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# **MECHANICAL, ELECTRICAL AND STRUCTURAL PROPERTIES OF AL-CU ALLOY**

## **THESIS**

Submitted to  
University College for Girls,  
Ain Shams University

For the Award of Degree  
DOCTOR OF PHILOSOPHY

in  
PHYSICS



By

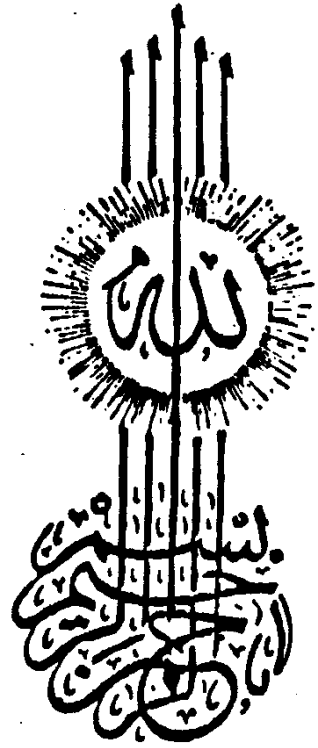
**MAGDA TALAAT MOSTAFA**

( B. Sc. ; M. Sc. )

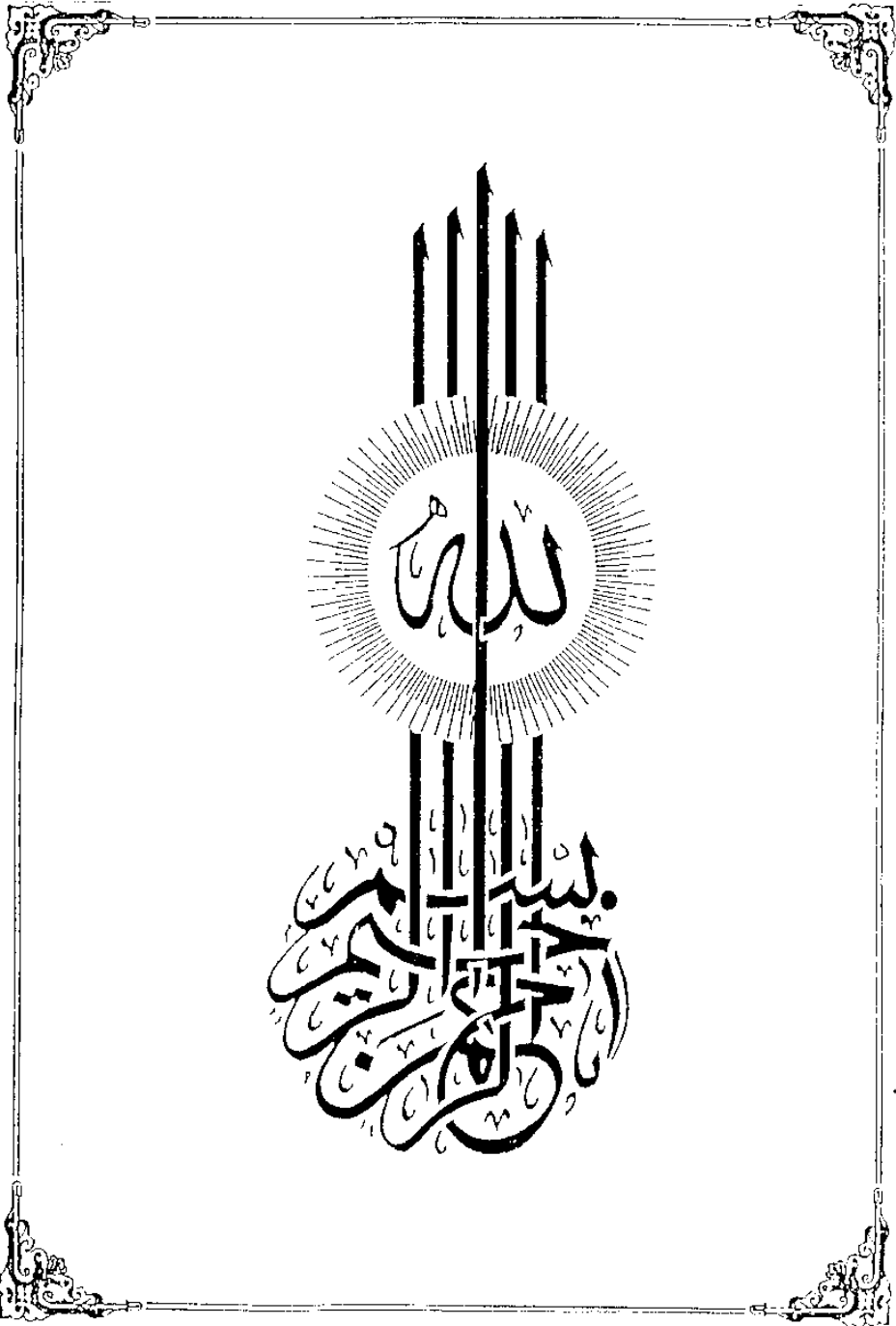
Physics Department, Faculty of Education  
Ain Shams University



**1986**



وَقُلْ اعْمَلُوا فَتَسْبِرَ لِي إِنَّهُ خَفِيكُنمْ وَرَسُولُهُ وَالْمُؤْمِنُونَ  
وَصَدَقَ اللَّهُ الْعَظِيمُ



MECHANICAL, ELECTRICAL AND STRUCTURAL  
PROPERTIES OF AL-CU ALLOY

Thesis Advisors:

Signature

1. Prof. Dr.M.A. Kenawy  
Head of physics dep.University  
College for Girls (Ain Shams  
University)

*M.A. Kenawy*

2. Dr.M.R. Nagy  
Assist.Prof., Faculty of Education  
(Ain Shams University).

*M.R. Nagy*

3. Dr. M.S. Sakr  
Lecturer, Faculty of Education  
(Ain Shams University)

*M.S. Sakr*

Approved

Head of Physics dep.  
Signature

*M.A. Kenawy*

## ACKNOWLEDGEMENT

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The auther wishes to express her deep gratitude and thanks to Prof. Dr.M.A. Kenawy, Head of physics Dept, Univ. College for Girls - Ain Shams University, for his valuable supervision, constant advice, fruitfull discussion and constructive suggestions throughout the period of this work.

The auther wish also to express her sincere appreciation and thanks to Dr. M.R. Nagy, Assis. Prof. of physics, Faculty of Education, Ain Shams University and Dr. M.S. Sakr Lecturer of physics, Faculty of Education, Ain Shams University for their stimulating supervision, valuable discussions and great help and encouragment during this work.

My thanks are also, due to the colleagues of the solid state Laboratory, Department of Physics, Faculty of Education cooperation and providing some experimental facilities.

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## A B S T R A C T

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The present work is mainly concerned with the effect of phase transformation of Al-2.5 wt.% Cu alloy on the plastic properties and also with studying kinetics of formation and subsequent dissolution of different precipitates. The changes of the microstructure were investigated by the measurements of electrical resistivity for the Al-2.5 wt.% Cu alloy.

Isothermal creep curves of Al-2.5 wt.% Cu alloy were determined under different tensile stresses 30, 33 and 36 MPa and at different temperatures up to 763 K.

From the transient creep, described by the equation  $\epsilon_{tr} = \beta t^n$ , the parameters  $\beta$  and  $n$  were calculated and found to change anomalously with the working temperature in the temperature range used.

The parameter  $\beta$  is related to the steady state creep  $\dot{\epsilon}_{st}$ , through the equation  $\beta = \beta_0 (\dot{\epsilon}_{st})^\gamma$ . The exponent  $\gamma$  was found to be 0.75 to 0.95 for the Al-2.5 wt.% Cu alloy.

The energy activating transient creep at transformation temperature (733K) was found to be 126 K. Joule/mole, characterizing the cross - slipping of dislocations during the dissolution of  $\theta$ -precipitates.

Steady state creep of Al-2.5 wt.% Cu alloy has been investigated near the phase transformation, the steady strain rate peaks of this alloy were obtained at the temperature range 673 K- 763 K. The steady strain rate sensitivity parameter  $m$  amounted to  $0.3 \pm 0.01$  at these peaks characterizing dislocation climb along  $\theta$  - grain boundaries and/or along its interface with the matrix.

The energy activating steady state creep as determined from the peak shift amounted to 210 K Joule/mole, characterizing dislocation climb mechanism during the dissolution of  $\theta$  precipitates. The microstructure analysis of isothermally deformed samples, confirmed that the above mechanism took place during transformation steady state creep.

The effect of annealing and quenching on the stress-strain characteristics of Al-2.5 wt.% Cu alloy was investigated relevant to the dissolution and formation of  $\theta$ -precipitate.

The stress-strain curves were determined at different temperatures up to 773 K. The curves exhibited two regions of tensile deformation, a linear hardening region and a cross-slip region.

The activation energy of fracture mechanism for slow cooled and quenched samples were found to be 79.8K. Joule/mole and 68.25 K. Joule/mole respectively in both temperature ranges from 693 K to 733 K and from 743 K to 773 K respectively. These values implied that the mechanism controlling the fracture process is dislocation intersection.

The minimum value of the lattice parameter  $a^{\circ}A$  at 733 K of Al-matrix and or the maximum value of  $C/a$  of the tetragonal  $\theta$ -phase are due to the relief of the internal strains or stresses during the dissolution of  $\theta$ -phase. This was more remarkable in case of the slow cooled samples as they have less concentration of vacancies than the quenched samples.

The change in electrical resistivity of the polycrystalline Al-2.5 wt.% Cu alloy was studied in the temperature range 373-758 K. It depends upon the scattering of conduction electrons from precipitates.

The sequence of structure transformation were (G.P.1, zones, G.P.2 zones, semicoherent  $\theta'$ -phase and incoherent  $\theta$ -phase) at various aging temperatures.

The activation energy of the four aging stages ranges between 1.26 and 7.06 K. Joule/mole. It concords with the binding energy between vacancy and Cu solute atoms.

The correlation between lattice parameter and resistivity change caused by  $\Theta$ -phase has been investigated in the fourth aging stage of this alloy.

**CHAPTER 1**  
**INTRODUCTION**

## INTRODUCTION

### 1- Creep and creep theories

#### 1.1 Creep curve

Creep of metals can be demonstrated directly by a creep curve representing creep strain as a function of time. An idealized creep curve is shown schematically in figure (1). As could be seen from this curve, three characteristic creep rates are defined:

- (i) The primary creep, taking place at the beginning between strains  $\epsilon_0$  and  $\epsilon_1$ . In this range the creep rate decreases continuously with time, where  $\epsilon_0$  and  $\epsilon_1$  are the creep strain at  $t = 0$ ,  $t_1$  respectively.
- (ii) Steady state "secondary creep" taking place during the period  $t_1 \longrightarrow t_2$ ; for strains from  $\epsilon_1 \longrightarrow \epsilon_2$ , in which the creep rate ( $\dot{\epsilon}_s$ ) remains almost constant. The value of the secondary creep rate

$$\dot{\epsilon}_s = \frac{\epsilon_2 - \epsilon_1}{t_2 - t_1} \quad (1)$$

- (iii) The tertiary creep for values of creep strain higher than  $\epsilon_2$ , in this region the creep rate increases continuously until rupture takes place at a value  $\epsilon_r$  of creep strain.