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EPDT's Products of the Year

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PRODUCT OF THE YEAR
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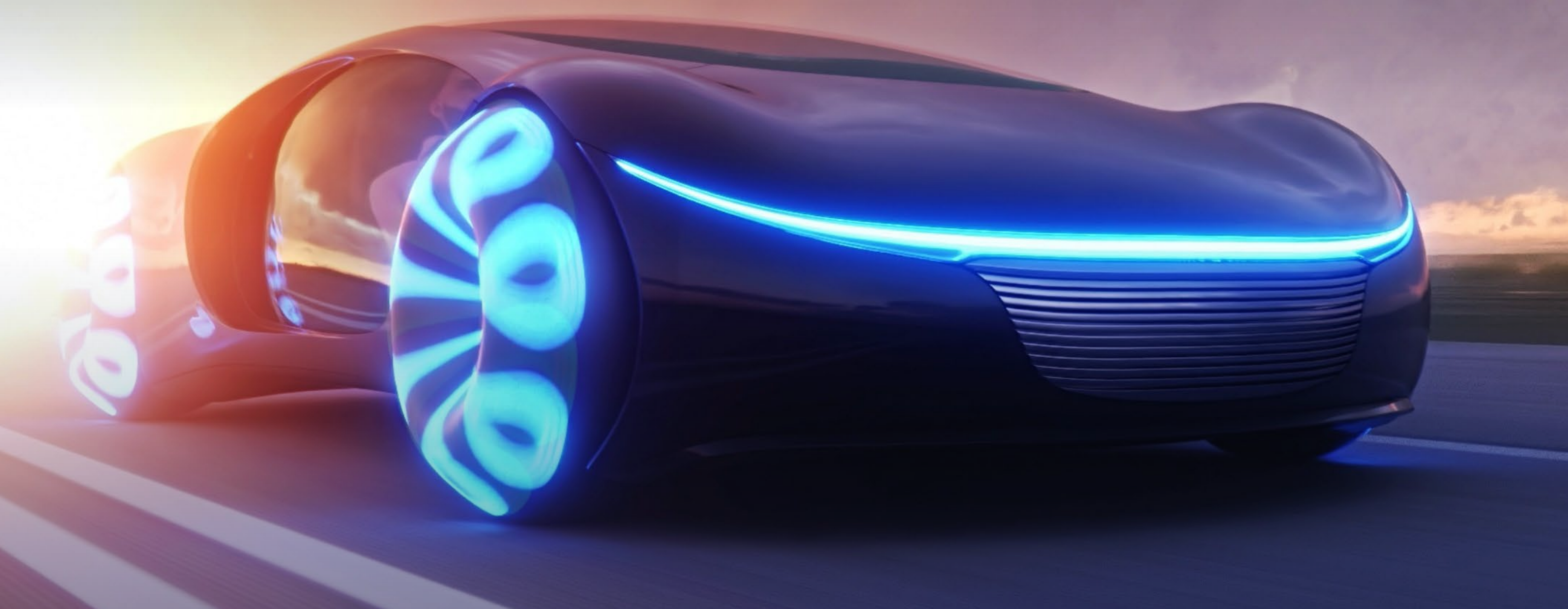
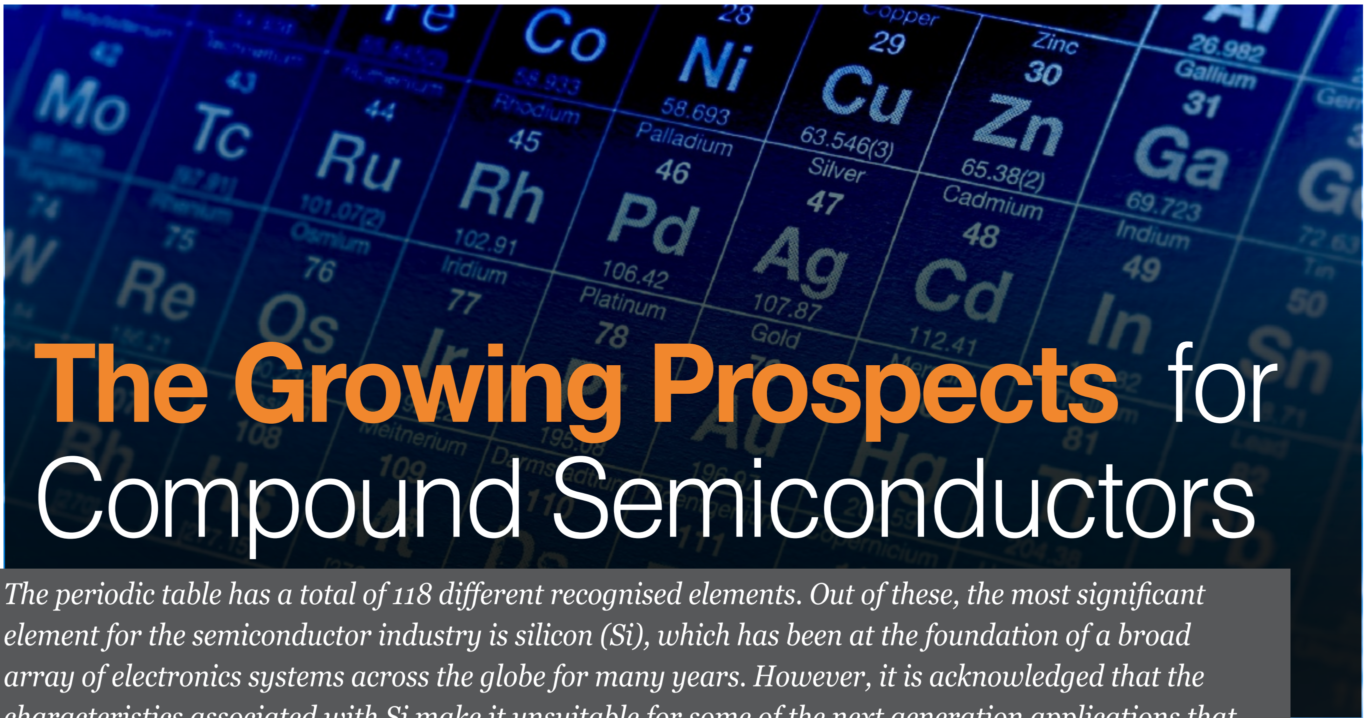


Could Direct Solar Powering of Vehicles Contribute to Long-Term Electrification Objectives?

Also inside

- *Charting the course of compound semiconductor progression*
- *EPDT's Mike Green interviews Jon Baxter from value-add distributor Solsta*
- *The potential for leveraging AI in test*



The Growing Prospects for Compound Semiconductors

The periodic table has a total of 118 different recognised elements. Out of these, the most significant element for the semiconductor industry is silicon (Si), which has been at the foundation of a broad array of electronics systems across the globe for many years. However, it is acknowledged that the characteristics associated with Si make it unsuitable for some of the next generation applications that are now starting to emerge - particularly those that demand accelerated speed or elevated power levels. As ***EPDT Contributor Chetan Arvind Patil*** *conveys in the following article, this has led to the industry looking to make greater use of compound semiconductor technology.*

In basic terms, compound semiconductors will comprise 2 or more elements from the periodic table. Through such combinations, it is possible for enhanced operational properties to be derived. Among these are heightened electron mobility, which is of huge benefit to power-oriented applications (enabling higher voltages to be handled and faster power supply switching speeds that boost conversion efficiencies), plus augmented photonic data transfer solutions.

The elements involved mainly come from the following periodic table groups:

- Group II-VI - Particularly zinc selenide (ZnSe), with its distinctive optoelectronics-related properties.
- Group III-V - Which includes gallium arsenide (GaAs), gallium nitride (GaN), indium phosphide (InP), indium gallium nitride (InGaN), etc.
- Group IV-IV - Notably silicon carbide (SiC) and silicon germanium (SiGe), for use in power and communications respectively.

Based on the data it has compiled, analyst firm Precedence Research projects that the global compound semiconductor market will experience a compound annual growth rate (CAGR) surpassing 11% in the coming years. Consequently, it is forecast to be worth over $119 billion by 2032.

Key opportunities

There's already a broad array of application areas where the demand for compound semiconductor usage is becoming increasingly intense. Among the most prominent of these are:

- Power electronics - Here wide bandgap (WBG) devices based on both GaN and SiC will have pivotal roles to play. For example, GaN (thanks to its exceptional electron mobility) can handle the high voltages needed in renewable energy inverter systems and faster electric vehicle (EV) charging infrastructure.
- Telecommunications - GaAs and GaN are already proving their value in high-frequency and microwave applications (including both cellular and satellite communication). The volumes of RF chips being fabricated using these compounds is rising all the time.

Besides power and telecom, compound semiconductors will also be critically important in relation to photonics, medical, radar and numerous other areas.

Current manufacturing status

Compared to Si, the compound semiconductor production output is still very small. That said, the installed capacity is increasing, with foundries and IDMs both making major investments into facilities for this purpose.

A recent outlook from semiconductor manufacturing body SEMI shows that the worldwide installed capacity for power and compound semiconductor fabs (in 200mm wafer diameter equivalents) is projected to top 10 million wafers per month (WPM) for the first time in 2023. This is forecast to grow to an average of 10.6 million WPM by the end of next year. According to SEMI figures, China has the largest share of installed capacity (33%). Next is Japan (17%), followed by Europe/Middle East (16%), and then Taiwan (11%).

Companies like Infineon Technologies, Hua Hong Semiconductor, STMicroelectronics and Silan Microelectronics are leading the way. Together, they are predicted to add around 0.7 million WPM to the current total within the relatively near future. On this front, Infineon acquired GaN Systems earlier this year, in order to strengthen the WBG portfolio. The German-headquartered IDM is also in the process of expanding its production facility in Kulim, Malaysia, which is set to soon become the world's largest 200mm SiC power fab. Similarly, STMicroelectronics and Sanan Optoelectronics have formed a joint venture for high-volume 200mm SiC device manufacturing. Located in mainland China, this is due to be operational by early/mid 2025.

On top of this, the CSconnected initiative is bringing a large-scale compound semiconductor cluster to South Wales - enabling it to become an important location with respect to 5G/6G communications, EVs, advanced medical hardware and suchlike in the future. CSconnected is a unique, since it focuses on bringing all the significant pillars of the semiconductor sector together - industry (via local companies like IQE and multinationals like Microsemi), academia (such as Cardiff University), research and engineering talent. Having gained tens of millions of pounds in both private sector and government funding, its objective is to generate at least 3,000 jobs in the region within the 2025 timeframe.

India has also launched an ambitious scheme to encourage the establishing of compound semiconductor fabs there. Its government will contribute 50% of the initial capital expenditure needed for such facilities. At this stage, the country does not have active private fabs in operation, but the proposed investment in compound semiconductors could help India become an outright leader in this sphere. It will also tie in well with the huge growth being seen in the Indian EV market.

Over in the United States, the National Science Foundation has announced semiconductor research investment that comes to more than $50 million, as part of the country's CHIPS Act. A significant percentage of this amount will be for work in relation to compound semiconductors.

Future implications

Though the unit costs are still high, compound semiconductor demand is growing, and the industry is bolstering its capacity accordingly. A symbiosis between the lowering of manufacturing expense and more widespread adoption is now starting to occur. Complementing the investment in dedicated fabs, compound semiconductor production lines are now being incorporated into numerous Si-based facilities.

With well-defined application areas and use cases, alongside an expanding manufacturing base, compound semiconductors are going to have a significant impact on the following areas in the years ahead:

- Next generation electronic systems - With much higher electron mobility being witnessed, compound semiconductors could lead to higher speed and more energy-efficient electronic devices. There is thus the prospect of a new era of computational power being ushered in.
- Quantum technologies - Thanks to the accelerated data rates supported, the potential of compound semiconductors in the context of quantum computing and communications is clear. If realised, it could have an incredible impact on data processing, as well as data security. As part of the CSconnected initiative, the Compound Semiconductor Centre is spearheading the 'Quantum Foundry' project. This 3-year long £5.7 million venture will explore possible ways to use compound semiconductors for quantum technologies, and look into how such solutions can be manufactured at scale.
- The customisation of electronics - The ability to engineer the properties of compound semiconductors could lead to customised electronic and optoelectronic devices that are tailored to fit with specific needs. For example, Keysight provides its clients with custom ICs designed in-house and manufactured at the company's InP/GaAs fab (located in Santa Rosa, California). This helps ensure the different measuring instruments required by semiconductor labs are equipped with electronic components that enable higher resolution measurements. Similarly, NXP has a GaN fab (situated in Chandler, Arizona) through which highly optimised custom RF solutions can be provided.

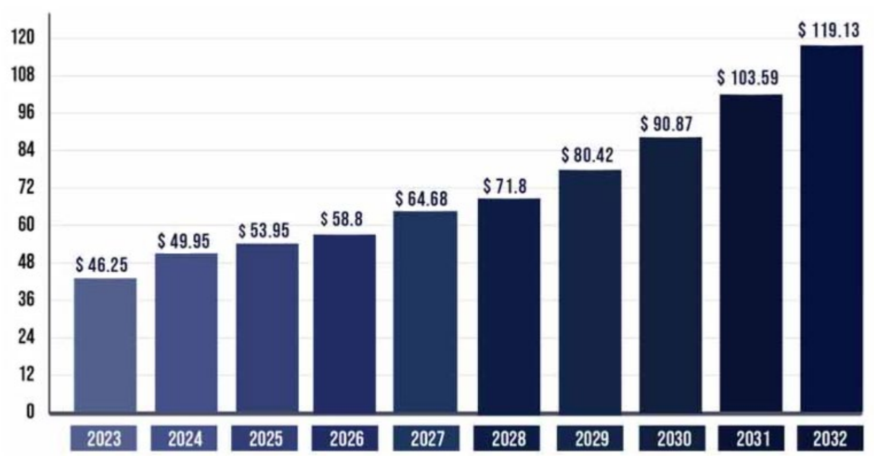


Figure 1: Projection of global semiconductor market over the next decade [Source: Precedence Research]

Summary

Compound semiconductors have evolved significantly over the decades. Back in the past, their discovery marked a pivotal shift from traditional elemental semiconductors, but the need was not quite there. Now, they are poised to enable a market generating hundreds of billions in revenue. Their unique properties, such as higher electron mobility and direct bandgaps, are going to make them indispensable in modern electronics implementations. Through ongoing research and development work, alongside capacity expansion, there is a promising future ahead.

Based in Arizona, USA, Chetan Arvind Patil is a Senior Product Engineer at NXP.