Composite Substrates May Boost Performance, Cut Costs of GaN RF Power Devices

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Aimed at allowing a new range of reasonably priced, high-performance radio-frequency (RF) applications, Les Ulis, France-based Picogiga International, a division of the Soitec Group and the leader of the European HYPHEN project reported today it has achieved excellent initial material characterization results surrounding gallium nitride (GaN) on compound engineered substrates.

The three-year project that started in 2005, aims to develop and evaluate new types of composite substrates based on silicon and silicon carbide materials with the new substrates designed to provide cost-efficient solutions for advanced high-power devices used in wireless communication systems such as radar, satellite communications and base stations, the group noted.

HYPHEN’s main objective is to bridge the gap between the low-performance, low-cost single crystal silicon and the high-performance; high-cost single crystal silicon carbide (SiC) currently used as the starting substrates for GaN-based RF devices.

The program says it expects to demonstrate that scalable composite substrates have dielectric and thermal properties far above those of silicon, yet costing significantly less than semi-insulating SiC.

In the first year, the project compared the industry's two standard materials -- GaN on bulk silicon and GaN on bulk SiC -- with GaN grown on two of the most promising composite, engineered substrates: silicon on poly-crystalline silicon carbide (SopSiC); and SiC on poly-crystalline SiC (SiCopSiC).

These substrates were engineered using Soitec's Smart Cut technology, best known as the key technology behind silicon-on-insulator (SOI) wafers.

The results show that all the critical performance factors including crystal quality, mobility, and surface morphology of GaN on composite substrate materials are equal to or better than the current industry standard materials. The substrate comparisons were assessed using metallic organic CVD (MOCVD) epitaxy and molecular beam epitaxy (MBE).

The group said the new composite substrates demonstrated superior results in terms of pilot production yield and repeatability. According to the preliminary results, the epitaxy of GaN HEMT on SopSiC composite substrates is more reliable than on conventional silicon substrates. SopSiC, as a substrate for GaN growth, also has the advantage of being substantially cheaper and better suited to high volumes than bulk SiC substrates for a frequency scale less than 10 GHz.
“Composite substrates engineered with Smart Cut technology offer a high-added value for power devices, which will be assessed through the overall performance of GaN transistors,” said Philippe Bove, Picogiga R&D director and HYPHEN project leader, in a statement.

“Until now, designers of GaN-based RF power devices have had to choose between the extremes of high-performance/high-cost SiC starting substrates and low-performance/low-cost silicon. The HYPHEN material characterization results indicate that composite materials like SopSiC provide a scalable, cost-effective substrate solution that can fill the chasm between the very high and the very low ends of the cost-performance trade-off,” he explained.

The HYPHEN project is developing and characterizing the complete technology chain, from substrate to GaN HEMT device. The second phase of the HYPHEN project now underway, involves device processing. Project partners include Picogiga (France), the III-V division of the Soitec Group; University of Padova (Italy) Information Engineering Department (DEI); Alcatel-Thales III-V Lab (France); The Research Institute for Technical Physics and Material Science (MFA) (Hungary); Norstel (Sweden), supplier of HTCVD-grown high-purity SiC wafers; Institute of Electron Technology (IET) (Poland); the IEMN research unit of the French national research organization, CNRS; and United Monolithic Semiconductors, a Thales-EADS joint venture.

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