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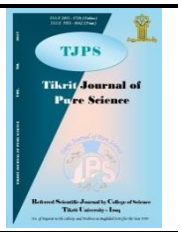

Effect of Vanadium addition on The Structural Properties of Alloy (Ni-Cu) Nano-Particles

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Abstract

This research aimed to prepare (Ni-Al) alloys by powder technology method because of it is technological and commercial important. Nickel and Copper powders were tacking then there powders mixed and blended together with percent (Ni-30% Cu), Vanadium powder added to matrix alloy powder with percent (0,1,2,3)% respectively then these powders mixed to obtain homogeneous powder, then the powders compacted isostatic cold pressure at (8ton). The sintering process done at (900° C) for one hour under argon gas.

The X-ray diffractions test indicated that all alloys have Face center Cubic (F.C.C), And D alloy has best properties which include increase of phases intensity and decrease of grain size according to Debye-Scherrer equation.

The Atomic Force Microscope (AFM) also shows better properties with increase vanadium concentration. Where increased softness of surface, homogeneity surface and decrease in grain size with increase Vanadium concentration.

1. Introduction

Nickel-base alloys are used in a wide range of applications and environments. This makes the alloy one of the most important classes of engineering materials. The Ni-base alloys are selected for applications in need of high and ambient temperatures, specific electrical properties, corrosion resistance at high temperatures and in aqueous environments [1].

Many of these alloys are metallurgical-related to austenitic stainless steels but are much more highly-alloyed. For Nickel-based alloys, besides the main element Ni, other elements, such as Cu, Cr, Mo, Mn are added to optimize the performance of the alloy according to different service environments [2].

Nickel and copper, neighbors in the Periodic Table, share the same atomic structure (F.C.C) . Moreover, this structure is retained in all mixtures of the two elements, at all temperatures in the solid range. This is basis for several commercially important nickel-copper and copper-nickel alloys [3].

The following are some literature review on the properties for some Nickel and Copper alloys prepared by powder technology :

- Study has been done by (Hayes) et al. in the year (2006) on the influence of chromium and molybdenum on the corrosion of nickel-based alloys. This study examines the complementary roles of chromium and molybdenum in nickel alloy passivation [4].
- The researcher (Andresen) et al. in the year (2008) stress corrosion cracking of stainless steels and nickel alloys in high-temperature water. Reveal that all grades and conditions are susceptible to stress corrosion cracking in high-temperature water [5].
- Study has been done by (Selembo) et al. in the year (2009) on the use of steel and nickel alloys as low-cost cathodes in microbial electrolysis cells. The results demonstrate that non-precious metal cathodes can be used in microbial electrolysis cells to achieve hydrogen gas production rates better than those obtained with cathode platinum [6].
- The researcher (Pal) et al. in the year (2011) preparation (Ni-Cu) and difference percents by nano grain size. The samples sintering at range (300-800) ° C. It is shown that whenever the sintering temperature been increased the grain size would be decreased [7].

2. Experimental

2.1 Preparation of alloys :

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The nickel alloy has been formed from high purity materials ≥ 99.96% of Ni, Cu, and Vanadium. The grain sizes of metallic powder are shown in the table (1). These powders have been mixed for the sake of preparation (Ni-Cu) and adding vanadium at these percentage (0,1,2,3)%. Then the powders compacted in cold pressure at (8 Ton) in a mold of steel for cylindrical samples (High=1.5 cm , Radius=0.4 cm). Then thermal treatment of samples by German furnace of type: (Renfert) model (Magma no.2300-0000) at temperature (900) °C for an hour with heating range (5 °C/min) with slow cooling . After that has been done X-Ray diffraction and Atomic Force Microscope tests. While table (2) shows the chemical composition of the prepared alloys.

Table 1: Purity and grain size for metallic powder.

Powder	Grain Size (nm)	Purity %	Origin
Nickel powder	85	99.98	Merck co.-GERMANY
Copper powder	95	99.99	Buchs Fluka AG co.-GERMANY
Vanadium powder	80	99.96	Buchs Fluka AG co.-GERMANY

Table 2 : Chemical composition of the experimentally studied alloys.

Alloy No.	Ni %	Cu %	V %
Alloy A	70	30	0
Alloy B	69.2	29.8	1
Alloy C	68.4	29.6	2
Alloy D	67.7	29.3	3

2.2 Examinations working

2.2.1 X-Ray diffraction Examination :

Crystal structure has been studied of prepared alloys by x-ray diffraction type (XRD-6000) and angle (2θ=30-70°). Diffraction phenomena occur according to Bragg's law [8] :

$2d \sin\theta = n\lambda$ -----(1)

Where (d) is the distance between two parallel levels , (θ) is the diffraction angle and (λ) is the wavelength for X- Ray.

The grain size was calculated for all peaks by Full Width at Half Maximum (FWHM) according Debye – Sherrer equation [9] :

$T = 0.9\,\lambda / \beta \cos\theta_B$ -----(2)

Where (T) is the grain size , (β) is the full width at half maximum and (θ_B) is the bragg diffraction angle.

A make sure that all Miller indices and phases that appeared at diffraction angle with American Standard for Testing Materials (ASTM) by computer program (International Center for Diffraction ICDD 1997) .

2.2.2 Atomic Force Microscope Examination :

Has been achieved with it to know roughness average, root mean square, grain size and percentage of grains distribution [10] .

The picture analyze has been done by computer program (SPM Software) to give information of picture [11] .

3. Results and discussion

3.1 Results and discussion of X-Ray diffraction Examination :

It is clear from the figures (1), (2), (3) and (4) that the diffraction peaks of the samples are prepared at the sintering temperature (900° C) for an hour. These figures indicate clearly that all of the samples have the same atomic structure, which is face-centered cubic (F.C.C). Also, Miller indices (hkl) on the diffraction peaks are either odd, or even, and this point is in lockstep with the studies [7, 12]. It's also observed that the appearance of the phases (Cu3.8Ni) and (Ni) in figure (1) with increase of vanadium concentration, the intensity for phase (Cu3.8Ni) increased due to crystal growth and the crystal structure homogeneity. A secondary phase of (Ni3V) has been observed by adding (1 %) of vanadium, and its intensity increases due to the increase in vanadium's concentration. This phase is the phase formed between nickel and grain surface of vanadium. It's observed from table (3), the grain size decrease with increasing vanadium concentration.

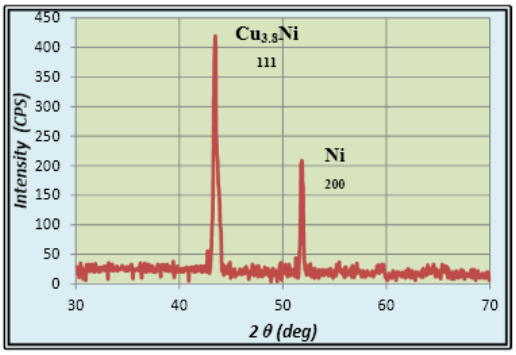

Fig. 1: Results of X-Ray diffraction for alloy (A)

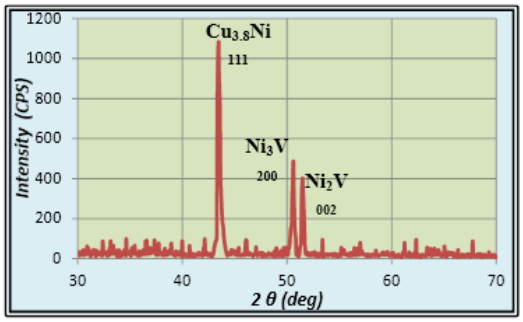

Fig. 2: Results of X-Ray diffraction for alloy (B)

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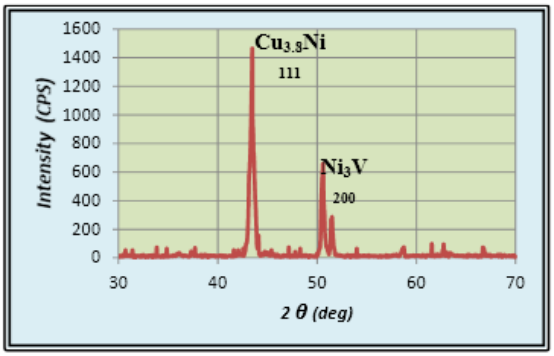

Fig. 3: Results of X-Ray diffraction for alloy (C)

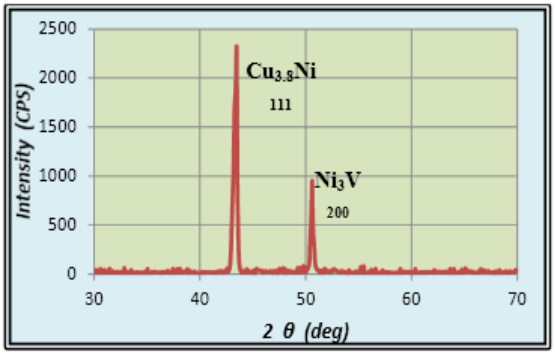

Fig. 4: Results of X-Ray diffraction for alloy (D)

Table 3: Analytic results of X-Ray diffraction for samples with difference of vanadium rate

	Alloy A	**Alloy B**	**Alloy C**	**Alloy D**
Structure	F.C.C	F.C.C	F.C.C	F.C.C
Lattice Constant (Å)	3.58	3.58	3.58	3.58
Phases	$Cu_{3.8}Ni$ (2θ=43.47)	$Cu_{3.8}Ni$ (2θ=43.47)	$Cu_{3.8}Ni$ (2θ=43.47)	$Cu_{3.8}Ni$ (2θ=43.47)
Grain size (nm)	81.27	74.78	68.45	61.93

3.2 Results and discussion of Atomic Force Microscope Examination:

Atomic Force Microscope is studied topographic for alloy samples as in the figures (5), (6), (7), (8) and table (4). Section (a) for every figure shows surface roughness with two dimension (2D). From these picture the value of roughness average decreased. This indicates surface smoothness with increase of vanadium ratio, i.e. grain size decrease. Also shown decrease in the value of (Root Mean Square). That value indicate average of surface roughness whenever it's increasing of value root mean square that mean increase surface roughness average for sample and vice versa.

The section (b) for every figure shows microscope picture (AFM) with three dimension (3D) where as observe the total surface topographic on sample surface. From this picture (3D) we observers that value of surface thickness decreased with increase of vanadium ratio, This value represent thickness of surface roughness. That is represented ratio to higher peaks of crystal grains.

The section (c) for every figure shows analysis of (AFM). Where shows graph of grain distribution groups. The graph shows how size distribution of grain groups on the surface of the sample with specific percentage.

We can observe from these four figures below that the alloy (D) has the best properties in terms of the grain sizes' reduction and the roughness since the increase in the vanadium's concentration leads to arrange the atoms homogenously, also to strengthen the connection between the atoms of both, nickel and copper [13].

Table (4) show analytic results of (AFM) test for samples with difference of vanadium concentration.

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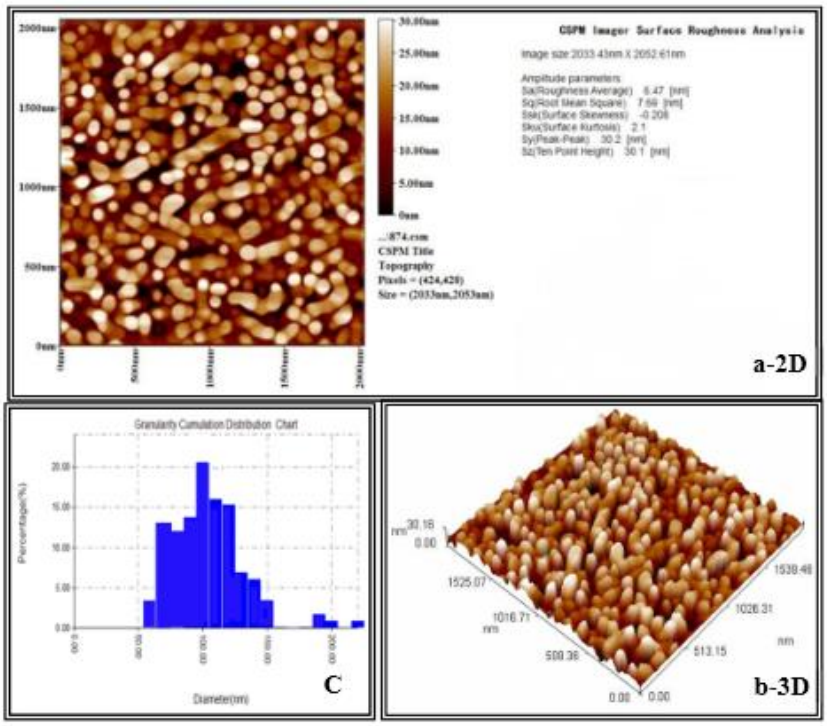

Fig. 5: Measure of (AFM) for sample of alloy (A)
(a) Two dimensions picture . (b) Three dimensions picture . (c) Grain size distribution

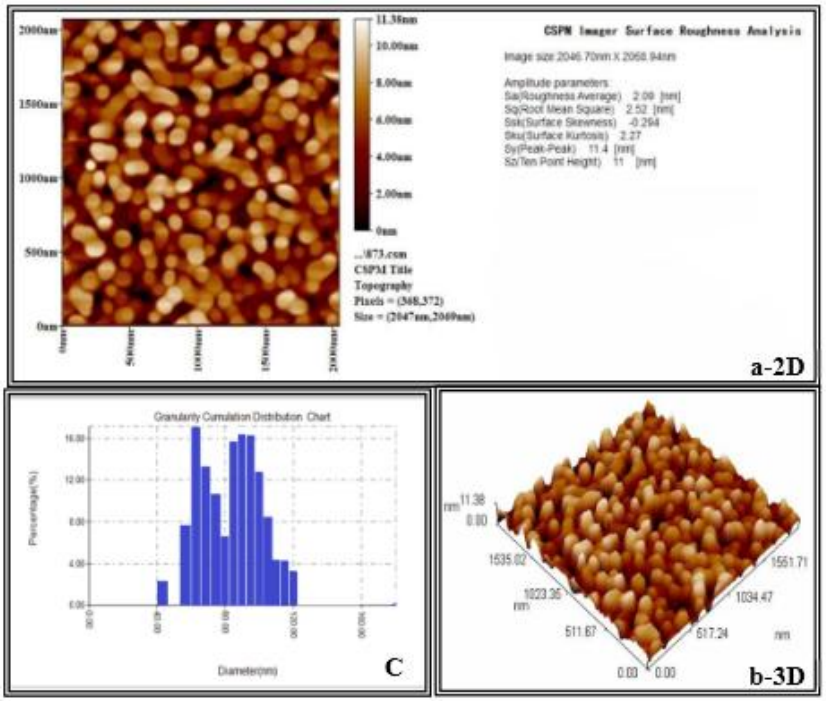

Fig. 6: Measure of (AFM) for sample of alloy (B)
(a) Two dimensions picture. (b) Three dimensions picture . (c) Grain size distribution

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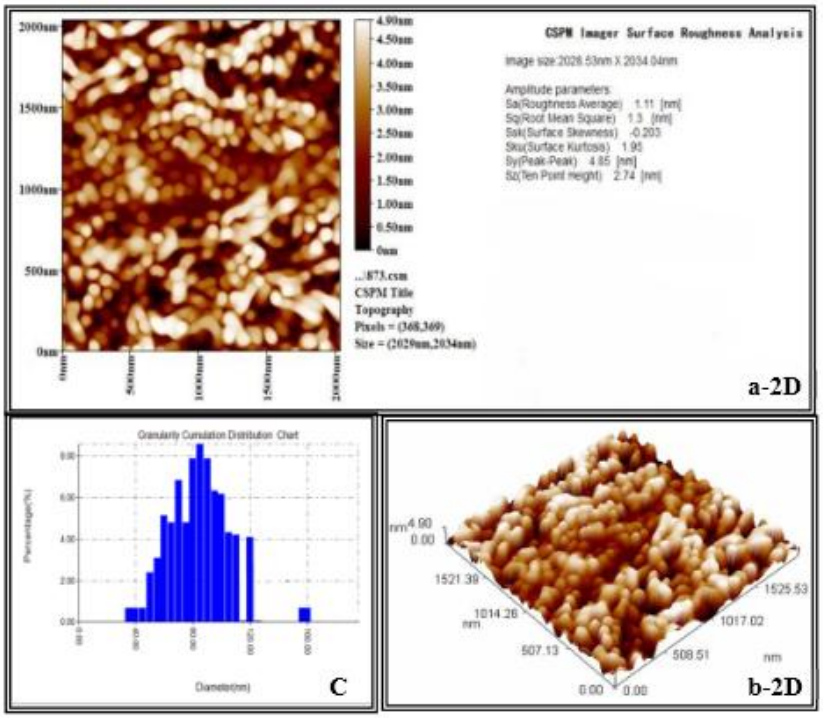

Fig. 7: Measure of (AFM) for sample of alloy (C)
(a) Two dimensions picture . (b) Three dimensions picture . (c) Grain size distribution

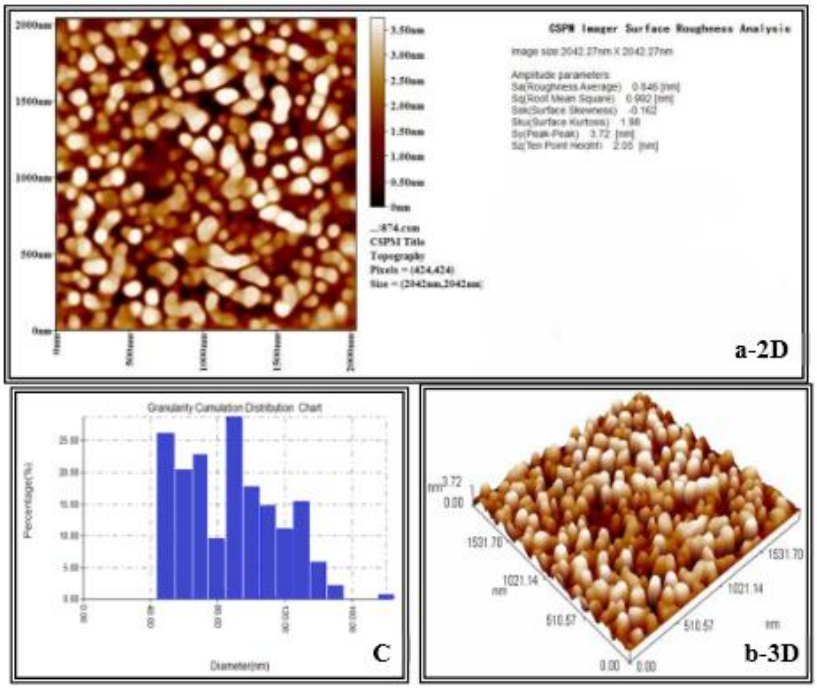

Fig. 8: Measure of (AFM) for sample of alloy (D)
(a) Two dimensions picture . (b) Three dimensions picture . (c) Grain size distribution

Table. 4: Results of (AFM) test for samples with difference of vanadium rate .

	Alloy A	Alloy B	Alloy C	Alloy D
Roughness Average (nm)	6.47	2.09	1.11	0.846
Root Mean Square (nm)	7.69	2.52	1.3	0.992
Surface Thickness (nm)	30.16	11.38	4.9	3.72
Grain size (nm)	93.86	88.15	82.15	70.78

With comparison to the table (3) we notice that the value of average of grain size measured by (XRD) would be lees than from average of grain size measured by (AFM) due to that the (XRD) measure grain size inside the sample, while the (AFM) measure grain size that on sample surface . And the grains on the sample surface would be grater the grains in the interior region

4. Conclusions: From (XRD) test_it's shown that crystal structure for samples is (F.C.C) and increase vanadium's percent lead to decrease in grain size . Observed increase in intensity of diffraction peaks at every addition. That refers to crystal growth and crystal structure homogeneity. While from (AFM) test_it's shown develop of samples surfaces through smoothness degree and homogeneity with increase vanadium's percent. Observed also decrease in grain size with increase vanadium concentration.

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تأثير اضافة الفناديوم على الخواص التركيبية لسبيكة (Ni-Cu) النانوية الجسيمات

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الملخص

يهدف هذا البحث الى تحضير سبيكة (Ni-Cu) بطريقة تكنولوجيا المساحيق لما تتمتع هذه الطريقة من اهمية تكنولوجية وصناعية . فقد تم اخذ مسحوق كل من العنصرين ومزجت بنسب *(70% Ni – 30% Cu)*، بعد ذلك تم اضافة مسحوق الفناديوم النانوي بنسب *(0, 1, 2, 3)%* على التوالي. ثم تم الكبس على البارد عند *(8 Ton)* وتم اجراء عملية التلبيد عند *(900)°C* ولمدة ساعة واحدة وباستخدام غاز الاركون .

وجد من فحص الاشعة السينية ان جميع السبائك تمتلك تركيب بلوري *(F.C.C)* وان السبيكة *(D)* كانت افضل السبائك من حيث زيادة في شدة الاطوار ونقصان الحجم الحبيبي بالاستناد الى معادلة ديباي–شيرر.

اما فحص مجهر القوة الذرية فقد بين كذلك تحسن واضح في الخواص مع زيادة نسبة الفناديوم ، حيث زادت كل من نعومة السطح وتجانسه مع نقصان في الحجم الحبيبي وذلك بزيادة نسبة الفناديوم.

الكلمات المفتاحية: فناديوم ، حيود الاشعة السينية ، جهر القوة الذرية ، سبيكة *(Ni-Cu)*، تكنولوجيا المساحيق.