MICROHARDNESS ANALYSIS NI $NI_{35}TI_{50}CU_{15}$ BY POWDER METALLURGY MODIFIED BY PLASMA IMMERSION ION IMPLANTATION TECHNIQUE

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1. Introduction

The NiTiCu SMA produced by powder metallurgy (PM) is a promising material due to variety of advantages in practical use. The addition of cooper (Cu), as ternary element, in NiTi SMA Increases the characteristic temperatures of the martensitic transformation, cause good stability of characteristic temperature, good corrosion resistance and reduces of Ti_3Ni_4 precipitation [1-5].

When this type of alloy is utilized as biomedical material, such as implants, can be occurs the rejection on the human body. One possibility is the surface modification by Nitrogen Plasma Immersion Ion Implantation (N-PIII) technique.

The hardness measure in SMA is important properties because it is a strong indicator of mechanical performance. It is interesting to note that for in NiTiCu SMA the evaluating hardness depends on temperature since the mechanical properties of SMAs are temperature dependent [5].

2. Experimental

For production of the $Ni_{35}Ti_{50}Cu_{15}$ alloy by powder metallurgy were used as starting material elemental powders Ni, Ti and Cu. The powders were mixed in pharmaceutical mixer for 150 minutes. The sample was compressed in uniaxial press at 250 MPa in cylindrical form with 9 mm in diameter and 2 mm in thickness and after cold isostatic pressed at 450 MPa. The sintering was performed at 1000 ºC for 60 minutes. The N-PIII technique was realized at 770 ºC for 60 minutes.

The microstructure of as cast and implanted by PBII samples were observed with scanning electron microscope. The phase's identification and structural parameters were established using the X ray diffraction. The microhardness test were made in the as cast sample and the surface modified sample by N-PIII using a micro Vickers indenter and a 100 g load at room temperature.

3. Results and Discussions

The morphology in surface sample before N-PIII sintered at 1000 ºC for 60 minutes showed significant pores sizes and their distribution can be observed. The porous in surface are randomly distributes, rarely interconnected and has an irregular shape. The diffratogram of the sample presented Ti_2Ni and CuTi stables phases, the metastable phase$TiCu_3$ that disappears with the increase of sintering temperature and intermetallic NiTi phase important for shape memory effect.

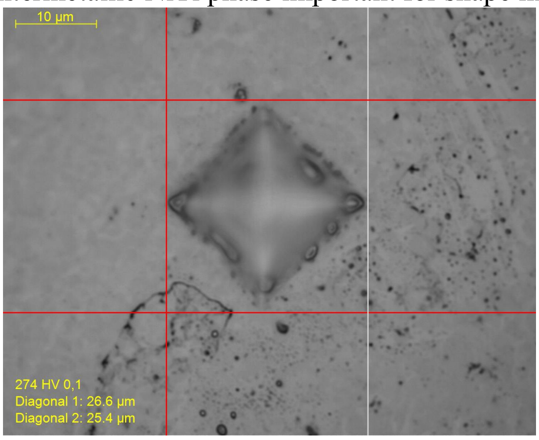

Fig. 1. *Hardness in $Ni_{35}Ti_{50}Cu_{15}$ sample sintered in 1000 C and for 120 minutes after N-PIII at 770 C for 60 minutes*

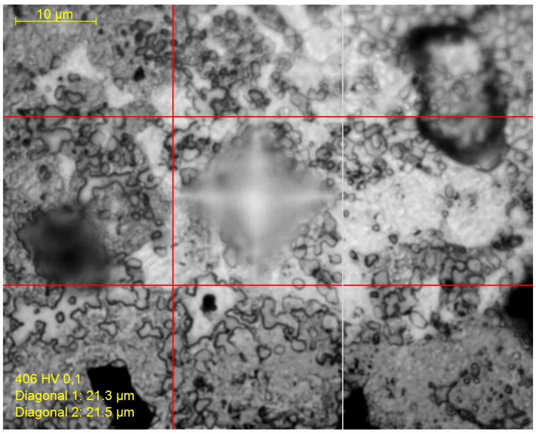

Fig. 2. *Hardness $Ni_{35}Ti_{50}Cu_{15}$ sample sintered in 1000 º C and for 120 minutes and after N-PIII at 770 C for 60 minutes*

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After surface modification by N-PIII at 770 ºC for 60 minutes, the implanted surface showed less quantified of porous and no presented residual particles inside. The surface demonstrated apparently roughness compared to surface sample before ion implantation (N-PIII). The diffratogram presented the TiN peaks demonstrating the surface modification occurs in the samples. However there is still the metastable phases Cu_3Ti and stable phases Ti_2Ni and Cu_2Ti affecting the mechanical properties.

In the microhardness test demonstrated that sample before surface implantation showed hardness near to 274HV and the N-PIII sample 406 HV, showed in figure 1 and 2 respectively.

4. References

[1] FUNAKUBO, H. Shape memory alloys. Translated from the Japanese by Kennedy, J. B., Stanford University. Tokyo: University of Tokyo, 1987.

[2] HUMBEECK, J.V. From a seed to a need: The growth of the shape memory application in Europe. *Material Research Society Proceedings*, v.246, p.377-387, dec. 1992.

[3] BANSIDDHI, T.D., SARGEANT, T.D., STUPP, S.I., DUNAND, D.C. Porous NiTi for bone implants: A review. *Acta Biomaterialia*, v.4, p. 773-782, dec. 2008.

[4] GANG, C., CAO, P., EDMONDS, N. Porous NiTi alloys produced by press-and-sinter from Ni/Ti and Ni/TiH_2 mixtures.

[5] GORYCZKA, T., HUMBEECK, J.V. NiTiCu shape memory alloy produced by powder technology. *Journal of Alloy and Compounds*, v.456, p.194-200, Feb. 2007.

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