

Analysis of the mechanism of diffusion limited oxygen precipitation in Cz-silicon

F. Stănculescu^{*}, M. Moldoveanu, M. Botea

Matpur, S.A. Șos. Gării Cărla nr. 5, 73611 Bucharest, Romania

Abstract

We develop models for diffusion limited oxygen precipitation. We analyze the specific boundary conditions for the diffusion equation and we study the validity of the synchronic evolution of the precipitation cells. The combined model describes the simultaneous evolution of growing and dissolving precipitates.

1. Introduction

The control of oxygen precipitation in silicon is a vital problem in VLSI-ULSI technology. The evolution of oxygen precipitates has been an intensively studied subject in scientific literature, but there still are unclarified aspects.

The precipitation process in solids was first studied in relation to steel metallurgy, the first models being intended to explain the carbon precipitation in steel [1,2]. The equation which describes this process was given in 1950 by Wert [1]. His hypotheses are the supports for a more rigorous development of the diffusion controlled precipitation model done by Ham [2] in 1958. This theory is based on the existence of analytical solutions of Wert's equation which are obtained as a series with a dominant first term.

In this paper we intend to analyze and explain some of the hypotheses of the earlier theories, and to suggest new developments of the theory of oxygen evolution in silicon.

2. Development of the models

In a real silicon crystal the oxygen precipitates are uniform and randomly distributed in space, and the sizes of the precipitates are arbitrary. The crystal may be divided into cells of arbitrary shape and size, in such a way that each cell contains one precipitate and only one. We accept, as an initial approach, that the precipitates are all growing, or are all dissolving.

In the bulk of the crystal the oxygen diffusion process can be described by the formula:

$$\frac{\partial C}{\partial t} = D \Delta C, \quad (1)$$

with the initial condition

$$C(r, t) = C_0, \quad (2)$$

where D is the diffusion coefficient, and C the concentration of interstitial oxygen. The boundary conditions are given generally at the surface of a precipitate by

$$-D \left. \frac{\partial C}{\partial n} \right|_s = \beta (C - C_s), \quad (3)$$

^{*} Corresponding author.

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Table of Contents Oxygen In Silicon Vol 42

1. Understanding the eBook Oxygen In Silicon Vol 42
 - The Rise of Digital Reading Oxygen In Silicon Vol 42
 - Advantages of eBooks Over Traditional Books
2. Identifying Oxygen In Silicon Vol 42
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Oxygen In Silicon Vol 42
 - User-Friendly Interface
4. Exploring eBook Recommendations from Oxygen In Silicon Vol 42
 - Personalized Recommendations
 - Oxygen In Silicon Vol 42 User Reviews and Ratings
 - Oxygen In Silicon Vol 42 and Bestseller Lists
5. Accessing Oxygen In Silicon Vol 42 Free and Paid eBooks
 - Oxygen In Silicon Vol 42 Public Domain eBooks
 - Oxygen In Silicon Vol 42 eBook Subscription Services
 - Oxygen In Silicon Vol 42 Budget-Friendly Options
6. Navigating Oxygen In Silicon Vol 42 eBook Formats

- ePub, PDF, MOBI, and More
- Oxygen In Silicon Vol 42 Compatibility with Devices
- Oxygen In Silicon Vol 42 Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Oxygen In Silicon Vol 42
 - Highlighting and Note-Taking Oxygen In Silicon Vol 42
 - Interactive Elements Oxygen In Silicon Vol 42
- 8. Staying Engaged with Oxygen In Silicon Vol 42
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Oxygen In Silicon Vol 42
- 9. Balancing eBooks and Physical Books Oxygen In Silicon Vol 42
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Oxygen In Silicon Vol 42
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Oxygen In Silicon Vol 42
 - Setting Reading Goals Oxygen In Silicon Vol 42
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Oxygen In Silicon Vol 42
 - Fact-Checking eBook Content of Oxygen In Silicon Vol 42
 - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
- 14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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