STUDY OF THE PHASE CHARACTERISTICS OF A BINARY ALLOY

Thesis

Presented in partial fulfilment
of the requirements for the
degree of Master of Teacher
Preparation of Science (Physics)

To

Physics Department
Faculty of Education
Ain Shams University

By

Rabei Abd El-Haseep Ahmed
B.Sc. and Education. Gen. Deploma and Spec. Deploma

Supervised by

Prof. Dr. F.Abd El-Salam **Prof. Dr. M.R.Nagy**

Physics Department
Faculty of Education
Ain Shams University

1996

CONTENTS

	Page
Acknowledgments	3
Abstract	5
CHAPTER I : INTRODUCTION	
(I-1) Lattice defects in crystalline solids.	7
(I-2) Deformation of metals.	8
(I-2-a) Tensile tests.	8
(I-2-b) Creep tests.	9
(I-2-c) Fracture.	13
(I-3) Mechanisms controlling creep deformation.	14
(I-4) Theories of high temperature creep.	21
(I-5) Dislocation mechanism involved in the annealing out of plastic deformation.	22
(I-6) Activation energy for creep.	24
(I-7) Stress-strain deformation.	25
(I-8) Stress-strain characteristics of crystalline solids.	26
(I-9) Mechanism of stable tensile deformation.	28
(I-10) Microstructure	30
(I-11) Effect of grain size on tensile testing characteristics.	30
(I-12) Pb-Sn Phase diagram.	32
(I-13) Literature concerning the mechanical properties of Pb-Sn alloys.	34
(I-14) Aim of the present work.	37

Page

CHAPTER II : EXPERIMENTAL PROCEDURE

(II-1) Preparation of the samples. 40

(II-2) X-ray diffraction measurements. 40

(II-3) The electric furnace. 41

(II-4) The tensile testing machine. 42

(II-5) Tensile measurements. 42

(II-6) Preparation of metallugraphic samples 48

CHAPTER III : EXPERIMENTAL RESULTS

(III-1) The transient creep. 49

(III-2) Energy activating transient creep. 53

(III-3) The steady-state creep stage. 53

(III-4) Correlation between the transient and steady-state creep. 57

(III-5) Structural studies after creep deformation. 62

(III-6) Stress-strain measurements. 62

CHAPTER IV : DISCUSSION

(IV-1) Transient creep. 77

(IV-2) Steady-state creep. 78

(IV-3) Structural variations due to creep. 80

(IV-4) Stress-strain deformation. 80

Conclusion 85

Summary 88

References 91

Equation index 96

Figure captions 99

Acknowledgments

I would like to express my deep gratitude and appreciation to **Dr. F. Abd El-Salam,** Professor of physics, Faculty of Education, Ain Shams University, for suggesting the point of research, valuable advices and kind supervision.

Thanks are also due to **Dr. M.R. Nagy,** Professor of physics and **Dr. M.M. El-sayed** lecturer of physics, Faculty of Education, Ain Shams University, for kind help at the starting and following up this work and continuous encouragement to complete this work. Deep thanks are due to **Dr. Mahmoud Yaseen El-Bakry** and all colleagues at physics Department, Faculty of Education, Ain Shams University where this work was conducted.

ABSTRACT

Abstract For M.Sc. Thesis

Researcher : Rabei Abd El-Haseeb Ahmed

Title : Study of the phase characteristics of a binary alloy.

District : Physics Department, Faculty of Education, Ain Shams University.

Wires of Pb-10 wt.% Sn alloy of diameter $6x10^{-4}$/wt. m were heated at 473K for 24 h then some of them were either quenched or slowly cooled to room temperature to get the single α phase or the dual $\alpha + \beta$ phase respectively. Tensile and x-rays investigations were used to trace the thermally induced variations of phase characteristics. The results clarified the integrated role of stress and temperature in tensile tests. The values of the hardening parameters showed that the quenched samples are more harder than the slowly cooled samples.

The mechanisms controlling the tensile processes at different temperatures were considered to be dislocations intersection, grain boundary diffusion in lead, and dislocation climb.

The state and the mode of distribution of the solute atoms (Sn) in the matrix mainly control the observed variations of the alloy characteristics.

CHAPTER I
INTRODUCTION

Chapter I

Introduction

(I-1) Lattice Defects In Crystalline Solids:

Real crystals are far from being perfect because they contain defects of different types [1]. Imperfections in solids are generally either lattice defects or impurity defects.

(A) Lattice Defects Include:

a) Point defects such as **Schottky [2]** or **Frenkel [3]** point defects could be introduced to the lattice as a result of **[1]** quenching, annihilation of dipole dislocation, fast climb of jogs induced by the direct applied stress, crossing dislocation lines, and cold work by a mechanism pointed out by **Friedel [4]** and **Mott [5]**.

b) Line defects or dislocations; a dislocation is geometrical fault or disturbance in the otherwise regular packing of the atoms forming a crystal in which (n) atoms of one row are faced by (n+1) atoms of the adjacent row. Dislocations are either edge **[6]** or screw [7] type. A compound dislocation of edge and screw components may also exist. The edge dislocation can move through a crystal by glide or slip under the action of stress in certain slip plane. It can also move in a direction perpendicular to its Burgers vector by generating or absorbing vacancies, a process known as climb which needs a large amount of energy to occur.

Motion of dislocations is generally adopted as the tool through which the plasticity of metals is studied [1].

c) Volume defects: these include **voids [8],** microcracks [9] and stacking faults [**10**].

B) Impurity Defects:

Impurity defects arise from the presence of foreign atoms in the host lattice. These may be substitutional or interstitial impurity defects. The presence of foreign atoms, similar to the existence of lattice defects, influence the properties of solids in different ways. They may cause pinning to dislocations, thus cause hardening of the metal.

(I-2) Deformation Of Metals:

Deformation is mainly the change in dimensions or form of matter caused by the mechanical action of external forces. The process of deformation comprises the following consecutive stages:

1) The deformation which completely disappears as soon as the action of the external forces cease is often defined as elastic deformation.

2) Plastic deformation defines the displacements of the atoms within the grains which cause permanent changes in the shape and dimensions of the matter .Plastic deformation in a crystal may occur either by slip or by twinning.

(I-2.a) Tensile Tests:

Tensile tests deal with the elongations induced by the applied stresses. Two main types of mechanical tests are followed according to the nature of the applied stress.

(I-2-b) Creep Tests:

Creep is the time dependent strain which may take place under constant stress at a certain temperature.
Creep characteristics depend on the applied stress, temperature, and the microstructure of the test samples **[11]**.

The behaviour of creep depends mainly on the range of both the applied stress and the working temperature. At low temperatures below $T_m/2$ and small stresses the instantaneous extension ε_0 is followed by a transient creep characterized by a decreasing rate and creep usually stops after a certain time (t). Such creep is the α or logarithmic creep which follows the equation

$$\varepsilon_\alpha = \alpha \log t + C \qquad (1)$$

This type of creep is shown in **figure (1-a).** At intermediate temperatures the creep behaviour fits the equation **[12]**

$$\varepsilon = \alpha \log t + B\, t^n + C \qquad (2)$$

Where B,C and n are constants, with the second term representing the transient stage.

At higher temperatures or under higher stresses the nature of the creep curve changes and takes the form given in **figure (1-b).** The curve shows three distinct creep stages, namely, the transient creep stage or the β-creep, the steady-state creep or viscous creep taken as the K-creep and the accelerated creep or the r-creep.