Elements of GaN-Based Integrated Power Electronics

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The realization of full pn-junctions in wide bandgap GaN has enabled substantial power savings in solid state lighting. The combination with AlN allows for superb carrier confinement and high mobility electron channel transistors. Moreover, the progressing development of GaN and AlN bulk substrate will allow high tension voltage blocking and superior thermal management for integrated power switching and conversion. All those aspects invite system level integration of power devices into a materials physical layer.

The breakthrough success of GaN-based solid state lighting has created a large volume market for group-III nitride technology, as well as a broad equipment and distributed manufacturing base. On the other hand, high electron mobility transistor (HEMT) in lateral field effect transistor (FET) geometry have evolved in the AlGaN/GaN heterostructure system for highest frequency and power switching capability. It therefore is only a natural step to integrate various device level functions into higher value system level integrated combinations.

The current voltage characteristics of a light emitting diode (LED) requires a current limitation while incandescent lamps can be operated under constant voltage. Therefore, to supplant DC operated LEDs for AC tolerating incandescent lamps requires current limiting driver electronics including short term power storage. All those aspects can be directly implemented in group-III nitrides on the material level.

We will present approaches for the direct integration of LEDs with FETs and the conceptual layout of power storing capacitors. Our approach demonstrates the suitability of group-III nitride materials development for the purpose of system level functionality integration for a very wide range of distributed low cost, high efficiency energy power control and energy conversion.

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