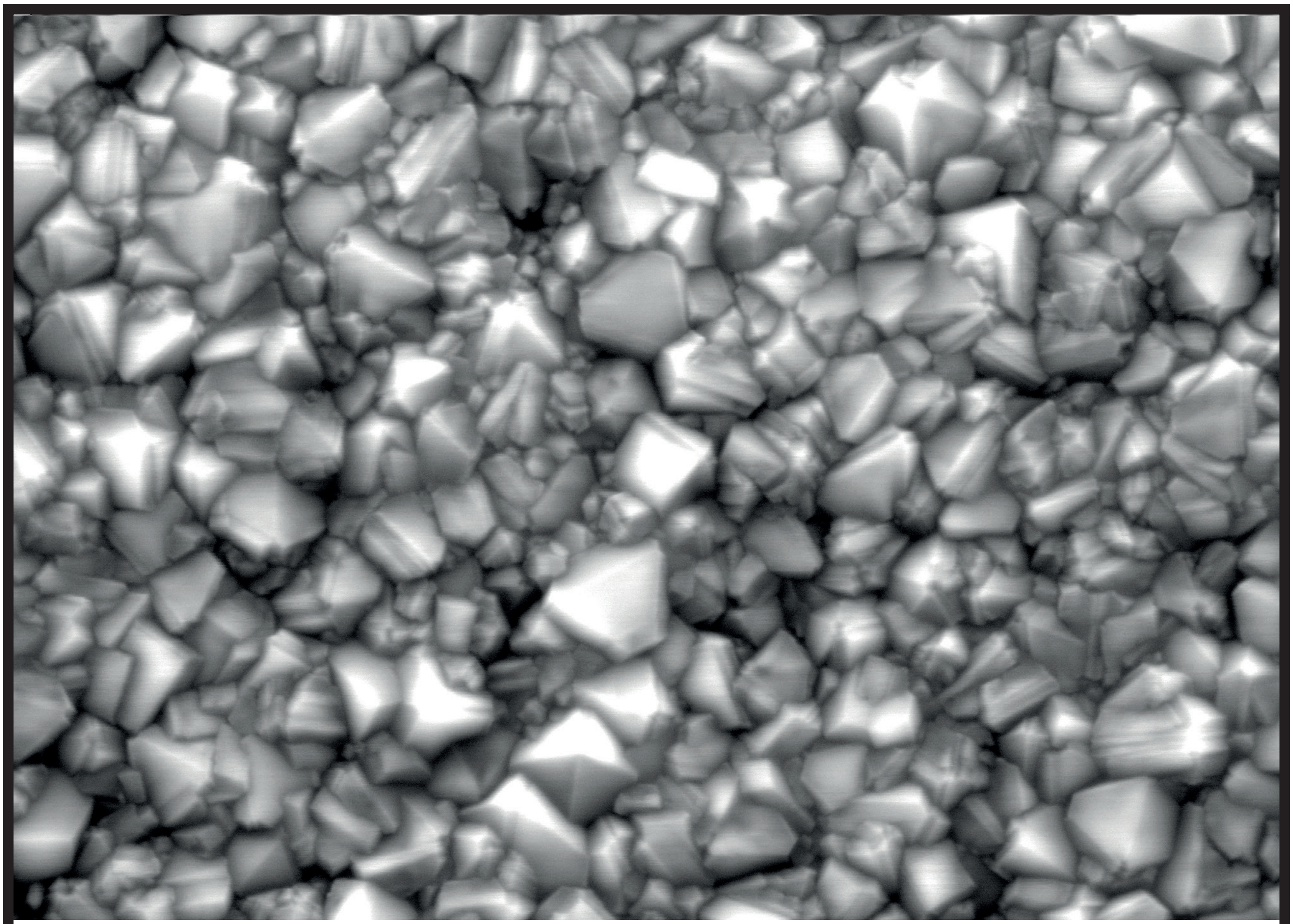

TECHNOLOGY OPPORTUNITY

Advanced Diamond Layer Growth on Ga-Based Semiconductor Substrates

OVERVIEW

Diamond is the best thermal conductor, and therefore is an ultimate material for use as a heat sink in Ga-based semiconductor devices. However, beyond a certain thickness, due to a thermal stress, a diamond layer has a tendency to peel off. Plasma chemistry used in chemical vapor deposition (CVD) diamond growth can also cause undesired etching of the Ga-based surfaces. Using an interfacial dielectric layer is an option that also helps to improve adherence of the diamond layer and prevent etching, however it reduces the thermal conductivity significantly. The current invention of imo-imomec, the joint research institute of Hasselt University and imec, enables the efficient growth of diamond layers directly on gallium-based (Ga-based) semiconductor substrates.

KEY INNOVATION

The invention is based on surface modification of a semiconductor device on which a diamond layer is to be formed. This surface modification can be obtained by fluorinating or sulfurizing the surface region of the Ga-layer and the optional metal layer. The diamond layer can then be formed on this intermediate structure by seeding of diamond nano-particles followed by diamond growth. This innovative approach delivers a diamond layer on Ga-based surface, with good attachment and thermal contact.

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UNIQUE FEATURES AND BENEFITS

1. **Direct Diamond Deposition**: Diamond layers are grown directly on Ga-based or metal substrates using fluorine (F) or sulfur (S) functionalization. This eliminates the need for interfacial dielectric layers, improving thermal conductivity and reducing complexity.
2. **Robust Adhesion**: The process ensures strong covalent bonding between the diamond layer and the substrate, preventing delamination and enabling arbitrary thickness growth.
3. **Low-Temperature Compatibility**: Diamond growth can occur at temperatures as low as 250°C, preserving substrate integrity and ensuring compatibility with thermal-sensitive materials.
4. **Customizable Functionalization**: The F or S treatment can be tailored to suit specific device requirements, enabling seamless integration in both p-type and n-type semiconductor architectures.
5. **Enhanced Thermal Management**: Diamond layers act as superior heat spreaders or sinks, boasting thermal conductivity above 2000 W/mK, making them ideal for high-power semiconductor devices like GaN-based transistors.
6. **Scalability**: The method utilizes accessible CMOS-compatible processes, allowing for economical large-scale manufacturing and adoption in conventional semiconductor fabrication lines.

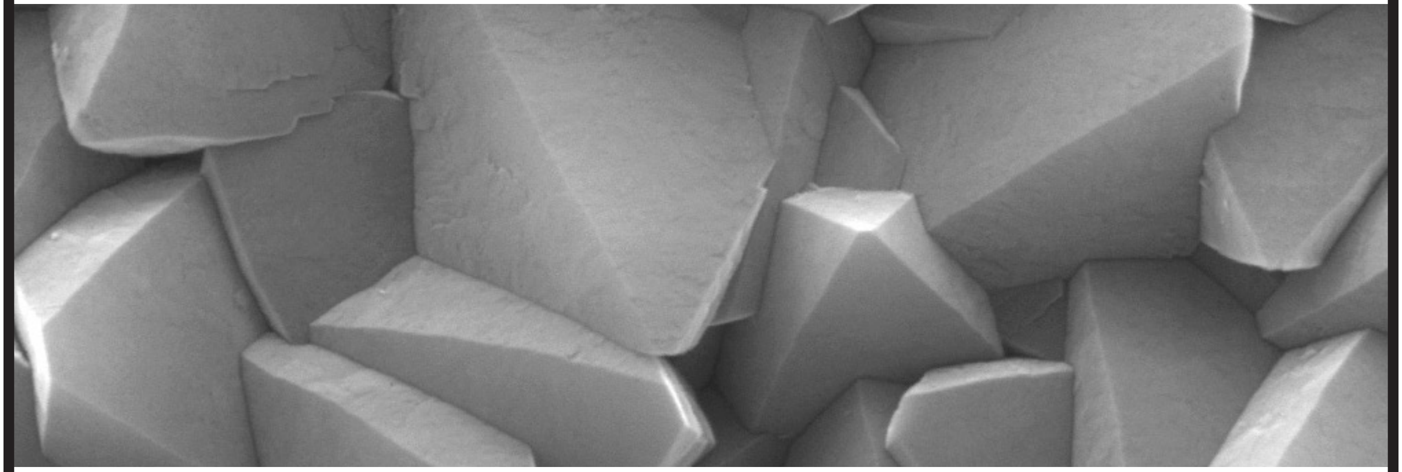
MARKET POTENTIAL

The demand for high-efficiency power electronics and advanced semiconductor devices is rapidly increasing, driven by trends in renewable energy, telecommunications, and consumer electronics. This technology addresses critical pain points in heat management and device longevity, offering a compelling value proposition for GaN-based semiconductor manufacturers. This technology can be applied in following domains:

1. **Electronics**:
   - GaN Transistors: Enhanced thermal dissipation improves device efficiency and reliability for RF and high-power applications.
   - LEDs: Diamond layers provide robust heat management for extended lifespan and higher performance.
2. **Thermal Management Systems:**
   - Heat sinks and spreaders for compact, high-performance devices like inverters and computing processors.
3. **Sensors and Specialized Devices:**
   - Integration of diamond with Ga-based substrates supports advanced bio- and quantum sensors with improved thermal and mechanical stability.

OPPORTUNITY

The invention has been protected through a patent application (EP 3745446). We are looking for companies interested in licensing this technology and/or in setting up an R&D collaboration.



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