Wide-bandgap RF devices: a $100m market by 2010

Yole Développement's Philippe Roussel asks what can displace the LDMOS monopoly.

The call for high-power, high-frequency transistors is rising along with the huge demand for wireless telecoms. More power, more frequency bands, better linearity and improved efficiency are driving development of RF devices able to handle all these specifications at a reasonable price.

The main market segments are:
- base-stations for cell phones (3G, 3G+);
- base-stations for WiMAX (fixed and mobile) and/or LTE (long-term evolution) future 4G wireless datacom standards;
- defense & military applications (radar, jamming, counter-measures, communications, guided weapons...);
- broadcast and communication satellites (VSAT, SatCom) can also benefit from solid-state transistors replacing vacuum tubes.

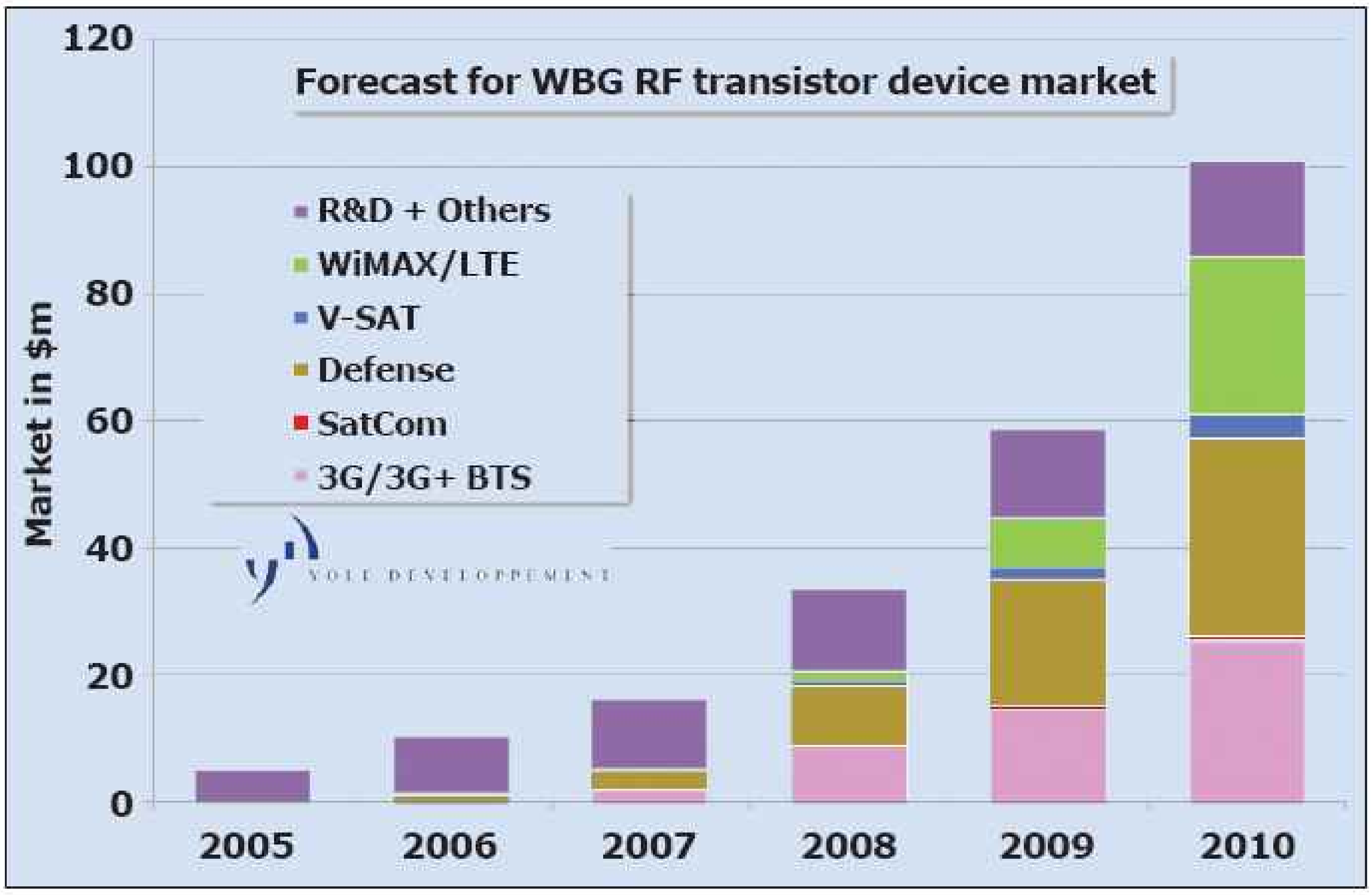

Figure 1: 2005–2010 wide-bandgap RF transistor device market.

Up to 2005, silicon LDMOS covered about 90% of high-power RF amplification applications in the 2GHz+ frequency range; the remaining 10% market share was addressed by GaAs pHEMT technology. However, this equilibrium is on the way to being turned around by the introduction of wide-bandgap (WBG) materials and related RF devices such as silicon carbide (SiC) MESFETs and gallium nitride (GaN) HEMTs.

WBG devices offer an impressive list of added-values over the solutions currently in use:

- Higher efficiency:
  - lower operating costs;
  - improved module power density and hence size;
  - reduced cost of ownership.
- Higher bandwidth and linearity:
  - more versatile devices;
  - fewer devices to cover the entire frequency spectrum;
  - cost saving at the development stage.
- Higher polarization voltage:
  - lower current level for the same power output;
  - fewer losses from the joule effect, leading to cost savings in thermal management.
- Higher junction temperature:
  - more robust devices, leading to improved expected lifetime and mean time to failure (MTTF);
  - reduced cooling system demands, leading to cost savings at the system level (BTS).

These WBG devices are now challenging silicon's dominant position in the industrial arena, for which a power amplifier (PA) market of $890m is forecasted for 2008.

As shown in Figure 1, military applications were first to use the possibilities of WBG devices, especially with SiC MESFETs being developed through widespread funding from DARPA and Department of Defense programs in the USA. Then, in 2006, Eudyna and NTT jointly announced that the first 3G network using GaN HEMTs had been deployed in Tokyo for test purposes. This first commercial application led to more than 250 wafer starts over 2006. Commercial offerings from Cree, RFMD and Nitronex have followed, targeting both base-station (3G, WiMAX etc) and general-purpose applications. In parallel, R&D for space applications has stayed very strong, and the first products are expected to be implemented in the next few years. Recent announcements have shown that key players are focusing increasingly on WiMAX/LTE markets, overlooking the current 3G/3G+ market, for which they claim the time-to-market for WBG devices has passed.

With strong penetration of WiMAX/LTE applications, we forecast that the market size for WBG RF transistors could reach a level of approximately $100m by 2010. The duality between WiMAX and LTE technologies should not widely impact this growth.

	Epi-wafers	Devices, MMIC & PA	Systems
USA	• Nitronex • RFMD • Oxford Instruments/TDI • Cree • Kyma • Kopin • IQE	• Nitronex • Raytheon • Northrop Grumman • RFMD • TriQuint • Cree • Freescale	• Lockheed Martin • L3Com • Lucent • Motorola • Flarion Technologies • Celerica • Arraycom
Europe	• QinetiQ (UK) • Picogiga (F) • Azzurro (D) • Saint-Gobain/Lumilog (F) • IMEC (B) • Alcatel-Thales 3-5 Lab (F) • CRHEA (F) • IAF (D)	• QinetiQ (UK) • MicroGaN (D) • UMS (F/D) + 3-5 Lab (F) + IAF (D) • RFMD/Filtronic (UK) • NXP (NL) • FBH (D) • Selex (IT)	• BAE Systems (UK) • Selex (IT) • MBDA (UK) • EADS (D) • Ericsson (SW) • SAAB Microwave (SW) • Alcatel-Lucent (FR) • Thales (FR) • Nokia-Siemens (FI)
Asia	• Samsung (K) • Sumitomo SEI (J) • Powdec (J) • Tocera (J) • NTT (J) • Hitachi Cable (J) • ITRI (TW) • Toyoda Gosei (J)	• Eudyna (J)/Fujitsu (J) • OKI (J) • NEC (J) • Furukawa (J) • RFHIC (K) • Mitsubishi (J)	• NTT (J) • Mitsubishi (J) • Samsung (K)

Table 1: Companies involved in manufacturing GaN HEMT epi, devices and systems.

Remote radio head configuration will help WBG penetration in RF base stations

With standard architecture (where the amplifier is at the base of the radio tower), a large part of the signal is lost on the cable link (typically about 3dB of losses).

However, in the remote radio head (RRH) configuration, RF equipment can be relocated from a cabinet to a remote location, where signals can be transmitted as close as possible to the antenna. Thus, from an efficiency of 13–15% traditionally, up to 30% can now be obtained with RRH. The key issue now is linked to accessibility for maintenance (i.e. someone has to climb the radio tower).

In the RRH configuration, there is a need to reduce the size of the PA to enable it to be near the antenna. In addition to its smaller size compared to LDMOS, WBG technology also provides a high operating temperature and better efficiency. These are strong drivers for the use of GaN or SiC in the growing RRH market. We forecast that RRH systems will increasingly be used in future thanks to their high efficiency.

Typical RRH power ranges from 20W to 50W, which matches WiMAX and future LTE requirements perfectly.

Company involvement

Nitronex, Cree and RFMD (in the USA) and Eudyna (in Japan) were the first companies to propose WBG RF devices. These were based on either GaN on silicon (Nitronex), SiC on SiC (Cree) or GaN on SiC (Cree, RFMD, Eudyna). Such devices are now in full production and implemented in complete RF systems in both defense and civilian applications.

The value chain for WBG devices is now being established. As detailed in the table, an impressive number of players are now involved in the WBG RF sector at various levels (materials, devices, and systems) and new challengers (Oki, NEC, NXP, UMS etc) should soon enter the field (Fig. 2).

Conclusion

With a forecasted size of $100m by 2010, the WBG transistor market is at the start of the growth curve. Military and space applications are strong drivers for technology development. However, WBG technology penetration in base-stations (for cell phones, WiMAX) remains a little unclear, as silicon performance and related cost seems compatible with the current market demand. This could slow down the emergence of WBG devices in this very cost-sensitive market segment, even if the intrinsic characteristics of WBG devices have now largely been proven. The battle will take place not only at the performance and reliability level but also at the cost level. Thus, innovating, GaN-based substrate manufacturers have a key role to play in helping to reduce the price of devices. ■

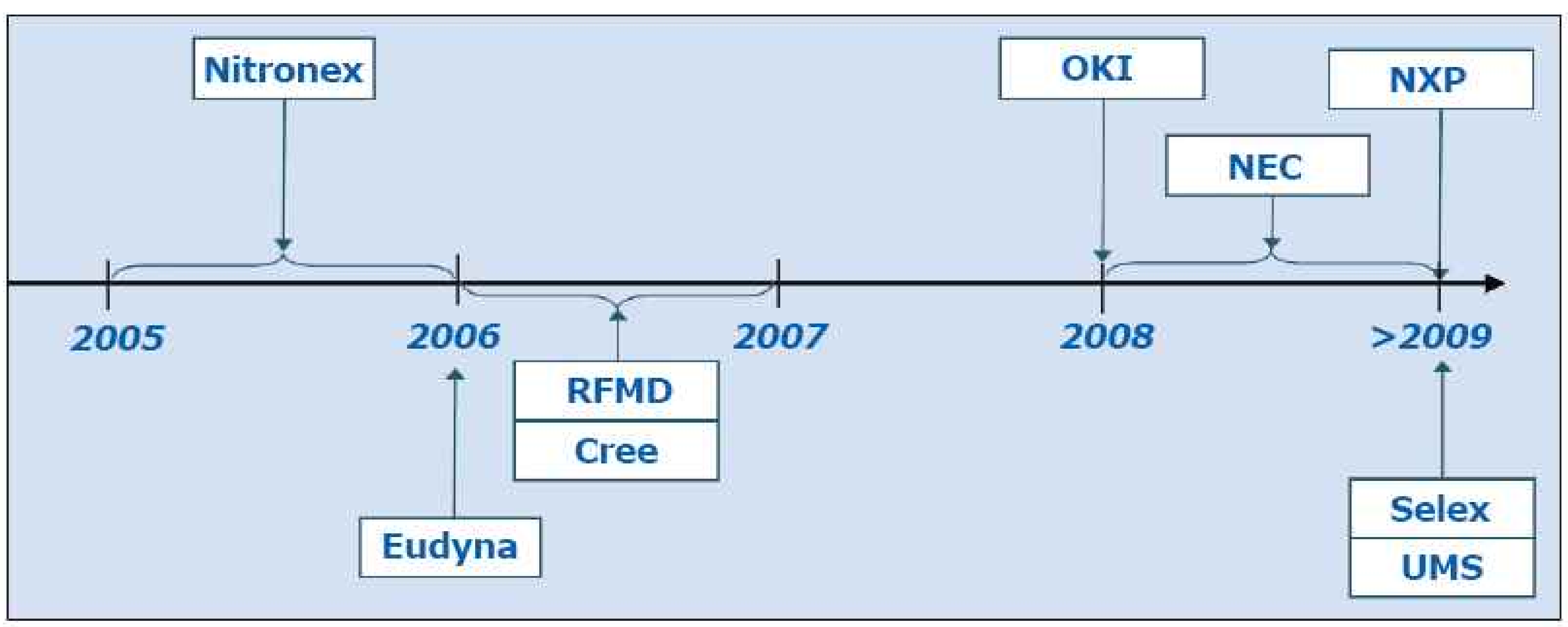

Figure 2: Tentative roadmap for wide-bandgap products introduction.

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Yole Développement is publishing its GaN RF'08 report in June.
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