

## Investigation the Annealing Temperature on Some Optical and Structural Properties of Alnico Films

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### Abstract

AlNiCo thin film where deposited on glass substrate by evaporation under  $10^{-6}$  torr presses to have 2  $\mu\text{m}$  thickness. The micro structure and optical properties were studied, after that the films were annealed under  $10^{-3}$  press torr for different times at 300 °C results show that the films structure was prevent after annealing also grain size change and increase in transmission with wavelength and annealing time.

### Introduction

The name of one of the most widely permanent magnet materials is derived from Aluminum, Nickel and Cobalt additions to the iron base metal, [1].

This alloys have attracted considerable work, both theoretical and experimental because of there magnetic properties, good corrosion resistance, heat treatment, high curie temperature and the highest saturation magnetization, [2]. These AlNiCo alloys can be divided into more than nine types, depending on a typical nominal composition and improvement in magnetic properties during a suitable method of preparing, [2,3]. These magnets are strong, and have low temperature coefficients. Alnico magnets are less expensive than rare-earth cobalt magnets but more expensive than most other materials. This alloy coatings have been widely used as recording head material in computer, [4].

### Experimental Work

Laboratory powders of AlNiCo magnetic materials with high purity more than 99.99% was evaporated on glass substrates (12×12 mm) with thickness 0.2 mm for ½ hour at  $10^{-6}$  torr pressure, also x-ray diffraction obtained from diffractometer type CoK $\alpha$  with  $\lambda = 0.179$  Å was used. The scanning speed was 3%. Samples was annealing in inert gas (Ni) at  $10^{-3}$  presser in 300°C for 10, 30 and 60 min.

After preparing the samples, optical transparent test was done. The optical transport test was from 350-900nm, surface morphology was done by using microscope

connected with digital camera with computer from type Olympus BH2.

The average particle size estimated from Scherrer formula which is connected to the XRD line width [5].

### Results and Discussion

The films have been prepared in this work having the X-ray diffraction pattern shows in Fig.(1), which approved that they have phase in cubic structure. It is clear from the figure that the diffraction peak at  $2\theta = 51.08$  exactly with cubic structure and grain size about = 8.9 nm which is agree with ASTM card and agree with [4].

Fig.(2) show the AlNiCo films deposited on glass substrate we can see that the films have smooth surface with some porosity in it with magnification 510X in (a) before annealing and in (b) after annealing for 5min, in (c) for ½ hour an increase in grain growth and re arrangement of dislocation so there was more smoothness in the surface and this has been increase as annealing time was increase and this agree with same literature for structure modeling to AlNiCo done by "basic" results [6], when we have annealed that films in nitrogen gas at 300°C for 1 hour we see that the surface of the films was more smooth and have very little porosity in it, this agree with [7], [8].

Optical properties was taken to the sample that annealed in nitrogen as we see before. Fig.(3) show the optical properties for AlNiCo in Fig.(3)-a- transmittance of AlNiCo films was shows the transmittance spectra exhibit low transparence from the visible region up to near IR region reach about 30% at  $\lambda = 900$  nm,

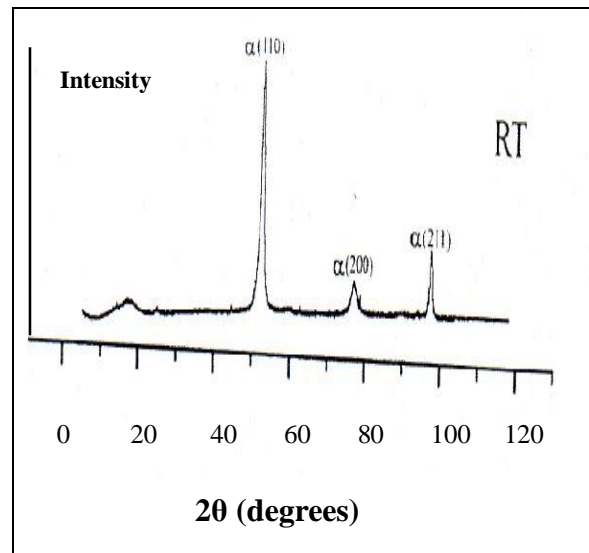
On the other hand absorption decrease with wave length in Fig.(3-b) allowed direct transition of AlNiCo films was show in Fig.(3-c) as show by the relation between  $(ahn)^2$  various  $hn$ , in which we can find that the optical energy gap was  $E_g=2.0364$  eV. In Fig.(3-d) forbidden direct transition for AlNiCo was done  $E_g = 1.92$  eV. This result agree with [9].

Fig.(3-e) show the relation between refractive index with wavelength, this figure indicated an exponential relation at the first part then it became gradually standed or constant.

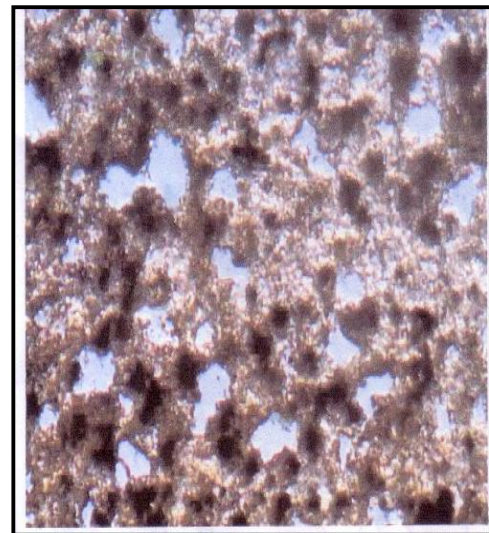
Fig.(3-f) show the relation between extinction coefficient  $K$  and wavelength  $\lambda$ , we show the extinction coefficient increase with increase wavelength and connected with absorption coefficient  $\alpha$  by using wavelength and absorption coefficient can be calculated as show in that figure, which is real part of dielectric constant depend on wavelength and increase with wavelength exponential, this show in Fig.(3-g) and the imaginary part of dielectric constant which is depend on wavelength and show this in Fig.(3-h). In semiconductor films  $\epsilon_1 > \epsilon_2$  while in our work magnetic AlNiCo film the valued  $\epsilon_1 \cong \epsilon_2$  and this result is logically because of being magnetic properties which is effect on the optical properties.

### Conclusion

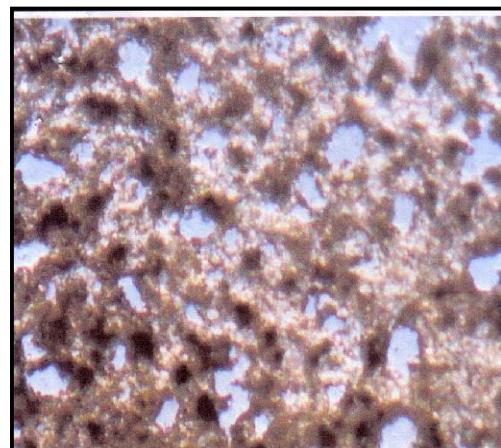
- 1- AlNiCo films can be grown on glass substrate with diffraction peak at  $2\theta=51.08$ .
- 2- There films were more smoothness in the surface and very little porosity in it when have annealed that films.
- 3- AlNiCo films have low transparency about 30% only and energy gap equal to 2.0364 eV for allowed transition and for forbidden direct transition was 1.92 eV.



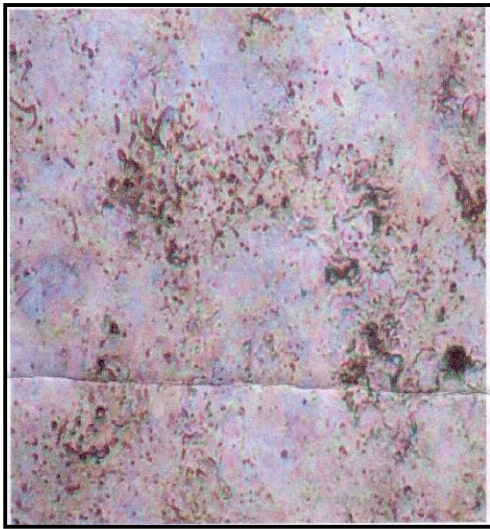
**Fig.(1) X-ray diffraction of Alnico-5 section.**



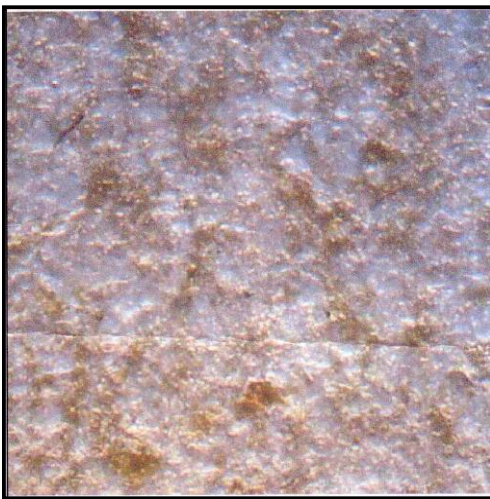
**Fig.(2-a) Surface morphology of AlNiCo thin film on glass substrate before annealing.**



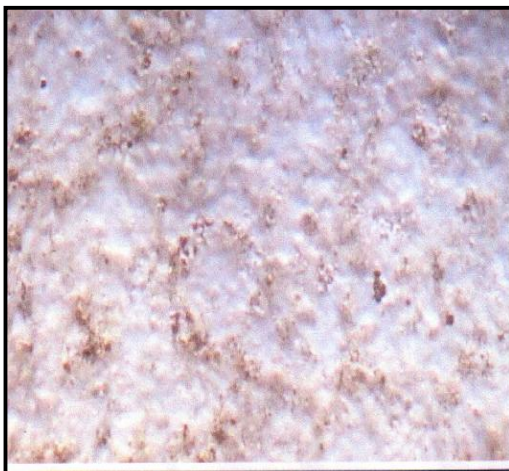
**Fig.(2-b) Surface morphology of AlNiCo thin film on glass substrate after annealing 5 min.**



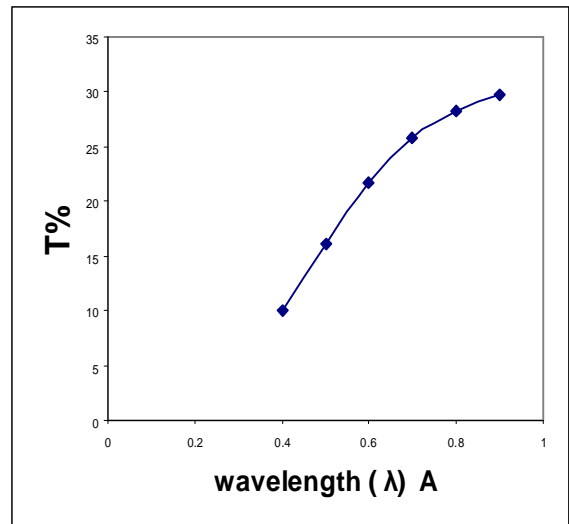
**Fig.(2-c)** Surface morphology of AlNiCo thin film on glass substrate after annealing 1/2 hour.



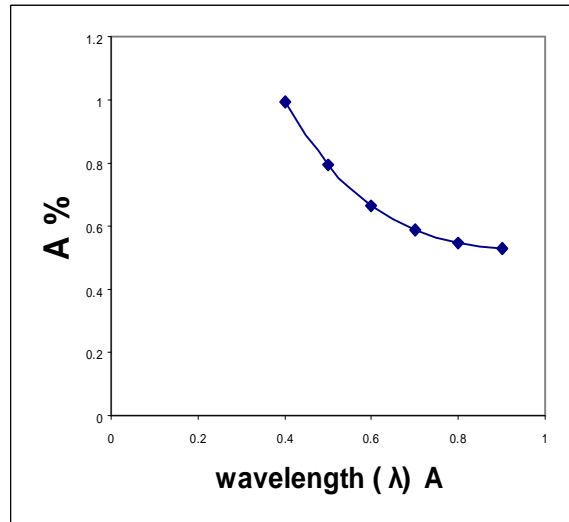
**Fig.(2-d)** Surface morphology of AlNiCo thin film on glass substrate after annealing 1 hour.



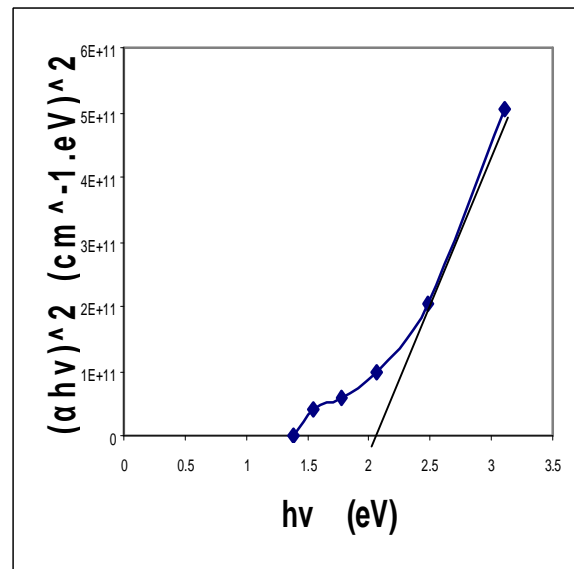
**Fig.(2-e)** Surface morphology of AlNiCo thin film on glass substrate after annealing in Nitrogen at 300°C for 1 hour.



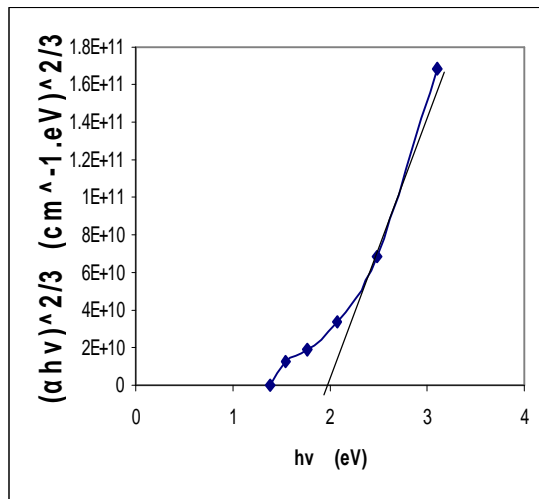
**Fig.(3-a)** Variation of transmittance with wavelength.



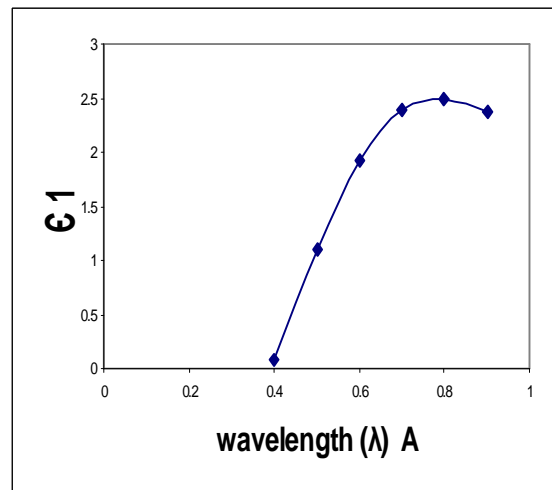
**Fig.(3-b)** Variation in absorption with wavelength.



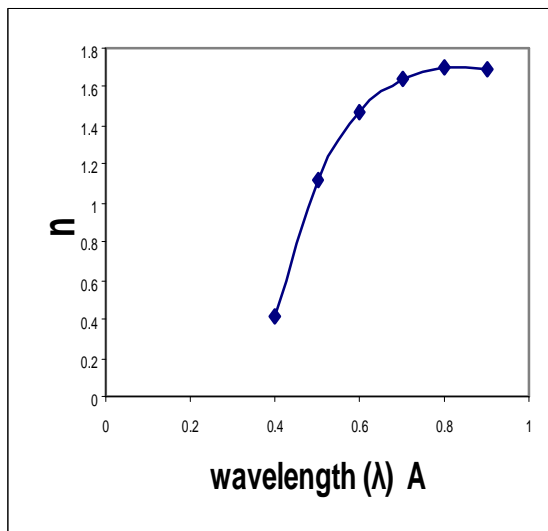
**Fig.(3-c)** Allowed direct transition of photon energy.



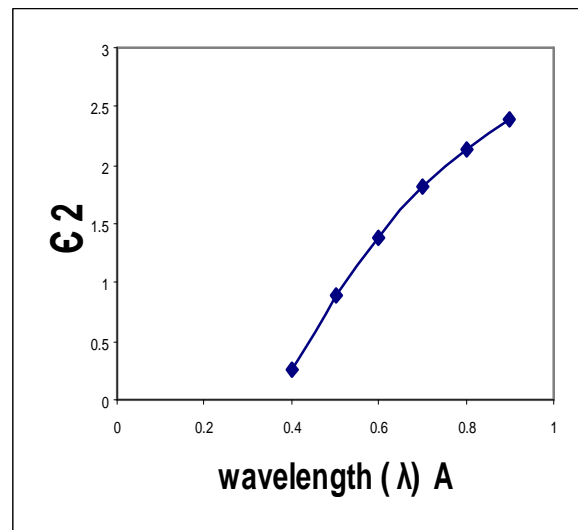
**Fig.(3-d) Forbidden transition with photoenergy.**



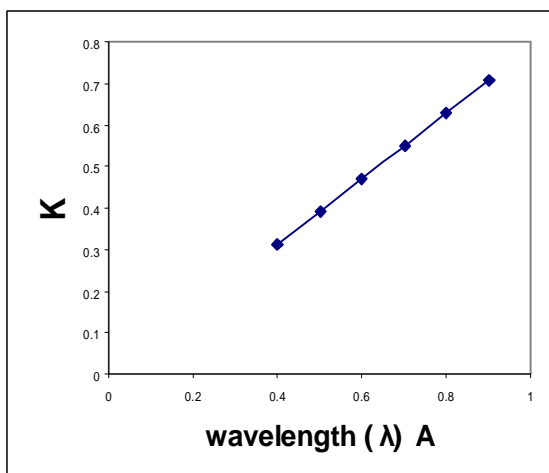
**Fig.(3-g) Real part of dielectric constant with wavelength.**



**Fig.(3-e) The relation between refractive index with wavelength.**



**Fig.(3-h) Imaginary part of dielectric constant with wavelength.**



**Fig.(3-f) The relation between extinction coefficient and wavelength.**

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#### الخلاصة

تم ترسيب اغشية AlNiCo على قواعد زجاجية بطريقة التبخير تحت ضغط  $10^{-6}$  تور للحصول على سمك  $2 \mu\text{m}$  بعد ذلك تم دراسة الخواص البصرية والبنية المجهرية لهذه الاغشية، تم اجراء التلدين الحراري لهذه الاغشية بدرجة  $300^{\circ}\text{C}$  وضغط  $10^{-3}$  تور ولاوقات مختلفة. اظهرت النتائج تغير في الحجم الحبيبي لهذه الاغشية مع زيادة في النفاذية مع زيادة الطول الموجي وزمن التلدين.