FRAUNHOFER INSTITUTE FOR APPLIED SOLID STATE PHYSICS IAF

About

The Fraunhofer Institute for Applied Solid State Physics IAF in Freiburg is one of the world's leading research institutes in III/V semiconductor technology and modules. Within its five business units Power Electronics takes a leading role. Fraunhofer IAF develops energy-efficient solutions for energy conversion, broadband communication systems, high data rate transmission, imaging, detectors as well as semiconductor lasers. In cooperation with a broad range of international project partners, Fraunhofer IAF performs its expertise material and process technology, in chip design, and in the manufacturing of devices and modules. In 2015, the institute had 280 employees including more than 30 PhD students.

Power Electronics at IAF

Power electronics at IAF is based on the development of Gallium Nitride (GaN) on up to eight inch silicon and diamond electronics, both with GaN on diamond substrates, and on the longer term, real diamond electronics. Overall, GaN-based devices on Silicon already have a direct impact on future efficient power conversion systems and will thus help save energy and miniaturize systems. GaN technology is promising for automotive, photovoltaic, IT- and consumer applications as well as motor control and appliances. Based on the longstanding experience and the successful industrialization of GaN RF-processes in Europe Fraunhofer IAF in power

Multiwafer MOCVD growth machine for up to 8-inch growth of GaN on Silicon.

electronics concentrates on the critical aspects of:

- Defect-reduced material growth up to 8-inches in diameter,
- Process development with a focus on integration for fast switching,
- In-depth characterization, chip-related packaging, EMC, and reliability.

The needs for ever-higher transistor performances and reliability drive a continuous search for improved epitaxy, process technology, and advanced characterization. GaN on diamond in wafer transfer approaches and, generically as a semiconductor material with ultimate performances are being developed for improved thermal performances. For pure diamond electronics, baseline growth of diamond and processes are under development.

Epitaxy

GaN-based devices with generically a wider bandgap than silicon have a much higher critical electrical field and, together with high carrier concentration and high mobility, they offer superior trade-off of specific on-state resistance $R_{DS(ON)}$ versus breakdown voltage rating and show low switching losses. For GaN to be cost effective silicon reenters GaN devices as a substrate material with large diameters, which is a challenge regarding defect reduction, overall material quality, and overall process yield. Fraunhofer IAF optimizes material growth with a strong focus on material characterization on improved growth schemes and machines.

Process Development and Reliability

IAF's baseline AlGaN/GaN high-voltage process technology is based on devices with standard 0.5 µm gate lengths. We pursue performance and reliability improvements of AlGaN/GaN-based devices for various voltage classes up to at least 1200 V and currents currently as high as 200 A per chip.

Characterization

IAF concentrates on the characterization of the static and losses on devices level, on critical defects, on EMC for the proposed increase of the switching speed of the GaN-based converters to the 10 MHz range, e.g. using multilevel converters. Starting from the material growth reliability is the central aspects for high-power-density devices, currently for large-area devices. We expect GaN to evolve in power electronics driving performances to unprecedented levels in converters and to open new applications and cost performance trade-offs.