CHARACTERIZATION OF SINTERED %50Ni-%48Cr-%2Ti POWDER MIXTURES CONTAINING INTERMETALLICS

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Abstract: Intermetallic materials are among advanced technology materials that have outstanding mechanical and physical properties for high temperature applications. Especially creep resistance, low density and high hardness properties stand out in such intermetallics. The microstructure, mechanical properties of %50Ni-%48Cr and %2Ti powders were investigated using specimens produced by tube furnace sintering at 1000-1400°C temperature. A composite consisting of ternary additions, a metallic phase, Ti,Cr and Ni have been prepared under Ar shroud and then tube furnace sintered. XRD, SEM (Scanning Electron Microscope), were investigated to characterize the properties of the specimens. Experimental results carried out for composition %50Ni-%48Cr and %2Ti at 1400°C suggest that the best properties as 184HV and 6,24/cm^3 density were obtained at 1400°C

Keywords: Sintering, intermetallic, high temperature, composite

1 Introduction

Nickel-based alloys are commonly used as the substructure of metal–ceramic crowns and were introduced into dentistry as a possible replacement for precious alloys due to the increasing cost of gold throughout the 1980s. Ni-based alloys offer the advantage of an increased modulus of elasticity compared with gold that allows thinner sections of the alloy to be used, and consequently less sound tooth destruction during the crown preparation. In addition, the thermal expansion coefficient of Ni-based alloys is well matched to that of conventional veneering porcelain, whichmaintains the metal and ceramic crown to be intimately bonded during firing and prevents cracking of the veneer [1-4].

The Ni–Cr alloys have been shown to be an excellent alternative for noble alloys, for use primarily in metal-ceramic prostheses. The high modulus of elasticity of Ni– Cr alloys, approximately two times higher than the base alloy of gold, allows a reduction in cross-section of the piece, provides more space for the porcelain and less wear on the tooth [5-7].

In spite of the benefits, Ni–Cr alloys have some limitations. The immediate biocompatibility risk with nickel alloys seems to be allergic contact dermatitis. Like all non-precious alloys, nickel alloys are subjected to corrosion products that might lead to soft tissue inflammation and contact dermatitis [8-11].

The purpose of this article is to present the results of an experimental study of the effect of titanium addition on the microstructure and some properties of Ni-Cr alloys. Hardness, density and shear strenght behaviour of the as-cast Ni–Cr–Ti alloys would be evaluated with a hope of developing an alloy suitable for biomedical application

2 Material-Method and Preparation Of Sample

Starting powders employed in this study were as follows: the purity of 99.8% for Ni powders with a particle size lower than 40 μm, the purity of 99.95% for Cr powders a particle size lower than 75 μm and the purity of 99.9% for Ti powders with a particle size lower than 150μm. The composition of %50Ni-%48Cr-%2Ti specimens was prepared in 10g rectangular compressed pre-form. They were mixed homogenously for 24 hours in a mixer following the weighing. The mixture was shaped by single axis cold hydraulic pressing using high strength steel die. A pressure of 300 Bar was used for the compacting all the powder mixtures. The cold pressed samples underwent for a sintering at 1000, 1100, 1200, 1300 and 1400°C for 2 hours in a traditional tube furnace using Argon gas atmosphere. The specimens were cooled in the furnace after sintering and their micro hardness and shear strengths measurements were carried out using METTEST-HT (Vickers) micro hardness tester and Shimadzu Autograph AG-IS 100KN universal tensile tester machine, respectively

Shimadzu XRD-6000 X-Ray Diffraction analyzer was operated with Cu K alpha radiation at the scanning rate of 2 degree per minute. LEO 1430 VP model Scanning Electron Microscope fitted with Oxford EDX analyzer was used for microstructural and EDX compositional analysis.

The volumetric changes of %50Ni-%48Cr-%2Ti composite material after sintering were calculated by using (d=m/V) formula (Fig. 1). The volume of post-sintered samples was measured with Archimedes principle. All the percentages and ratios are given in weight percent unless stated otherwise.

3 Experimental Results and Discussion

3.1 Characterization of specimens

In the study, the samples prepared and shape were sintered at temperatures ranging from 1000ºC to 1400ºC 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 6,24gr/cm^3.

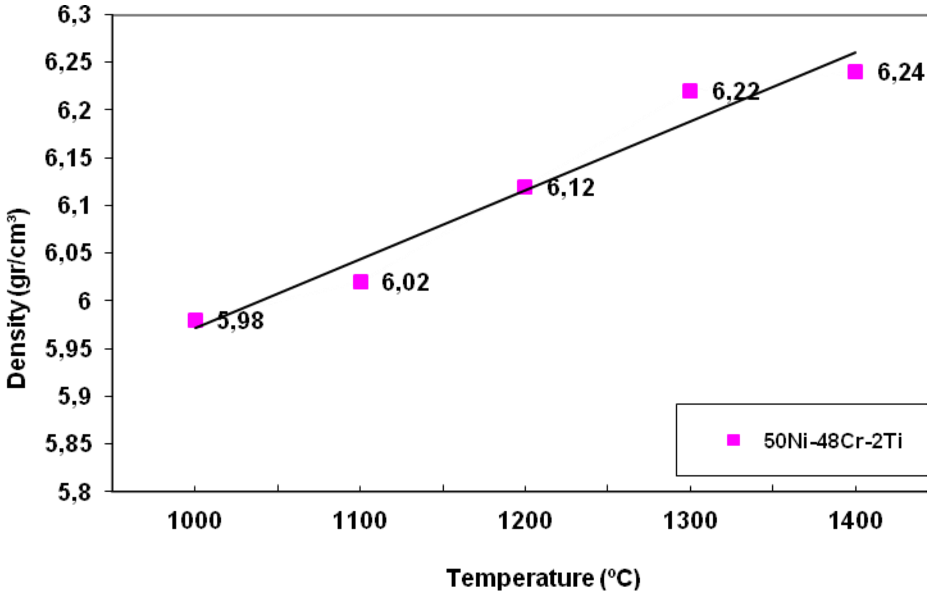


Fig.1: The density change with respect to sintering temperature

The micro hardness-temperature change diagram is shown in figure 2. The micro hardness values of the composite samples produced using conventional sintering technique within the temperature range 1000-1400°C. According to this, the highest micro hardness value in the composite samples produced using powder metallurgy method was observed to be 184HV at 1400°C.

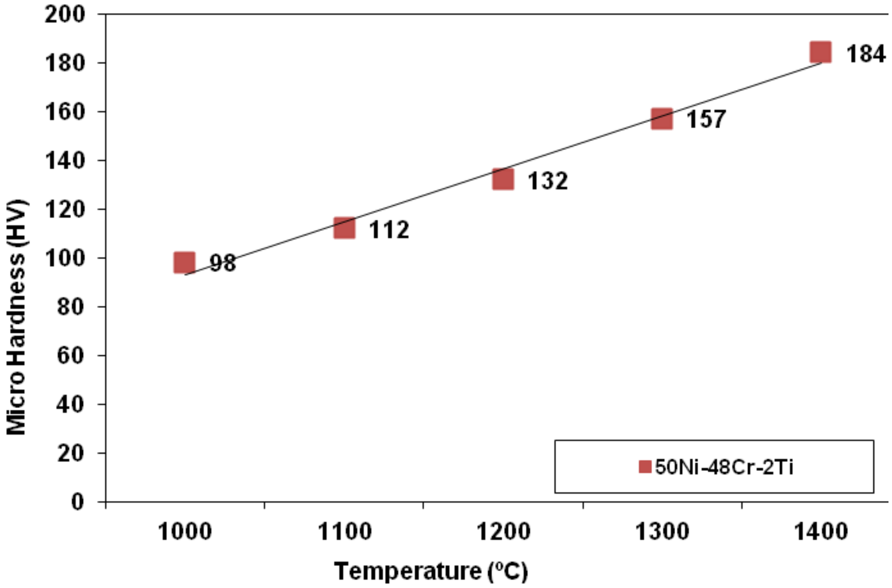


Fig. 2: The micro hardness tests results from sintered specimens treated at different temperatures

Shear strength and hardness of the metal-matrix composite specimens were also determined. The relation between the sintering temperatures and Shear strength values is shown in Figure 3. The shear strength value in the composite samples was observed to be 254.34 MPa at 1400°C.

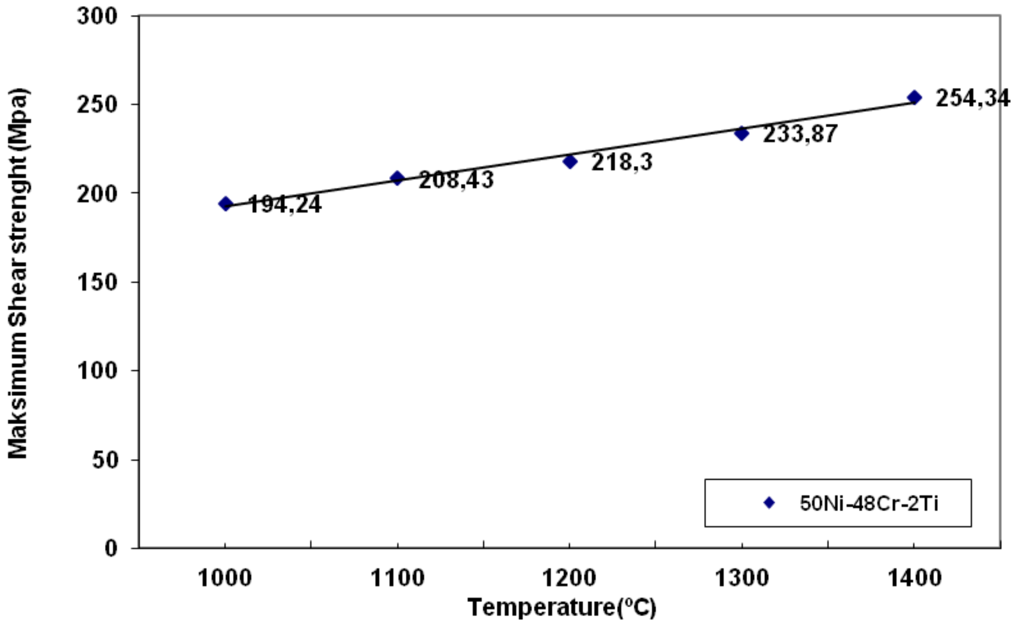


Fig. 3: Shear strength results from specimens sintered at different temperatures

3.1 Metallographic Analysis

The SEM analysis result of the metal matrix composite specimen obtained from Ni-Cr-Ti powders sintered at 1000ºC is shown in Figure 5. grain growth is observed and a homogeneous structure. In Figure 6, 1400 ºC to become apparent degree of grain boundaries and grain boundaries can be seen that the pores very smaller and circular shapes. Sintering is better understood at 1400 ºC temperature. This density, hardness and shear strength values are confirmed.

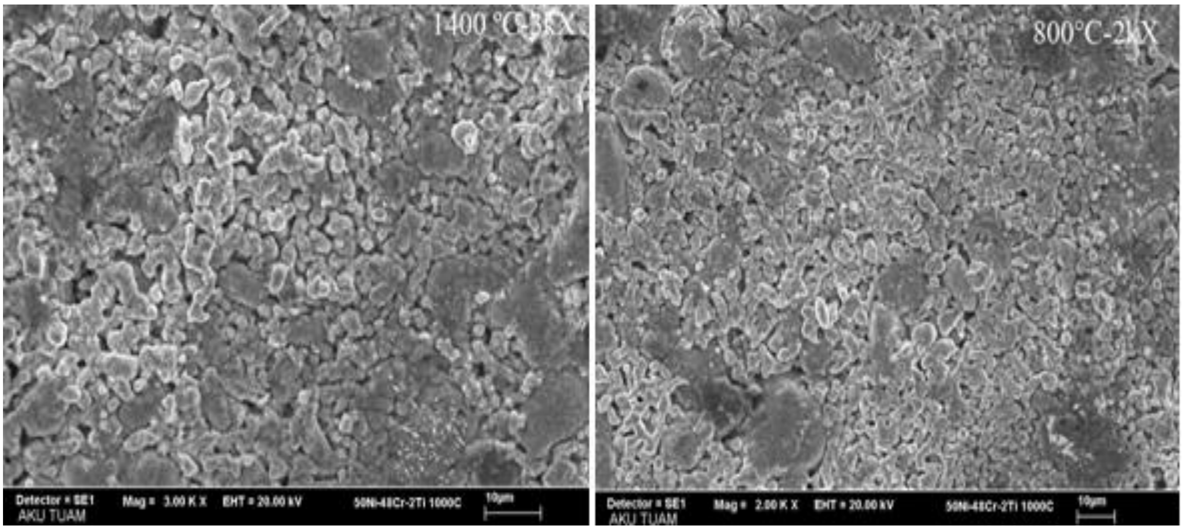


Fig. 5. SEM view of Ni-Cr-Ti composite 1000°C

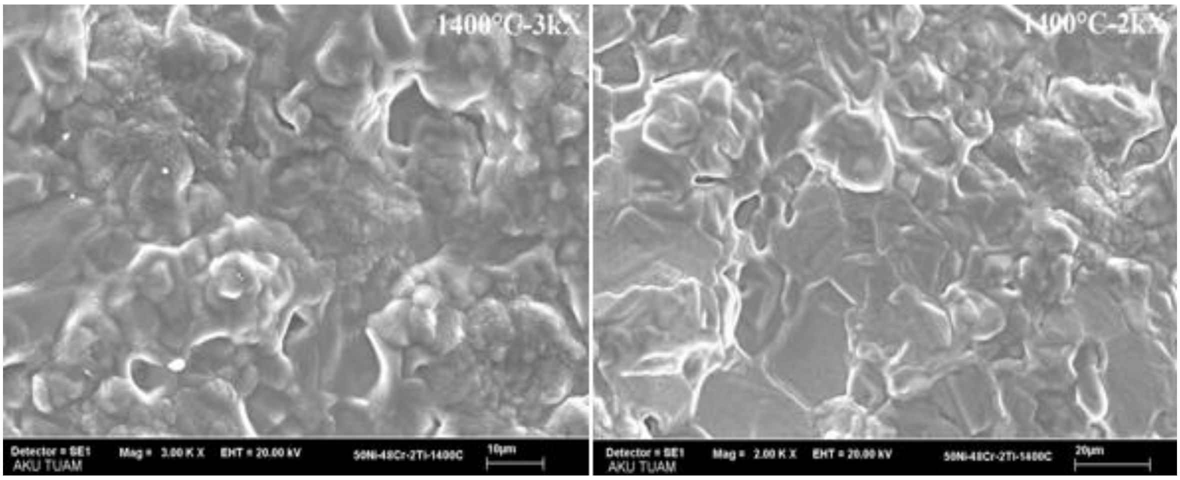
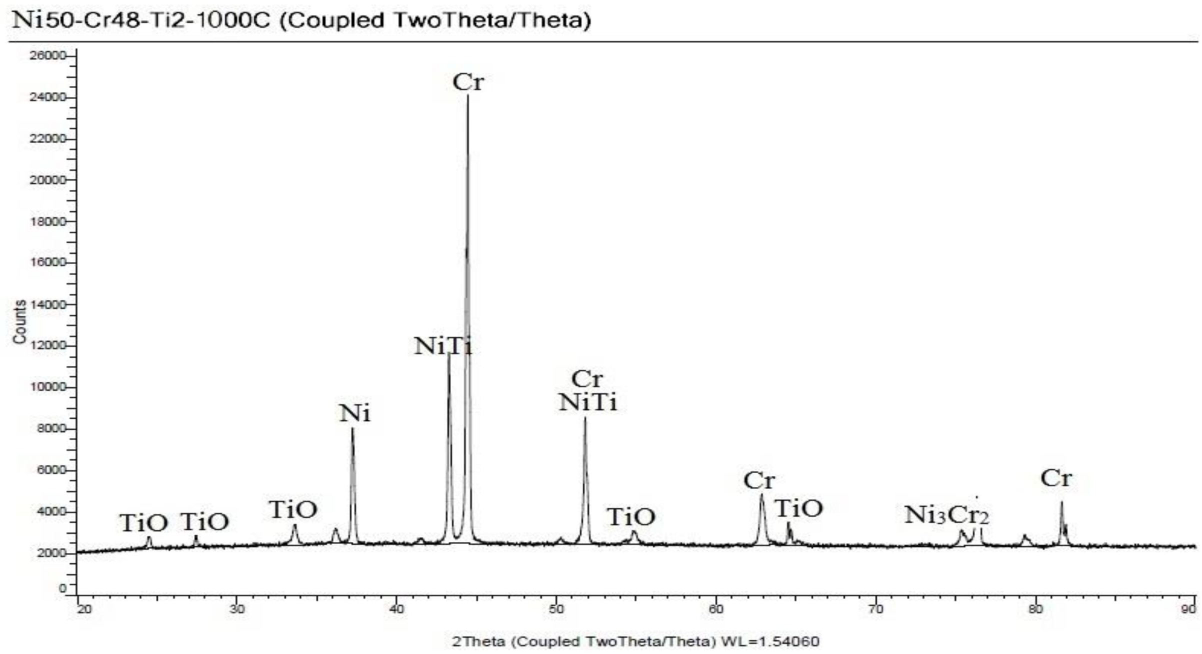


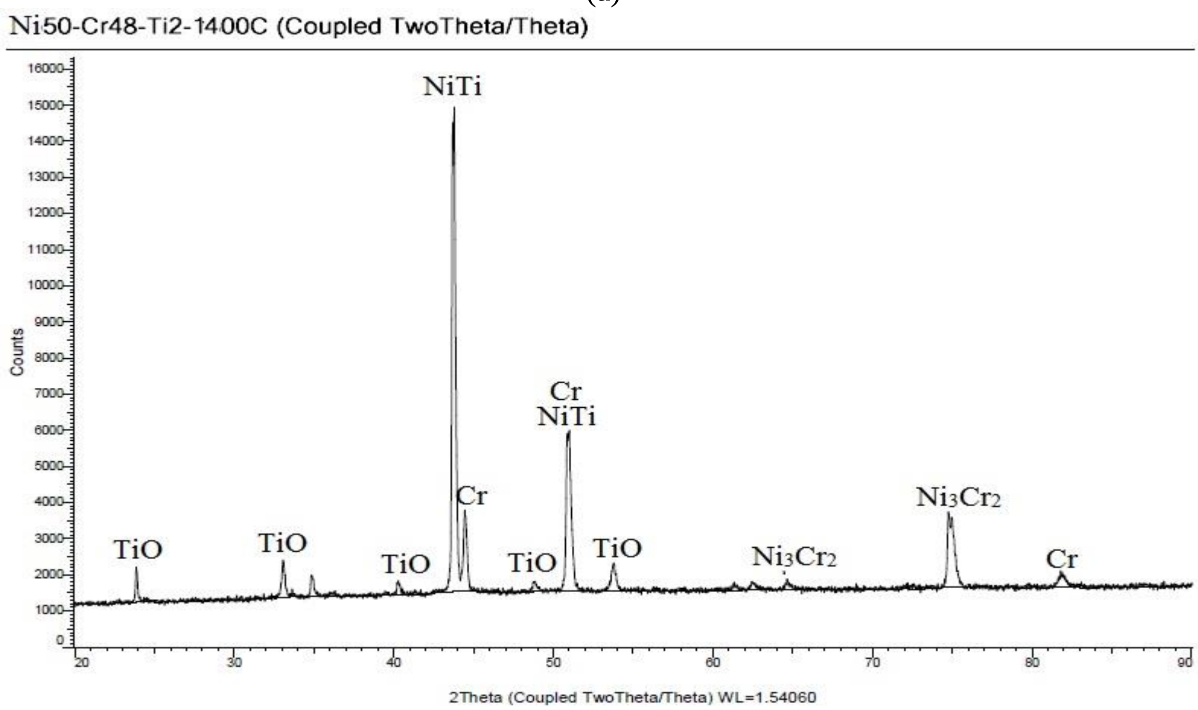
Fig. 6. SEM view of Ni-Cr-Ti composite 1400°C

3.2 XRD Analysis

In Figure 7, NiTi, Ni_3Cr_2, TiO, and Cr peaks can be seen in the XRD analysis from Ni-Cr-Ti composite sintered in tube furnace at 1000°C and1400°C.



(a)



(b)

Fig.7: The XRD analysis Ni-Cr-Ti composites sintered at 1000°C and 1400°C

Ni-Cr-Ti powders were mixed and then sintered in a conventional furnace. After sintering, a considerable drop in the mechanical properties of specimens sintered at 1000°C and 1400°C were observed. It was concluded that Ni-Cr-Ti particles were occured by NiTi, and Ni_3Cr_2 intermetallic phase at 1400°C and Hardness test results suggest that Ni-Cr-Ti composite sintered at 1400°C shows Vickers micro hardness values respectively.

4 Conclusion

The following results were concluded from the experimental findings

- The highest density in composite made from Ni-Cr-Ti powders sintered at different temperatures was obtained as 1400°C The highest density sample was found as 6,24gr/cm^3 at 1400°C.

- The highest microhardness in Ni-Cr-Ti composite samples fabricated using powder metallurgy method was found as 184HV at 1400°C.

The highest Shear strength sample was obtained as 254,34MPa at 1400°C.

- It was also found out for composition %50Ni-%48Cr- %2Ti at 1400°C suggest that the best properties.

5 Acknowledgements

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