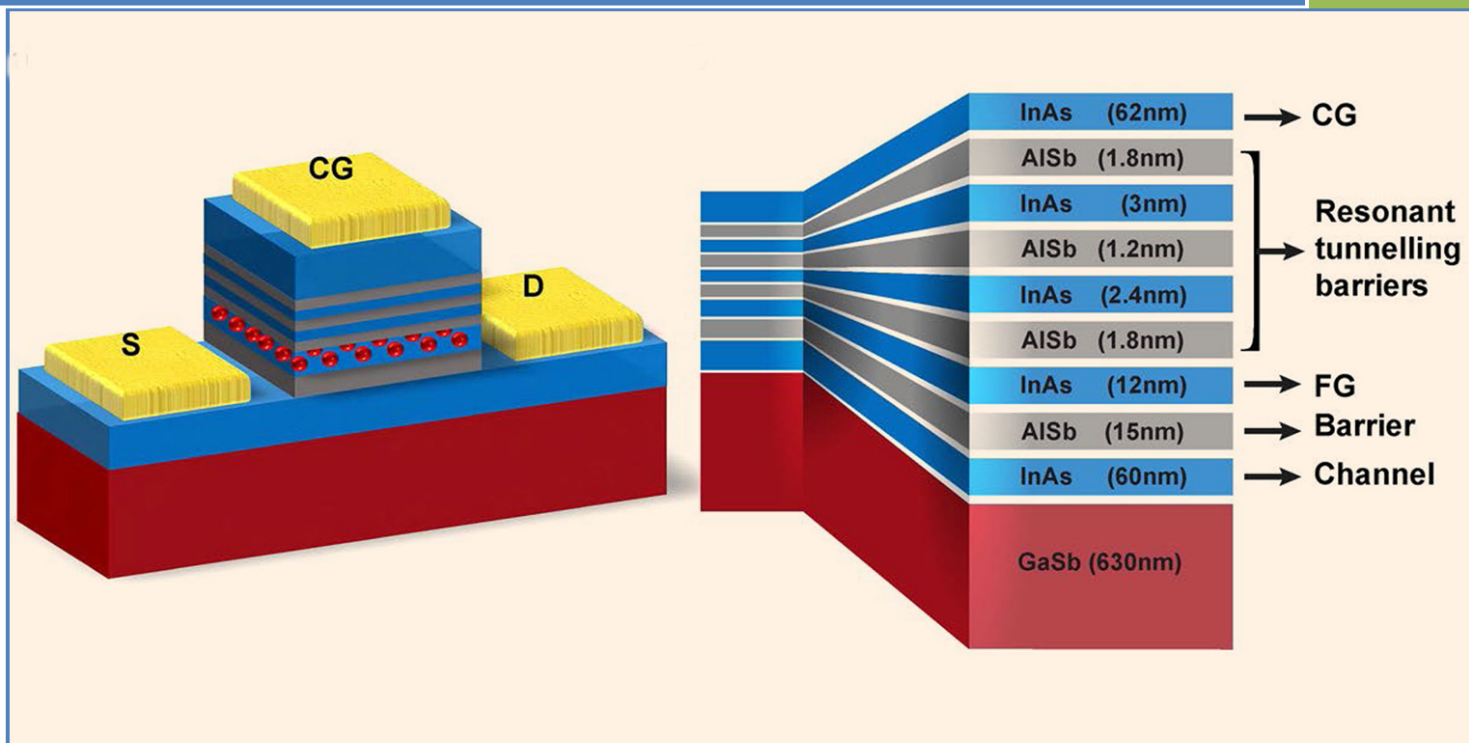




2024

IMPULSE



NEWSLETTER

Team Members

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Editorial Board: Mr. Tirthadip Sinha

*Electronics & Communication Engineering
Haldia Institute of Technology*

2024

The Institute's Vision and Mission

Vision

To achieve Centre of Excellence in the field of Science, Technology and Management Education for creating dynamic human resources of global standards with capabilities of accepting new challenges.

Mission

- ✓ To impart quality and value based education to raise satisfaction level of all stakeholders.
- ✓ To create competent, creative professionals, and great entrepreneurs who can work as individual or in group in multi-cultural global environments.
- ✓ To prepare citizens who would grow to be competent enough to contribute significantly with personal integrity and civic responsibility for the betterment of mankind throughout their careers and profession.

Department Vision and Mission

Vision:

To produce dynamic human resources of global standards by imparting quality teaching, carrying out research and technology development in the emerging areas of Electronics & Communication Engineering.

Mission:

- ✓ To produce electronics and communication engineers having strong theoretical foundation, good design experience and exposure to research and technology development in frontier areas of electronics and communication engineering.
- ✓ To create competent professionals who can work as an individual or in a group with effective communication and leadership skills meeting the requirements of multi-cultural global environments.
- ✓ To help the student be a successful and responsible engineer for the betterment of mankind by inculcating social and ethical values in professional engineering programme.

Program Educational Objectives (PEOs)

PEO-1: To equip graduates with strong foundation in Electronics and Communication Engineering with an objective of being real time problem solvers.

PEO-2: To provide exposure to emerging technologies in order to become competent both as an individual and team with ever changing industrial requirements.

PEO-3: To prepare successful and responsible engineering graduates with socio-ethical values and leadership qualities in professional engineering practices.

Program Specific Outcomes (PSOs)

After completion of the program, the students will have ability to:

PSO-1: Apply basic knowledge in diversified fields of Electronics and Communication Engineering to solve engineering and socio-ethical problems.

PSO-2: Design, Verify and Validate electronic functional elements for a variety of experiments and projects with skills to analyze, interpret and communicate results either independently or in teams.

PSO-3: Recognize contemporary issues to adapt lifelong learning and develop consciousness for technical, professional, managerial and legal responsibilities.



IMPULSE

Vision

IMPULSE is a yearly newsletter to share upcoming technologies in various fields of Electronics & Communication Engineering. This issue of newsletter introduced the advanced research topics in the field of Device and Materials Science. These brief technical articles will influence many students and faculty members to extend research works in these fields in near future.

Content

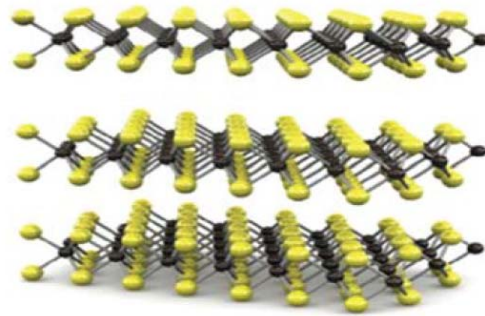
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New 2-D Quantum Materials for Nano Electronics

Dr. Kushal Roy, Assistant Professor, ECE

In this 21st century we are enjoying well developed electronics. The field of electronics has got tremendous impact on the contemporary society and in plenty of real time applications. The revolution in electronics is through the discovery of the transistors. They have been considered as the backbone of the development of electronics and electronic era because the real electronics what it is called today was actually started after the visualization of transistor effect. Transistor opened the road for the electronics and there after electronics got its independent identity in electronics engineering. More importantly it laid the path for the progress of computing world. Surprisingly, our scientists gave birth to the idea of assembling many electronic components on a single mother board called INTEGRATED CIRCUIT. In 1965 Gordon Moore came out with an awesome paper called “Cramming more Components onto Integrated Circuits”. In that paper he described that the number of transistors used on a single chip of silicon will grow exponentially. Modern technology is characterized by its emphasis on miniaturization and at the same time with improved efficiency and less power consumption. This paper will show case such devices with a family of new two dimensional (2-D) materials exhibiting exotic quantum properties that may enable a variety of nanoscale electronics. These 2-D materials are predicted to show a phenomenon called the quantum spin Hall (QSH) effect, and belong to a class of materials known as transition metal dichalcogenides (TDMC), with layers a few atoms thick. Using these materials a design for a new kind of transistor called a

topological field-effect transistor, or TFET, is being made by scientists at MIT. The design of this device is based on a single layer of the 2-D material sandwiched by two layers of 2-D boron nitride. Such devices could be produced at very high density on a chip and have very low losses, allowing high-efficiency operation.



Schematic model of transition metal dichalcogenide atomic layers.

Nanotechnology is the understanding and control of matter at dimensions between approximately 1 and 100 nanometers (nm), where unique phenomena enable novel applications not feasible when working with bulk materials or even with single atoms or molecules. It has wide range of applications such as boat hulls, sporting equipment and automotive parts, sunscreens and cosmetics. A thought provoking application of nanotechnology has made on a family of two-dimensional materials exhibiting exotic quantum properties that may enable a new type of nanoscale electronics. These materials are predicted to show a phenomenon called the Quantum Spin Hall (QSH) effect and belong to a class of materials known as transition metal dichalcogenides, with layers a few atoms thick. QSH materials have the unusual property of being electrical insulators in the bulk of the material, yet highly conductive on their edges. This could potentially make them a suitable material for new kinds of quantum electronic devices. This could further lead

to new kinds of low-power quantum electronics, as well as spintronics devices — a kind of electronics in which the spin of electrons, rather than their electrical charge, is used to carry information. These compounds naturally form thin sheets, just atoms thick, that can spontaneously develop a dimerization pattern in their crystal structure resulting a design for new kind of transistor based on the calculated effects called a topological field-effect transistor, or TFET, the design is based on a single layer of the 2-D material sandwiched by two layers of 2-D boron nitride. These devices could be produced at very high density on a chip and have very low losses, allowing highefficiency operation. In addition, this is one of the most promising known materials for possible use in quantum computers. This exciting result will bridge two very active subfields of condensed matter physics, topological insulators and dichalcogenides.

Perovskites: A Revolution in Materials Science

Dr. Dibyendu Chowdhury, Assistant Professor, ECE

Perovskites are a class of materials that have captured the attention of researchers and engineers due to their exceptional properties and versatility. Originally named after the mineral perovskite, discovered by Russian mineralogist Lev Perovski in the 19th century, the term now refers to a broader group of materials that share a unique crystal structure. The general formula for perovskite materials is ABX_3 , where "A" and "B" are cations (positively charged ions), and "X" is an anion (negatively charged ion) that binds the cations together. This structure provides the

foundation for perovskite materials' remarkable range of applications, particularly in electronics and energy.

- **The Structure Behind the Power:**

The perovskite structure is made up of a three-dimensional framework, where the larger "A" cations sit at the corners of the cube, the smaller "B" cations are in the center, and the "X" anions fill the spaces between them. This arrangement allows perovskites to exhibit tunable electronic, optical, and chemical properties. The ability to easily substitute different atoms within the structure is a key reason why perovskites can be customized for various applications, from solar cells to LEDs.

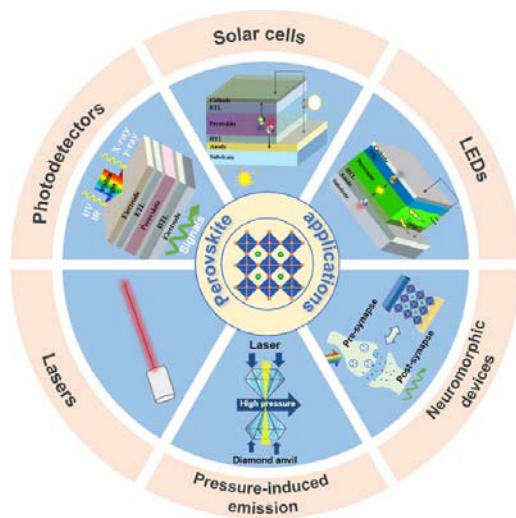
- **A Breakthrough in Solar Cells:**

One of the most significant areas of research for perovskites is in solar cell technology. Perovskite solar cells (PSCs) have emerged as a promising alternative to traditional silicon-based solar panels. These cells offer a combination of high power conversion efficiency and low manufacturing costs. Since their introduction in the early 2000s, perovskite solar cells have seen remarkable improvements in efficiency, with some lab-grown cells reaching over 25% efficiency, close to the levels of conventional silicon cells.

The primary advantage of perovskite solar cells is their simple and cost-effective manufacturing process. Traditional silicon solar cells require high-energy, high-temperature procedures, whereas perovskite solar cells can be produced using low-cost, solution-based methods like spin-coating and inkjet printing. This makes them particularly attractive for large-scale production, potentially revolutionizing the solar energy industry by making solar power more affordable and accessible.

- **Other Applications: LEDs, Photodetectors, and More:**

Beyond solar cells, perovskites show great promise in other areas of electronics. For example, in light-emitting diodes (LEDs), perovskites can provide more efficient and brighter light emissions compared to conventional materials. Their tunable optical properties allow for precise control over the emitted light's wavelength, making them ideal for display technologies and lighting applications.



Perovskites also have potential in photodetectors, used in imaging and sensing systems. The ability to detect light across a wide spectrum of wavelengths makes them useful for applications ranging from night vision cameras to medical imaging.

- **Challenges and Future Directions:**

Despite their potential, perovskite materials face several challenges. The most notable issue is stability. Perovskite solar cells, for instance, can degrade when exposed to moisture, oxygen, and UV light, which limits their long-term viability. Researchers are actively working to improve the durability of perovskites by exploring various encapsulation techniques and stabilizing materials.

Another challenge is the use of lead in many high-performance perovskite solar cells. Lead toxicity raises environmental and health concerns, prompting research into lead-free alternatives. Materials like tin-based perovskites and other non-toxic elements are being explored as potential solutions.

- **The Future of Perovskites:**

Perovskite materials are reshaping the future of technology, especially in energy and electronics. Their unique properties offer new possibilities for renewable energy, lighting, and advanced electronic devices. While there are still hurdles to overcome, the continued research into their stability and sustainability could lead to a new era of high-performance, cost-effective materials. As these challenges are addressed, perovskites have the potential to drive significant innovations, contributing to a more sustainable and energy-efficient world.

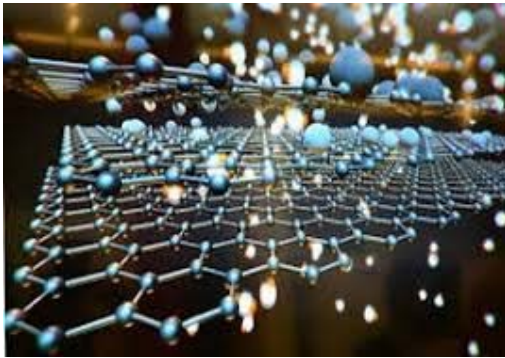
Memory Devices Using Graphene: The Future of High-Speed Storage

Prof. (Dr.) Malay Kumar Pandit, Professor, ECE

Graphene, a single layer of carbon atoms arranged in a two-dimensional honeycomb lattice, has rapidly gained attention for its remarkable electrical, thermal, and mechanical properties. Since its discovery in 2004, graphene has been heralded as a material with vast potential for a wide range of applications in electronics, energy storage, and materials science. One of the most exciting possibilities lies in its use for memory devices, where its unique properties could revolutionize how data is stored and accessed in the digital age.

- **The Promise of Graphene in Memory Technology**

Memory devices are the cornerstone of modern computing, with applications ranging from personal computers to data centers and embedded systems in everyday devices. Traditionally, memory technologies have relied on silicon-based materials, such as DRAM (Dynamic Random-Access Memory) and flash memory. However, as the demand for faster, more efficient memory increases, silicon-based devices face limitations in terms of speed, power consumption, and scalability. This is where graphene comes in.



Graphene's exceptional electrical conductivity and high surface area make it an ideal candidate for developing memory devices that offer faster data retrieval times, lower power consumption, and improved durability compared to conventional memory technologies.

- **Types of Memory Devices Using Graphene:**

1. **Graphene-Based Resistive RAM (ReRAM):** One promising area of research is Graphene-based Resistive Random-Access Memory (ReRAM), a type of non-volatile memory that stores data by changing the resistance of a material. In ReRAM, the data is stored in the form of different resistance states, which can be read by applying a small voltage. Graphene, combined with

transition metal oxides, is being explored as a potential material to replace traditional metal electrodes in ReRAM devices. The high conductivity of graphene allows for faster switching speeds, enabling quicker read and write operations.

2. **Graphene Field-Effect Transistors (FETs) in Memory:** Graphene Field-Effect Transistors (FETs) are another avenue for memory devices. Graphene FETs have the potential to revolutionize the speed and efficiency of memory storage. These transistors can switch between different states at incredibly high speeds, providing faster access to data. Additionally, when combined with materials like boron nitride or other two-dimensional materials, graphene FETs could enable the development of ultra-fast and low-power memory systems.
3. **Graphene-Based Flash Memory:** Traditional flash memory is based on charge storage, which can degrade over time, leading to a limited number of read and write cycles. Researchers are investigating graphene as a material for improving flash memory, specifically in reducing the wear and tear on storage cells and enhancing the endurance of the device. Graphene's high mechanical strength and flexibility could allow for more durable flash memory with longer lifespan cycles.
4. **Spintronic Memory Using Graphene:** Spintronic memory is an emerging technology that utilizes the intrinsic spin of electrons in addition to their charge for data storage. Graphene's unique electronic properties make it a suitable candidate for spintronic applications, potentially leading to more efficient memory devices. These devices could have higher data density and faster speeds, providing a significant leap over conventional magnetic storage.

- **Challenges and Future Directions:**

Despite the tremendous potential of graphene in memory devices, several challenges remain. For instance, graphene's lack of an inherent bandgap (the energy difference between the valence band and the conduction band) limits its use in conventional logic and memory devices. Researchers are actively investigating ways to introduce a bandgap into graphene through techniques like doping, strain engineering, or combining graphene with other materials.

Moreover, integrating graphene into large-scale manufacturing processes remains a challenge, particularly in terms of uniformity and scalability. However, as production methods improve, these hurdles are expected to be overcome.

- **Graphene's Role in the Future of Memory Devices:**

Graphene offers a promising future for next-generation memory devices. Its unique properties—high conductivity, flexibility, and strength—make it a strong contender for use in faster, more efficient, and more durable memory technologies. As research progresses and the challenges of scalability and integration are addressed, graphene could play a central role in transforming how data is stored and accessed in the digital era, ushering in a new age of ultra-fast and low-power memory systems.

Antenna Technology Using Organic Materials: A Sustainable Future for Wireless Communication

Dr. Avishek Das, Associate Professor, ECE

Antenna technology has come a long way since its inception, playing a crucial role in modern communication systems, from

mobile networks to Wi-Fi and satellite communication. Traditionally, antennas are made from metals like copper or aluminum, which offer high conductivity but can be bulky, rigid, and costly to produce. In recent years, however, there has been a shift towards using organic materials in the development of antennas. Organic materials—carbon-based compounds that are typically lightweight, flexible, and cost-effective—are being explored for their potential to revolutionize antenna design, offering a more sustainable and adaptable alternative to conventional metal-based systems.

- **The Advantages of Organic Materials in Antenna Design:**

1. **Flexibility and Lightweight:** Organic materials, particularly conductive polymers, are inherently flexible and lightweight. This property makes them ideal for applications that require antennas to be incorporated into wearable devices, smartphones, or even flexible electronics. Organic antennas can be seamlessly integrated into fabrics, packaging, or curved surfaces, opening up new possibilities for the Internet of Things (IoT) and wearable technology.
2. **Cost-Effectiveness:** The production of organic materials can be more cost-efficient compared to traditional metal antennas. Organic antennas can be fabricated using inexpensive techniques such as inkjet printing or screen printing, which are scalable and suitable for mass production. This reduces the cost of manufacturing, especially for consumer electronics that require large quantities of antennas.
3. **Environmental Sustainability:** Organic materials are often more environmentally friendly compared to metals, especially in terms of their lifecycle. Many organic compounds are derived from renewable resources, and the manufacturing processes tend to

require less energy. This makes organic antennas an attractive option for industries focused on sustainability and reducing the environmental impact of electronic waste.

4. **Tunable and Adaptive Properties:** Organic materials can be engineered to have tunable electrical properties, such as variable conductivity or dielectric constants. This allows for the design of adaptive antennas that can change their performance based on the environment, enabling more efficient use of the electromagnetic spectrum. For example, the performance of an antenna could be dynamically adjusted depending on the frequency range or directionality needed for communication.

- **Types of Organic Materials for Antenna Applications:**

1. **Conductive Polymers:** Conductive polymers, such as polyaniline, polypyrrole, and PEDOT:PSS, are the most commonly used organic materials in antenna design. These materials exhibit electrical conductivity similar to metals, making them suitable for wireless communication applications. Their conductivity can be tailored by doping or chemical modification, providing versatility in antenna performance.
2. **Carbon Nanotubes and Graphene:** Carbon-based nanomaterials like carbon nanotubes and graphene are also being explored for antenna applications. Their exceptional electrical conductivity, high surface area, and mechanical strength make them ideal candidates for improving the performance of organic antennas. Graphene, in particular, is known for its flexibility and conductivity, and when incorporated into organic materials, it can enhance the efficiency of the antenna, even at higher frequencies.

3. **Organic-Inorganic Hybrid Materials:** Hybrid materials, which combine organic polymers with inorganic compounds (such as metal nanoparticles), are another promising avenue for antenna design. These materials can leverage the advantages of both organic and inorganic components, improving the conductivity and performance of the antenna while maintaining the flexibility and ease of fabrication offered by organic materials.

- **Challenges and Future Directions:**

While organic materials present numerous advantages, there are challenges that must be addressed before they can replace traditional metallic antennas in mainstream applications. One of the main obstacles is their relatively lower conductivity compared to metals, which can limit the efficiency of the antenna, particularly at high frequencies. Research is ongoing to improve the conductivity and performance of organic materials, such as by doping them with conductive nanoparticles or combining them with other advanced materials.



Durability is another concern. Organic materials can be more susceptible to environmental degradation from

moisture, oxygen, or UV radiation, which may affect the longevity of the antennas. To combat this, protective coatings or advanced encapsulation techniques are being developed to enhance the stability of organic antennas.

- **A Bright Future for Organic Antennas:**

The potential of organic materials in antenna technology is vast, offering a combination of flexibility, cost-effectiveness, and sustainability that could transform how antennas are used in the future. With continued research and development, organic antennas could play a significant role in the next generation of wireless communication systems, powering everything from wearable devices to IoT networks. As these materials continue to evolve, we can expect to see a shift toward more adaptable, environmentally friendly, and affordable antenna solutions, driving innovation in the wireless communication landscape.

Gallium Nitride (GaN): A Game-Changer in Electronics and Power Systems

Ashutosh Anand, 4th Year, ECE

Gallium Nitride (GaN) is a wide-bandgap semiconductor material that has garnered significant attention in recent years due to its impressive properties and wide-ranging applications, particularly in power electronics and optoelectronics. GaN is composed of gallium (Ga) and nitrogen (N) and is part of a group of semiconductors known for their ability to operate at higher voltages, frequencies, and temperatures compared to traditional silicon (Si) semiconductors.

- **Key Properties of GaN:**

One of GaN's most important features is its wide bandgap of approximately 3.4 eV, which allows it to handle high-power applications more efficiently. This wide bandgap gives GaN devices the ability to function at higher temperatures and voltages without overheating or breaking down, unlike silicon-based components. GaN also has high electron mobility, enabling faster switching speeds and greater efficiency in electronic devices.



- **Applications of GaN:**

1. **Power Electronics:** GaN is widely used in power conversion systems, such as in electric vehicles, renewable energy inverters, and power supplies. GaN transistors and diodes offer higher efficiency and faster switching compared to traditional silicon devices, leading to smaller, lighter, and more energy-efficient systems.
2. **5G Communication:** GaN is also critical in the development of 5G technology. It is used in power amplifiers for base stations, where its ability to operate at higher frequencies and handle greater power ensures reliable communication with minimal signal loss.
3. **LEDs and Lasers:** GaN is a key material in blue and white light-emitting diodes (LEDs) and lasers. These devices are used in a wide variety of applications, from consumer electronics to medical and automotive lighting.

- **Conclusion:**

GaN's unique combination of high efficiency, power-handling capability, and fast switching speeds positions it as a transformative material for the future of electronics. As technology continues to advance, GaN is poised to play a critical role in improving the performance of everything from power systems to communication networks.

Silicon Carbide (SiC): The Future of High-Performance Electronics

Ashish Mishra, 4th Year, ECE

Silicon Carbide (SiC) is a semiconductor material that has become increasingly important in modern electronics, particularly for applications that require high power, efficiency, and thermal conductivity. Composed of silicon (Si) and carbon (C), SiC boasts remarkable properties that make it a superior choice over traditional silicon (Si) for certain high-performance applications.



- **Key Properties of SiC:**

SiC has a wide bandgap of about 3.26 eV, much higher than that of silicon (1.1 eV).

This allows SiC devices to operate at much higher temperatures, voltages, and frequencies, making them ideal for extreme environments. Additionally, SiC has excellent thermal conductivity, enabling better heat dissipation in high-power devices. The high breakdown electric field also allows SiC devices to handle higher voltages without breaking down.

- **Applications of SiC:**

1. **Power Electronics:** SiC is revolutionizing power electronics, especially in electric vehicles (EVs), power inverters, and industrial equipment. SiC-based transistors and diodes enable more efficient power conversion with less heat generation, leading to smaller and lighter power systems with improved energy efficiency.
2. **Electric Vehicles (EVs):** In EVs, SiC is used in the powertrain and battery management systems, helping to increase the overall efficiency and range of the vehicle by enabling faster charging and reducing energy loss.
3. **Renewable Energy:** SiC plays a vital role in renewable energy systems like solar and wind power by improving the efficiency of power inverters, which convert the energy into usable forms.

- **Conclusion:**

SiC is a game-changer in the field of electronics, offering superior performance over silicon in high-power, high-temperature, and high-efficiency applications. As industries continue to move towards more energy-efficient and sustainable solutions, SiC's role will only grow, powering everything from electric vehicles to renewable energy systems and beyond.