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Semiconductor

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ABSTRACT

Semiconductors, with their unique ability to manipulate electrical conductivity, have become the cornerstone of the technological revolution sweeping across the globe. This research paper delves deep into the world of these extraordinary materials, exploring their fundamental properties, diverse applications, and the frontiers of research pushing the boundaries of what's possible. From the ubiquitous transistors powering our smartphones to the solar panels capturing the sun's energy, semiconductors have woven themselves into the very fabric of our lives. This voyage of discovery aims to illuminate the enigmatic nature of these materials, their impact on the present, and their potential to shape the future.

Keywords: Semiconductor, Conductivity, Crystal Diode

I. INTRODUCTION

A semiconductor is a material whose electrical conductivity falls between that of a good conductor (like copper) and an insulator (like glass). Its conductivity can be vastly modulated by adding small amounts of impurities (doping), making it the crucial building block of modern electronics. Imagine a switch that can control the flow of electricity with incredible precision – that's the essence of a semiconductor.

Detailed Information

History of Semiconductor

The discovery of semiconductors was a gradual process with many contributors. Early observations of the rectifying properties of certain materials like galena (lead sulfide) led to the invention of the crystal diode in 1906. Later, in the 1930s, researchers like Karl Lark-Horovitz and Walter Schottky further explored the conductivity properties of semiconductors. The invention of the transistor in 1947 by William Shockley, John Bardeen, and Walter Brattain marked a crucial turning point, solidifying the role of semiconductors in electronics.

Properties of Semiconductor

Conductivity modulation: As mentioned earlier, doping allows precise control over the conductivity of semiconductors, unlike conductors whose conductivity is fixed.

Temperature dependence: Unlike metals, the conductivity of semiconductors increases with temperature due to thermally generated free electrons and holes.

Light sensitivity: Certain semiconductors alter their conductivity when exposed to light, forming the basis of solar cells and photodetectors.

Rectification: Semiconductors can convert alternating current (AC) to direct current (DC), a crucial property in power

electronics.

Types of Semiconductors

Intrinsic Semiconductor

Imagine a pristine semiconductor, like pure silicon. Its valence band, packed with tightly bound electrons, separates from the conduction band by a forbidden energy gap. At absolute zero, no electrons possess enough energy to leap across this gap, rendering the material an insulator. But as temperature rises, some electrons gain enough thermal energy to jump, leaving behind "holes" in the valence band. These excited electrons and their corresponding holes become the charge carriers, enabling minimal conductivity, hence the "intrinsic" moniker.

Extrinsic Semiconductors

Here's where things get exciting! We can dope an intrinsic semiconductor with tiny amounts of impurities, fundamentally altering its conductivity. This doping creates two main types:

N-type semiconductors: Introducing elements from Group V (e.g., phosphorus) adds extra electrons to the crystal lattice. These loosely bound "donor" atoms readily release their electrons, increasing the number of free electrons and making them the majority carriers. N-type semiconductors conduct like metals, with electrons flowing from low to high potential.

P-type semiconductors: Doping with Group III elements (e.g., boron) creates "acceptor" atoms with missing electrons. These vacancies, called holes, act as positive charge carriers. Holes move in the opposite direction of electrons (high to low potential), contributing to p-type conductivity.

II. ADVANTAGES

Precise control over conductivity: Enables diverse functionalities and miniaturization of electronic devices.

Energy efficiency: Compared to earlier technologies, semiconductors consume less power, leading to longer battery life and reduced heat generation.

Scalability: Semiconductor fabrication allows for mass production of highly complex integrated circuits at affordable costs.

III. DISADVANTAGES

Sensitivity: Susceptible to ESD, heat, and light, necessitating careful handling and design considerations.

Manufacturing complexity: Fabrication of advanced chips requires sophisticated and expensive processes.

Environmental impact: Some aspects of semiconductor production raise concerns about resource depletion and waste generation.

IV. APPLICATION

Semiconductors are the backbone of modern electronics, used in:

Integrated circuits (ICs): Microchips containing billions of transistors, forming the core of computers, smartphones, and other devices.

Transistors: The fundamental building block of modern electronics, controlling and amplifying electrical signals.

Diodes: Allow current to flow in one direction, used in rectifiers and voltage regulation.

Solar cells: Convert sunlight into electricity, contributing to renewable energy.

LEDs: Emit light efficiently, replacing traditional incandescent bulbs.

Sensors: Detect various physical and chemical parameters, used in medical devices, security systems, and environmental monitoring.

V. CONCLUSION

Semiconductors have transformed our world, powering information technology, communication networks, renewable energy solutions, and countless other advancements. As research continues to push the boundaries, we can expect even more remarkable advancements in the years to come. From personalized healthcare to sustainable energy solutions, the possibilities enabled by these versatile materials are truly boundless. However, challenges lie ahead. Ensuring responsible sourcing and addressing the environmental impact of semiconductor production are crucial considerations. Additionally, the rapid pace of technological progress necessitates fostering a diverse and inclusive workforce equipped with the skills and knowledge necessary to navigate the complexities of this field. In conclusion, semiconductors stand as a testament to human ingenuity and a beacon of hope for a brighter future. By nurturing a spirit of scientific exploration, embracing a commitment to sustainability and inclusivity, and harnessing the transformative power of these enigmatic materials, we can collectively build a world driven by innovation, opportunity, and progress.

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