The Structural of the Ternary Alloy Fe-Ni-Cr System

I. K. Jassim
Center of Materials Science, Ministry of Science and Technology

Abstract

Structural analysis by X – ray diffraction is used to monitor the phases for each sample in the ternary system Fe0.65 Ni0.35 – x Crx.

The XRD results show that all the sample with X = 0.00, 0.10, 0.20 and 0.30 have γ - Fcc phase, with a lattice parameter increasing from 3.578 A to 3.604 °A with increasing Cr.

Introduction

The Fe – Ni system displays many interesting properties and no doubt most of the attention has been focused on the Invar behavior of this alloy which has a bout 35 at %Ni [1,2]. Further, the phase which is responsible for the observed anomalies in the physical properties of this alloy system in the γ- Fcc phase which evolves at a bout 35 at %Ni. X-ray diffraction results [3] show that the alloy system Fe1-x Nix ($0.35 \leq x \leq 0.86$) prepared by electrodeposition method.In this study a structural trarsformation of the γ- Fcc phase to the α - Bcc phase was observed. The alloys with x < 0.44) displayed a single phase of α – Bcc whereas those with (x > 0.53) displayed (a single γ – Fcc phase. A mixture of α –Bcc and γ – Fcc phases was observed in the region of concentration ($0.44 \leq X \leq 0.53$). Baldokhim *et al.*, [4] reported the results of XRD studies and the phase composition of the mechanically alloyed Fe1-x Nix ($0.10 \leq x \leq 0.90$). As milled samples with 10 and 20at % Ni contain single Bcc phase, while those with 22, 26, 28, at %Ni consist of two phases (Bcc and Fcc), and alloy with more Ni content a single Fcc phase. Annealing the alloys at 350 °c did not lead to any change in the crystal structure. However, anncaling the alloy at 650 °c gave the following results:

Samples with 10 and 20 at % Ni were found to be a mixture of Bcc and Fcc phases and all other alloys with higher Ni concentrations have a single Fcc phase.

X-ray diffraction measurements were performed on Fe1-x Nix (x = 0.20, 0.35 and 0.50) prepared both by low and high energy ball milling processes [3]. The diffraction patterns for the sample with x=0.20 ball milled for different times at low energy, show that the characteristic Ni lines gradually shrink down with increasing milling time and α – Bcc FeNi phase appears after milling for 200 hr, and the value of the lattice parameter increased from a=2.866°A for 25 hr to a=2.870°A for 400 hr milling. Meanwhile, high energy ball milling leads to the appearance of the α –Fcc Fe Ni phase after 20h of milling, with a lattice parameter similar to that observed in the low energy process. In the case of the sample with x = 0.35, high energy milling produces the γ- Fcc Fe Ni phase after 36 hr of milling finally the sample with x = 0.50 at both low and high ergegy milling processes, result in γ-Fcc formation after 200hr and 22 hr with lattice parameters of 3.588 °A and 3.592 °A, respectively

In the present work, the other 3rd elements such as Cr have been introduced to the Fe – Ni system. The effect of this substiution on the structural properties have been investigated. X –ray diffraction is used to monitor the structural properties of these alloy as Cr concentration is increased.

Experimental Techniques

The alloy series of $Fe_{0.65}$ $Ni_{0.35-x}$ Cr_x with x=0.0, 0.10, 0.20, and 0.30 were prepared by arc furnace, melting the proper amount of high purity (at least 99.9%) Fe, Ni and Cr under argon atmosphere. After the intial melt, the alloy were turned over and remelted to ensure good mixing. Care was taken to minimize any loss by vaporiztion. In each case the losses in weight ranged less than 1.5% from 10 or 15 gram ingots. Specimens for X-ray studies were cut from different parts of each ingot and then crushed to fine powders in a steel mortar. Each alloy was sealed in quartz tube under vacuum and annealed for 24 hours at 800 °c. The samples were slow cooled for 72 hours using a temperature control device.

The alloy samples for the X-ray diffraction were prepared by sprinkling the alloy powders on a piece of tape that has no structural peaks. The samples were circular in shape with a diameter of 2.5 cm. The structure of the alloy was investigated by X ray diffraction using a Phillips PW1729 diffract meter with Co – K α radiation (≅ 1.7902 5°A). The diffraction patterns were recorded over the angular range ($40° < 2\theta < 110°$).

Results and Discussion

The recorded diffraction patterns of the alloy systems $Fe_{0.65}$ $Ni_{0.35-x}$ Cr_x with x =0.00, 0.10, 0.20, and 0.30, are shown in figure 1. The results of the structural analysis are listed in table 1. The structural analyses show that the patterns for all samples are consistent with a single Fcc type phase, with a lattice parameter increasing from 3.578 °A

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up to 3.604 °A with increasing the rate of Cr. Comparing the lattice parameter for the Fcc phase with that of pure Ni (a=3.52 °A), we find about 2% expansion in the Fcc cell. This is because the atomic radius for Fe (r_{Fe} = 1.241 °A) is small than that for Ni (r_{Ni} = 1.245 °A) [6,7]. Substituting Ni by Cr results in an additional increase in the lattice parameter since the atomic radius for Cr (r_{Cr} = 1.252 °A) is large than that for both Fe and Ni. It is worth noting that we see lattice expansion in the Fcc phase. Baldokim *et al.*, [4] found that the Fcc phase could be due to the fact that this phase has a close – packed structure, and in this case the size of the atoms is expected to play an important role in the lattice parameter [5].

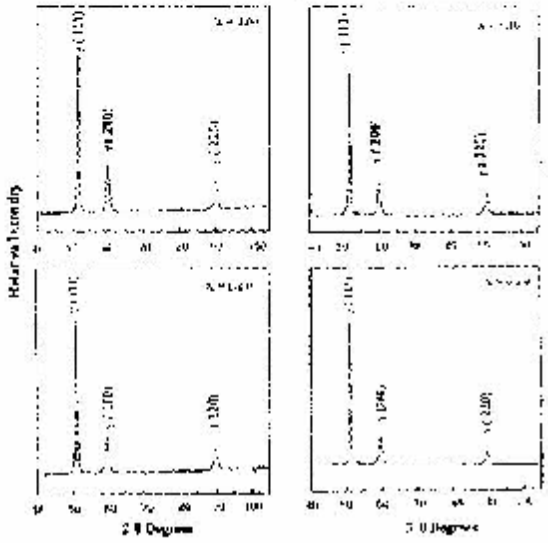

Figure (1): X-ray diffraction patterns for $Fe_{0.65}$ $Ni_{0.35-x}$ Cr_x Samples

Table 1: The angular position (2θ) of the diffraction lines, the corresponding d–spacing, Mille indices (hkl), the sum of squares of miller indices N and the lattice parameter (a) for each sample of the system Fe0.65 Ni 0.35 – x Crx.

Sample	2°θ	d (°A)	N	(hkl)	a(°A)	Type
$Fe_{0.65}$	51.08	2.0823	3	111	3.578 ±	Fcc
$Ni_{0.35}$	59.68	1.8034	4	200	0.01	
	89.92	1.2721	8	220		
$Fe_{0.65}$	51.12	2.0823	3	111	3.590 ±	Fcc
$Ni_{0.25}$	59.76	1.8022	4	200	0.005	
$Cr_{0.10}$	89.88	1.2712	8	220		
$Fe_{0.65}$	51.40	2.0841	3	111	3.602 ±	Fcc
$Ni_{0.15}$	60.04	1.7852	4	200	0.005	
$Cr_{0.2}$	90.04	1.2650	8	220		
$Fe_{0.65}$	50.92	2.0747	3	111	3.602 ±	Fcc
$Ni_{0.5}$	59.56	1.7968	4	200	0.005	
$Cr_{0.3}$	89.52	1.2672	8	220		

To continue work with this series, it is interesting to obtain magnetic and thermal expansion information on he Invar phase which is still need to focuse in it, since Fe,Ni, are Feromagnetic 3rd transition metals but Cr has a magnetic moment aligned antiferromagnetically.

References

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الخلاصة

تم دراسة التركيب البلوري باستخدام حيود الأشعة السينية للنظام الثلاثي السبيكة $Fe_{0.65}Ni_{0.35-x}Cr_x$ عند ضب بإضافة Cr مختلفة ($X = 0.00, 0.10, 0.20, 0.30$) أكدت النتائج التجريبية بان جميع حيثات النظام تحتوي على الطور المكعب من نوع Fcc.