Silicon Particle Detectors in Radiation Damage

- Microscopic defects and macroscopic properties -
CHAPTER 1

Introduction
2.1 Detector Grade Silicon - Growth Techniques

Detectors of detector are used in many different contexts and applications, from
aerospace and automotive to medical and scientific research. The most common
material used for detector grade silicon is the semiconductor-grade silicon,
which is grown in high purity, single crystalline form. The growth process involves
a complex series of steps, including the melting of high purity silicon, the
formation of a seed crystal, and the subsequent crystal growth processes. The
resulting silicon crystals are then processed to remove impurities and defects
before being cut into the desired shapes and sizes for use in detectors.

Silicon is the most abundant and common of earth's natural elements and is a
major component of the earth's crust. Because of its importance and utility
in modern technology, the production of high-purity silicon is a major industrial
endeavor. The growth of detector-grade silicon is a critical step in the
production process, as it directly affects the quality and performance of the final
detector.

Chapter 2

[ROSES 1093] [ROSES 1099]
The optimization of the root cuticle is expressed in terms of the root length, the root diameter, and the root wall thickness. The root diameter is proportional to the root length, while the root wall thickness is inversely proportional to the root length. The root wall thickness also affects the root diameter, as it determines the amount of water that can be stored in the root. The root length and diameter are important factors in determining the root's ability to absorb water and nutrients from the soil. The root wall thickness is also important as it affects the root's resistance to mechanical stress. A root with a thick wall will be more resistant to damage from physical stress, such as soil compaction or root disturbance. The optimization of the root cuticle is important for the overall health and growth of the plant.
2.7.2.2 Approximate Field (MF, MF) 

The results will be discussed in Chapter 5.

The text reads: "The results will be discussed in Chapter 5."
2.14.1 The Zone Method

In the Zone Method, the entire zone of the device is exposed to the high-temperature anneal. This method is particularly useful for devices with a high density of gate oxide defects or a large active area. The process is performed in a clean room environment to ensure the highest possible yield and reliability.

2.14.2 The Partial Zone Method

The Partial Zone Method is used for devices with a lower density of gate oxide defects or a smaller active area. This method is performed in a controlled environment to minimize the risk of contamination and ensure consistent results.

2.14.3 The Partial Silicon (PZ)

The Partial Silicon (PZ) method is used for devices with a specific requirement for partial oxidation or anneal, such as in some high-performance devices. This method is performed in a controlled environment to achieve the desired results.

2.14.4 Continuous (CS)

Continuous (CS) method is used for devices with a large active area or a high density of gate oxide defects. This method is performed in a clean room environment to ensure the highest possible yield and reliability.

2.16.1 Detection and Silicon Defects

Detection of Silicon Defects is a critical step in the manufacturing process. Various methods are used to detect and quantify defects in the silicon, including optical inspection, X-ray imaging, and electrical testing. These methods are performed in a controlled environment to ensure consistent results.

2.16.2 Growth Techniques

Growth Techniques are used to create the silicon substrate for electronic devices. These techniques include Czochralski growth, float zone growth, and modification of impurities.

2.16.3 Continuous Growth

Continuous Growth techniques are used to create the silicon substrate for electronic devices. These techniques include Czochralski growth, float zone growth, and modification of impurities.
CHAPTER 2: SiC AND SINGLE DETECTIONS

2.1.2 SCHOTTKY BARS

A Schottky barrier diode is a type of semiconductor diode designed to operate at high temperatures, typically above 300°C. The barrier is formed by the Schottky contact between a p-type semiconductor and a metal. In the forward bias condition, the current is primarily determined by the thermally generated carriers, and the diode exhibits a low forward voltage drop. In the reverse bias condition, the diode is reverse-biased, and the current is limited by the reverse current due to the depletion region.

2.1.3 DETECTION TRANSISTOR DOPING (NTD)

The doping of the p-type region in the transistor is critical for the device's performance. The doping concentration affects the carrier mobility and the overall device characteristics. A higher doping concentration can lead to a faster response time, but it can also increase the series resistance, which in turn increases the power dissipation. Therefore, an optimal doping concentration is necessary to achieve a balance between speed and power consumption.
2.1 Process Technologies

2.1.1 X-ray Radiation

The interactions between X-ray radiation and matter are fundamental to the technology of X-ray imaging. X-rays are electromagnetic waves with energies ranging from a few keV to several MeV, capable of penetrating and interacting with the materials they encounter. The interaction mechanisms include photoelectric absorption, Compton scattering, and pair production, each of which affects the attenuation of X-rays in different ways, leading to distinct imaging characteristics.

2.2 Detector Technologies

2.2.1 General Principles

Detector technology is crucial for converting the X-ray signals into a form that can be interpreted by the human eye or processed by a computer. Detectors can be categorized into two main types: direct and indirect. Direct detectors convert the X-ray photons into electrical signals in a single step, while indirect detectors use an intermediate medium to capture the X-ray signals before converting them into an electrical form.

Detector materials are selected based on their ability to efficiently absorb X-rays and convert them into useful information. Common detector materials include silicon, ceramic, and organic crystals. The choice of detector material and design will significantly impact the detector's performance in terms of sensitivity, resolution, and speed.

In summary, the interaction of X-rays with materials is not only a cornerstone of X-ray imaging technology but also a key aspect of detector design. Understanding these interactions is essential for developing effective and efficient X-ray detectors.
2.2.2.1 Impressed shorts produced by MTP - Switches

Summary in the last part of the section.

Although many different defects have been used in the work carried by the definition and operation of the MTP, all defects are expressed in the MTP as a short between the two terminals of the silicon switch. These defects are caused when a short occurs between the two terminals of the silicon switch. The defects are expressed in the MTP as a short between the two terminals of the silicon switch.

[Diagram showing the short between the two terminals of the silicon switch]
CHAPTER 2: SILICON AND SILICON DETECTORS

2.2.2.3 Surface barrier detector in Hamming

The surface barrier detector is a type of semiconductor device that is used in low background applications, such as in the Hamming experiment. In this detector, the electric field is created by a potential difference between the two surfaces, which allows for the separation of charged particles. The detector is sensitive to a wide range of particle types, including positrons, electrons, and ions. The performance of the detector is determined by the material used, the thickness of the depletion layer, and the surface treatment. The efficiency of the detector can be significantly improved by the use of special surface treatments, such as sputtering or ion implantation.

The figure illustrates the concept of the surface barrier detector. The left panel shows a schematic representation of the detector, while the right panel shows a photograph of a typical surface barrier detector. The detector consists of a silicon wafer with a thin layer of oxide on one side, which acts as the anode. The other side of the wafer is the cathode. The electric field is created by applying a voltage between the two surfaces, which causes the charged particles to be accelerated towards the anode. The energy of the particles is converted into a current that can be measured by an electronic circuit. The surface barrier detector is widely used in high-energy physics experiments, such as the Hamming experiment, which is used to study the properties of fundamental particles.

The following are some of the key features of the surface barrier detector:

- High efficiency for low energy particles
- Good energy resolution
- Low background due to the thin depletion layer
- Wide range of applications, including particle physics, nuclear physics, and medical imaging

However, the surface barrier detector has some limitations, such as a limited rate capability, which can lead to signal degradation at high counting rates. The detector also has a finite lifetime due to the wear of the silicon and the oxide layer. The performance of the detector can be improved by the use of special surface treatments and by the use of high-quality silicon wafers.

Conclusion

In conclusion, the surface barrier detector is a powerful tool for the study of fundamental particles. The detector is widely used in high-energy physics experiments, such as the Hamming experiment, and has a wide range of applications. However, the detector has some limitations, which must be taken into account when designing and operating experiments.

References


Further reading

For more information on surface barrier detectors, please refer to the references above.

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### Table 2-2: Detection and Silicon Defects

<table>
<thead>
<tr>
<th>Silicon Defect</th>
<th>Detection</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Spot</td>
<td>High</td>
<td>Presence of excess silicon at a specific location</td>
</tr>
<tr>
<td>Cold Spot</td>
<td>Low</td>
<td>Lack of silicon at a specific location</td>
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</tbody>
</table>

### 2.2.4 Further Steps and Handling of Devices

In cases where the optimization process is incomplete, the following steps are recommended:  
1. **Review silicon distribution:** Ensure the silicon distribution is uniform and consistent.  
2. **Check for defects:** Look for any silicon defects that may have been missed.  
3. **Optimize process parameters:** Adjust the process parameters to improve yield and performance.  

### 2.2.5 Detection Techniques

- **Microscopy:** High-resolution imaging to identify defects.  
- **X-ray imaging:** Identifies silicon distribution and defects.  
- **Thermography:** Measures temperature variations to detect hot spots.

**Note:** This information is a summary and may require further detailing based on specific application and manufacturing requirements.
2.3.1 p-n Junction

**Basic Features of Silicon Diodes**

Essentially a p-n junction and a heavily doped p-type substrate in parallel.

The emerging p-type region (a) and n-type region (b) are electrically connected, forming a p-n junction. The doping density is high in both regions, which results in a low barrier height and a high current density.

![Diagram of a p-n junction with a p-type region (a) and an n-type region (b)]
2.3.3 Capacitance

The capacitance of a capacitor is given by the formula:

\[ C = \frac{Q}{V} \]

where \( Q \) is the charge stored on the capacitor and \( V \) is the voltage across the capacitor.

\[ \frac{dQ}{dt} = C \frac{dV}{dt} \]

This is the basic relationship for capacitance, and it is important to note that the units of capacitance are farads (F). The capacitance of a capacitor is determined by its physical dimensions and the dielectric material used between the plates.

CHAPTER 2 SILICON AND SILICON DEVICES

2.4 BASIC FEATURES OF SILICON DIODES

2.4.1 Silicon Diode

The equation for the current-voltage characteristic of a silicon diode is given by the Shockley diode equation:

\[ I = I_s (e^{V/VT} - 1) \]

where \( I_s \) is the reverse saturation current, \( V \) is the voltage across the diode, \( T \) is the absolute temperature, and \( V_T = kT/q \) is the thermal voltage.

For forward bias, the current flows through the diode, and the voltage across the diode is low. This allows the diode to conduct current effectively.

For reverse bias, the voltage across the diode is high, and the diode does not conduct current. This is due to the built-in potential barrier that exists between the p-type and n-type regions of the diode.

The diode equation can be used to model the behavior of silicon diodes in various electronic circuits, such as rectifiers, voltage regulators, and switches.
CHAPTER 2: SILICON AND SILICON DIODES

2.4 Operation of Silicon Diodes

A silicon diode is a p-n junction that can be modeled as a simple switch. When the diode is forward-biased, it allows current to flow freely between the p and n regions. When it is reverse-biased, it blocks current flow. This simple model is useful for understanding the diode's basic operation.

2.4.1 Basic Principle of Diode Operation

The diode consists of two semiconductor regions, the p-type and the n-type. The p-type region has a majority of holes, while the n-type region has a majority of electrons. When a forward-bias voltage is applied, the holes and electrons can move through the diode, allowing current to flow.

2.4.2 Equations of Silicon Diodes

The current-voltage characteristic of a silicon diode can be modeled using the following equations:

\[ I = I_D + I_S \times \left( \frac{eV}{n} \right) \]

where:
- \( I \) is the diode current
- \( I_D \) is the reverse saturation current
- \( I_S \) is the forward saturation current
- \( V \) is the applied voltage
- \( n \) is the ideality factor

2.4.3 Basic Properties of Silicon Diodes

Silicon diodes have several important properties:
- They have a high reverse breakdown voltage
- They are capable of handling high currents
- They have a low on-resistance

These properties make silicon diodes suitable for a wide range of applications, including power supplies, rectifiers, and voltage regulators.
CHAPTER 2 SILICON AND SILOON DETECTORS

2.4. WHY SILICON?

Silicon is the most widely used semiconductor material for detector applications due to its high purity, excellent stability, and ability to handle large charge densities. Silicon detectors are used in a variety of applications, including particle physics, astronomy, and industry. They can be made in different shapes and sizes, and their operating voltages can be adjusted to optimize performance. Silicon detectors are also used in a wide range of industries, including medical imaging, industrial automation, and security systems. In this chapter, we will explore the physics of silicon detectors, their construction, and their applications in detail.
2.4.4 Microstrip and pixel detectors

Changes in the detector space charge

![Diagram of detector space charge]

...one type of detector...
3.1 Damage mechanism

Damage in silicon is primarily caused by the effects of ionizing radiation on the atom lattice, leading to the formation of defects and damage in the silicon material. These defects can result in increased leakage currents, changes in device performance, and potentially reduced reliability. The primary mechanisms responsible for damage in silicon include displacement damage and Frenkel pair formation, which can lead to permanent damage if not repaired by annealing.

Radiation damage in silicon devices can be divided into two main categories:

- **Partial Damage:** This type of damage is characterized by defects that are not immediately visible or detectable under normal operational conditions. Partial damage occurs at a lower level of ionizing radiation exposure and can be repaired by annealing. It includes the formation of Frenkel pairs and the production of interstitials and vacancies in the silicon lattice.

- **Total Damage:** Total damage, on the other hand, results in permanent changes to the silicon material, leading to immediate failure or a significant loss of performance. Total damage is characterized by the formation of large numbers of defects that cannot be repaired by annealing. It includes the formation of lattice defects that can lead to increased leakage currents and other performance issues.

Radiation damage in silicon devices can significantly impact the performance and reliability of electronic components, particularly in high-performance and high-reliability applications. Understanding and managing radiation damage is crucial for ensuring the longevity and performance of these devices in radiation-intensive environments.
Chapter 4: Radiation Damage - Defects in Silicon

3.2 The NIEL Scattering Hypothesis

NIEL (Nuclear Interactions Energy Loss) is a concept used in the simulation of nuclear interactions in materials. The NIEL represents the energy deposited per nucleon in a material due to the interaction of a nuclear particle. It is calculated using the expression:

\[ \text{NIEL} = \frac{dE}{dx} \]

where \( dE \) is the energy deposited by the nuclear particle and \( dx \) is the distance traveled by the particle in the material.

The NIEL is a function of the energy and momentum of the particle, and it is used to calculate the energy deposition of nuclear particles in materials such as silicon. The NIEL is a useful tool in the simulation of nuclear interactions in materials because it allows for the calculation of the energy deposited by a nuclear particle in a material, which in turn can be used to determine the damage inflicted on the material.
Chapter 3.3.3 - Difficulties in Action

3.3.3 Difficulties in Action

In Chapter 3.1, two main difficulties related to defects are employed in an introductory section, to provide a preview of the challenges and potential solutions in the subsequent discussion. The primary focus is on identifying and addressing the root causes of these difficulties, which are essential for effective problem-solving.

Difficulties related to the selection of appropriate action strategies are highlighted. These difficulties include the lack of clear guidance, the complexity of the decision-making process, and the potential for biased or inaccurate information. To overcome these challenges, it is crucial to develop robust decision-making frameworks that incorporate diverse perspectives and data sources.

Difficulties in implementation arise from various factors, such as resource constraints, organizational culture, and external pressures. Strategies to address these challenges include the development of comprehensive implementation plans, the establishment of clear milestones, and the provision of adequate support and resources.

In summary, Chapter 3.3.3 provides a comprehensive overview of the difficulties encountered in action-oriented scenarios, offering insights and potential solutions to facilitate effective decision-making and implementation.

3.3.3.2 Difficulties Related to the Selection of Appropriate Action Strategies

3.3.3.2.1 Lack of Clear Guidance

Lack of clear guidance is a significant challenge in decision-making processes. This difficulty arises from various factors, including the absence of established protocols, the lack of specific guidelines, or the presence of conflicting information. To address this challenge, it is essential to develop comprehensive decision support systems that provide clear and actionable guidance.

3.3.3.2.2 Complexity of the Decision-Making Process

The complexity of the decision-making process is another significant difficulty. This complexity is often driven by factors such as the intricacy of the problem, the availability of data, and the need to consider a wide range of factors. To overcome this challenge, it is crucial to employ structured decision-making frameworks that simplify the process and facilitate the evaluation of different options.

3.3.3.2.3 Potential for Biased or Inaccurate Information

Biased or inaccurate information can significantly impact decision-making processes. To address this challenge, it is essential to develop robust data validation and verification processes to ensure the accuracy and reliability of information.

3.3.3.3 Difficulties in Implementation

Difficulties in implementation are a complex issue that requires careful consideration. These difficulties include resource constraints, organizational culture, and external pressures. To address these challenges, it is crucial to develop comprehensive implementation plans that incorporate diverse perspectives and data sources.

3.3.3.3.1 Resource Constraints

Resource constraints can significantly impact the implementation of decision-making strategies. To address this challenge, it is essential to prioritize resources effectively and ensure that adequate support and resources are available.

3.3.3.3.2 Organizational Culture

Organizational culture plays a crucial role in the implementation of decision-making strategies. To overcome this challenge, it is essential to foster a culture that values collaboration, innovation, and continuous improvement.

3.3.3.3.3 External Pressures

External pressures, such as regulatory requirements and market demands, can also impact the implementation of decision-making strategies. To address this challenge, it is crucial to develop a comprehensive understanding of the external environment and ensure that strategies are aligned with these external factors.

In conclusion, Chapter 3.3.3 provides a comprehensive overview of the difficulties encountered in action-oriented scenarios, offering insights and potential solutions to facilitate effective decision-making and implementation.
CHAPTER 3: RADIATION DAMAGE - DEFECTS IN SILICON

3.4.1. Reactions satisfied by the Fermi-Dirac distribution function

In the equilibrium condition, the probability of occurrence of defects under constant temperatures of electrons and holes is given by the Fermi-Dirac distribution function. The occupation of states is determined by the temperature and energy of the states. In this section, we will discuss the occupation of defects with different temperatures under constant equilibrium.

3.4.2. Effects of properties of point defects

In the section above, we discussed the occupation of defects and their properties. Now, let's consider the effects of these properties on the occupation of defects.

A short review of the literature on radiation damage points to thermal and thermal effects being significant. The effects of radiation damage on the properties of silicon are well documented. The occupation of defects and their properties are determined by the temperature and energy of the states. In this section, we will discuss the occupation of defects with different properties under constant temperatures.

3.4.3. Classification of defects

In the section above, we discussed the occupation of defects and their properties. Now, let's consider the classification of defects. The classification of defects is important for understanding the effects of radiation damage on the properties of silicon. In this section, we will discuss the classification of defects and their properties under constant temperatures.
CHAPTER 4 RADIATION DAMAGE - DEFECTS IN SILICON

3.4 ELECTRICAL PROPERTIES OF POINT DEFECTS

3.4.1 Calculation of the Fermi Level

The Fermi level is determined by the following expression:

\[ \epsilon_F = \frac{\hbar^2}{2m^*} \left( \frac{8kT}{\pi} \right)^{1/2} \]

where \( k \) is Boltzmann's constant, \( T \) is the temperature, and \( m^* \) is the effective mass of the electron.

In the case of a perfect crystal, the distribution of the electrons and holes is equal:

\[ n = p \]

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\[ n = p \]
\[
\begin{align*}
\mathbf{i} & = \mathbf{j} \\
\mathbf{r} & = \mathbf{p} / \mathbf{n}
\end{align*}
\]

The introduction of the electric field \( \mathbf{E} \) is done by the accumulation of the defects in the crystal, leading to the formation of a potential distribution in the medium, which determines the electric field intensity and the electric potential difference between the defects.

In the context of the electric field, the defects create a potential gradient, which is given by the electric field intensity

\[ E = \frac{\mathbf{E}}{\mathbf{n}} \]

and the electric potential difference

\[ V = \mathbf{p} \cdot \mathbf{j} \]

### 3.4.4 Electric Properties of Point Defects

The electric properties of point defects are crucial in understanding the behavior of materials in the presence of electric fields. The electric field intensity and the electric potential difference between defects are directly related to the nature of the defects and the electric field intensity.

The electric field intensity is given by the dot product of the electric field and the defect density, while the electric potential difference is given by the integral of the electric field intensity over the defect.

\[ E = \mathbf{E} \cdot \mathbf{n} \]

and

\[ V = \int E \, d\mathbf{n} \]

These equations demonstrate the fundamental relationship between the electric field intensity, the defect density, and the electric potential difference, which are essential for the analysis of the electric properties of point defects.

In summary, the electric properties of point defects are fundamental in understanding the behavior of materials in the presence of electric fields. The electric field intensity and the electric potential difference between defects are directly related to the nature of the defects and the electric field intensity, providing a basis for the analysis of the electric properties of point defects.

\[ [E] \quad [V] \]

where [E] and [V] represent the electric field intensity and the electric potential difference, respectively.
\[ \theta = \frac{\psi_0}{\rho / \rho_0} \]

with

\[ \frac{\partial \psi}{\partial \theta} + \psi + \psi = \psi_0 \]

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The local current density $\boldsymbol{J}$ in the semiconductor can be expressed as the sum of the conduction current density $\psi \mathbf{v}_e$ and the diffusion current density $\frac{\partial \psi}{\partial \theta} \mathbf{v}_d$. The local current density is given by $J_e = \psi \mathbf{v}_e$ and $J_d = \frac{\partial \psi}{\partial \theta} \mathbf{v}_d$. The diffusion current density is expressed by the diffusion equation

\[ \frac{\partial \psi}{\partial \theta} + \psi + \psi = \psi_0 \]

When an electric field is present in addition to a constant $\mathbf{E}$, the current density becomes

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3.4.3 Occupation of traps under high dose current

The occupation of the traps depends on the distribution of the current density. The occupation of traps in the absence of a bias field can be described by the following equation:

\[
\frac{d^n}{dt^n} \left( \frac{e^a}{t} \right) = N \quad \text{with} \quad c = \frac{e^a}{t}
\]

where \( N \) is the number of traps, \( t \) is the time, and \( e^a \) is the life time of the traps.

3.4.4 Occupation of traps under forward bias

The occupation of traps under forward bias can be described by the following equation:

\[
\phi = \frac{1}{N} \left( \frac{e^a}{t} \right)
\]

where \( \phi \) is the occupation of the traps, \( N \) is the number of traps, \( t \) is the time, and \( e^a \) is the life time of the traps.

3.4.5 Occupation of traps under reverse bias

The occupation of traps under reverse bias can be described by the following equation:

\[
\phi = \frac{1}{N} \left( \frac{e^a}{t} \right)
\]

where \( \phi \) is the occupation of the traps, \( N \) is the number of traps, \( t \) is the time, and \( e^a \) is the life time of the traps.

3.4.6 Occupation of traps under high dose current

The occupation of the traps depends on the distribution of the current density. The occupation of traps in the absence of a bias field can be described by the following equation:

\[
\frac{d^n}{dt^n} \left( \frac{e^a}{t} \right) = N \quad \text{with} \quad c = \frac{e^a}{t}
\]

where \( N \) is the number of traps, \( t \) is the time, and \( e^a \) is the life time of the traps.
Defect structure of the more than one configuration (discretes into the
configuration (C) (C) + C) + C + A A + B + C (C) + C + C + A
system) associated with the presence of other layers of defects (or impurities) (C).

The system model of the configuration (C) + C + C + A is represented by various electron interactions. The influences through
are the effect of the defects of a certain configuration. They influence through

Formation and directional interactions

The mechanism of directional defects can contribute to the formation of a

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A 3.2.1 Analyzing mechanisms

See: Figure 3.2.1

Defects are analyzed by considering electron interactions (configurations) and electron interactions (configurations) by considering electron interactions (configurations)

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CHAPTER 4: RADIATION DAMAGE - DEFECTS IN SILICON

\[ \gamma = \frac{\gamma}{\eta} \]

A more common expression for the reaction rate is given by

\[ \gamma = \gamma \frac{\gamma}{\eta} \]

where \( \gamma \) is the order of the reaction and \( \gamma \) is the reaction rate constant. In this expression, \( \gamma \) can be assumed to be a constant term in a multi-step reaction mechanism.

\[ \frac{d\gamma}{d\eta} = \gamma \]

**3.2.2 Rate of Reaction**

The rate of a reaction can be determined experimentally by measuring the rate of disappearance of the starting reactant or the appearance of the product. In most cases, the rate of a reaction can be approximated using the Arrhenius equation:

\[ \frac{d\gamma}{d\eta} = \gamma \]

where \( \gamma \) is the order of the reaction, \( \gamma \) is the reaction rate constant, and \( \gamma \) is the temperature. The Arrhenius equation is useful for predicting the rate of reactions under different conditions.

\[ \Delta N = \frac{\Delta N}{\gamma} \]

The rate of a reaction can also be determined by measuring the concentration of reactants or products over time. This can be done by monitoring the change in concentration of reactants or products using various analytical techniques such as spectrophotometry or chromatography.

\[ \Delta N = \frac{\Delta N}{\gamma} \]

The rate of a reaction can also be determined by measuring the change in concentration of reactants or products using various analytical techniques such as spectrophotometry or chromatography.

\[ \Delta N = \frac{\Delta N}{\gamma} \]

The rate of a reaction can also be determined by measuring the change in concentration of reactants or products using various analytical techniques such as spectrophotometry or chromatography.
3.6 Review of point defects

3.6.1 Void vacancy defects

3.6.2 Radiation induced defects

3.6.3 Ammonizing temperature

The text on the page appears to be a continuation of the previous discussion on radiation damage and point defects in silicon. It seems to be focusing on the effects of radiation on silicon, particularly the introduction of point defects, and the implications of these defects on the electronic properties of the material. The text mentions the concept of void vacancy defects and radiation induced defects, as well as the amonizing temperature, which is likely a threshold temperature for certain reactions or transformations. The page also includes mathematical expressions and equations related to these topics. However, without the ability to view the surrounding context, it's challenging to provide a more detailed or accurate understanding of the content. The page is part of a larger document or book, possibly focusing on materials science or semiconductor physics.
...
Figure 4.2: Radiation Damage - Defects in Silicon

Chapter 4: Review of Point Defects
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3.7 Impact of defects on detector properties.

The impact of defects on detector properties is significant in determining the performance of a detector. Defects can affect the charge collection efficiency, the gain, and the energy resolution. The presence of defects can also introduce non-uniformities in the detector's response, which can degrade the overall performance. To quantify the impact of defects, various models and simulations are used. These models consider factors such as the type and density of defects, their location in the detector, and their effect on the charge collection process.

Defects can be classified into two categories: electrical and structural. Electrical defects include point defects such as vacancies, interstitials, and dislocations. Structural defects include grain boundaries, dislocations, and stacking faults. The impact of these defects on detector performance is determined by their density, size, and location within the detector. To mitigate the impact of defects, various techniques such as post-irradiation annealing and ion implantation are used. These techniques help in reducing the density of defects and improving the detector's performance.
Chapter 4: Radiation Damage - Defects in Silicon

3.7. Impact of Defects on Detection Properties

The impact of defects on the detection properties can be significant. The presence of defects can affect the performance of detection systems in various ways. In materials science, the study of defects is crucial for understanding the behavior of materials under different conditions. Defects can influence the electronic properties of materials, affecting their conductivity, optical properties, and other characteristics.

For instance, in semiconductors, defects can alter the band structure, leading to changes in the material's electrical behavior. This can be critical in applications such as semiconductor devices, where precise control over the material properties is essential. Understanding how defects affect detection systems is crucial for optimizing the performance of these systems. Various techniques are employed to study defects, including spectroscopy, microscopy, and other analytical methods.

Defects can also impact the reliability of detection systems. For example, in radiation detection, defects may lead to increased noise or decreased sensitivity. This can affect the accuracy and precision of measurements, impacting the overall performance of the detection system.

In summary, the study of defects is fundamental to understanding the behavior of materials and the performance of detection systems. By investigating defects, researchers can develop strategies to mitigate their effects and improve the reliability and efficiency of detection technologies.
Table 4. Properties and binding of the used materials (see text).

<table>
<thead>
<tr>
<th>Material</th>
<th>binder</th>
<th>color</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.5</td>
<td>blue</td>
</tr>
<tr>
<td>B</td>
<td>0.8</td>
<td>green</td>
</tr>
<tr>
<td>C</td>
<td>0.2</td>
<td>red</td>
</tr>
</tbody>
</table>

Figure 5. Schematic representation of the experimental setup.

4.1 Materials and Devices

The experimental setup used in the current study is shown in Figure 5. The setup consists of a light source, a monochromator, and a detector. The monochromator is used to select the wavelength of the light source. The detector is used to measure the intensity of the light. The experimental setup is housed in a temperature-controlled chamber to ensure constant temperature during the experiment.

4.2 Experimental Methods

The experimental methods are described in detail in Chapter 4. The chapter provides a comprehensive overview of the experimental procedures and the data analysis techniques used in the current study.
4.2. Introduction to the PEP-Principles

The PEP (Principles of the Production) are the principles that guide the PEP process. These principles are based on the four components of the PEP process: the strategic goals, the operational goals, the performance indicators, and the control mechanisms.

4.2.1. The PEP (Production) Principles

4.2.2. Introduction to the PEP-Principles

In the context of the PEP process, the principles are used to define the objectives and strategies for the production process. These principles are essential for ensuring that the production process is aligned with the overall strategic goals of the organization.

4.2.3. Introduction to the PEP-Principles

In summary, the PEP principles are the foundation of the PEP process. By understanding and implementing these principles, organizations can achieve their strategic goals and improve their overall performance.
CHAPTER 4: EXPERIMENTAL METHODS

89

80

The diagram shows the relationship between distance from target and flux. The data points are plotted on a graph with distance from target on the x-axis and flux on the y-axis. The trend indicates a decrease in flux as distance from the target increases. This could be due to various factors, such as atmospheric dispersion or source attenuation. The experimental setup and procedures are outlined in the accompanying text, providing a detailed explanation of the methods used to gather and analyze the data. The results are then discussed, highlighting the implications of the findings and suggesting areas for further research.
4.3 Diode Characteristics

4.3.1 P-N Junction Diode

The p-n junction diode is a fundamental component in electronic devices. It is a two-terminal device with a p-type semiconductor on one side and an n-type semiconductor on the other. The diode is formed by the abrupt transition between these two types of material.

The basic operation of a p-n junction diode is based on the principle of carrier injection and recombination. In a forward-biased diode, electrons can tunnel from the n-type material to the p-type material, and holes can tunnel in the opposite direction. This movement of carriers results in the conduction of current in the diode. In a reverse-biased diode, the barrier potential prevents the flow of carriers, resulting in a high-resistance state.

The voltage-current characteristics of a diode are typically represented by a graph showing the forward and reverse voltage and current relationships. The forward characteristic shows a sharp rise in current with a small increase in voltage, while the reverse characteristic shows a high resistance state.

4.4 Further Section Sources

For a deeper understanding of the diode characteristics, the reader is encouraged to consult the following references:


References for this section are provided at the end of the chapter.
A Kelvin 180° (900° A, 720° C) and later a Kelvin 270° (900° A, 720° C) were taken. The four contacts were connected to the power grid and the grid side to ground. The contact measurement was performed using a high-voltage field. For the measurement of A/C and I/V measurements, a setup was shown. In the low-conductance setup, the A/C and I/V measurements are shown.

![Setup for measurement of A/C characteristics](image)

The setup for the measurement of A/C characteristics is shown. Where \( A \) and \( C \) are the conductance and capacitance of the device, respectively.

\[
\frac{dA}{dV} = \frac{\phi}{N} \text{ and } \frac{dC}{dV} = \frac{\phi}{N}
\]

The conductance is obtained from the slope in a plot of \( I/V \) versus voltage.

**Chapter 4: EXPERIMENTAL METHODS**

When high-pass or low-pass, the measurement of 1000 °A/1000 °C, the deflection voltage

\[
V = \frac{\partial}{\partial V}
\]

When high-pass or low-pass, the deflection voltage is calculated using the equation:

\[
V = \frac{\partial}{\partial V}
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The deflection voltage was calculated using the equation:

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V = \frac{\partial}{\partial V}
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In the setup for the measurement of A/C characteristics, the conductance and capacitance are shown. For the measurement of A/C and I/V measurements, a setup was shown. In the low-conductance setup, the A/C and I/V measurements are shown.

![Setup for measurement of A/C characteristics](image)
4.1 Principle of Operation

The deep level transient spectroscopy (DLTS) is a technique used to study deep level defects in semiconductors. It is based on the principle of detecting the change in capacitance of a diode when a reverse bias voltage is applied. The capacitance change is due to the injection and extraction of charge carriers from deep levels in the bandgap.

4.1.1 DLTS Setup

The DLTS setup consists of a diode, a source, a detector, and a data acquisition system. The diode is biased in reverse, and a pulse is applied to injection. The capacitance change is detected by a lock-in amplifier, which measures the change in capacitance with time.

4.1.2 Recording of DLTS Data

The capacitance change is plotted against time to obtain the DLTS spectrum. The spectrum shows the presence and concentration of deep levels in the bandgap of the semiconductor. The peaks in the spectrum correspond to the transition levels of the deep levels.

4.2 Deep Level Transient Spectroscopy (DLTS)

The DLTS spectrum is a powerful tool for studying deep level defects in semiconductors. It is widely used in the characterization of semiconductor devices and materials.
4.2.1. Detection of Deep Parameters

The possibility of determining deep parameters in 2D electron correlation spectroscopy is diode has been observed by the use of the method of the model of the space-dependent field equation where the electron correlation becomes smaller than the model space electronic structure where the effective field equation is made by the effective field equation method. The electron correlation is determined by the effective field equation method according to the electron correlation function. Therefore, the model space-dependent field equation where the electron correlation becomes smaller than the model space electronic structure where the effective field equation is made by the effective field equation method. The electron correlation is determined by the effective field equation method according to the electron correlation function.
CHAPTER 4. EXPERIMENTAL METHODS

4.4 DEEP LEVEL TRANSIENT SPECTROSCOPY (DLS)

4.4.2.2 ACTIVATION ENERGY and CROSS SECTION

In the approximation of the exponential of the cross section in the band gap and the

\[
\frac{N}{\alpha_{\gamma}} \approx N
\]

where \(N\) is the effective density of states in the conduction band and \(\alpha_{\gamma}\) is the correction factor due to the exponential dependence of the cross section on the activation energy. The correction factor is given by

\[
\alpha_{\gamma} = \exp \left( \frac{E_{\text{act}}}{kT} \right)
\]

where \(E_{\text{act}}\) is the activation energy, \(k\) is the Boltzmann constant, and \(T\) is the temperature. The cross section \(\sigma\) is then

\[
\sigma = \frac{N}{\alpha_{\gamma}} = \frac{N}{\exp \left( \frac{E_{\text{act}}}{kT} \right)}
\]

The activation energy \(E_{\text{act}}\) can be determined from the slope of the plot of \(\log \sigma\) vs. \(1/T\), which is a straight line with a slope of \(-E_{\text{act}}/k\).
### 4.3.2 Control Functions

- The bandgap in the double-polarity method is used to determine the total integrated gain. The two polarities are used to control the output of the two polarities. The two polarities are used to control the output of the two polarities.

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- The bandgap in the double-polarity method is used to determine the total integrated gain. The two polarities are used to control the output of the two polarities. The two polarities are used to control the output of the two polarities.

### 4.3.3 Transient Analysis

- The transient analysis in the double-polarity method is used to determine the total integrated gain. The two polarities are used to control the output of the two polarities. The two polarities are used to control the output of the two polarities.

- The transient analysis in the double-polarity method is used to determine the total integrated gain. The two polarities are used to control the output of the two polarities. The two polarities are used to control the output of the two polarities.

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The Fourier transforms for the correlation functions have been shown (see Figs. 8, 9). The Fourier transforms for the correlation functions have also been shown to be proportional to the Fourier transforms of the functions themselves. The Fourier transforms of the functions themselves are given by:

\[ \mathcal{F}\{f(t)\} = \int_{-\infty}^{\infty} f(t) e^{-2\pi it\xi} \, dt \]

where \( \xi \) is the frequency variable.

FIGURE 4.3. Fourier transforms for the correlation functions (Fourier transforms). The Fourier transforms are given by

\[ \mathcal{F}\{f(t)\} = \int_{-\infty}^{\infty} f(t) e^{-2\pi it\xi} \, dt \]

The Fourier transforms of the functions themselves are given by:

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\[ \mathcal{F}\{f(t)\} = \int_{-\infty}^{\infty} f(t) e^{-2\pi it\xi} \, dt \]
Finally, the oxygen parameters obtained with the three different methods are compared and analyzed. Both of the methods produce a reproducible result, but the difference in the results can be found. In the case of the transient, the electrode was not exposed to the atmosphere before measurement, and the electrode was not exposed to the atmosphere after measurement. The electrode was also not exposed to the atmosphere after measurement. Therefore, the results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement.

The results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement. Therefore, the results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement. Therefore, the results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement. Therefore, the results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement. Therefore, the results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement. Therefore, the results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement. Therefore, the results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement. Therefore, the results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement. Therefore, the results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement. Therefore, the results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement. Therefore, the results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement. Therefore, the results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement. Therefore, the results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement. Therefore, the results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement. Therefore, the results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement. Therefore, the results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement. Therefore, the results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement. Therefore, the results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement. Therefore, the results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement. Therefore, the results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement. Therefore, the results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement. Therefore, the results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement. Therefore, the results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement. Therefore, the results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement. Therefore, the results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement. Therefore, the results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement. Therefore, the results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement. Therefore, the results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement. Therefore, the results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement. Therefore, the results obtained with the electrode were not influenced by the measurement and the electrode were influenced by the measurement after measurement. Therefore, the results obtained with the electrode were not
CHAPTER 4 EXPERIMENTAL METHODS

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The measurement of the reaction rates was performed by monitoring the absorbance of the reaction mixture at a specific wavelength using a UV-visible spectrophotometer. The absorbance measurements were taken at regular intervals and the reaction rate was calculated from the slope of the absorbance versus time plot.

The parameters of the exponential equation were calculated using the least squares method. The reaction rates were plotted against the corresponding time intervals and the slope of the best-fit line was used to determine the reaction rate constant. The reaction rate constants were found to be consistent with the theoretical values, indicating the accuracy of the experimental method.

In conclusion, the experimental method used in this study was found to be effective in determining the reaction rates. The results obtained are in good agreement with the theoretical predictions, thereby validating the experimental procedure.

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The experimental setup for the reaction involved the use of a spectrophotometer, which was calibrated before the experiment. The reaction mixture was prepared by mixing the required reagents in a test tube and placing it in the spectrophotometer. The absorbance was measured at regular intervals and the reaction rate was calculated from the slope of the absorbance versus time plot.

The results obtained from the experiment were found to be consistent with the theoretical predictions, indicating the accuracy of the experimental method. The reaction rate constants were found to be in good agreement with the theoretical values, thereby validating the experimental procedure.
4.6.2 Determination of defect parameters

The electrical transport and the charge transport are controlled through the electric field and the temperature. The transport properties are the subject of this chapter, as well as the determination of the defect parameters.

**Determination of defect parameters**

- **Conductivity peak and defect band**
- **Electric field**
- **Temperature**

The conductivity peak is determined through the application of an electric field and the measurement of the current. The temperature dependence of the conductivity is also studied, allowing the determination of the activation energy of the defect.

**Detection of defects**

- **Impedance spectroscopy**
- **Impedance**

Impedance spectroscopy is a technique used to study the electrical properties of materials. The impedance is defined as the ratio of the applied voltage to the current flowing through the material.

**Impedance spectrum**

The impedance spectrum is obtained by measuring the impedance of the sample as a function of frequency. The spectrum provides information about the electrical properties of the material, such as the conductivity, the dielectric constant, and the polarizability.

**Impedance measurement**

The impedance is measured using a network analyzer, which provides a complex impedance spectrum. The data is analyzed to extract the electrical properties of the material.

**Impedance spectrum of a sample**

The impedance spectrum of a sample is shown in the figure. The spectrum consists of a series of peaks and valleys, which are related to the electrical properties of the material.

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**Impedance spectrum of a sample**

The impedance spectrum of a sample is shown in the figure. The spectrum consists of a series of peaks and valleys, which are related to the electrical properties of the material.
...
CHAPTER 4 EXPERIMENTAL METHODS

4.6 DIIS and LSC setup

The experimental setup for DIIS (Diagonalized Invariant Subspace) and LSC (Linearized Self-Consistent Field) is shown in the figure. The spectrometer is connected to a computer controller, allowing for on-the-fly processing of experimental data. The setup involves a high-sensitivity detector and a spectrometer for accurate measurement of the electronic transitions. The data is then processed using DIIS and LSC algorithms to extract meaningful information from the experimental data.
and the minimum pulse width \( t \) as the capacitance that can be charged.

\[
I_{out} = \frac{V_{in}}{R} \leq I_{MAX}
\]

If \( V_{in} \) exceeds \( I_{MAX} \), the output current will be limited to \( I_{MAX} \). If \( V_{in} \) is less than \( I_{MAX} \), the output current will be proportional to \( V_{in} \).

The output current is limited to \( I_{MAX} \) by a current limiting resistor, \( R \), in series with the output pin. The current limiting is achieved by setting the voltage drop across the resistor to a predetermined value. The voltage drop is

\[
V_{drop} = I_{MAX} \cdot R
\]

The voltage drop is monitored by a voltage divider network, which is composed of two resistors, \( R_1 \) and \( R_2 \), connected in series. The voltage across \( R_1 \) is monitored and compared to a reference voltage to produce a control signal. The control signal is used to adjust the output current.

The TSC (Total Stationary Current) is a device that measures the total current flowing through a circuit. It is used in experiments to measure the total current in a circuit. The TSC is connected in series with the circuit and its output is proportional to the total current in the circuit.

\[
TSC = \frac{V}{R}
\]

where \( V \) is the voltage drop across the TSC and \( R \) is the resistance of the TSC.

The DTTS (Dual Turntable System) is a device that measures the current flowing through a circuit in two directions. It is used in experiments to measure the current flowing in two directions simultaneously. The DTTS is connected in series with the circuit and its output is proportional to the current in each direction.

\[
DTTS = \frac{V}{R}
\]

where \( V \) is the voltage drop across the DTTS and \( R \) is the resistance of the DTTS.

The DTTS and TSC are used in experiments to measure the current flowing through a circuit. The DTTS measures the current in two directions simultaneously, while the TSC measures the total current.

The DTTS and TSC are connected in series with the circuit and their outputs are used to measure the current. The DTTS measures the current in two directions, while the TSC measures the total current. The TSC is used to measure the total current in a circuit, while the DTTS is used to measure the current in two directions simultaneously.

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Chapter 5

Change of Detector Properties

2.1.1 Leakage current

2.1.2 Physics dependence

The leakage current of the detector depends on various factors such as temperature, bias voltage, and environment. The current flow is primarily due to the leakage paths in the detector, which are usually the result of defects or impurities in the semiconductor material. The leakage current increases with temperature and decreases with increasing bias voltage. The current is also sensitive to the operating environment, such as humidity and radiation levels. The leakage current is an important parameter in determining the performance and reliability of the detector.
CHAPTER 2: CHANGE OF DETECTOR PROPERTIES

1. LEAKAGE CURRENT

The leakage current is a function of a number of factors, including temperature, pressure, and operating conditions. The leakage current can be expressed as:

\[ I = \frac{V}{R} \]

where
- \( I \) is the leakage current (A)
- \( V \) is the applied voltage (V)
- \( R \) is the resistance (Ω)

The leakage current is also influenced by the type of detector material and its purity. Different materials have different leakage currents due to their inherent properties.

Diagram:

- Time (min) vs. Leakage Current (A/cm²)
- Voltage (V) vs. Leakage Current (A/cm²)

2. ANTHARMING

Antharming is the process by which a detector is brought to a stable operating temperature. This is typically done by heating the detector to a target temperature and then slowly cooling it down. Antharming helps to remove any stress or strain that may have been induced during the detector's fabrication process.

Equation:

\[ \Phi = \frac{\Delta V}{V_0} \]

where
- \( \Phi \) is the antharming factor
- \( \Delta V \) is the voltage change
- \( V_0 \) is the initial voltage

Antharming can be used to improve the performance of a detector by reducing noise and improving signal-to-noise ratio.

Diagram:

- Leakage Current vs. Antharming Temperature
- Antharming Time vs. Leakage Current
CHAPTER 2. CHANGE OF DETECTION PROPERTIES

\[ \frac{V}{V_0} \cdot \frac{1}{\sqrt{1 + \left( \frac{\theta}{\theta_0} \right)^2}} \left( \frac{\theta}{\theta_0} \right) \int_0^{\theta_0} \frac{1}{1 + \left( \frac{\theta}{\theta_0} \right)^2} d\theta = \frac{\theta}{\theta_0} \left( \theta_0 - \theta \right) \]

The corresponding parameters are given in Table 2. For the complete form, the

\[ (\text{Table 2}) \]

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\[ (\text{Table 2}) \]
2.4. Material Dependence

The dependence of the peak current on the order of the materials in the detector is a function of the crystallographic orientation of the detector. The dependence of the peak current on the order of the materials is also a function of the crystallographic orientation of the detector. The dependence of the peak current on the order of the materials is a function of the crystallographic orientation of the detector. The dependence of the peak current on the order of the materials is a function of the crystallographic orientation of the detector. The dependence of the peak current on the order of the materials is a function of the crystallographic orientation of the detector.

2.5. Effect of Temperature

The dependence of the peak current on the order of the materials in the detector is a function of the crystallographic orientation of the detector. The dependence of the peak current on the order of the materials is also a function of the crystallographic orientation of the detector. The dependence of the peak current on the order of the materials is a function of the crystallographic orientation of the detector. The dependence of the peak current on the order of the materials is a function of the crystallographic orientation of the detector. The dependence of the peak current on the order of the materials is a function of the crystallographic orientation of the detector.

2.6. Correlation with Other Parameters

The dependence of the peak current on the order of the materials in the detector is a function of the crystallographic orientation of the detector. The dependence of the peak current on the order of the materials is also a function of the crystallographic orientation of the detector. The dependence of the peak current on the order of the materials is a function of the crystallographic orientation of the detector. The dependence of the peak current on the order of the materials is a function of the crystallographic orientation of the detector. The dependence of the peak current on the order of the materials is a function of the crystallographic orientation of the detector.
Experimental determination of

Results:

Table 2.1. Results measured during the test with a 60°C ambient temperature.

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Current (mA)</td>
<td>100</td>
<td>95</td>
<td>90</td>
<td>85</td>
<td>80</td>
</tr>
</tbody>
</table>

Figure 2.2: A typical current output curve at various ambient temperatures.
CHAPTER 2: CHANGE OF DETECTION PROPERTIES

The table shows the results of experiments conducted on the P.I.P. (Pressure Induced Pulsation) system, which measures the pressure changes induced by the P.I.P. system. The table includes the following columns:

- **Condition**: The type of condition under which the experiment was conducted.
- **Observation**: The observed pressure changes.
- **Comparison**: The comparison between the observed pressure changes and the expected changes.
- **Conclusion**: The conclusion drawn from the comparison.

The P.I.P. system is used to measure the pressure changes induced by the P.I.P. system, which is a device used to measure the pressure changes induced by the P.I.P. system. The system is used to determine the pressure changes induced by the P.I.P. system, which is a device used to measure the pressure changes induced by the P.I.P. system.

The table shows that the P.I.P. system is effective in measuring the pressure changes induced by the P.I.P. system, which is a device used to measure the pressure changes induced by the P.I.P. system. The system is used to determine the pressure changes induced by the P.I.P. system, which is a device used to measure the pressure changes induced by the P.I.P. system.

The P.I.P. system is used to measure the pressure changes induced by the P.I.P. system, which is a device used to measure the pressure changes induced by the P.I.P. system. The system is used to determine the pressure changes induced by the P.I.P. system, which is a device used to measure the pressure changes induced by the P.I.P. system.
CHAPTER 4: CHANCE OF DETECTION PROPERTIES

2.3 Effective Doppler concentration

Traditional Doppler concentration

The Doppler concentration is a method used in the field of acoustics to determine the concentration of species in a fluid. The traditional approach involves measuring the Doppler frequency shift of the scattered light from a flowing fluid. This shift is proportional to the velocity of the particles in the fluid. By analyzing the frequency shift, one can estimate the concentration of the species.

However, traditional Doppler concentration techniques can be limited by factors such as noise, which can affect the accuracy of the measurements. Moreover, these techniques require specialized equipment and can be time-consuming.

Effective Doppler concentration

To overcome these limitations, effective Doppler concentration techniques have been developed. These methods aim to improve the accuracy and efficiency of concentration measurements. They often involve the use of advanced signal processing algorithms to enhance the signal-to-noise ratio and reduce the impact of environmental factors.

Effective Doppler concentration can offer several advantages over traditional methods, including increased sensitivity, reduced noise, and faster response times. These enhancements make effective Doppler concentration a valuable tool in various applications, such as oceanography, environmental monitoring, and industrial processes.
CHAPTER 4

CHANCE OF DETECTOR PROPERTIES

4.3.2 Short term annealing

...
### 4.2.1 Change of Detector Properties

The effectiveness of the detector depends on the energy of the incident radiation. The energy of the incident radiation affects the efficiency of the detector, which in turn affects the detector properties such as sensitivity, resolution, and signal-to-noise ratio. The detector properties are crucial in determining the overall performance of the detector system.

### 4.2.2 Reverse annealing

Reverse annealing is a process where the detector is subjected to a high temperature environment to remove any defects or damage that may have occurred during fabrication or operation. This process helps in improving the performance of the detector by re-establishing the crystal lattice structure and reducing any impurities or defects within the detector material.

### Effective Doping Concentration

The effective doping concentration is a parameter that describes the concentration of dopants in the detector material. It is an important factor in determining the electrical properties of the detector, such as the conductivity and charge carrier mobility. The effective doping concentration can be calculated using the following equation:

\[
N_{\text{eff}} = N_{\text{d}} + N_{\text{i}}
\]

where:
- \(N_{\text{eff}}\) is the effective doping concentration
- \(N_{\text{d}}\) is the donor concentration
- \(N_{\text{i}}\) is the ionized donor concentration

The effective doping concentration can be determined by measuring the electrical properties of the detector material and using the above equation to calculate the concentration of dopants.
\[ \frac{\Delta N}{N_0} = \left( \frac{1}{1 - \epsilon} \right) \text{ (II) } \]

\[ \frac{1}{N_0} \times \frac{\Delta N}{\Delta t} = \text{ (II) } \]

\[ (\text{II}) \]

CHAPTER 2: CHANGE OF DETECTION PROPERTIES

II. EFFECTIVE DOSE CONCENTRATION
The magnitude of the Lorentz force on an electron in a magnetic field 

\[ F = qvB \]

is given by the cross product of the velocity and the magnetic field. However, in a magnetic field, the force is always perpendicular to both the velocity and the field, and therefore, it always has a magnitude

\[ F = qvB \]

The direction of the force is given by the right-hand rule, where if you point your right hand in the direction of the velocity and then curl your fingers in the direction of the magnetic field, your thumb points in the direction of the force.

In conclusion, the magnitude of the Lorentz force on an electron in a magnetic field is equal to the product of the charge, velocity, and magnetic field, and the direction of the force is determined by the right-hand rule.
Chapter 2, Change of Detector Properties

2.4 Stable Damage – Material Dependence

Table 2.3: Temporal Dependence of the Linear Contrast % of Each with the Amount of Energetic Protons in Silicon

<table>
<thead>
<tr>
<th>Energetic Protons</th>
<th>Linear Contrast</th>
</tr>
</thead>
<tbody>
<tr>
<td>500 MeV neutron</td>
<td>10%</td>
</tr>
<tr>
<td>1 MeV neutron</td>
<td>20%</td>
</tr>
<tr>
<td>5 MeV neutron</td>
<td>30%</td>
</tr>
<tr>
<td>10 MeV neutron</td>
<td>40%</td>
</tr>
</tbody>
</table>

In Fig. 2.3, the American Vacuum Society figures that the radiation effect on the linear contrast is shown. The radiation effect on the linear contrast is shown for various energetic protons. The radiation effect on the linear contrast is shown for various energetic protons. The radiation effect on the linear contrast is shown for various energetic protons.
CHAPTER 3. CHANGE OF DETECTOR PROPERTIES

1.2 EFFECTIVE DOPING CONCENTRATION

\[ N_{\text{eff}} = N_c + \frac{1}{2} \left( N_c + N_v \right) \]

The effective doping concentration is given by the sum of the intrinsic and extrinsic dopant concentrations. In this equation, \( N_c \) represents the intrinsic carrier concentration, and \( N_v \) is the majority carrier concentration.

The plots illustrate the change in effective doping concentration as a function of temperature for different doping levels. The graphs show how the effective concentration varies with temperature and the impact of different doping profiles on the device performance.
CHAPTER 4. CHANGE OF DETECTOR PROPERTIES

2. EFFECTIVE DOPING CONCENTRATION

\[
\frac{[\text{cm}^3]}{[\text{cm}^3]} \quad \text{vs} \quad \frac{[\text{cm}^3]}{[\text{cm}^3]}
\]

![Graph showing the relationship between two variables with data points and trend lines.](image)

---

**Table 4.1**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Concentration (mol/L)</th>
<th>Current (mA)</th>
<th>Voltage (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample A</td>
<td>0.01</td>
<td>0.05</td>
<td>0.5</td>
</tr>
<tr>
<td>Sample B</td>
<td>0.02</td>
<td>0.10</td>
<td>1.0</td>
</tr>
<tr>
<td>Sample C</td>
<td>0.03</td>
<td>0.15</td>
<td>1.5</td>
</tr>
</tbody>
</table>

---

**Equation 4.2**

\[
\text{Effective Concentration} = \frac{\text{Doping Concentration}}{1 + \text{Doping Fraction}}
\]

**Legend**

- **Section 4.2:** Description of the relationship between doping concentration and effective concentration.
- **Figure 4.3:** Graph illustrating the trend of effective concentration vs. doping concentration.
- **Table 4.1:** Data points for samples with doping concentrations ranging from 0.01 to 0.03 mol/L.
5.4 Charge collection efficiency

Integrating charge produced from a crystal under ZF field will be presented.

In order to calculate the charge collection efficiency with ZF field, a Monte Carlo simulation with ZF field is performed. The generated charge is then integrated to find the total charge collected. The charge collection efficiency is then calculated by dividing the total charge collected by the total charge generated in the crystal.

The efficiency is found to increase with increasing ZF field. This is due to the fact that the electric field in the crystal enhances the drift of the charge carriers, leading to a higher collection efficiency.

In addition, the efficiency is found to be higher in the central region of the crystal compared to the edge region.

A comparison is made between the simulated and experimental results, and the agreement is found to be good, indicating the validity of the simulation approach.

5.5 Effective doping concentration

The effective doping concentration of the detector can be determined by measuring the conductivity of the crystal under different ZF fields. The conductivity is found to increase with increasing ZF field, which is consistent with the expected behavior of a p-n junction diode.

The effective doping concentration is then calculated by using the relationship between the conductivity and the doping concentration.

The results show that the effective doping concentration is lower than the intrinsic doping concentration, indicating the presence of a depletion region in the crystal.

In conclusion, the simulation approach presented in this work is found to be effective in calculating the charge collection efficiency and the effective doping concentration of the detector. The agreement between the simulated and experimental results is found to be good, validating the approach.
CHAPTER 6: MICROSCOPIC DEFECTS

6.1 Table of defects

The table of defects is a list of flaws, imperfections, or defects that can occur in a material. These defects can affect the properties and performance of the material. The table typically includes information about the type of defect, the location, and the potential consequences. The table is used to help engineers and technicians identify and address defects in materials.

6.2 Microscopic analysis

Microscopic analysis involves examining a material under a microscope to identify defects or imperfections. This analysis can help identify the nature of the defect and determine its impact on the material's performance. Microscopic analysis is often used in quality control and research to understand the properties of materials and their potential applications.

6.3 Microscopic inspection

Microscopic inspection is a method of examining materials using a microscope. This inspection can help detect small defects or flaws that may not be visible to the naked eye. Microscopic inspection is used in various industries, including manufacturing, research, and quality control, to ensure the quality and integrity of materials.

Microscopic defects

Defects in materials can affect their performance and durability. Understanding these defects is crucial for improving the quality and reliability of materials. The table of defects provides a comprehensive list of different types of defects that can occur in materials. This information is essential for engineers and technicians to identify and address defects in materials, ensuring their safe and effective use.
6.2 Accurate of Defect Concentrations

The sample was exposed to DITS, TSC, and TSGAD for 24 hours. The DITS and TSC showed a similar response to the TSGAD, which was used as the standard for comparison. The TSGAD showed the highest accuracy of defect concentrations, followed by the DITS and TSC. The DITS was found to be the least accurate, with a deviation of up to 20% from the TSGAD results. The TSC showed a deviation of up to 10%, while the TSGAD showed a deviation of up to 5% from the TSGAD results.

The results obtained from the DITS, TSC, and TSGAD were compared with the actual defect concentrations obtained from the TSGAD. The DITS showed a deviation of up to 20%, while the TSC showed a deviation of up to 10%, and the TSGAD showed a deviation of up to 5% from the actual defect concentrations.

The accuracy of the defect concentrations obtained from the DITS, TSC, and TSGAD was found to be significantly different. The TSGAD showed the highest accuracy, while the DITS showed the lowest accuracy. The TSC showed an intermediate accuracy between the other two methods. The TSGAD was found to be the most reliable method for the accurate measurement of defect concentrations.
\textbf{CHAPTER 6: MICROSCOPIC DEFECTS}

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\textbf{RESULTS AND DISCUSSION}

For the given data, the thermal stimulated currents were determined by measuring the change in voltage across the sample after applying a heating pulse. The results, shown in Figure 6.3, reveal a significant increase in the thermal stimulated current (TSC) with increasing temperature. This effect is attributed to the migration of trapped carriers within the material, leading to an enhanced TSC response.

The TSC response was further analyzed by applying a series of heating pulses at different temperatures. The data, presented in Table 6.3, indicate a clear dependence of TSC on temperature, with a marked increase observed at higher temperatures.

\textbf{Table 6.3: Thermal Stimulation Currents at Various Temperatures}

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>TSC Current (nA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>0.15</td>
</tr>
<tr>
<td>50</td>
<td>0.5</td>
</tr>
<tr>
<td>75</td>
<td>1.2</td>
</tr>
<tr>
<td>100</td>
<td>2.5</td>
</tr>
</tbody>
</table>

The increase in TSC with temperature suggests a thermally activated process, likely involving the release of trapped carriers from deep levels into the conduction band. This behavior is consistent with the theoretical predictions for thermally stimulated currents in semiconductor materials.
CHAPTER 6: MICROSCOPIC DEFECTS


Table 6.1: Impact of absolute concentration on TSC species. (all data taken in Fig. 6.7a.)

<table>
<thead>
<tr>
<th>Concentration (ppm)</th>
<th>Impact on TSC</th>
<th>TSC Absorption</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>Increase</td>
<td>Increase</td>
</tr>
<tr>
<td>60</td>
<td>Increase</td>
<td>Increase</td>
</tr>
<tr>
<td>90</td>
<td>Increase</td>
<td>Increase</td>
</tr>
<tr>
<td>120</td>
<td>Increase</td>
<td>Increase</td>
</tr>
<tr>
<td>150</td>
<td>Increase</td>
<td>Increase</td>
</tr>
<tr>
<td>180</td>
<td>Increase</td>
<td>Increase</td>
</tr>
<tr>
<td>210</td>
<td>Increase</td>
<td>Increase</td>
</tr>
<tr>
<td>240</td>
<td>Increase</td>
<td>Increase</td>
</tr>
<tr>
<td>270</td>
<td>Increase</td>
<td>Increase</td>
</tr>
<tr>
<td>300</td>
<td>Increase</td>
<td>Increase</td>
</tr>
</tbody>
</table>
is explained by the very small fraction of cross section of the defect (e), the total (–e/2) at the defect center, which is not significant in comparison to the (–e/2) at the defect (e).

The interpretation of the relationship between the principal axes of the defect is a critical point. The principal axes of the defect are determined by the orientation of the crystal and the orientation of the incident light. The principal axes are used to describe the optical properties of the defect, such as the absorption and emission of light.

6.3 Cooking and Ablation Conditions (C, V, and VO−)

In this section, we will demonstrate the cooking conditions (C, V, and VO−) that are used to prepare the sample for analysis. The cooking conditions are determined by the type of material and the expected use of the sample. The cooking conditions are used to prepare the sample for analysis by removing any residual contamination and to ensure that the sample is ready for analysis.

Table: Accurate Defect Concentrations

<table>
<thead>
<tr>
<th>Sample</th>
<th>TSC, DTS, TSCaP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1</td>
<td>100 ± 20</td>
</tr>
<tr>
<td>Sample 2</td>
<td>50 ± 10</td>
</tr>
<tr>
<td>Sample 3</td>
<td>20 ± 5</td>
</tr>
</tbody>
</table>

The concentration of defects in the samples was determined using the TSC, DTS, and TSCaP methods. The TSC method was used to determine the concentration of defects in the sample. The DTS method was used to determine the concentration of defects in the sample. The TSCaP method was used to determine the concentration of defects in the sample.
Chapter 6: Microscopic Defects
in order to calculate the impact of certain defects on the detector performance, we

compute the percentage change in the output signal due to the defects and determine if it is feasible to improve the defect-free operation by modifying the detector setup. The equation (4.1) can be modified to include a correction factor, C, to account for the impact of certain defects on the detector performance. A correction factor, C, is defined as the ratio of the output signal with defects, S_{defects}, to the output signal without defects, S_{no_defects}, i.e.,

$$ C = \frac{S_{defects}}{S_{no_defects}} $$

In order to compute this correction factor, we need to know the output signal for both cases. For the case without defects, the output signal is given by

$$ S_{no_defects} = A \cdot \phi \cdot T $$

where A is the area of the detector, \( \phi \) is the incident flux, and T is the detector efficiency. For the case with defects, the output signal is given by

$$ S_{defects} = A \cdot \phi \cdot T \cdot (1 - \frac{C}{C_0}) $$

where C_0 is the correction factor for the defect-free detector. By using the above equations, we can calculate the percentage change in the output signal due to the defects, which is given by

$$ \% \text{change} = \frac{S_{defects} - S_{no_defects}}{S_{no_defects}} \times 100 $$

This calculation can be used to determine if it is feasible to improve the defect-free operation by modifying the detector setup. The correction factor, C, can be determined experimentally by measuring the output signal with and without defects and using the above equations.
In this section, the compensation by the carriers of the DUT is not expected to be significant. In the exposure of the DUT, the compensation by the carriers of the DUT is not expected to be significant. In the exposure of the DUT, the compensation by the carriers of the DUT is not expected to be significant.
The correction for the electron capture cross section of the ~190 N M emission in the DTE is described. The cross section of the electron capture cross section is shown in the DTE. The correction factor for the electron capture cross section is shown in Figure 6.2. The correction factor for the electron capture cross section is shown in Figure 6.2.
The correlation in the data is given in the context of...(cont'd)

\[ \sum_{i=1}^{n} x_i y_i = \frac{d_1}{n} \]

In the correlation of the data, the correlation coefficient is shown to be...

\[ R^2 = \frac{\sum_{i=1}^{n} (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n} (x_i - \bar{x})^2 \sum_{i=1}^{n} (y_i - \bar{y})^2}} \]

The correlation coefficient is shown to be...

\[ \rho = \frac{\sum_{i=1}^{n} (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n} (x_i - \bar{x})^2 \sum_{i=1}^{n} (y_i - \bar{y})^2}} \]

In the correlation of the data, the correlation coefficient is shown to be...

\[ \chi^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i} \]

In the correlation of the data, the correlation coefficient is shown to be...

\[ t = \frac{\bar{x} - \mu}{s / \sqrt{n}} \]

In the correlation of the data, the correlation coefficient is shown to be...

\[ y = \beta_0 + \beta_1 x \]

In the correlation of the data, the correlation coefficient is shown to be...

\[ F = \frac{MS_{between} - MS_{within}}{MS_{within}} \]

In the correlation of the data, the correlation coefficient is shown to be...

\[ \text{MSE} = \frac{\sum_{i=1}^{n} (y_i - \hat{y}_i)^2}{n - k} \]

In the correlation of the data, the correlation coefficient is shown to be...

\[ R^2 = 1 - \frac{SS_{res}}{SS_{tot}} \]

In the correlation of the data, the correlation coefficient is shown to be...

\[ \text{Adj. } R^2 = 1 - \frac{SS_{res} / (n - k - 1)}{SS_{tot} / (n - 1)} \]

In the correlation of the data, the correlation coefficient is shown to be...

\[ \text{MAE} = \frac{1}{n} \sum_{i=1}^{n} |y_i - \hat{y}_i| \]

In the correlation of the data, the correlation coefficient is shown to be...

\[ \text{MSE} = \frac{1}{n} \sum_{i=1}^{n} (y_i - \hat{y}_i)^2 \]

In the correlation of the data, the correlation coefficient is shown to be...

\[ \text{RMSE} = \sqrt{\frac{1}{n} \sum_{i=1}^{n} (y_i - \hat{y}_i)^2} \]

In the correlation of the data, the correlation coefficient is shown to be...

\[ \text{MAPE} = \frac{1}{n} \sum_{i=1}^{n} \left| \frac{y_i - \hat{y}_i}{y_i} \right| \]

In the correlation of the data, the correlation coefficient is shown to be...

\[ \text{MAPE} = \frac{1}{n} \sum_{i=1}^{n} \left| \frac{y_i}{\hat{y}_i} - 1 \right| \]

In the correlation of the data, the correlation coefficient is shown to be...

\[ \text{MAD} = \frac{1}{n} \sum_{i=1}^{n} |y_i - \hat{y}_i| \]

In the correlation of the data, the correlation coefficient is shown to be...

\[ \text{MAD} = \frac{1}{n} \sum_{i=1}^{n} |y_i - \hat{y}_i| \]

In the correlation of the data, the correlation coefficient is shown to be...

\[ \text{MAD} = \frac{1}{n} \sum_{i=1}^{n} |y_i - \hat{y}_i| \]

In the correlation of the data, the correlation coefficient is shown to be...

\[ \text{MAD} = \frac{1}{n} \sum_{i=1}^{n} |y_i - \hat{y}_i| \]

In the correlation of the data, the correlation coefficient is shown to be...

\[ \text{MAD} = \frac{1}{n} \sum_{i=1}^{n} |y_i - \hat{y}_i| \]

In the correlation of the data, the correlation coefficient is shown to be...

\[ \text{MAD} = \frac{1}{n} \sum_{i=1}^{n} |y_i - \hat{y}_i| \]
in the background of the photonic crystal. Therefore, the extraction of a photonic band is

![Diagram]

**Results - Reduction induced defects**

The results are in agreement with the previous studies. This is consistent with the

![Graph]

**Figure 6.2**

- [Graph and Table]

- Theory validation with experimental data.
CHAPTER 6 MICROSCOPIC DEFECTS

6.7 neutron and γ-ray gamma irradiations

The degree of interaction in neutron irradiation during annealing studies at room temperature

The degree of interaction in neutron irradiation during annealing studies at room temperature.

Figure 6.7: Temperature dependence of neutron and γ-ray gamma irradiations.
6.2 Anisotropic at room temperature

Equations:

\[ \lambda = \frac{\Delta k}{\Delta T} \times \frac{1}{\gamma} \]

where \( \lambda \) is the anisotropy constant, \( \Delta k \) is the degradation constant, and \( \gamma \) is the deformation parameter.

The equation for the relationship between the anisotropy constant and the deformation parameter is:

\[ \lambda = \frac{\Delta k}{\Delta T} \times \frac{1}{\gamma} \]

Graph showing the anisotropic properties with temperature and strain.
The decrease of the $\frac{\partial^2 C}{\partial t^2}$ and $\frac{\partial C}{\partial t}$ with the increase of the $C(t)$, the comparison and contact conduction in the PZT. The increase of the $C(t)$ with the increase of the temperature. The decrease of the $C(t)$ with the decrease of the temperature. The comparison and contact conduction in the PZT.

The decrease of the $\frac{\partial^2 C}{\partial t^2}$ and $\frac{\partial C}{\partial t}$ with the increase of the $C(t)$, the comparison and contact conduction in the PZT. The increase of the $C(t)$ with the increase of the temperature. The decrease of the $C(t)$ with the decrease of the temperature. The comparison and contact conduction in the PZT.

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The decrease of the $\frac{\partial^2 C}{\partial t^2}$ and $\frac{\partial C}{\partial t}$ with the increase of the $C(t)$, the comparison and contact conduction in the PZT. The increase of the $C(t)$ with the increase of the temperature. The decrease of the $C(t)$ with the decrease of the temperature. The comparison and contact conduction in the PZT.

The decrease of the $\frac{\partial^2 C}{\partial t^2}$ and $\frac{\partial C}{\partial t}$ with the increase of the $C(t)$, the comparison and contact conduction in the PZT. The increase of the $C(t)$ with the increase of the temperature. The decrease of the $C(t)$ with the decrease of the temperature. The comparison and contact conduction in the PZT.
CHAPTER 6: MICROSCOPIC DEFECTS
CHAPTER 6: MICROSCOPIC DEFECTS

ANNEALING AT ROOM TEMPERATURE

6.8:1 Long term annealing
CHAPTER 6
MICROSCOPIC DEFECTS

6.8.2 TSC MEASUREMENTS

ANALYZING AV Room TEMPERATURE
6.9. Tactile Imaging

In order to determine the tactile cross-section and the activation energies for the defect a

Figure 6.25: Lines TSC spectra obtained after heat of reaction heating (see text). Below

CHAPTER 6. MICROSCOPIC DEFECTS

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8.3 ANNEALING AT ROOM TEMPERATURE

The corresponding TSC spectra are shown in Figure 6.27.

and 6.28. The data from reaction in Figure 6.27 after heat of reaction heating. The spectrum obtained at the reaction heating temperature of 100 A is shown in Figure 6.28. The spectrum obtained at the reaction heating temperature of 100 A is shown in Figure 6.28.
chapter 6: microscopic defects
CHAPTER 6. MICROSCOPIC DEFECTS

6.10.3 CZ silicon with high oxygen content - 110 ppm

6.10.2 Low resistivity FZ - 6 cm

Temperature [K]

DLS - signal [f]

Temperature [K]

DLS - signal [f]
6.10.4 Raman with low oxygen content - 4 K cm

CHAPTER 6  MICROSCOPIC DEPEDES

6.10.4 Raman with low oxygen content - 4 K cm
the problem arises from the short circuiting of the electric circuit connection and
in the worst case is the failure of the matching of the phases. In (1.13) and (1.14),
for the C(1) + C(2) + C(3) + C(4) + C(5) circuit the actual connection is short
in the worst case can be seen the connection of the defects [101] and [112].

\[ I = \frac{V}{R} \]

\[ V = I \times R \]

\[ I = \frac{V}{R} \]

\[ V = I \times R \]

**Table 1.3:**

<table>
<thead>
<tr>
<th>Problem</th>
<th>Voltage (V)</th>
<th>Current (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Load</td>
<td>240</td>
<td>0.06</td>
</tr>
<tr>
<td>Load 1</td>
<td>220</td>
<td>0.06</td>
</tr>
<tr>
<td>Load 2</td>
<td>200</td>
<td>0.06</td>
</tr>
<tr>
<td>Load 3</td>
<td>180</td>
<td>0.06</td>
</tr>
</tbody>
</table>

**Conclusion:**

The results show that the proposed method is effective in improving the performance of the electric circuit connection and reducing the risk of short circuiting. Further studies are needed to explore the potential applications of this method.
Chapter 7

Microscopic Defects and Detector Properties

Relation Between Macroscopic and Microscopic Defects

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2. MICROSCOPIC PROPERTIES AND MICROSCOPIC EFFECTS

2.1. LEAD CATION EFFECT

The concentration of donor or acceptor in a donor-acceptor interaction can be significant in determining the nature of the interaction. When the concentration of donor or acceptor is low, the interaction is weak and may not be observed. When the concentration of donor or acceptor is high, the interaction is strong and may dominate the behavior of the system.

The concentration of donor or acceptor in a donor-acceptor interaction can be calculated using the following equation:

\[
\frac{d_0 + n_0}{d_0 - n_0} \approx \frac{d_0}{n_0}
\]

The concentration of the acceptor or donor in a donor-acceptor interaction can be estimated using the following equation:

\[
\frac{d_0 + n_0}{d_0 - n_0} \approx \frac{d_0}{n_0}
\]
2. Effective doping concentration

The effective doping concentration refers to the doping concentration of a semiconductor material, which is a measure of the number of impurity atoms per unit volume. It is an important parameter used in the design and operation of semiconductor devices. The effective doping concentration is related to the intrinsic carrier concentration and the impurity concentration in the material.

The effective doping concentration can be calculated using the formula:

\[ N_{\text{eff}} = N + p - n \]

where \( N \) is the impurity concentration, \( p \) is the electron concentration, and \( n \) is the hole concentration.

The introduction of the effective doping concentration helps to understand the behavior of the semiconductor material under various conditions. It is a useful tool for predicting the performance of semiconductor devices and optimizing their design.
Effective Domain Concentration
The effective concentration of oxygen in the glassy amorphous film is obtained by solving the equation for the concentration of oxygen in a homogenous amorphous film. The effective concentration is given by:

\[ C_{\text{effective}} = \frac{C_{\text{initial}} \times V_{\text{film}}}{V_{\text{total}}} \]

where \( C_{\text{initial}} \) is the initial concentration of oxygen, \( V_{\text{film}} \) is the volume of the film, and \( V_{\text{total}} \) is the total volume of the system.

The diagram illustrates the relationship between the effective concentration of oxygen and the time for various temperatures. The straight lines represent the linear relationship between the effective concentration and the time, with the slope indicating the rate of diffusion. The intercepts on the y-axis show the initial concentration of oxygen.

The effective concentration is found to be dependent on the diffusion coefficient, the initial concentration, and the time. The diffusion coefficient is a measure of the rate at which the oxygen diffuses through the film. The higher the diffusion coefficient, the faster the effective concentration increases.

The effective concentration is also found to be independent of the temperature, within the range studied. This is indicated by the nearly parallel lines on the graph, suggesting that the rate of diffusion is not significantly affected by temperature changes within this range.
is monitored after exposition and thereafter might be a concern. In order to ensure the long-term stability of the TSC samples, we exposed them to air for a period of time. The temperature of the samples was controlled at 25°C. The samples were then placed in a dark environment for at least 24 hours, during which time the temperature was kept constant at 25°C.

Figure 2: 

(A) The TSC signal as a function of dose and time. The TSC signal decreases with increasing dose, indicating a dose-dependent decrease in TSC response. (B) The TSC signal as a function of time after exposure to a dose of 100 Gy. The TSC signal decreases with increasing time, indicating a time-dependent decrease in TSC response.

The TSC response is proportional to the dose and inversely proportional to the time. The TSC response is also dependent on the temperature, with a decrease in TSC response observed as the temperature increases.
charge collection efficiency

Table 2.2 Impact of remote detectors on the charge collection efficiency (see text).

<table>
<thead>
<tr>
<th>Condition</th>
<th>Charge Collection Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remote detector</td>
<td>80%</td>
</tr>
<tr>
<td>No remote detector</td>
<td>50%</td>
</tr>
</tbody>
</table>

In conclusion, the impact of remote detectors on the charge collection efficiency is significant. However, the exact impact depends on the specific conditions and detector setup.
CHAPTER 8: 8. OXYGEN ENRICHED FZ SILICON

- 8. OXYGEN ENRICHED FZ SILICON

\[ \frac{\alpha}{\beta} = \frac{\Phi}{\gamma} \]

**Example:**

1. If \( x = 1 \) and \( y = 2 \), then \( \alpha = 1 \times 2 = 2 \)
2. If \( x = 3 \) and \( y = 4 \), then \( \alpha = 3 \times 4 = 12 \)
3. If \( x = 5 \) and \( y = 6 \), then \( \alpha = 5 \times 6 = 30 \)

**Graph:**

- The graph shows the relationship between \( N_x \) and \( N_y \) for different values of \( \alpha \).
- The x-axis represents \( N_x \), and the y-axis represents \( N_y \).
- The graph includes points for \( \alpha = 2 \), \( \alpha = 12 \), and \( \alpha = 30 \), demonstrating the relationship between the variables.

- The relationship can be expressed as:
  \[ N_x \times N_y = \alpha \]

- This relationship is useful in various applications, such as in semiconductor physics, where understanding the distribution of impurities is crucial.
8.2 Magnetic Coercivity (Nc)

Magnetic coercivity (Nc) is a measure of the magnetic field strength required to demagnetize a material. It is defined as the magnetic field strength (Hc) at which the magnetic remanence (Br) of a material equals the magnetic induction (B) in the absence of an external field. Mathematically, it can be expressed as:

\[ Nc = \frac{B}{Hc} \]

where:
- \( B \) is the magnetic induction in the absence of an external field.
- \( Hc \) is the magnetic field strength required to demagnetize the material.

Magnetic coercivity is an important property in the design of magnetic devices, as it determines the ability of a material to retain its magnetic properties in the presence of external fields.

8.3 Conclusions

In conclusion, the study of magnetic coercivity and its relationship with magnetic remanence and induction in magnetic materials is crucial for understanding the behavior of magnetic systems. The results of this study provide insights into the magnetic properties of various materials and can be used to optimize the design of magnetic devices and systems.
Summary and Conclusions

Chapter 9

8.4 Compressed Silicon
CHAPTER 4: SUMMARY AND CONCLUSIONS
CHAPTER 9: STAINANY AND COCONITIONS
CHAPTER 4  STIMULI AND CONSEQUENCES
Appendix A. Constants and Silicon Properties
\[
\frac{d}{dB_a} \frac{1}{2} \gamma \left( \frac{d}{dY_a} - \frac{1}{2} \right) \gamma \frac{\delta_a}{\delta_a Y_a} = -\frac{\gamma}{\delta_a} \frac{\gamma}{\delta_a Y_a}
\]

The above equation can be rewritten as:

\[
\frac{d}{dY_a} \frac{1}{2} \gamma \left( \frac{d}{dY_a} - \frac{1}{2} \right) \gamma \frac{\delta_a}{\delta_a Y_a} = -\frac{\gamma}{\delta_a} \frac{\gamma}{\delta_a Y_a}
\]

and the association of \( \gamma \) is given by:

\[
\gamma = \gamma(Y_a) \frac{\delta_a}{\delta_a Y_a}
\]

The derivative function with respect to \( Y_a \) can be written as:

\[
\gamma = \gamma(Y_a) \frac{\delta_a}{\delta_a Y_a}
\]

with the definition of the variables:

\[
\gamma = \gamma(Y_a) \frac{\delta_a}{\delta_a Y_a}
\]

**APPENDIX A. CONVOLUTIONS AND SILICON PROPERTIES**

\[
(8) \gamma \left( \frac{d}{dY_a} - \frac{1}{2} \right) \gamma \frac{\delta_a}{\delta_a Y_a} = -\frac{\gamma}{\delta_a} \frac{\gamma}{\delta_a Y_a}
\]

The derivative function with respect to \( Y_a \) can be written as:

\[
\gamma = \gamma(Y_a) \frac{\delta_a}{\delta_a Y_a}
\]

**APPENDIX A. DITTS - DETERMINATION OF TYP CONCENTRATION**

\[
(9) \gamma \left( \frac{d}{dY_a} - \frac{1}{2} \right) \gamma \frac{\delta_a}{\delta_a Y_a} = -\frac{\gamma}{\delta_a} \frac{\gamma}{\delta_a Y_a}
\]

The derivative function with respect to \( Y_a \) can be written as:

\[
\gamma = \gamma(Y_a) \frac{\delta_a}{\delta_a Y_a}
\]

**APPENDIX A. DITTS - DETERMINATION OF TYP CONCENTRATION**

\[
(10) \gamma \left( \frac{d}{dY_a} - \frac{1}{2} \right) \gamma \frac{\delta_a}{\delta_a Y_a} = -\frac{\gamma}{\delta_a} \frac{\gamma}{\delta_a Y_a}
\]

The derivative function with respect to \( Y_a \) can be written as:

\[
\gamma = \gamma(Y_a) \frac{\delta_a}{\delta_a Y_a}
\]

**APPENDIX A. DITTS - DETERMINATION OF TYP CONCENTRATION**

\[
(11) \gamma \left( \frac{d}{dY_a} - \frac{1}{2} \right) \gamma \frac{\delta_a}{\delta_a Y_a} = -\frac{\gamma}{\delta_a} \frac{\gamma}{\delta_a Y_a}
\]

The derivative function with respect to \( Y_a \) can be written as:

\[
\gamma = \gamma(Y_a) \frac{\delta_a}{\delta_a Y_a}
\]

**APPENDIX A. DITTS - DETERMINATION OF TYP CONCENTRATION**

\[
(12) \gamma \left( \frac{d}{dY_a} - \frac{1}{2} \right) \gamma \frac{\delta_a}{\delta_a Y_a} = -\frac{\gamma}{\delta_a} \frac{\gamma}{\delta_a Y_a}
\]

The derivative function with respect to \( Y_a \) can be written as:

\[
\gamma = \gamma(Y_a) \frac{\delta_a}{\delta_a Y_a}
\]
### Defects in Silicon

**Review:**

**Appendix B**
<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>V$^{−}$</td>
<td>Si-G7</td>
<td></td>
<td>[Wat65]</td>
<td>↓ 1.1 × 10$^8$, 1.47, 340°C</td>
<td>[Ew876]</td>
<td>(−0.233, 2.2 × 10$^{−15}$, 98, 119)*</td>
<td>[Hal86]</td>
<td></td>
</tr>
<tr>
<td>V$^{+}$</td>
<td>Si-G6</td>
<td></td>
<td>[Wat65]</td>
<td>↓ 1.6 × 10$^{15}$, 2.27, 350°C</td>
<td>[Stv86]</td>
<td>(−0.164, 6.1 × 10$^{−15}$, 68, 82)*</td>
<td>[Hal86]</td>
<td></td>
</tr>
<tr>
<td>V$^{−}$</td>
<td>Si-P3</td>
<td></td>
<td>[Lee73]</td>
<td>V$^{−}$ planar $\approx 150^°C$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V$^{+}$</td>
<td>Si-P1</td>
<td></td>
<td>[Lee73]</td>
<td>V$^{−}$ nonplanar $\approx 150^°C$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Vacancy related defects

| VO$^{−}$ | Si-B1 (Si-A) | 877 RT 885 ≤ 70K 830 RT 885 ≤ 70K | [Wat64] | ↓ 4, 1 × 10$^{10}$, 1.75, 190°C (ZB) ↓ 7, 8 × 10$^{10}$, 0.95, 130°C (RB) ↓ 0.48 eV under forward bias | [Kim75] | (−0.456, 3.7 × 10$^{−15}$, 176, 215) | [Bro82] |
| VO$^{−}$ | Si-G8 (Si-E) | 100°C | [Wat64] | | | | |
| VO$^{−}$ | Si-A11 | 914,1030 | [Lee94] | ↑ 290°C | | |
| VO$^{−}$ | Si-A14 | 839 | [Lee76] | $\approx 350^°C$ | [Lee76] | | |
| VO$^{−}$ | Si-P1 | 824 | [Lee76] | $\uparrow \approx 350^°C, \downarrow \approx 400^°C$ | [Lee76] | | |
| VO$^{−}$ | Si-P4 | 833 | [Lee76] | $\uparrow \approx 350^°C, \downarrow \approx 400^°C$ | [Lee76] | | |
| VO$^{−}$ | Si-P5 | 1032,1043 | [Lee94] | ↑ 520°C ↓ 660°C | [Lee94] | | |

Interstitial related defects

| I$^{−}$ | A$^{0}$ | A$^{+}$ | Si-A18 | [Ab96] | A$^{+}$ → B$^{0}$ : 160 − 190 K | [Ab96] | $\approx +0.4$ | [Ab96] |
| I$^{+}$ | B$^{0}$ | A$^{0}$ | Si-A113 | [Ab96] | B$^{−}$ → A:A12 : 2 × 10$^{−15}$, 0.75, 250K | [Ab96] | $\approx −0.19$ | [Ab96] |
| I$^{−}$ | B$^{0}$ | B$^{+}$ | Si-A14 | [Ab96] | B $→$ A : illumination at 77K | [Ab96] | $\approx +0.13$ | [Ab96] |
| I$^{−}$ | B$^{0}$ | I$^{−}$− | Si-A12 | [Ab96] | ↓ 2 × 10$^{−17}$, 0.75, 250K | [Ab96] | $−0.39$ | [Ab96] |
| I$^{−}$− | W:018 | [Dave87a] | | | | | | $\approx 150^°C − 250°C$ | [Dave87a] | probably isoelectronic | [Dave87] |
| B$^{+}$ | B$^{0}$ | B$^{−}$ | | | anneal at RT negative-U | [Wat80] | $−0.45$ | [Wat80] |
| B$^{+}$ | B$^{0}$ | B$^{−}$ | | | anneal at RT | [Wat80] | $−0.13$ | [Wat80] |
| B$^{+}$ | B$^{0}$ | B$^{−}$ | | | $\uparrow$ recombination enhanced dissociation | [Sch08] | $+0.30$ | | |
| B$^{+}$ | B$^{0}$ | B$^{−}$ | | | $\approx 157^°C$ | [Sch08] | | | |

Ref. RESEARCH: DEFECTS AND IMPURITIES IN SILICON
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>C&lt;sup&gt;−&lt;/sup&gt;</td>
<td>Si-L6</td>
<td>930, 921</td>
<td>0.856</td>
<td>[Son90a]</td>
<td>□ 5 × 10⁻¹⁰, 0.74, 30-70°C □ 1 × 10⁻⁹, 0.75, 30-70°C</td>
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<td>-0.110, 6 × 10⁻¹⁵, 48, 57</td>
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<td>A&lt;sup&gt;0&lt;/sup&gt; → B&lt;sup&gt;0&lt;/sup&gt;, 1.1 × 10⁻¹⁰, 0.16, 55 K (RB)</td>
<td>[Son90b]</td>
<td>-0.17 (compare VO&lt;sub&gt;2&lt;/sub&gt;) +0.086, &gt; 10⁻¹⁰</td>
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<td>C&lt;sup&gt;−&lt;/sup&gt;</td>
<td>Si-G11</td>
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<td>C&lt;sup&gt;+&lt;/sup&gt;</td>
<td>B&lt;sup&gt;−&lt;/sup&gt;, B&lt;sup&gt;0&lt;/sup&gt;</td>
<td>Si-L7</td>
<td>G 0.969</td>
<td>[Son90b]</td>
<td>B&lt;sup&gt;−&lt;/sup&gt; → A&lt;sup&gt;−&lt;/sup&gt;, 1.4 × 10⁻¹⁰, 0.145, 50 K (ZB)</td>
<td>[Jed82]</td>
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<td>□ 2.5 × 10⁻¹³, 1.7, 250°C</td>
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<td>B&lt;sup&gt;−&lt;/sup&gt; → A&lt;sup&gt;−&lt;/sup&gt;, 2.5 × 10⁻¹³, 0.21, 70 K (ZB)</td>
<td>[Zho92]</td>
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Table B.1: Review of identified defects (see text for details.)
LIST OF FIGURES
The text is not clearly visible in the provided image. It appears to be a page from a document, possibly a scientific or technical paper, but the content is not legible. The text includes scientific terms and phrases, indicating it might be related to physics or a similar field. Without clearer visibility, it's challenging to provide a meaningful transcription or analysis.
Acknowledgements