Promote Scientific Research is Our Way to Serve the Community

Structural and Magnetic Properties of the ($Pd_{2-x}Ag_xMnIn$) alloys

Salih Y. Darweesh[1] , Ismael K. Jassim[2] , Amer SH. Mahmood[2]
[1] *Physics Department , College of Education Tuzkormato , Tikrit University , Tikrit , Iraq*
[2] *Physics Department , College of Education for Pure Sciences , Tikrit University , Tikrit , Iraq*

ARTICLE INFO.
Keywords: Neutron diffraction, Heusler alloys, powder metallurgy, magnetization, material engineering.
Name: Salih Y. Darweesh
E-mail: Salih.youns@gmail.com
Tel:

ABSTRACT

The series of the Heusler alloys type ($Pd_{2-x}Ag_xMnIn$) with($0 \le x \le 2$) have been investigated. X-ray, Neutron diffraction and magnetic susceptibility have been measured. The lattice parameters were determined from Nelson Riley extrapolation. In these series several of magnetic structures are observed such as antiferromagnetic Fcc type and ferromagnetic. The Neel and Curie temperatures(θ_N, θ_F) with the effective magnetic moment(μ_B) are determined for all samples.

Introduction

Heusler alloy have been of interest, which are ternary alloys are of the from X_2YZ, which Y and X are usually transitions metals such as (Ni, Pd, Fe and Co) and Z is a main group elements with S, P valence electrons (Al, Sn, In and Ge)[1-3]. The majority of these alloys for an L_2, structure with a FCC- face centered cubic lattice (Fcc)[4,5]. Further investigation indicated that the magnetic properties of these alloys are in relation with their L_2, crystal structure and the ordering of the Y atoms on an FCC sub lattice. Many of the Heusler alloys of X_2YZ compositions are good attractive attention candidate for devices in magneto electronic[6]. Heusler alloy composed a transition elements like Ni, Co, Fe are interesting for thermal, structural and magnetic characterization [7,8]. This alloys have received increasing attention which is call as smart materials due to the effective of magnetic shape memory alloys (MSMA)[9,10]. As example, Pd_2-xMnIn composition have recently been studied as an attractive to the magnetic change in a moderate magnetic field, makes these materials promising candidates for several applications as sensors or magnetic actuators [1, 11]. Some shape memory allots change from plastic deformation to the origin elastic shape when heated [12]. It includes also some change in the magnetic phase transformation from ferromagnetic structure to the antiferromagnetic structure, which is strong defenders behavior in this alloys[12,13]. As example, the (Pd_{2-x} Ag_xMnIn) compositions have been chosen. No much references were found in this series. We focused in this study to investigate structured and magnetic properties by using several techniques.

Experimental Techniques

All the Heusler alloys type were prepared by Arc melting the appropriate proportion of pure elements. After the initial melt, the alloys were turned over and remitted to ensure good mixing. Care was taken to minimize any loss by vaporization. The resulting ingot was crushed into a fine powder using a steel pestle and mater. These powders were used for X-ray, and magnetic susceptibility studies all samples were slow cooled after being sealed in a quartz tube under vacuum and annealed for 12 hours at 800℃. The magnetic properties for all samples were investing a ted using Cahn electro balance susceptibility and reciprocal electro balance. Susceptibility verse temperature curves were plotted for paramagnetic and antiferromagnetic Heusler alloys. Neel paramagnetic θ_N were measured and paramagnetic curie temperatures θ_p were extrapolated. From the slope of the reciprocal susceptibility the Bohr magneton μ_B numbers were obtained. The structure of the Heusler alloys were initially investigated using x-ray diffraction techniques at room temperature with a Philips diffract meter abroad focus by using radiation (Cu(Kα)) tube was used. As mall error in the measurement of the Bragg angle θ produces an error in the calculated value of the lattice constant ($a_\circ$). To obtain the lattice parameter more accurately, the Nelson-Riley extrapolation is used[14]. This method use a plot of the lattice constant ($a_\circ$). against the functions 1/2 ($\cos^2\theta/\sin\theta+\cos^2\theta$) the line is extrapolated back at θ=90 to get the exact value of ($a_\circ$). the magnetic susceptibility of the alloys were measured in five applied filed over temperature range

77K to 300K. Cushn Faradey balance measured the force Fz excited on a small specimen of mass m, by a magnetic gradient (∂H/∂Z). The force is given by[14]:
$F_z=m\chi H(\partial H/\partial Z)$……(1)
Where χ is the susceptibility. This method is called (Faradey method). Before measuring the magnetic versus applied filed, sample of Ni as referees was used.

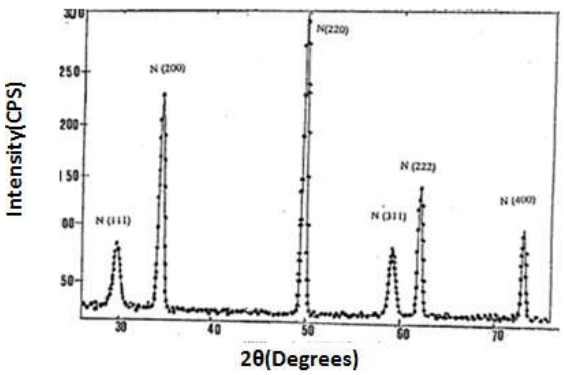
Results and discussion

No references were found to any previous investigation in the $Pd_{2-x}Ag_xMnIn$, were $0\leq X\leq 2$ changes from zero to 2 by increasing 0.2 for every sample. The lattice parameters and electron concentrations are shown in table(1). This work presented was concerned with establishing the structure, magnetic properties of the intermetallic composition of $Pd_{2-x}Ag_xMnIn$. By mixing group IB electrons by $Ag^{47}(4d^{10}\ 5s)$with a group VIIt element $Pd^{46}(4d^{10})$ gives rise to a gradual change of the number of electrons (n_c from 4 to 5 to 6). Thus, it was possible to determine the relationship between the continuous change in n_c and the change the different types of structures. At room temperature, the symmetry of all alloys are cubic type FCC structure as shown in figure(1). Variation of the lattice parameters(a) at room temperature as a function of n_c is shown in figure(2). It is noted that the lattice parameters increased slightly in proportion to n_c with a gradient of dal n_c 0.174 Å [13,14]. X-ray powder diffraction patterns were taken for all samples. The majority of alloys are order in the face structure. The results show that nuclear intensities peaks are odd or even like(111)(200)(220)(222)(311)…etc super lattice indicate that the alloys were highly (FCC) structure as shown in figure(1). The reciprocal susceptibility($1/\chi$) versus temperature curves are shown in figure(3). The paramagnetic(θ_p) and ferromagnetic curie temperature (θ_F) and Neel temperature (θ_N) for the series are and shown in table(1). It can be seen that there is a very slight increase in (θ_p) with increasing n_c, at $n_c \geq 4.8$, ferromagnetic ordering is observed with increasing (n_c). The results also show that the Farady balance technique is appropriate for such materials. The effective magnetic moment per atom(P_{eff}) versus composite x also in table(1). (P_{eff}) changes slightly with increasing n_c but generally takes a rang value of 4.4 μ_B ±0.2.

This is no evidence in all the alloys investigated through on this work that the magnetic moment reside on any atom other the Mn. This results are identical with Brown…etc.[2]2000, Jassim et al[5] 1992, using polarized neutron techniques, have shown that the magnetic moment in Pd_2MnSn are well localized on the Mn atoms, with no observable moment on the Pd sites.

Table(1) structure and magnetic properties of the alloys $Pd_{2-x}Ag_xMnIn$.

Alloy	a_o±0.003 (A°)	$_p$(k)θ ±2	$_N$ or θ_Fθ ±3	$P_{eff}(\mu_B)$ (1/X,T)	structure	Nc c/cheng. form
Pd_2MnIn	6.373	52	141	4.9	FCC	4
$Pd_{1.8}Ag_{0.2}MnIn$	6.397	71	168	4.5	FCC	4.2
$Pd_{1.6}Ag_{0.4}MnIn$	6.410	106	174	4.48	FCC	4.4
$Pd_{1.4}Ag_{0.6}MnIn$	6.440	123	176	4.31	FCC	4.6
$Pd_{1.2}Ag_{0.8}MnIn$	6.470	129	148	4.24	FCC	4.8
$Pd_{0.8}Ag_{1.2}MnIn$	6.552	136	151	4.27	FCC	5.2
$Pd_{0.6}Ag_{1.4}MnIn$	6.576	139	146	4.48	FCC	5.4
$Pd_{0.4}Ag_{1.6}MnIn$	6.647	137	140	4.51	FCC	5.6



Figure(1): X-ray diffraction at RT showing the reflections from the nuclear (FCC) peaks.

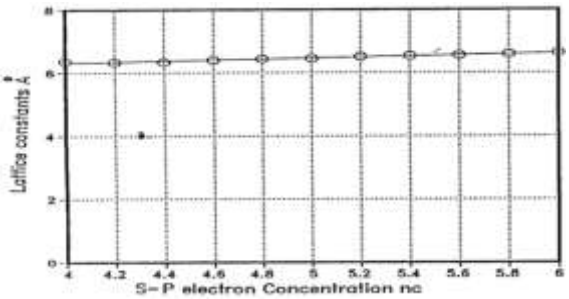


Fig.(2): Lattice Constants Å versus electron concentration n_c at room temperature for $Pd_{2-x}Ag_xMnIn$.

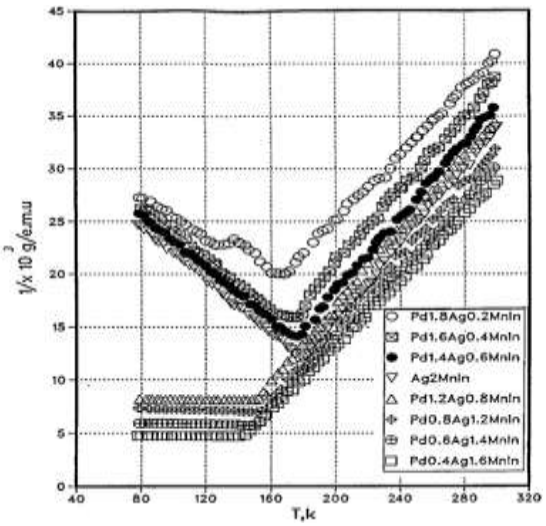


Fig.(3): The reciprocal Susceptibility versus temperature curve $Pd_{2-x}Ag_xMnIn$ alloys.

Conclusion

The interment metallic compound formed at the compositions $Pd_{2-x}Ag_xMnIn$ with $0 \leq X \leq 2$ have been investigated. X-ray, neutron diffraction and Faraday balance provides useful information in the analysis of the structural and magnetic properties. The series are highly order in the face cubic center (FCC) structural. Manganess the element common to all the alloys, carries in every case a large magnetic moment ≈4.3 μ_B. paramagnetic and ferromagnetic curie temperatures θ_p , θ_F and Neel temperatures θ_N for all samples are calculated from the reciprocal susceptibility curves.

Acknowledgements: The authors are thankful to University of Al-Yrmok Jordon for support doing X-ray diffraction and magnetic test by using Faraday balance.

References

[1] Webster, P. J. (1968). The magnetic and chemical structures of the Heusler alloys ph. D. thesis, University of Sheffield.

[2] Brown, P. J. et al. (2008). Magnetic and atomic order in the potential half metallic ferromagnets Ru_2–xFexCrGe. Journal of Physics: *Condensed Matter*, **20(45)**: 455201.

[3] Nakajima, R.; Stöhr, J. and Idzerda, Y. U. (1999). Electron-yield saturation effects in L-edge x-ray magnetic circular dichroism spectra of Fe, Co, and Ni. *Physical Review B*, **59(9)**: 6421.

[4] Webster, P. J. (1971). Magnetic and chemical order in Heusler alloys containing cobalt and manganese. *Journal of Physics and Chemistry of Solids*, **32(6)**: 1221-1231.

[5] Jassim, I.K. (1992). Neutron imaging with fission and thermal neutrons at NECTAR at . Elsevier. *physics B:condensed matter*, **180:** 145-146.

[6] Webster, P.J. and Ramadan, M.R. (1980). Magnetic skyrmions as future information carriers. *Journal Magnetism and Magnetic Materials*, **20(271)**.

[7] Du, J.; Zheng, Q. and Zhang, D. (2007). *Journal of physics Applied*, **44:** 5523-5526.

[8] Balke, B. et al.(2007). Structural characterization of the Co_2 Fe Z (Z= Al, Si, Ga, and Ge) Heusler compounds by x-ray diffraction and extended x-ray absorption fine structure spectroscopy. *Applied physics letters*, **90(17)**: 172501.

[9] Joshi, S. J. (2008). Growth and Characterization of Iron-Managenese Mixed Tartrate Crystals and the Derivative Compounds ph. D. thesis, Saurashtra University.

[10] Agrawal, A., and Dube, R. K. (2018). Processing of Cu–Al–Ni Alloy by Spray Atomization and Deposition Process. *Transactions of the Indian Institute of Metals*, **71(10)**: 2541-2552.

[11] Abbass, M. K.; Al-Kubaisy, M. M., and Adnan, R. S. A. (2016). The effect of thermo-mechanical treatment on mechanical properties & microstructure for (Cu-Al-Ni) shape memory alloy. *Engineering and Technology Journal part(A) Engineering*, **34(13)**: 2518-2526.

[12] Zhang, T. et al. (2015). Sequencing of allotetraploid cotton (Gossypium hirsutum L. acc. TM-1) provides a resource for fiber improvement. *Nature biotechnology*, **33(5)**: 531.

[13] Brühwiler, D. et al. (2009). Nanochannels for supramolecular organization of luminescent guests. *Journal of materials chemistry*, **19(43)**: 8040-8067.

[14] Nelson, J. B., and Riley, D. P. (1945). An experimental investigation of extrapolation methods in the derivation of accurate unit-cell dimensions of crystals. *Proceedings of the Physical Society*, **57(3)**: 160.

الخصائص التركيبية و المغناطيسية لسبائك ($Pd_{2-x}Ag_xMnIn$)

صالح يونس درويش[1] ، اسماعيل خليل جاسم[2] ، عامر شاكر محمود[2]

[1]قسم الفيزياء ، كلية التربية طوزخورماتو ، جامعة تكريت ، تكريت ، العراق

[2]قسم الفيزياء ، كلية التربية للعلوم الصرفة ، جامعة تكريت ، تكريت ، العراق

الملخص

تم دراسة سلسلة سبائك الهايسلر نوع ($Pd_{2-x}Ag_xMnIn$) مع ($0\leq x\leq 2$) و تم قياس كل من حيود الاشعة السينية والنيترون والقابلية المغناطيسية لها. معالم الشبيكة تم تحديدها من خلال استقراء نيلسون–رايلي. من خلال هذه السلسلة لوحظ هنالك العديد من التراكيب المغناطيسية مثل الفيرومغناطيسية وضديد الفيرومغناطيسية نوعFCC. وكما تم تحديد درجتي حرارة نيل وكيوري (θ_N, θ_F) مع العزم المغناطيسي الفعال لجميع العينات.