Research on GaN for Space and Nano scale Technology

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R&D Projects: GaN for Space

- The main advantage of GaN is: It can have a Power Amplifier (PA) whose Drain Voltage can swing up to 40 volts
- Gallium nitride (GaN) is a very hard, mechanically stable, binary III/V direct bandgap semiconductor.
- The GaN device inherently poses the quality of Wide Band (WB) quality

R&D Projects: GaN for Space

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- GaN-based device is towards higher output power density, higher Power-Added-Efficiency (PAE), higher operation frequencies and improved reliability.

R&D Projects: GaN for Space

- The RF power electronic requires the introduction of wide bandgap material due to its potential in high output power density, high operation voltage and high input impedance. GaN-based RF power devices can have the substantial potential for that purpose.

- Due to the strong chemical bonds in the semiconductor crystal, GaN based devices are also reliable for high temperature operation and applications under radiation exposure. This will be useful for RF payloads in space.

Research at Stanford: Nano-scale technology

The scaling of conventional Si-based MOSFETs is currently running into fundamental problems.

Hot electron effects, Velocity Saturation, Short Channel Effects, Punchthrough and Tunneling effects are some of challenging factors of CMOS Technology beyond 10nm gate length.

Research at Stanford: Nano-scale technology

Alternate High-mobility channel materials is vital for the next generation of high-performance MOSFETs.

Germanium (Ge) has been considered as an attractive channel material because of its higher carrier mobility and process compatibility with Si-based device.

Hole Mobilities of Primary Semiconductors [$cm^2/V{\cdot}s$]

Si	Ge	AlGaAs	InGaAs	InP	GaN
450	1900	140 – 400	300 – 400	200	350

Research at Stanford: Nano-scale technology

- *Due to its small band gap, Ge has big advantage for high-speed semiconductor. It does come with a concern, however.*

- *It is well known that the germanium-on-insulator (GOI) structure, like its silicon-on-insulator (SOI) counterpart, is advantageous for reducing junction leakage current, parasitic capacitance and also for improving immunity against short-channel effects.*

Low Power Design on Solid State Device

Knobs for Low Power Design	CHANGE	Threshold V_{th}	Leakage Current, I_{Leak}
Device Length l	IF DECREASES	DECREASES	INCREASES
Device Width W	IF DECREASES	INCREASES	DECREASES
V_{BULK}	IF DECREASES	INCREASES	DECREASES
Doping-Cont N_A	IF INCREASES	INCREASES	DECREASES
Gate Thickn T_{Si}	IF DECREASES	DECREASES	INCREASES
Temperature	IF INCREASES	DECREASES	INCREASES