RF Power Market and Technologies 2017
GaN, GaAs and LDMOS
REPORT OBJECTIVES

• Provide an overview of the entire RF power market.

• Analyze different players in different markets, along with their product range and technologies.

• Outline market access – market size evolution from 2016-2022 and technology split.

• Highlight the main technologies in the different applicative markets.

• Explain the needs of different RF markets and the corresponding impact on the needs for different technologies, along with geographical specificities.
REPORT METHODOLOGY

Market forecast methodology

Market segmentation methodology

USES
- Variant
- Quasi segments
- Commercial key success factors behaviour and competitor behaviour matrices

APPLICATIONS
- Fonction and technological application matrices

SEGMENTS
- BEHAVIOUR
REPORT METHODOLOGY

Technology analysis methodology

- Define the key parameters
- Understand the requested specifications per parameter and application
- Define the competing technologies and the potential evolutions of the technologies
- Define the roadblocks and challenges to be overcome
- Establish the technology roadmaps and maps
- Experts discussions

Information collection

- Material makers
- Equipment makers
- Device makers
- System designers
- OSAT

Analysts’ processing to answer your needs and questionings on market size, positioning, technical challenges…

Trade show attendance and participation

Analysis of the literature, web, academic publications, white papers…
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SCOPE OF THE MARKET

At 2016, more than \( \frac{3}{4} \) of RF PA revenue comes from cellular terminals.

- Our RF Power market does not include the RF PA revenue from cellular terminals. Because if we include GaAs in the report it will takes more than 80% of the market share and less meaningful for our comparison.

- The report covers the market above 3W, including mainly LDMOS, GaAs and GaN, as well as some other devices such as SiGe, Si BJT and InP.
Overall market size increases from 1.9B to 2.9B.
RF POWER DEVICES: TECHNOLOGY BREAKDOWN
Comparison by application: 2015 - 2025

Market share development of different technologies.

2015-2025, RF Power market in terms of technology

- **LDMOS**
- **GaAs**
- **GaN**

*Only consider RF Power semiconductor above 3W, exclude applications such as mobile PA*
Different markets and drivers for RF Power development are presented and explained.
ESTIMATE OF OVERALL RF POWER PLAYERS’ MARKET SHARE IN 2016

Overall RF Power Market: $1.9 Billion

Overall LDMOS: $XXXM  Overall GaAs: $XXXM  GaN: $XXXM

Player A  XX%  Player A  XX%  Player A  XX%
Player B  XX%  Player B  XX%  Player B  XX%
Player C  XX%  Player C  XX%  Player C  XX%
Player D  XX%  Player D  XX%  Player D  XX%
Player E  X%  Player E  X%  Player E  X%
Player F  X%  Player F  X%  Player F  X%
Player G  X%  Player G  X%  Player G  X%
Others  XX%  Others  XX%  Others  XX%

Others: $XXX M
Different business models exist in the RF power market.

*There's no direct supply correspondence between different columns!

*non-exhaustive list

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The comparison of GaN-on-Si and GaN-on-SiC has been one of the most concerned questions in GaN RF industry.

GaN-on-Si Pros
- More mature in terms of technology
- Multisource supplier possibility
- An established supply chain
- Better performance

GaN-on-Si Cons
- Relatively smaller size of wafers
- Cost, cost, cost

GaN-on-SiC Pros
- Lower cost
- Compatible with silicon process
- Sufficient (slightly inferior) performance
- Possibility of 8 inches (or larger) wafer production

GaN-on-SiC Cons
- Reliability issues
- Not many suppliers
- Still expensive compared to LDMOS

The RF Power Market and Technology 2017 report
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After a fall in 2015, the overall RF power market is still declining in 2016 as telecom operators invest less. By year-end, the total RF power semiconductor market was close to $1.5B for all applications above 3W.

We expect the market to recover in coming years thanks to increasing demand for telecom base station upgrades and small cell implementations. Overall market revenue could potentially increase 75% by the end of 2022, posting a CAGR of 9.8% from 2016-2022.

We are today standing at the threshold of completion of 4G network, and then beginning the transition to 5G. There’re still a lot to be settled and established, however some things are for sure: the new radio network will require more devices and higher frequencies. Chip providers therefore have a tremendous opportunity, especially RF power semiconductor sellers. We estimate the market size of telecom infrastructure including base stations and wireless backhaul accounts for about half of the total market size. It will continue growing fast at an expected 12.5% CAGR for base stations and 5.3% CAGR for telecom backhaul over 2016–2022.

In the meantime, defense applications are also providing good opportunities for RF power devices as there’s a trend of replacing old vacuum tube designs with solid state technologies exploiting GaAs and GaN. These new technologies provide better performance and reduced size as well as robustness in various use cases, and are gradually taking more market share. We estimate this market segment’s revenue to increase around 20% by 2022 with a CAGR of 4.3% for 2016-2022. We invite you to read our report and discover more details about the telecom and military markets, as well as other markets including civil radar, wired broadband, satellite communication, RF energy and many others. This report offers a complete analysis covering different RF Power players such as NXP, Ampleon, Qorvo, Infineon, Sumitomo Electric, M/A/COM, Wolfspeed, UMS, Analog Devices and devices developed and implemented in power amplifier applications. This report also includes a detailed comparison of the technology landscapes for LDMOS, GaAs, GaN and SiGe in different markets.

Technology is evolving, with GaN device revenues now more than 20% of the overall market. Sales numbers are soaring with ever more implementations in diverse markets. GaN is replacing LDMOS in telecom macro base stations, vacuum tubes in radar and avionic applications, as well as other broadband applications. GaN’s increased implementation in base stations and wireless backhaul stems from the growing demand for data traffic and higher operating frequencies and bandwidths. In future network designs, new technologies like carrier aggregation and massive
A BRAWL AMONG RF POWER PLAYERS?

As the developing trends become ever clearer, RF power players are investing and hoping to win the competition to be the leader in next generation technology. Major LDMOS players like NXP, Ampleon and Infineon are gaining access to GaN technology by using external foundries. Meanwhile, traditional GaAs players have been investing in GaN technologies. Some have succeeded in converting their production capacity, with their savoir-faire in the compound semiconductor area allowing them to adapt to GaN technology and take the lead in today’s market. Pure GaN players like Wolfspeed are on one hand supplying major LDMOS players, hoping to grow the market together. On the other hand, they are trying to ensure their leading place in GaN technologies with better processes and larger wafer production capacities.

We see that today’s leading RF power players are still the leaders in the LDMOS area. However, when GaN devices become dominant in the future, the leaders will become those who hold the largest GaN market share. The current top GaN RF players mostly have GaAs experience and there’s only one pure GaN player: Wolfspeed.

Under these circumstances, Infineon Technologies’ acquisition offer for Wolfspeed seemed insightful and beneficial. If it wasn’t for the disapproval from US government, this deal could have brought Infineon a dominant position in the future GaN industry, providing it with a complete portfolio in both RF and power applications. At the same time, the legal action initiated by M/A-COM Technology Solutions against Infineon concerning GaN patents caused a sensation last year. Although it is still ongoing, we wonder if more blood will be spilled in the future, and how much value these leading players are fighting for.

In the meantime, GaAs will also secure a considerable share in the industry with its implementation in defense and CATV markets. Thanks to the mobile cellular industry, GaAs technology is very mature and accessible in the market. This will allow a smooth transition into solid state technology in several military applications.

But this does not necessarily mean the doom of LDMOS. There will still be a very solid market share that LDMOS can handle with its maturity and low cost. Also, the development of the RF energy market also potentially offers future prospects for LDMOS.

For the next 5-10 years, Yole Development envisions that GaN will gradually replace LDMOS and become the major technology for RF power applications above 3W. GaAs will keep its share thanks to its proven reliability and good cost performance ratio. LDMOS will decline and drop to around 15% of the overall market size.

This report also covers the development of GaN-on-SiC devices versus GaN-on-silicon and their impact on the industrial supply chain and on players involved.
COMPANIES CITED IN THE REPORT (non exhaustive list)

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