Available online at www.elixirpublishers.com (Elixir International Journal)

Applied Chemistry

Elixir Appl. Chem. 46 (2012) 8587-8589

ISSN: 2229-712X

The Effect of Vertical and Horizontal Exposure of Beta-Radiation and Magnetic Field on Ni-Cr Alloy Properties

Farhan Lafta Rashid, Ahmed Hashim and Majeed Ali Habeeb
Ministry of Science and Technology, Baghdad-Iraq.

ARTICLE INFO

Article history:
Received: 15 April 2012;
Received in revised form:
15 May 2012;
Accepted: 28 May 2012;

Keywords
Ni-Cr alloy,
Magnetic field,
Radiation,
Alloy properties.

ABSTRACT
An experimental investigation of applying a magnetic field and a radiation source horizontally with the direction of alloy once and vertically in another, current range passing through alloy is (1-3) AMP. Alloy conductivity increase with magnetic field strength in the case of applying a magnetic field horizontally with the electrons movement direction once and vertically in another. Alloy electrical conductivity decreases with irradiation time when applying a magnetic field horizontally with the electrons movement direction once and vertically in another. Alloy conducutivity decreases with irradiation time by applying a magnetic field and a radiation source horizontally with the direction of alloy once and vertically in another. Magnetic field intensity increases with temperature when applying a magnetic field and a radiation source horizontally with the electrons direction in the alloy once and vertically in another.

Introduction

Alloying a metal is done by combining it with one or more other metals or non-metals that often enhances its properties. The physical properties, such as density, reactivity, Young's modulus, and electrical and thermal conductivity, of an alloy may not differ greatly from those of its elements, but engineering properties such as tensile strength [Adelbert ,1922] and shear strength may be substantially different from those of the constituent materials. This is sometimes due to the sizes of the atoms in the alloy, since larger atoms exert a compressive force on neighboring atoms, and smaller atoms exert a tensile force on their neighbors, helping the alloy resist deformation. Sometimes alloys may exhibit marked differences in behavior even when small amounts of one element occur. For example, impurities in semi-conducting ferromagnetic alloys lead to different properties, as first predicted by White, Hogan, Suhl, Tian Abrie and Nakamura.[Hogan -1992, Zhang -1985].

All of the various forms of an alloy containing only two constituents, like iron and carbon, is called a *binary system,* while all of the different alloy combinations possible with a ternary alloy, such as alloys of iron, carbon and chromium, and is called a ternary system [Michael, 2005].

When a molten metal is mixed with another substance, there are two different mechanisms that can cause an alloy to form, called atom exchange and the interstitial mechanism. The relative size of each atom in the mix plays a primary role in determining which mechanism will occur. When the atoms are relatively similar in size, the atom exchange method usually happens, where some of the atoms composing the metallic crystals are replaced with atoms of the other constituent. With the interstitial mechanism, one atom is usually much smaller than the other, and so cannot successfully replace an atom in the crystals of the base metal. The smaller atoms become trapped in the spaces between the atoms in the crystal matrix, called the interstices [Jon, 2006].

The magnetic properties of Fe-Ni-Cr alloys are very sensitive to the Fe-Cr nearest neighbors. The distribution of Cr atoms in as-rolled and annealed samples can be solved with spectroscopy. The magnetic hyperfine field of Fe atoms decreases with increasing Cr concentration and the orientations of moments are very sensitive to the distribution of Cr atoms [Ghafari, 2002].

Warnes [Warnes ,2003] studied The magnetic properties of ternary Fe-Cr-Ni alloys containing 17 wt% Ni and 18–24% Cr over a range of temperature from 4.2–35 K by both ac and dc techniques in fields from 5 Am^{-1} − 6 MA m^{-1}. At room temperature, the matrix of all the alloys was the paramagnetic fcc austenite phase (with 0.1 – 0.5 wt% δ ferrite) and on cooling all the alloys showed distinct peaks in ac susceptibility, though equivalent peaks in dc susceptibility were only observed at low fields in the alloy containing 18 wt.% Cr. An analysis of the magnetization /field/ temperature results showed that all the alloys were super paramagnetic at low temperature, due to the formation of ferromagnetic clusters in the disordered antiferromagnetic matrix, and that the chromium atoms make no measureable contribution to the magnetization of these clusters.

Kiran et al.[Kiran,2005] studied the magnetic properties in Ni-rich perm alloy (Ni=80%) material in which process conditions have been controlled under hydrogen annealing by varying holding time, cooling rate and annealing temperature.

Experimental Part

The material that used in this work is $Ni^{70\%}$-$Cr^{30\%}$ alloy wired as coil of 10cm length and three coils. The resistivity was measured using Keithly electrometer.

The electrical conductivity σ_V was calculated by:

$$\sigma_v = \frac{1}{\rho_v} = \frac{L}{RA} \quad \text{..........................(1)}$$

Where:
A = cross-sectional area (cm^2)
R = volume resistance (Ohm).
L = wire length (cm).

Tele:
E-mail addresses: ahmed_taay@yahoo.com

The source of radiation was Beta with activity of 4.5µCi, current range passing through alloy is (1-3) AMP.A digital thermometer was used as temperature measurement.

Results and Discussions

When a magnetic field applied vertically with the direction of alloy we note that the resistance be higher than in case of applying it horizontally, that is due to the magnetic field direction in line with the flow of free electrons, that's lead to reduce resistance .

when a radiation source and the magnetic field applied together vertically with the direction of electrons movement in the alloy, the temperature approximately satiable, while in the case of the horizontal its increased significantly , that's due to collisions between the beta particles and electrons in the alloy, which leads to increased resistance therefore increasing temperature.

It is noted from Figure (1) the electrical conductivity of (Ni-Cr) alloy increases with the magnetic field intensity, where it works as regulator of the charge carriers flow. In the case of horizontal position, where the magnetic field direction is towards the flow of charge carriers, the electrical conductivity increases more.

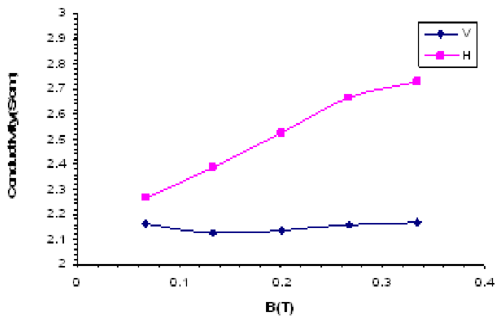

Figure (1) Alloy conductivity versus magnetic field strength in the case of applying magnetic field horizontally with the electrons movement direction once and vertically in another

Fig. (2) Shows that the electrical conductivity decreases with time, this is due to obstruction of the electrons in the alloy.

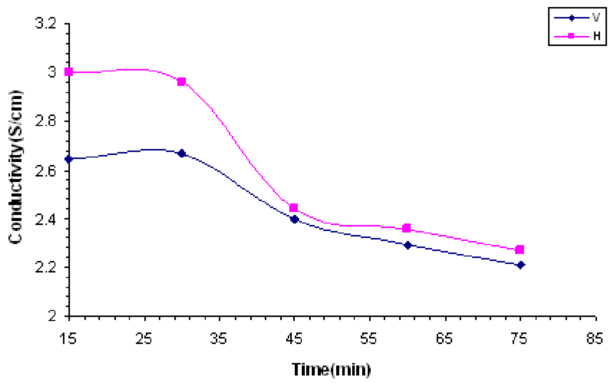

Figure (2)Alloy electrical conductivity versus irradiation time in the case of applying magnetic field horizontally with the electrons movement direction once and vertically in another

Fig. (3) Shows that the electrical conductivity is increase significantly which due to the beta particles that promoters the number of electrons in the alloy.

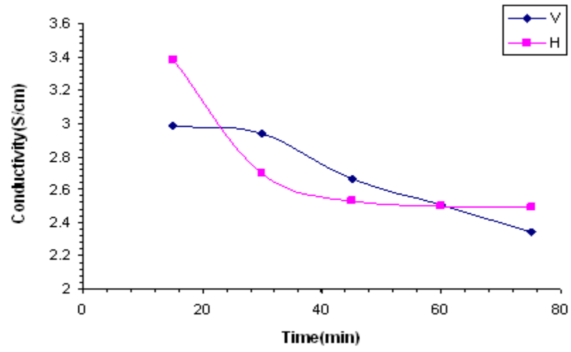

Figure (3) Alloy conductivity versus irradiation time by applying a magnetic field and a radiation source horizontally with the direction of alloy once and vertically in another

Figure (4) shows the relationship between temperature and magnetic field intensity. Current range passing through alloy is (1-3) AMP. Was toshed a magnetic field and radiation applied on the alloy each separately then they applied together

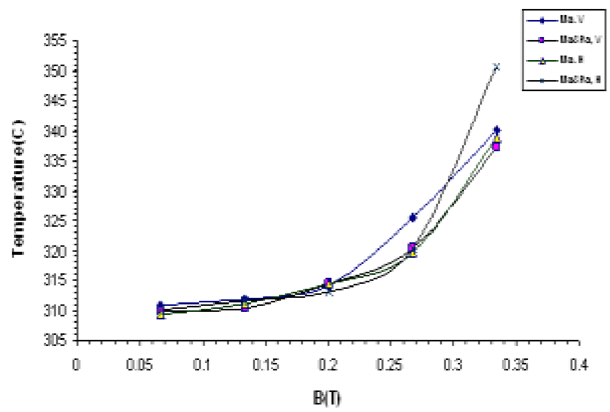

Figure (4) Magnetic field intensity versus temperature by applying a magnetic field and a radiation source horizontally with the electrons direction in the alloy once and vertically in another

Conclusions

From the present work, we can deduce the following conclusions:

1. Alloy conductivity increases with magnetic field strength in the case of applying a magnetic field horizontally with the electrons movement direction once and vertically in another.
2. Alloy electrical conductivity decreases with irradiation time in the case of applying a magnetic field horizontally with the electrons movement direction once and vertically in another.
3. Alloy conductivity decreases with irradiation time by applying a magnetic field and a radiation source horizontally with the direction of alloy once and vertically in another.
4. Magnetic field intensity increases with temperature by applying a magnetic field and a radiation source horizontally with the electrons direction in the alloy once and vertically in another.

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