Compound Semiconductors Overview & Comparative Study

Dapsara Kapuge
2190009

1. Introduction

- What Are Semiconductors

  Electrical conductivity between conductors and insulators.

  Silicon (Si)
  Germanium (Ge)

- What Are Compound Semiconductors

  Materials formed by combining two or more elements

  Silicon Carbide(SiC)
  Gallium Nitride (GaN)
  Gallium Arsenide (GaAs)

2. Compound Semiconductor Materials

Bonding

- **Silicon Carbide(SiC)**

  Has a strong covalent bond
  Crystal structure
  4H-SiC.

- **Gallium Nitride (GaN)**

  Has a strong covalent bond
  Robust crystal structure
  has an ionic character

- **Gallium Arsenide (GaAs)**

  Has a strong covalent bond
  Zinc blende crystal structure
  Has an ionic character

Comparative Analysis

Property	Silicon Carbide (Sic)	Gallium Nitride (GaN)	Gallium Arsenide (GaAs)
Bandgap	3.26 eV	3.4 eV	1.42 eV
Electron Mobility	Moderate	High	Very High
Thermal Conductivity	High	Moderate	Low
Switching Frequency	High	Very High	Moderate
Temperature Tolerance	Very High	High	Moderate
Cost	Relatively High	High	Lower than SiC & GaN
Best User Cases	High-power Electronics	RF, High-frequency charges	Optoelectronic , RF Devices
Radiation Resistance	Excellent	Good	Moderate

3. User cases

- **Silicon Carbide (SiC)**

  SiC MOSFETs and Diodes
  Industrial Power Systems;power converters, motor drives, solar inverters and wind turbines
  High-voltage direct current (HVDC) systems
  Military radar and communications systems

- **Gallium Nitride (GaN)**

  Power Electronics and Fast Chargers
  5G network infrastructure,
  Audio amplifiers
  Medical equipment

- **Gallium Arsenide (GaAs)**

  High-speed digital circuits
  Radio frequency (RF) and microwave devices
  Optoelectronic Devices;LEDs, laser diodes, and photodetectors
  Satellite-based communication systems

4. Disadvantages

- **Silicon Carbide (SiC)**

  High Production Cost
  Manufacturing Complexity
  Limited Short Term Adoption

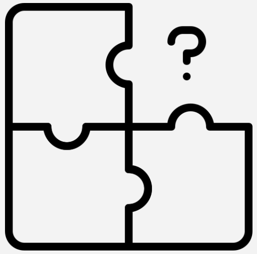
- **Gallium Nitride (GaN)**

  Cost
  Manufacturing Challenges
  Material Availability
  Limited Market Adoption

- **Gallium Arsenide (GaAs)**

  Fragility
  Thermal Conductivity
  Environmental and Safety Concerns:
  Limited Substrate Size

5. Can Silicon be Replaced in SoC Applications?



Compound semiconductors are more likely to coexist with silicon, complementing it in hybrid designs or specialized areas where their unique properties provide a distinct performance advantage.

SiC and GaN could dominate power management and high-efficiency modules within SoCs

GaAs may continue to lead in optoelectronics and RF applications

5. Future Trends

Advancements in SiC Wafer Technology
Integration with Other Semiconductors
Cost Reduction Strategies
Sustainable and Green Technology
Broader Market Penetration

7. Resources

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Thank You !