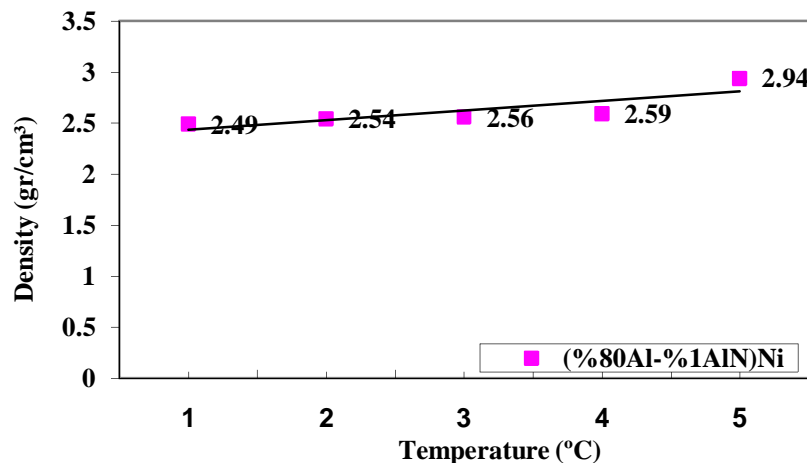


Fig 1. Density-temperature changes in Ni plated specimen

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The microhardness (HV) of the sintered specimens was also measured as well as compression strength. According to the microhardness-temperature graphic given in Fig 2 for the sintered specimens, the highest microhardness for the plated specimen was obtained as 681HV at 650 °C.

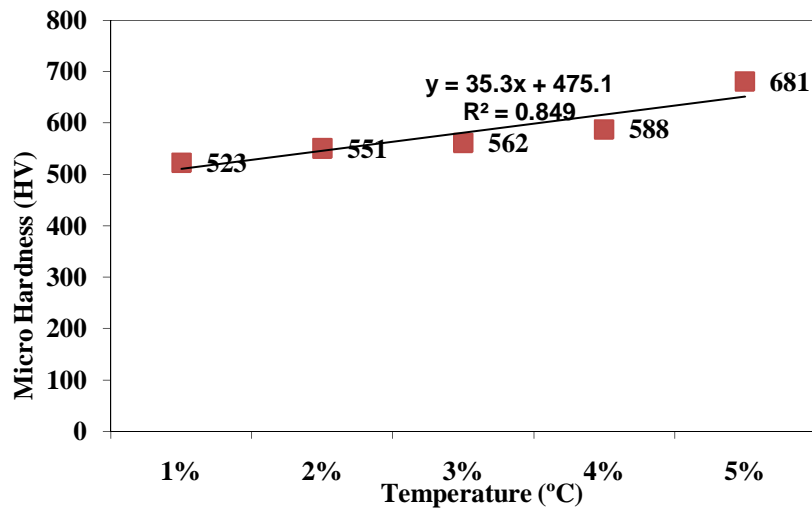


Fig 2. Micro hardness-temperature changes in Ni plated specimen

In the compression strength from mechanical tests applied on the specimens after sintering was examined. In Fig 3, compression test was applied on the plated specimens and specimens fabricated without plating. As can be understood from the graphic, the highest strength was achieved as 47,62MPa at 650°C in the plated specimen.

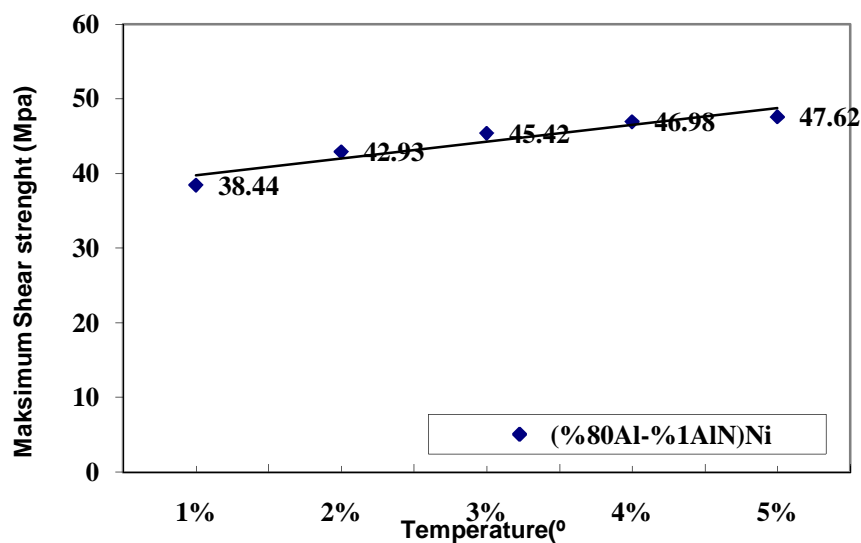


Fig 3. Shear Strength-temperature changes in Ni plated specimen

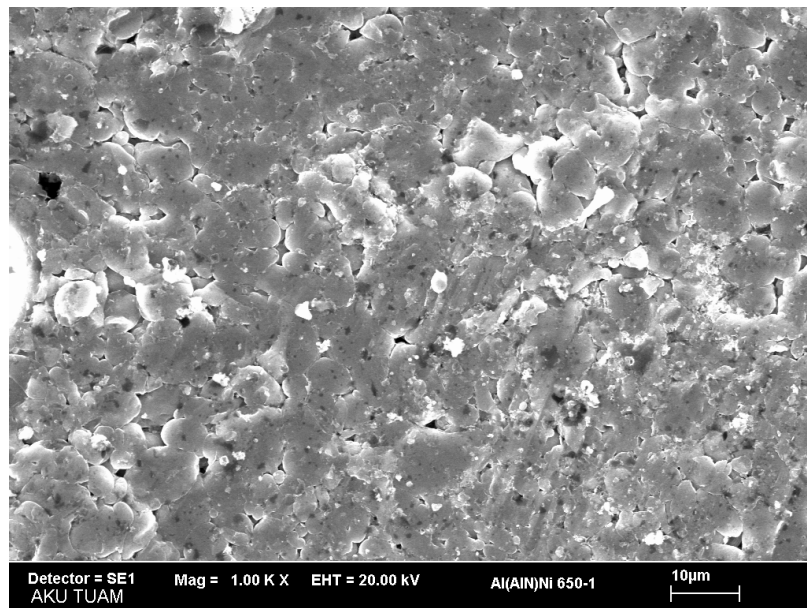
SEM Analysis

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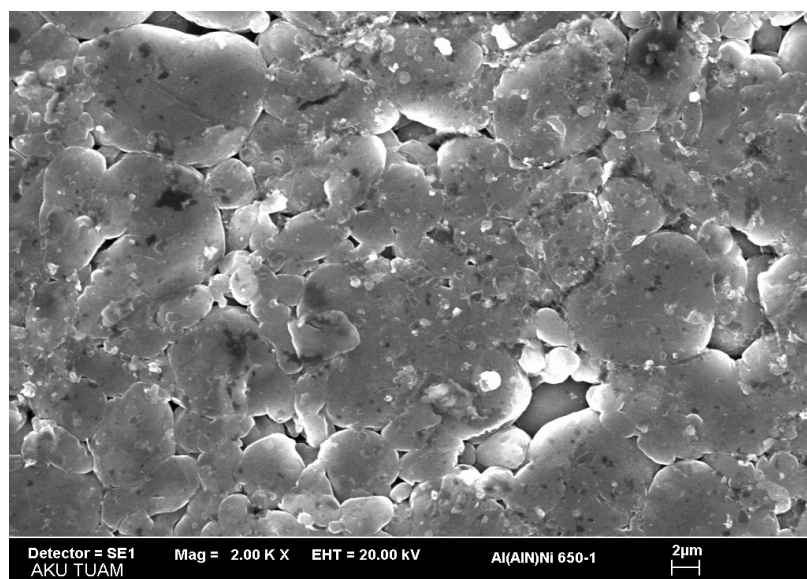
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After the specimens sintered at different sintering temperatures were secured within resin and surface polishing processes were completed, their photographs were taken and EDX analyses were carried out by SEM (LEO 1430 VP equipped with RONTEC EDX) with magnifications of 1kX. The SEM photograph of Ni plated AlN-Al powders, which yielded the best result in terms of mechanical strength in the sintered specimens (plated with Ni and prepared by normal mixture method) during the study, after sintering at 650°C is shown in Figures 4a and 4b.



a)(Al-AlN)Ni Composite specimens 650°C 1KX

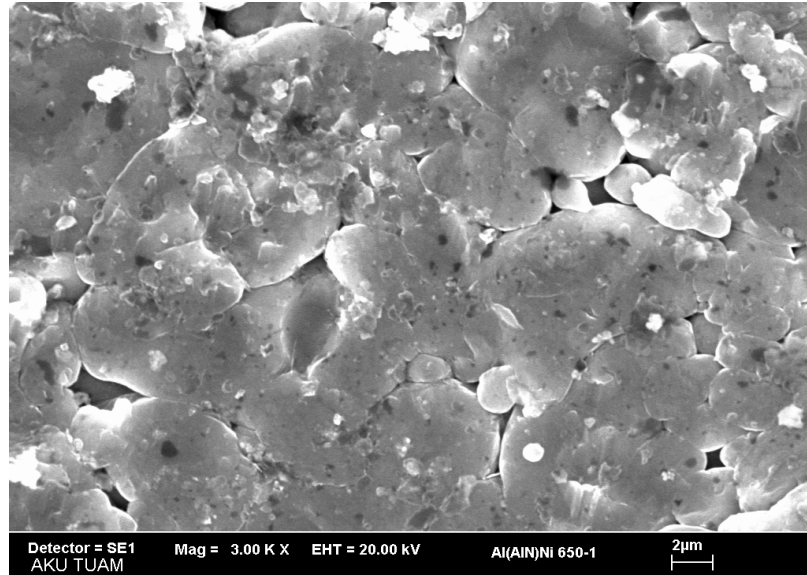


b)(Al-AlN)Ni Composite specimens 650°C 2KX

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c)(Al-AlN)Ni Composite specimens 650°C 3KX

Fig. 4. SEM view of (Al-AlN)Ni composite 650°C

XRD Analysis

After sintered, plated specimens were characterized by XRD analysis. See in Fig.5-6. As can be understood from the analysis results, the existence of Al, AlN, Ni, and AlNi peak in the graphs shows that Al-AlN powders were plated with Ni.

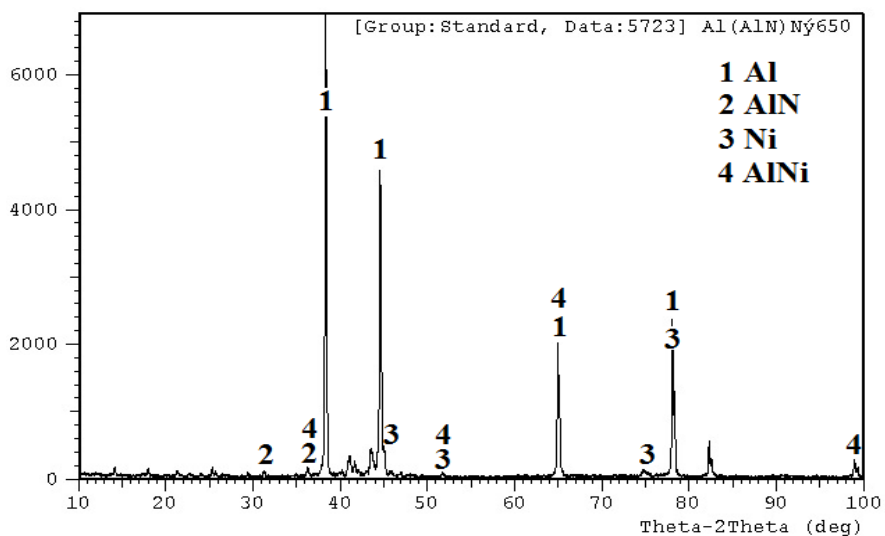


Fig. 5 X-ray diffraction patterns of the (%80Al-%5AlN)Ni sintered at 650°C

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IV. RESULTS

The following results were concluded from the experimental findings

- The highest shear strength was obtained as 47,62MPa at 650°C.
- The highest density in composite made from Ni-plated Al-AlN powders sintered at 650°C temperature was obtained as 650°C The highest density plated sample was found as 2,94gr/cm³ at 650°C.
- The highest microhardness in composite samples fabricated using electroless Ni-plating method was found as 681 HV at 650°C.
- It was also found out (Al-%5AlN)Ni that the best mechanical properties of the other samples.
It was concluded that (Al-%5AlN)Ni powders give positive results to Ni-plating other samples.

V. ACKNOWLEDGMENTS

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