Will GaN-on-Si Displace Si and SiC in Power Electronics?

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Abstract

GaN is an already well implanted semiconductor technology, widely diffused in the LED optoelectronics industry. For about 10 years, GaN devices have also been developed for RF wireless applications where they can replace Silicon transistors in some selected systems. That incursion in the RF field has open the door to the power switching capability in the lower frequency range and thus to the power electronic applications.

Compared to Silicon, GaN exhibits largely better figures for most of the key specifications: Electric field, energy gap, electron mobility and melting point. Intrinsically, GaN could offer better performance than Silicon in terms of: breakdown voltage, switching frequency and Overall systems efficiency.

A $16.6B 2010 TAM AND SOME KEY PROMISING APPLICATIONS

GaN technology is maturing and now offers transistor, diode and even ICs compatible with Power Electronic expectations, at least in the 0-600V range. Looking at Total Accessible Market, a $16.6b market size is envisioned, split in:

- Power IC s
- Power Discretes
- Power Modules

Now, considering the GaN current state-of-the-art, we assume the most promising applications for Nitride Semiconductors would be IT and consumer, automotive and the following industries: PV inverters, UPS and motor control.

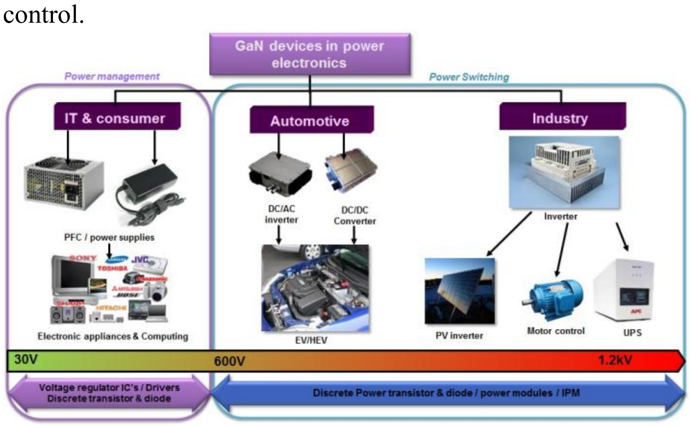

Figure 1: Fields of applications for GaN power devices

GAN POWER DEVICES: A $350M MARKET IN 2015

GaN power electronics market has just started in 2010 along with the announcements of IR and EPC Corp. about their first products introduction. To now, the maximum commercially available Vb is of 200V that partially covers the IT and consumer segments.

In their roadmap, these 2 companies and the other possible new incomers (MicroGaN, Furukawa, GaN Systems, Panasonic, Sanken, Toshiba and so on…) are announcing 600V and even 900V devices in a very short time. Such an increase in the Vb range, will allow GaN to step by step enter into the industrial and automotive segments.

Taking into account the minimum qualification period needed for new technology implementation, we do forecast that the inflexion point for GaN market ramp-up will occur early 2012, leading to a $50M+ market size by 2013 and ~$350M by 2015.

In 2015, GaN device business should be equally split between IC's, discretes and modules.

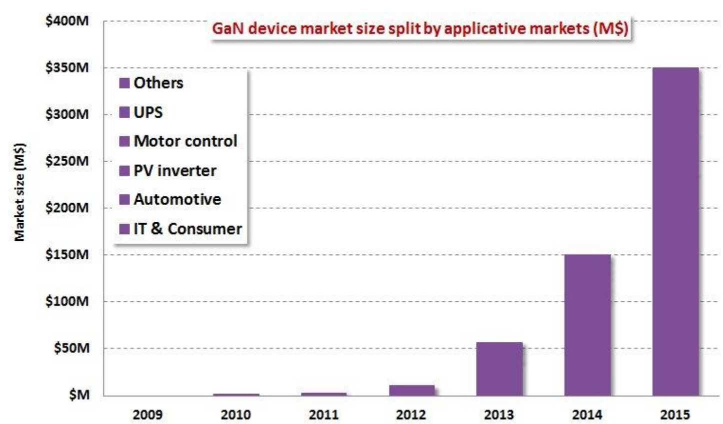

Figure 2: GaN device market size split by applicative markets to 2015 in M$

GAN-ON-SI IS PROBABLY THE MOST COST-EFFECTIVE SOLUTION AT SHORT TERM

About 67 % of Power Electronics market is looking at 0-900V voltage range, mostly made of cost-driven consumer and IT applications".. To address these segments require a high-volume manufacturing capability as well as a very aggressive market price positioning. Thus, the technical solution involving expensive bulk-GaN substrates are not compatible with market requirements. GaN-on-Si appears as the most cost-effective setup to reach at least the 0-900V applications. It has been calculated that GaN-on-Si HEMT could be 50% cheaper than the same SiC device. However, as of today state-of-the-art, it remains twice and even 3 times more expensive than the similar silicon device.

The choice to integrate GaN instead of Silicon will be made at system level, while calculating the overall module cost. Implementing GaN will allow reducing:

- Thermal management costs (fewer fans, smaller heat-sink…)
- RF filtering costs (higher switching frequency will need small capacitors and inductances)
- Overall housing cost (30% to 50% overall module size shrinking is expected)

CONCLUSIONS

We assume GaN-on-Si is the preferred solution to enhance GaN market penetration over the power electronics industry at least in the early times. Based on the expected price erosion of the GaN-on-Si 6" epiwafers over the time, the GaN substrate market should exceed $100M in 2015

REFERENCES

Data extracted from YOLE DEVELOPPMENT "Power GaN" report published in 2010.

ACRONYMS

HEMT: High Electronic Mobility Transistor