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Synthesis and Characterization Structure and Physical Properties [50-xTiNi – x Ag] Shape Memory Alloy

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Abstract-- In this research, a metal alloy was prepared and its structural and physiological properties were studied. The method of powder technology was used in mixing and mixing powders. The ratio of 1: 1 was mixed with 100 micron granular powder and nickel powder with granular size of 78 microns. The mixture was then reinforced with a nanocrystalline powder with a mixing ratio of 0%, 1%, 3% , 5% and 7%), where the powders were mixed in an effective mechanical mixing method at a rate of 350 rpm and 6 hours continuously. Physical tests (density, hardness, , yield strength, young modulus) were performed. The electrical tests were carried out using four sensors (probs) such as resistivity and electrical conductivity, as well as structural tests such as X-ray diffraction and scanning electron microscopy. The results showed a significant improvement in the micro hardness values using Vickers hardness, which resulted in improved yield strength and young modulus respectively. The results of the test showed that the electrical conductivity properties showed a clear reduction in the resistivity values of the alloys supported by the nano-silver powder and an increase in the values of the electrical conductivity compared to the base alloy (nickel-titanium).

Keywords--Effective mechanical mixing, nickel-titanium, yield strength, ionic coefficient, conductivity.

1. Introduction

The uses of metal alloys in the electrical and medical industries have a great impact in the adoption of many researchers in the development of various ways [1]. The methods of preparing these alloys varied in variety of use. There are two methods in the manufacture of them, including the method of powder technology and the other method is plumbing [2]. The method of powder technology, or so-called effective mechanical mixing, was adopted in this research, where accuracy, cleanliness, loss of material and waste of preparation and quality of product [3]. In this work, alloys of titanium and nickel (nitrinol) have been prepared. They are alloys that have the ability to restore their natural form after stress has been eliminated. This remarkable property is due to the atomic composition of the nickel, titanium and silver atoms, which can arrange themselves in two different ways, and can switch between these two methods repeatedly [5, 6, 7]. This alloy (Shape Memory Alloy SMA) is superior to many alloys which can be mentioned (copper alloy - aluminum - nickel, nickel alloy - aluminum - iron and others) [8, 9]. These alloys tend to lose their ability to return to their original form after extensive use. There are many uses of nickel-titanium-silver alloys, which can be suggested in aircraft wings or solar panels for spacecraft or as an alternative to liquids in cooling devices or even used as artificial heart valves [11, 12, 13]. Many alloys studied the properties of these alloys. The nickel-titanium alloy system is mainly based on a nickel- and titanium-neutral alloy with high electrical resistance and large corrosion resistance. It has a moderate melting rate, allowing for modifications in its composition or other adaptive elements. Our current research so that the mechanical properties remain as much as possible [14, 15]. It is also important to know that these alloys cannot be used in all applications. When used, the conditions of application should be addressed in terms of the stresses and movement required (pressure, temperature). Particular attention should be given to temperature as it is the main factor in determining the shape of the alloy.



2. Theoretical part

The four sensors technique was used to determine the values of electrical resistivity and conductivity through equation [16]:

$$\rho = \frac{v}{I} \cdot \pi \cdot d \dots \dots (1)$$

Where **d** is the distance between the poles of the sensors and their value (0.02 mm) and the symbol (**v**) represents the voltages while the symbol (**I**) is the current passing through the sample, which is in the form of a disk diameter of 1 cm and thickness of 2 mm. Through inverted resistivity (**ρ**), the electrical conductivity (**σ**) can be found in Siemens units per meter. Mathematical relations were also used [17]. To calculate the hardness of minutes:

$$Hv = \frac{1.84 F}{d^2} \dots \dots \dots (2)$$

$$E\text{-Modulus} = 81.9 Hv \dots \dots \dots (3)$$

$$Y\text{-yield Strength} = \frac{Hv}{3} \dots \dots \dots (4)$$

Where (**Hv**) represents the hardness values and the symbol (**E**) represents the elasticity coefficient values while the (**Y**) symbol is the stress of submission, which depends entirely on the hardness values. The process density was calculated using the Archimedes method and the method of dimensions to estimate the percentage of pores in the prepared alloys and to know the efficiency of the powder technology method in the preparation of such alloys.

3. Experimental Part

In this study, a nickel and titanium alloy was prepared by 1: 1 using powdered technology as a base material for comparison. After that, the alloy with silver powder was increased by 1%, 3%, 5% and 7% by fixing the nickel ratio and decreasing the titanium ratio. The method of powder technology is summarized as a method that needs to be accurate in dealing with the variables. Any variation in the ratios will affect the required properties. First, the weight of the powders starts according to the percentages accurately, and then mixed and mixed using a mixing machine with 350 rpm for 6 continuous hours to ensure homogenization and mixing of powder components. The models are then weighed according to the required test and then the initial configuration is done by using the hydraulic piston with a pressure of 6 tons and for 5 minutes to ensure full configuration. The samples are then sintering with Argon gas to prevent oxidation and sample failure. This is done at 600 ° C and at 5 ° C for 6 hours continuous. Paper of carbide silicon No. 1000, after which the density of samples is measured using the method of dimensions to ensure density and porosity after the tests are required for each type of samples by type of examination. Formal tests were carried out for samples (pre-fouling and post-fouling powders) such as x-ray diffraction and electron microscopy.

4. Results and discussion

A. Resistivity and electrical conductivity:

Table 1 and Figure 1 and Figure 2 show the practical results of the electrical properties of the prepared models. The four sensors technique was used in the examination procedure according to the mathematical equation (1). The practical results showed a significant improvement in the electrical resistivity values,

which decreased from 80.7 for the nickel- Silver to 40.5% supported by 7% of silver. The reason for the abundance of electronic charge carriers in the alloy supported by silver, which has high electrical conductivity because of the abundance of electrons in the connection package and acquisition by the alloy and according to the rate of support and the reason for mixing Effective homogeneous mixing of powders before the sintering and this is evident in the examination of X-ray diffraction, which explained an increase in the intensity and the high peaks of silver Figure 3 represents X-ray diffraction powders before the sintering.

Table 1 shows the practical values of resistivity and electrical conductivity as a function to the ratio of n-Ag powder reinforcement

Sample NO.	Resistivity $\times 10^{-4}$	Electrical Conductivity
0%Ag	80.7	123.91
1%Ag	73	158.72
3%Ag	50.7	197.23
5%Ag	43.2	232.55
7%Ag	40.5	246.91

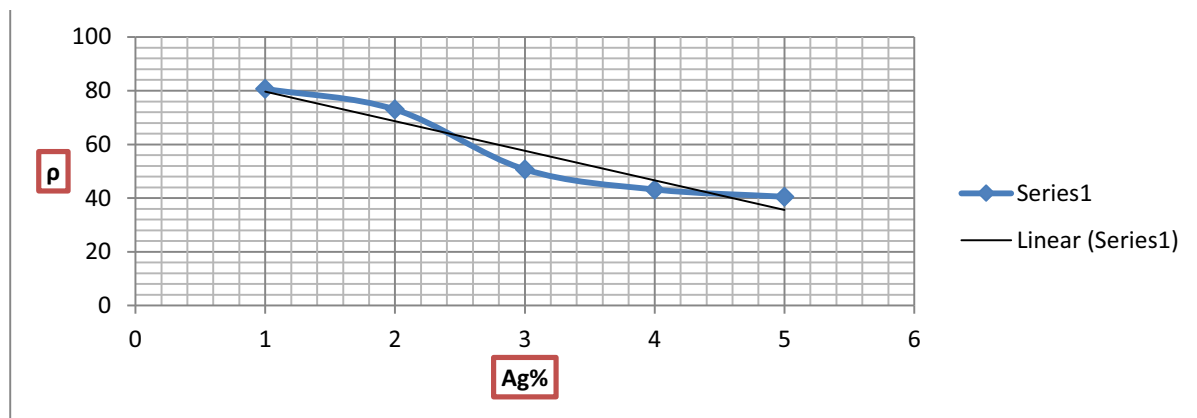


Figure 1 shows the practical results of electrical resistivity as a function of the percentage of silver. The values show a clear reduction and a 50% improvement of resistance at 7% of silver.

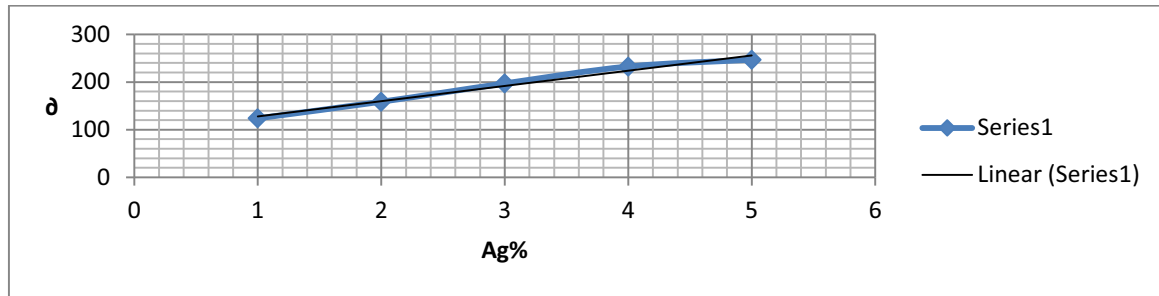


Figure 2 shows the significant improvement and increased conductivity by increasing the ratio of silver supported to the non-reinforced alloy, where the ratio of 50% to 10% of silver is better than the nickel-free titanium alloy.

5. Physical properties

Table 2 and shapes (3, 4, 5, 6) show the practical results of the mechanical properties of the observed alloy of the figure (0, 1, 3, 5, 7). Figure (3) shows the values of the micro hardness (Vickers hardness) The hardness and hardness of the alloy is due to the flexibility of silver, so it is less hard and resistant to scratching and plowing than the original nickel and titanium alloy due to the low durability and hardness. Silver.

Table 2 shows the practical results of the physical tests (mechanical) as a function of the supporting material

Sample NO.	Hv MPa	E- Modulus GPa	Density g\cm ²	y- yield Strength MPa
0%Ag	415	3.4013	6.24	133.33
1%Ag	380	3.114	7.09	126.66
3%Ag	310	2.540	7.22	103.33
5%Ag	280	2.294	7.52	93.33
7%Ag	234	1.191	7.67	78

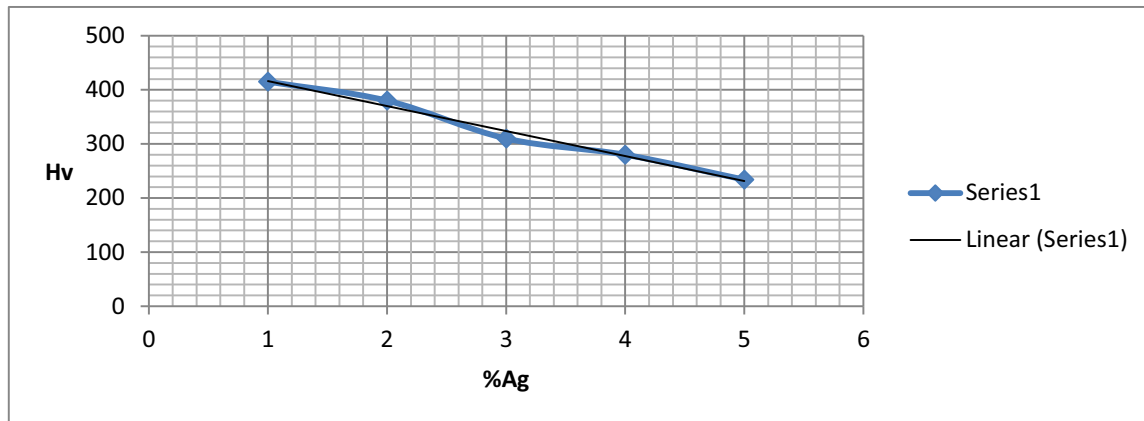


Figure 3 The values of the hardness of the minutes as a function of the percentage of silver.

An important test for the shape alloys is the calculation of the elasticity coefficient and the durability of the yield based on the hardness of the minutes and the use of the ratios (2,3,4). We can calculate the young coefficient and yield strength respectively. Figure 4 shows a decrease in elasticity coefficient due to a decrease in hardness values. While Figure 5 shows the durability of the alloy and the free alloy. It is noticeable that the strength of the silver-plated alloys is low and that the silver is of low hardness and moderate elasticity compared with nickel and titanium. The higher the hardness and elasticity of the mill. This gives the alloy the basis of the impact and returns to its original condition easily and easily when exposed to any stress within the limits of durability of submission.

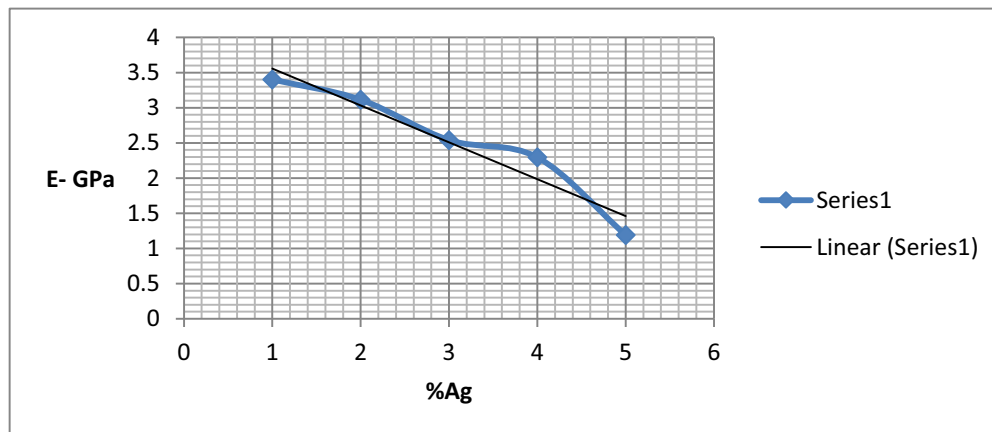


Figure 4 shows the elasticity coefficient of the observed alloys of the shape as a function with the percentage of silver at room temperature.

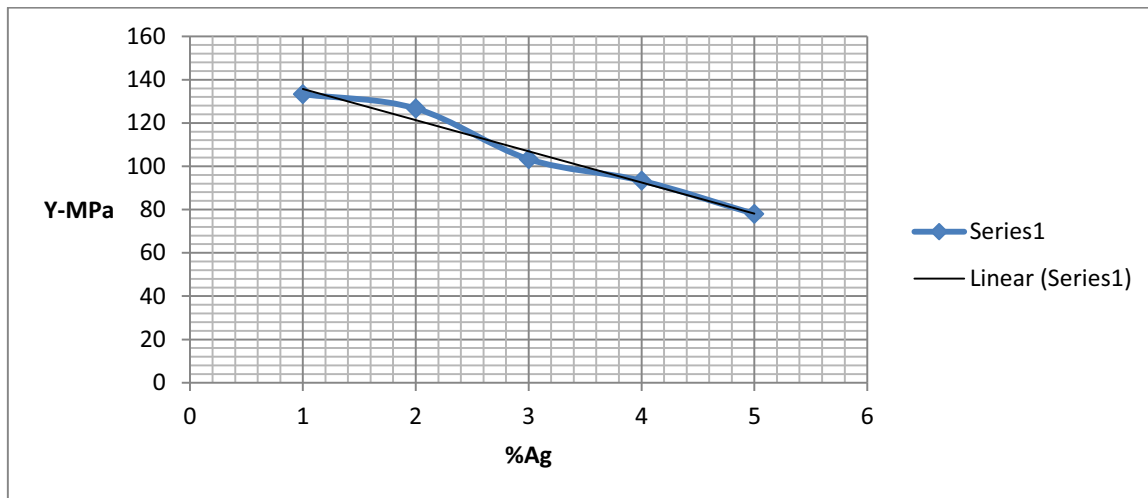


Figure (5) shows the values of the durability of the alloy or the breakdown of the alloys of the shape as a function of the percentages of silver at room temperature.

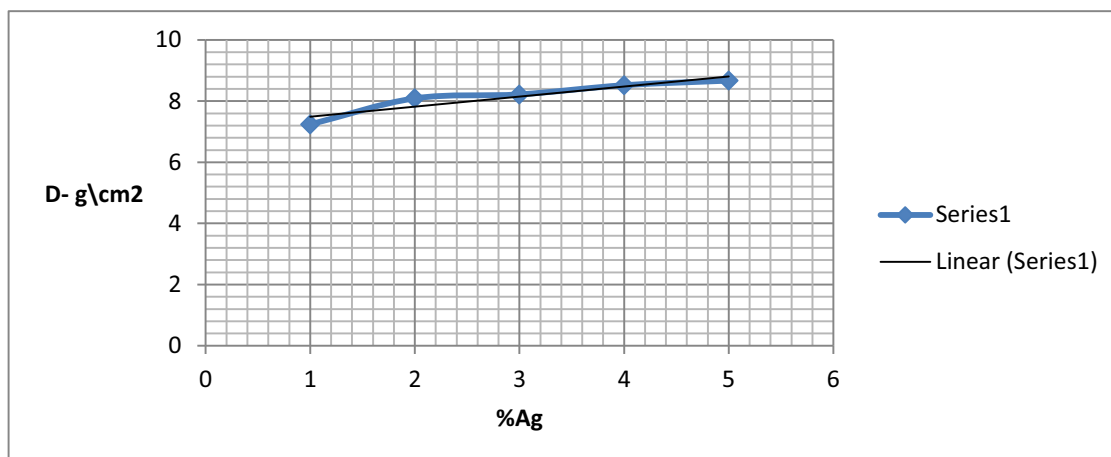


Figure (6) practical results of the density values as a function of the percentage of silver The figure shows a gradual increase in the density values of the reinforced alloys compared to the base alloy.

6. X-Ray Diffraction

Synthetic tests were conducted for the prepared alloys supported by the nanoparticle powder as well as the basic alloy (nickel - titanium) Figure 7 shows X-ray diffraction prior to heat treatment of the homogeneous mixture of powders (silver, nickel, titanium) and the added percentages in the working method. The figure shows the growth of the silver peaks by increasing its percentage compared to the base material. The mixing process of the powders is highly homogenous and has a positive effect after sintering to ensure the formation of the phases to obtain the alloys of the shape. Figure (8) shows the X-ray diffraction of the alloys prepared after the process of frying and heat treatment and the high peaks of the silver larger than the pre-fouling. This indicates the occurrence of regular interaction and homogeneity in the alloys when using the method of powder technology to prepare them and note from the form also the absence of oxidation of the three powders.

7. Scanning electron microscopy SEM:

The most important structural tests are the topography of the surfaces and the particle size study of the alloy. Figure (9) shows images of the scanning electron microscopy of the samples prepared. The microscopic images of sample (a) are found to be silver-free and have uniform homogeneity and are almost free of gaps. At 600 ° C is suitable for this purpose so that the latest fusion between nickel and titanium cannot be distinguished between them. As for the samples (b, c, d, e) representing the electron microscopy images of silver-plated alloys of (1,3,5,7) respectively, it is clear (white) silver powder which increases from one model to another according to the added ratio and represents The phase is the link between nickel and titanium and the clarity is greater at 7% of the last image (e). This result explains all the changes that occur in the characteristics studied in this work.

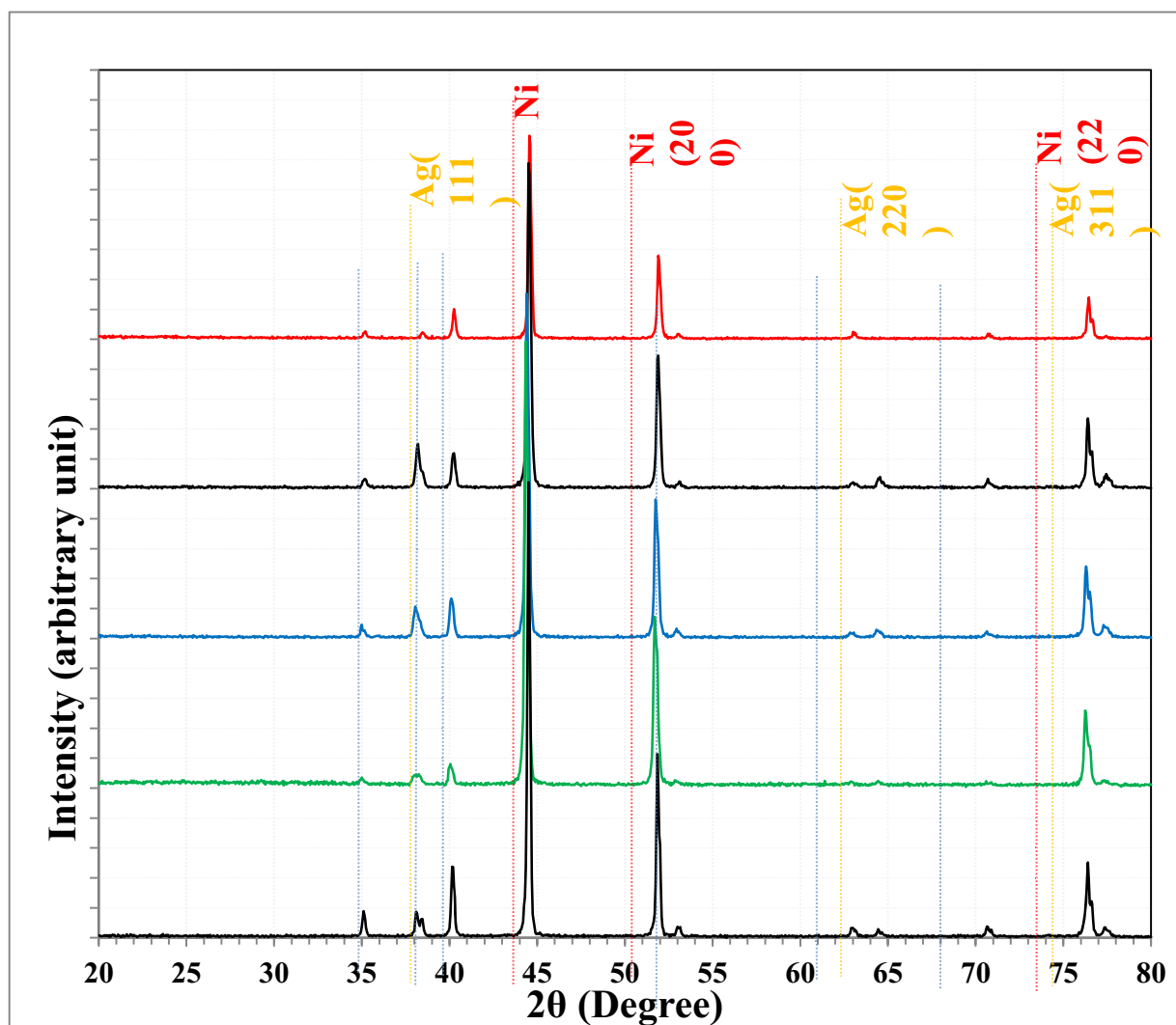


Figure (7) shows the X-ray diffraction of the prepared models by effective mixing of powders. After thermal treatment, we observe from the shape starting from the top of the non-silver-backed alloy, showing the height of the tops and the increase in the silver strength of the supported models compared to the silver-free alloy.

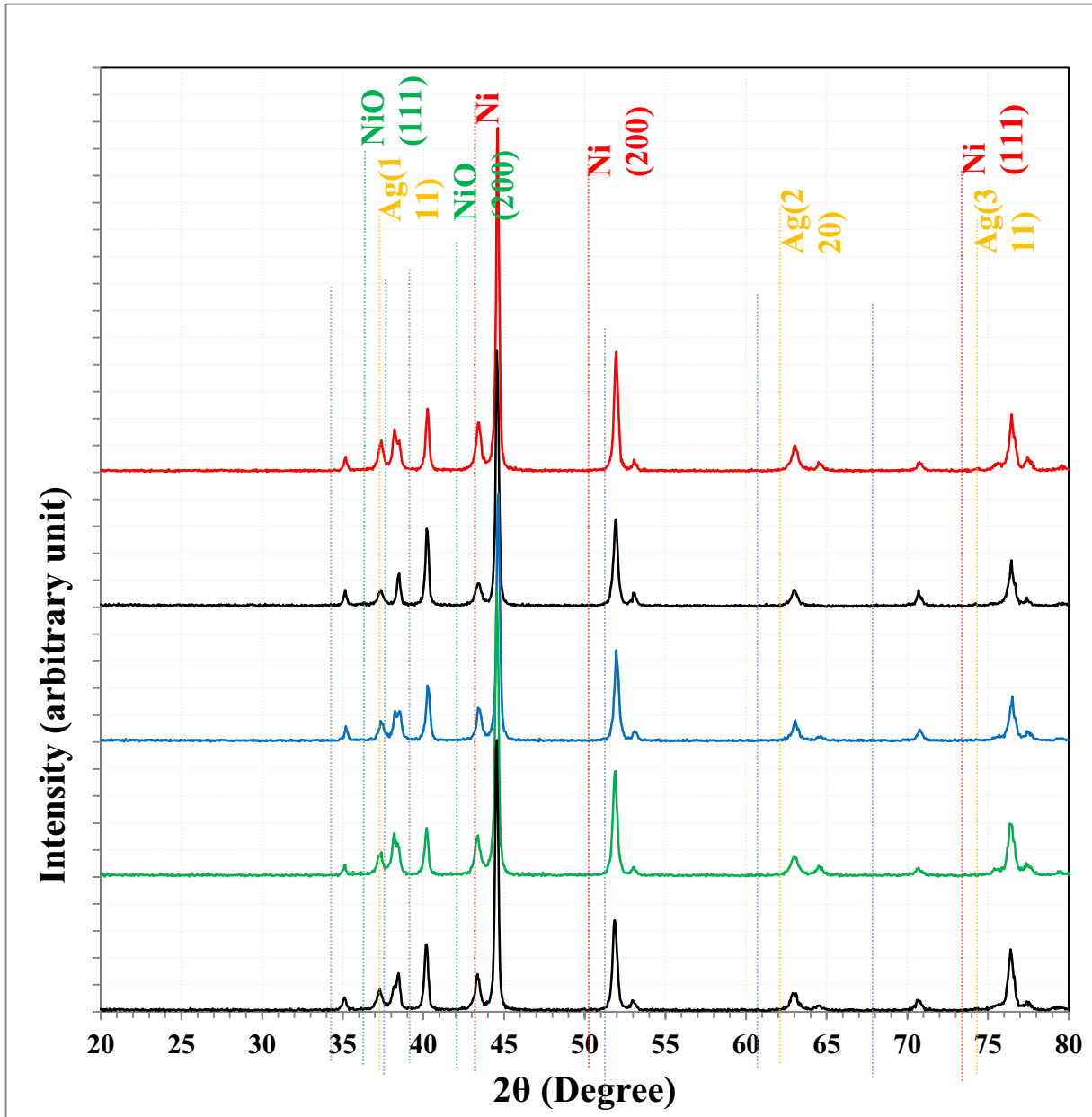


Figure 8 shows the X-ray diffraction of the silver-backed samples and the free samples after forming and sintering at a temperature of 600 ° C for 6 hours with an atmosphere of Argon gas. The shapes show a gradual increase in the tops of the silver as compared to the nickel-titanium alloy. This indicates the formation of the Ni-Ti-Ag nucleus of the high-crystalline form of high crystallization due to the presence of silver.

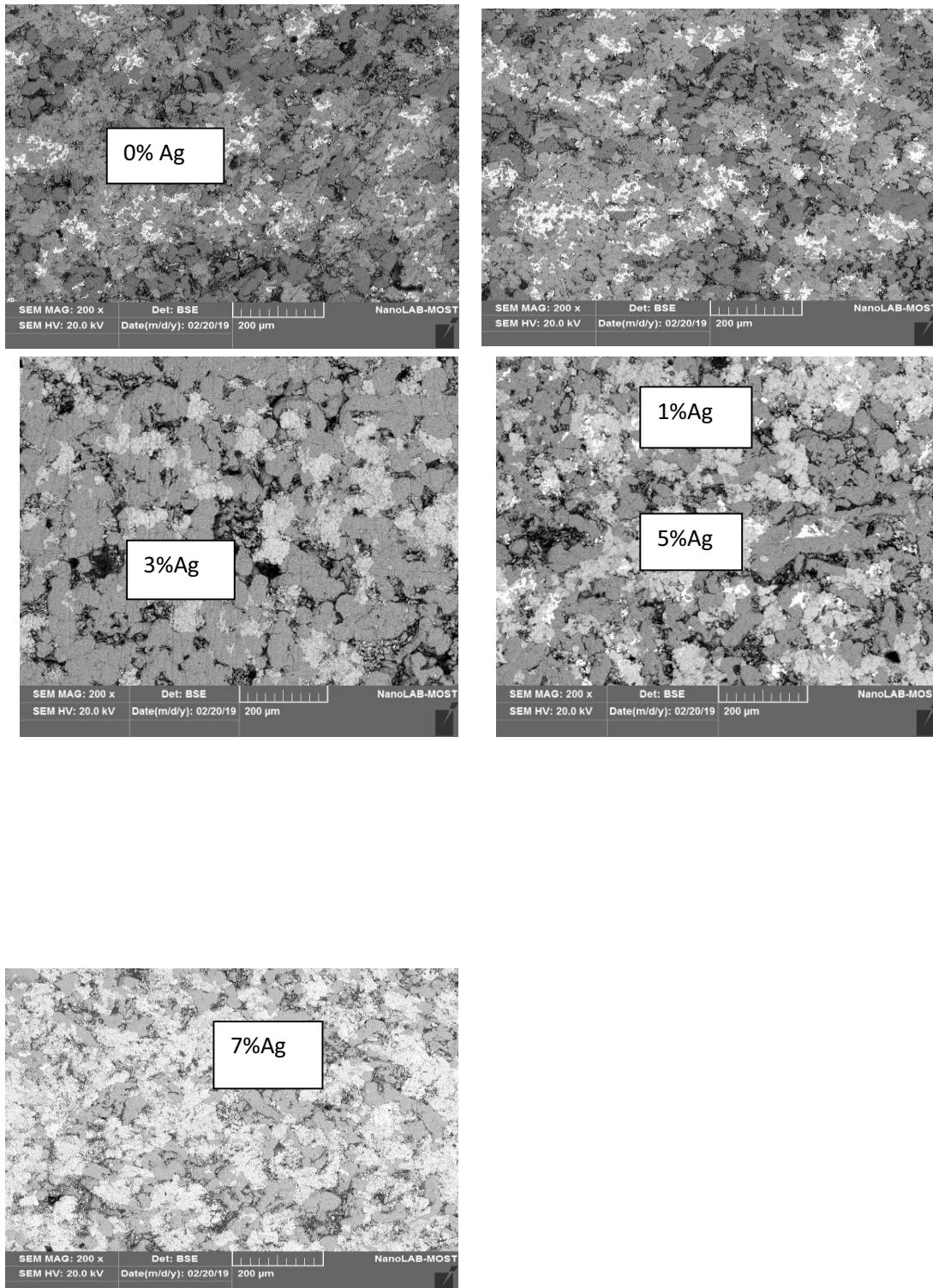


Figure (9) shows the images of the scanning electron microscopy of the samples after formation and sintering.

8. Porosity

The porosity is one of the defects that accompany the formation of alloys using the method of powder technology, which is clear and cannot be eliminated, but can be reduced in different ways, including the use of homogeneous granular size of the powders formed for the alloy, mixing and mixing effective as well as the use of pressure suitable for the formation in addition to the treatment of heat micro and slow to ensure the closing of gaps Among the methods that can measure the porosity ratio is the calculation of the density of samples in practice and theoretically and calculate the difference between them. Table (3) shows the ratio of porosity which is the difference between theoretical density and practical density

Table 3 shows the porosity values of the alloys of the shape with the addition of silver.

Sample NO.	Thero. Density gcm^2	Expr. Density gcm^2	Porosity Ratio
0%Ag	7.20	6.24	9.6%
1%Ag	7.33	7.09	2.4%
3%Ag	7.50	7.22	2.8%
5%Ag	7.60	7.52	0.8%
7%Ag	7.80	7.67	1.3%

9. Conclusions

We conclude from this work

- The method of using powder technology and the effective mechanical mix is a successful and appropriate method in the preparation of such complex alloys.
- 2 - The addition of silver powder in these percentages gain the alloy (nickel - titanium) high flexibility and this reflects positively on its work as reminder alloys of the form.
- The effect of adding silver powder to the base alloy reduces its electrical resistance so that it can be considered as superconducting alloys.
- 4 - These alloys can be considered prepared for electrical, thermal and mechanical applications within the limits of high flexibility.

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