# A Review on Semiconductor Technology In Nanowires & Its Applications

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***Abstract***- *Semiconductor technologies have witnessed remarkable advancements in modern years, paving the way for pioneering innovations across various industries. This review paper aims to provide an overview of the latest developments in new semiconductor technologies and their diverse applications. The paper begins by highlighting the key challenges faced by traditional semiconductor materials and manufacturing processes, which have necessitated the exploration of alternative approaches. It then practice into the emerging semiconductor technologies that have gained prominence, such as organic semiconductors, nanowires and two-dimensional materials. Each of these technologies is discussed in terms of their unique properties, fabrication technique and potential applications, in the field of nanotechnology. Furthermore, the review paper is an effort to expose the application areas where these new semiconductor technologies have demonstrated significant potential. The findings of this contributes to the understanding of the current state of the field and shed light on the opportunities and challenges that lie ahead researchers, engineers and industry professionals in the semiconductor industry.*

***Keywords***- Semiconductor materials, Nanotechnology, Nanowires-Applications, Semiconductors- Manufacturing Process.

## I. INTRODUCTION

Semiconductor technologies have been at the forefront of technological advancements, driving innovation across various industries. In recent years, there has been a growing interest in exploring new semiconductor materials and fabrication techniques to overcome the limitations of traditional semiconductor technologies. This has led to the emergence of exciting new semiconductor technologies that hold tremendous potential for diverse applications. The continuous demand for smaller, faster and more efficient electronic devices has prompted researchers and engineers to seek alternatives to conventional silicon-based semiconductors.**[1][2][3].** New semiconductor technologies, such as organic semiconductors, nanowires and two-dimensional materials, have emerged as promising candidates for overcoming the challenges faced by traditional materials. Organic semiconductors offer flexibility, low-cost fabrication and compatibility with large-area manufacturing processes. They have paved the way for the development of flexible and wearable electronics, enabling innovative applications in areas such as smart textiles, electronic skin and flexible displays.

## II. INTRODUCTION TO SEMICONDUCTOR MATERIALS

Nanowires, on the other hand, possess unique properties due to their nanoscale dimensions. These one-dimensional structures exhibit superior electrical and optical properties, making them suitable for high-performance transistors, sensors and energy harvesting devices. Nanowire-based semiconductor technologies have the potential to revolutionize fields like electronics, photonics and energy conversion.

Two-dimensional materials, such as graphene and transition metal dichalcogenides (TMDs), have also gained significant attention in recent years. These atomically thin materials possess remarkable electrical, thermal and optical properties, making them ideal for next-generation electronics and optoelectronics. Two-dimensional semiconductor technologies hold promise for applications in ultra-thin transistors, photo detectors and quantum devices. The application areas for these new semiconductor technologies are diverse and far-reaching. Optoelectronics, including light-emitting diodes (LEDs) and solar cells, can greatly benefit from the unique properties of these materials. Flexible and wearable electronics offer new possibilities in consumer electronics, healthcare monitoring, and human-machine interfaces. Energy harvesting and storage devices can harness the efficiency and scalability of new semiconductor materials for renewable energy systems. Sensors with enhanced sensitivity and selectivity can find applications in environmental monitoring, healthcare and industrial sectors. Furthermore, the field of quantum computing holds promise for exponential computational power and solving complex problems.

## III. SEMICONDUCTOR MATERIALS USED IN NANOTECHNOLOGY –NANOWIRES

One-dimensional nanostructures are generally cited as nanowires, nanofibers, nanotubes and so on. The foremost prominent feature of these materials is their electrical conductivity, which, unlike classical physics, doesn't increase their resistance because the diameter decreases. The wire is usually a structure that extends in one direction (longitudinal direction) and is extremely limited within the other two directions. A vital feature of those structures, which has two outputs, is electrical conductivity.

## IV. VARIOUS TYPES OF NANOWIRES WITH THEIR DIVERSE APPLICATIONS [10]

| Types of Nanowires | Applications of Nanowires |
|---|---|
| Silicon | Electronics, biosensors, Electroluminescence |
| Germanium | Electronics, IR detectors |
| GaAs | High speed electronics, Photoconductive roles |
| InAs | Photodetector, Solar cell, NWFET, Tunnel diode,<br>TFET, SET |
| InP | NWFET, Single-photodetectors, Single-photon dete<br>ctor, Tunnel diode |
| GaP | Single-photonsource, Photodetector, Solar cell |
| Ag NWs | Wearable devices |
| CuO NWs | Electronic-conductor |
| Zn NWs | Optoelectronics, light emitters and lasers |
| DNWs | Radiation particle detectors, UV-light detectors and emitters, high-speed and high-power field effect transistors, field emission sources, position-sensitive biochemical substrates, and room temperature-stabilized high-efficiency single-photon emitters. |
| Cadmium telluride | IR detectors for various wavelengths |

## V. SEMICONDUCTOR MANUFACTURING PROCESS- (GENERAL PROCESS) [11]

Semiconductor devices are built up in a series of nanofabrication processes performed on the surface of substrates made from highly pure single crystal silicon. These substrates are usually known as wafers.

Commonly used wafers include the 300 mm type, which offers the advanced miniaturization required for cutting-edge devices and 200 mm type, which is better suited to the mixed, small lot production needed for devices for the Internet of Things (IoT).

1. Cleaning

The silicon wafers forming the base of the semiconductor are cleaned. Even slight contamination of a wafer will cause defects in the circuit. Therefore, chemical agents are used to remove all contamination, from ultra-fine particles to minute amounts of organic or metallic residues generated in the production process or unwanted natural oxide layers generated due to exposure to air. Refer Fig. 1 Wet Station: FC-3100 Single Wafer Cleaner: SU-3200, SU-3300, SU-3400

2. Film Deposition

Thin film layers of silicon oxide, aluminum and other metals that will become the circuit materials are formed on the wafer. There are a variety of ways to form these thin films, including "sputtering", in which a target material, such as aluminum or other metal, is bombarded with ions, which knocks off atoms and molecules that are then deposited on the wafer surface, "electrodeposition", which is used to form copper wire layers (copper interconnect), chemical vapor deposition (CVD), in which special gases are mixed to cause a chemical reaction that forms a vapor containing the desired material and then the molecules generated in the reaction are deposited onto the wafer surface to form a film and thermal oxidation, in which the wafer is heated to form a silicon oxide film on the wafer surface. Refer Fig. 2

3. Post-deposition Cleaning

Minute particles adhering to the wafer after the film deposition are removed using brushes or Nanospray with deionized water or other physical cleaning methods. Refer Fig. 2 Spin Scrubber: SS-3200 Single Wafer Cleaner: SU-3200, SU-3300, SU-3400

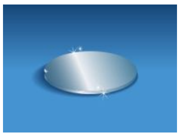
Fig-1 Cleaning

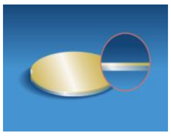
Fig-2 Film Deposition

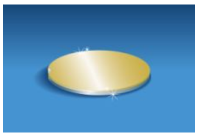
Fig-3 Post-deposition Cleaning

4. Resist Coating

The wafer surface is coated with resist (photosensitive chemical). Then the wafer is spun, causing a uniform layer of resist to be formed on the wafer surface by centrifugal force. Coat/Develop Track: DT-3000, SK-60EX/SK-80EX, SC-80EX Refer Fig. 4

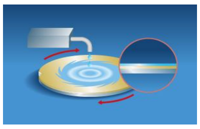
Fig.4. Resist Coating

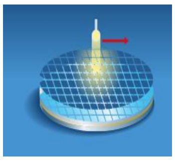
Fig. 5. Exposure

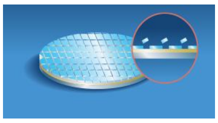
Fig.6 Development

5. Exposure

The wafer is exposed using short wavelength deep ultraviolet radiation projected through a mask on which the circuit pattern has been formed. Only the areas of the resist layer that are exposed to the light undergo a structural change, thereby transferring the pattern to the wafer. There are a variety of exposure units, including steppers, which expose several chips at a time and scanners, which expose the wafer using a slit through which light is projected onto the wafer. Refer Fig. 5

6. Development

Developer is sprayed onto the wafer, dissolving the areas exposed to the light and revealing the thin film on the wafer surface. The remain-ing resist areas that are not exposed at this point become the mask for the next etching process and that resist pattern becomes the pattern on the layer below. Coat/Develop Track:DT-3000, SK-60EX/SK-80EX Refer Fig. 6

7. Etching

In wet etching, the exposed thin film on the surface layer is dissolved using chemicals, such as hydrofluoric acid or phosphoric acid, and removed. This forms the pattern. There is also a dry etching method in which the wafer surface is bombarded with ionized atoms to remove the film layer.

Wet Station: FC-3100, Single Wafer Cleaner: SU-3200, SU-3300, SU-3400 Refer Fig. 7

8. Implantation of Impurities

In order to give the silicon substrate semiconducting properties, impurities, such as phosphor or boron ions, are implanted in the wafers. Refer Fig. 8

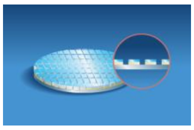
Fig. 7. Etching

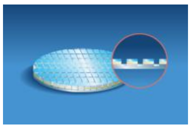
Fig.; 8. Implantation of Impurities

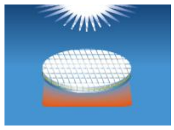
Fig. 9. Activation

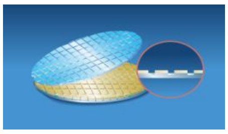
Fig. 10. Resist Stripping

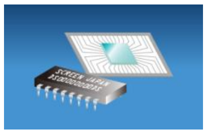
Fig. 11. Assembly

9. Activation

Heat processing is performed using flash lamps or laser radiation to activate the doped ions implanted in the wafer. Instantaneous activation is required to create the micro transistors on the substrate. Refer Fig. 9
Flash Lamp Annealing System:LA-3100

10. Resist Stripping

W Resist can be stripped off at a wet station, which uses chemicals that remove the resist or by ashing, which removes the resist by inducing a chemical reaction using gases. The wafer is cleaned after the ashing. Refer Fig. 10
Wet Station:FC-3100
Single Wafer Cleaner:SU-3200, SU-3300, SU-3400

11. Assembly

The wafer is separated into individual chips (dicing), the chips are connected to a metal frame called a lead frame using metal wire (wire bonding) and then enclosed in epoxy resin material (packaging). Refer Fig. 11

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