

# An Investigation of Ceramic-Metal Composite Using By Powder Metallurgy

Ahmet YONETKEN<sup>1</sup>, Ayhan EROL<sup>2</sup>Faculty of Engineering, Afyon Kocatepe University, Afyonkarahisar, Turkey<sup>1</sup>Faculty of Technology, Afyon Kocatepe University, Afyonkarahisar, Turkey<sup>2</sup>

**ABSTRACT:** Ni-Ti metal matrix composites reinforced with WC have been fabricated by Tube furnace sintering at various temperatures. A uniform nickel layer on %50Ni, %46.66WC and %3.33Ti powders using powder metallurgy technique. A composite consisting of quaternary additions, a ceramic phase, WC, within a matrix of WCNi, NiTi has been prepared at the temperature range 1000°C-1400°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 1400°C suggest that the best properties as comprehension strength  $\sigma_{max}$  and hardness 301,8(HV) were obtained at 1400°C and the tube furnace sintering of electroless %50Ni, %46.66WC and %3.33Ti powders is a promising technique to produce ceramic reinforced WC to NiTi intermetallics.

**KEYWORDS:** Ceramic-Metal Composite, Mechanical Properties, and Powder metallurgy.

## I. INTRODUCTION

The production of composite materials, including composite electrochemical coatings of a heterogeneous system of the electrodeposited metal and micrometer-sized particles, has been of interest upto now. [1-7]. Hard materials, such as WC-Ni and TiC-Ni, find their main use as cutting tools and in wear resistant applications because of their superior hardness and reasonable fracture toughness. Generally, ceramic-metal composites are produced by conventional sintering methods, which are productive and produce fully dense parts [8]. Composites of titanium carbide and Iron plated with nickel have been widely used as cermet materials for production of various dies and tool parts [9-11]. Ceramic-metal powders can be easily achieved using elemental particles that are finer and more uniform, many studies on the production of high strength cermet materials which have been focused on developing direct fabrication methods for a uniformly distributed fine composite powder [12,13]. The carbides of tungsten, boron, silicon, titanium and tantalum have been used for a variety of applications over the years. In general, they are very hard and possess excellent wear resistance as well as oxidation resistance [14]. Electroless nickel plating technique, being widely used in many fields, therefore, allows a high performance product with high hardness, wear resistance and corrosion resistance. Several advantages of this method, such as; low cost, easy formation of a continuous and uniform coating on the surface of substrate with complex shape. The capability of depositing on either conductive or

nonconductive parts has also attracted a lot of interests from the academy and the industry [15]. 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 [16,17].

In this study, the ceramic-metal composites were obtained by using powder metallurgy Ni, WC and Ti powders and it is followed by compaction and sintering of powders in conventional furnace to produce dense compacts. X-ray and SEM techniques were employed to characterize microstructures and phases occurred during the sintering process.

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## II. EXPERIMENTAL DETAILS

In this study, Tungsten Carbide (WC) ceramic powder and as metal powder Titanium (Ti) powders, Nickel Powders (Ni) were used. Tungsten Carbide (WC) was used as ceramic powder, and Titanium (Ti) powders as metal. WC powders with 10µm grain size and 99.5% purity and Ti powders with 40µm size and 99.5% purity which both were provided from Sigma Aldrich. and Ni powders -325 mesh, grain size and 99.8 %, purity which was provided from Alfa Aesar. The aim of this study was to reinforce WC ceramic powders with Ni-Ti. It was thought that Ni powders can either be added in the mixture directly WC-Ti-Ni powders for making ceramic-metal composites.

In the experimental study the samples were mixed powders. In the first (%46,66WC) powders (%3,33Ti) powders and (%50 Ni) powders were mixed and then shaped in hydraulic press again coolly under 300 bar pressure. The shaped samples were sintered for two hours within the temperature range 1000-1400°C under argon gas atmosphere in tube furnace. The sintered samples were made ready for mechanical and metallographic analyses.

### CHARACTERIZATION SPECIMENS

In the study, the samples prepared and shape were sintered at temperatures ranging from 1000°C to 1400°C in conventional furnace and made ready for physical, mechanical and metallographic analyses. Density-temperature change curve is shown in Figure 1. The highest sintered density was achieved at 1400°C as 8,02/cm<sup>3</sup>

## III. EXPERIMENTAL RESULTS

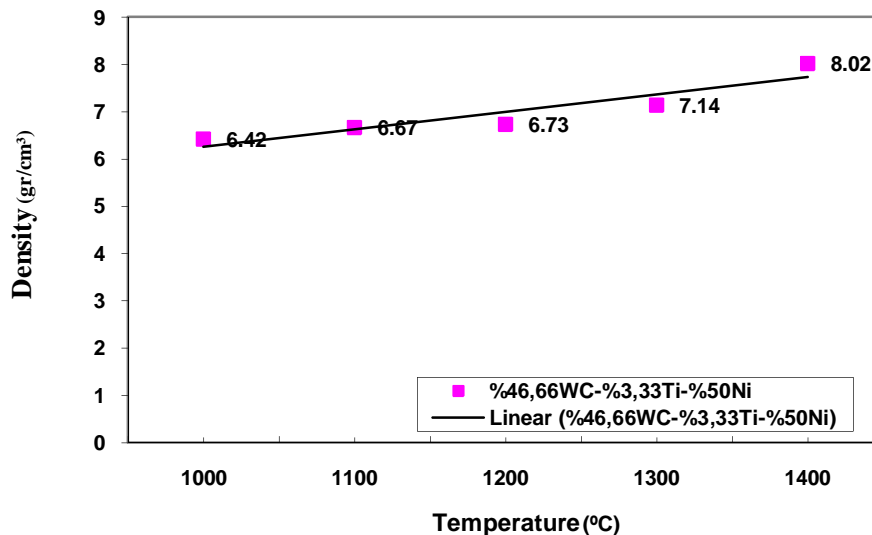


Fig 1. Density-temperature changes in WC-Ti-Ni specimen

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 301HV at 14000 °C.

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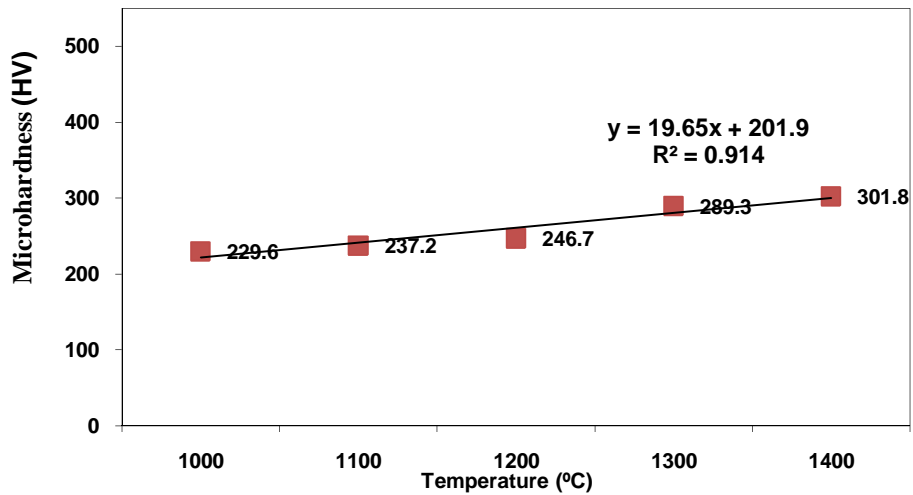


Fig 2. Micro hardness-temperature changes in WC-Ti-Ni specimen

In the compression strength from mechanical tests applied on the specimens after sintering was examined. In Fig 3, compression test was applied on the WC-Ti-Ni specimens. As can be understood from the graphic, the highest strength was achieved as 244,53MPa at 1400°C in the WC-Ti-Ni specimens.

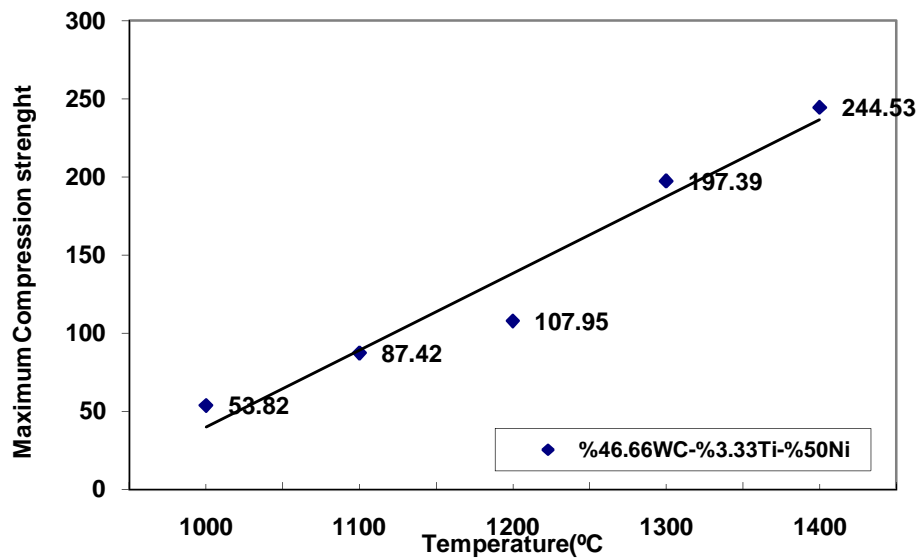


Fig 3. Maximum Compression Strength-temperature changes in WC-Ti-Ni specimen

## SEM Analysis

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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, 2kX and 3kX. The SEM photograph of WC-Ti-Ni ceramic-metal composites, which yielded the best result in terms of mechanical strength in the sintered specimens during the study, after sintering at 1000°C is shown in Figures 4a, 4b and 4c.

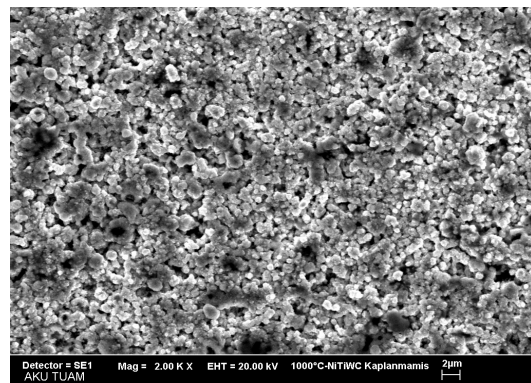
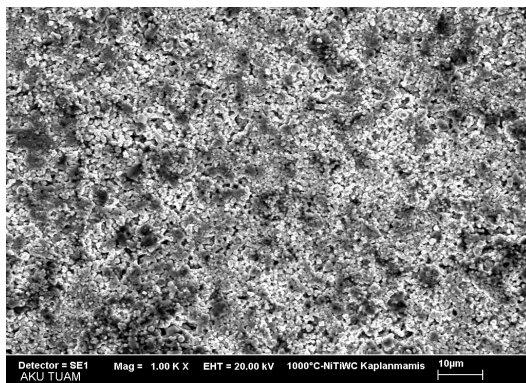


Fig. 4a WC-Ti-Ni Composite specimens 1000°C 1KX Fig. 4b WC-Ti-Ni Composite specimens 1000°C 2KX

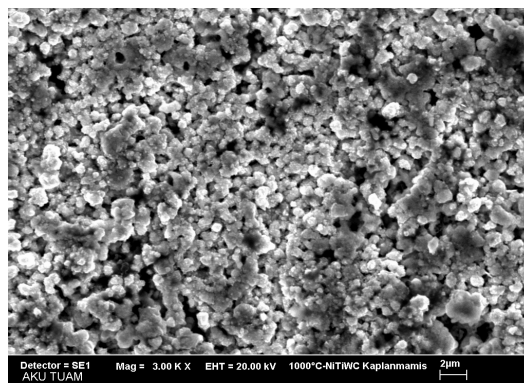


Fig. 4c WC-Ti-Ni Composite specimens 1000°C 3KX

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, 2kX and 3kX. The SEM photograph of WC-Ti-Ni ceramic-metal composites, which yielded the best result in terms of mechanical strength in the sintered specimens during the study, after sintering at 1400°C is shown in Figures 5a, 5b and 5c



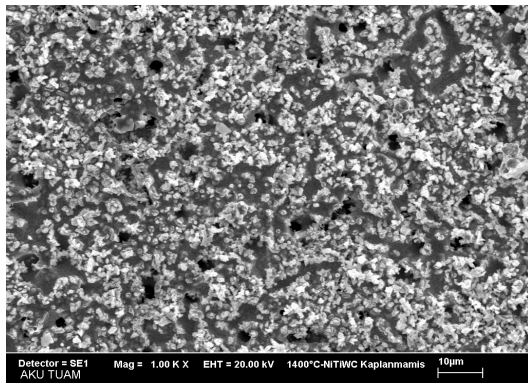


Fig. 5a WC-Ti-Ni Composite specimens 1400°C 1KX

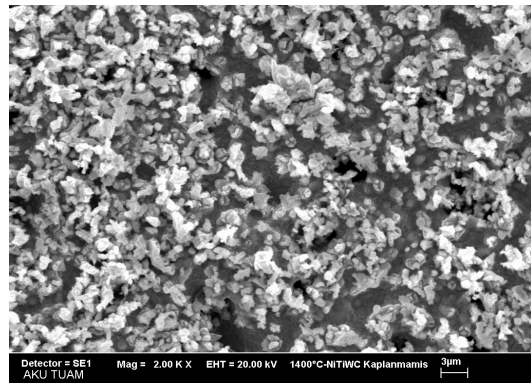


Fig. 5b WC-Ti-Ni Composite specimens 1400°C 2KX

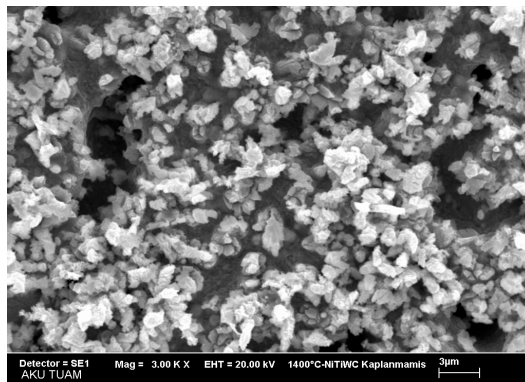


Fig. 5c WC-Ti-Ni Composite specimens 1400°C 3KX

### XRD Analysis

After sintered, specimens were characterized by XRD analysis. See in Fig.6a and 6b. As can be understood from the analysis results, the existence of WC, Ti, Ni, NiTi and Ni<sub>3</sub>Ti peak in the graphs shows that WC-Ti-Ni ceramic-metal composites specimens.

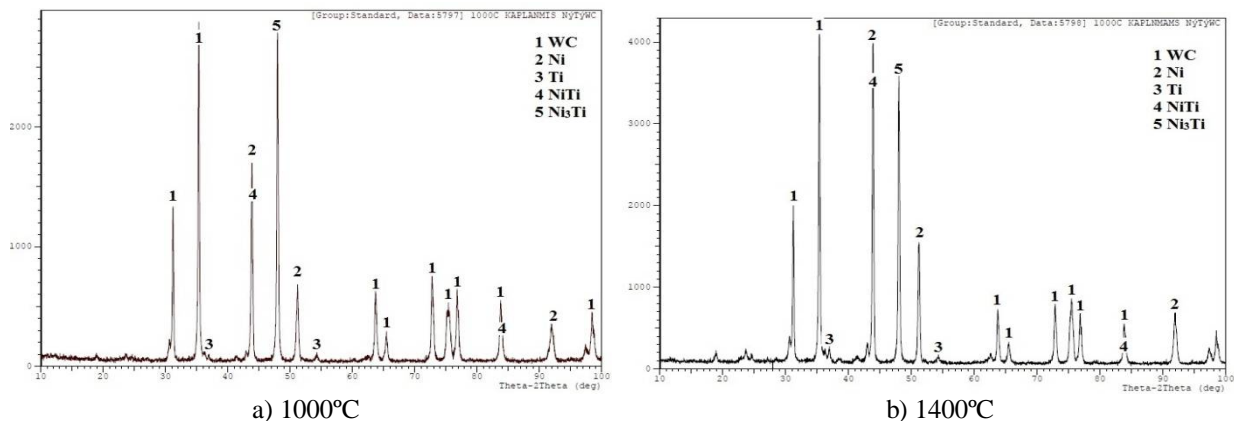


Fig. 6 X-ray diffraction patterns of the %50Ni-%46.66WC- %3.33Ti sintered at 1000-1400°C

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## IV. RESULTS AND DISCUSSION

The following results were concluded from the experimental findings

- The highest density in composite made from %50Ni,%46.66WC and %3.33Ti powders sintered at different temperatures was obtained as 1400°C The highest density sample was found as 8, 02gr/cm<sup>3</sup> at 1400°C.
- The highest hardness %50Ni,%46.66WC and %3.33Ti composite samples fabricated using powder metallurgy method was found as 301,8HV at 1400°C.
- The highest Compression strength %50Ni,%46.66WC and %3.33Ti composite samples fabricated using powder metallurgy method was found as 244,53MPa at 1400°C.
- It was also found out for composition %50Ni,%46.66WC and %3.33Ti at 1400°C suggest that the best properties.

## V. ACKNOWLEDGMENTS

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