

MMIC Futures

by

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Some Definitions

For the purposes of this talk let us:

- Define “microwave” (‘MW’) as frequencies between some 100s of MHz up to 18 GHz
- Define “millimeter-wave” (‘MMW’) as frequencies between 18 GHz & 110 GHz (occasionally even higher)
- There are a great many MW MMICs
- But considerably fewer MMW MMICs

Players: c. 2013

There are about 60 supply-side players (worldwide)

- Most operate in-house fabs
- Some are pure-play foundry facilities (e.g. WIN Semiconductor)
- Around eight use the fabless business model (Hittite and Plextek RFI are probably the best known)
- Most are (**currently**) US- headquartered
- Other major players include: AMCOM, Avago, Cree, Custom MMIC, Freescale, Macom, MWT, RFMD, TowerJazz, TriQuint & UMS

Proportions of Players

The charts show the proportions of players involved in each type of MMIC

Figure 1 Proportions of Players Involved in Each Type of Semiconductor Substrate for MMICs (2013)

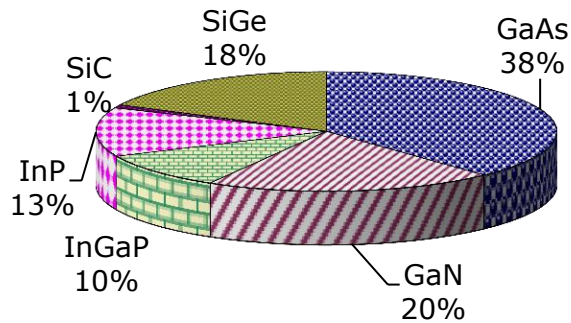
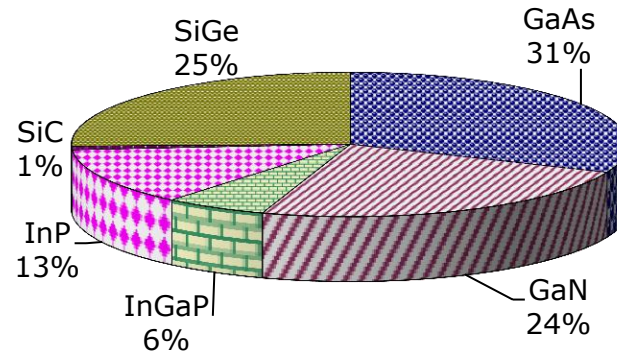


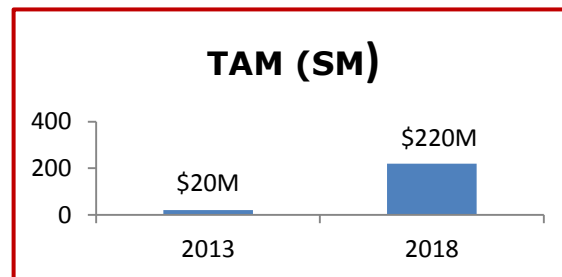
Figure 2 Proportions of Players Involved in Each Type of Semiconductor Substrate for MMICs (2018)



Comments are on the next two slides:-----

Commentary on these Industry Features (1)



- Whilst Figures 1 & 2 show proportions of players – increased activity by existing players will of course make market increases relatively larger than this – especially with GaN & SiGe
- One forecast for GaN MMICs is a \$2.2bn market in 2019 – mainly driven by 4G network requirements
- The global market for SiGe BiCMOS into MMW radios alone is forecasted to go from about \$20M currently to \$220M by 2018



Commentary on these Industry Features (2)

- Some say: “GaAs is dead, GaN is here from now onwards”.
This is totally incorrect regarding GaAs –
- **although absolutely right about GaN. GaN** MMIC PAs:
>> more output power at substantially higher efficiencies than achievable with **GaAs** MMIC PAs. **REMEMBER:**
- **GaAs** MMICs: DC supply rails around 8 to 15 V or so & can make excellent LNAs (GaAs MESFETs)
- BUT **GaN** MMICs require DC supply voltages of more like 30 or even 45 V
- AND this means that no GaN-based MMIC can ever be a plug-in replacement for a GaAs-based chip

Commentary on these market Features (3)

- Currently x13 MMIC-suppliers offer products based on **GaAs** as well as products based on **SiGe**  + 
- This strategy is likely to continue for the foreseeable future
- c. 2018 the total number of players is likely to remain around the same as currently (i.e. about 60) – ***BUT the pattern will have shifted fundamentally***, with increased emphasis on **silicon solutions**
- There will be further acquisitions & some new entrants
- MMICs adopting **RF CMOS** & **SiGe BiCMOS** technologies will be increasingly important for:
 - (I) 4G wireless handsets (esp. Peregrine Semi's Global 1 UltraCMOS SOI CMOS PA)
 - (II) MMW designs for 60 GHz, E-bands & W-band

Details on a Selection of Players (1)

Player	MW	MMW	Bare Die (chip)	Package/s
Avago Technologies	√ (mainly)	√ (a few bare die)	√	Mainly SMT
Custom MMIC Design Services (CMDS)	√	√ (to 77 GHz)	√	
Freescale Semiconductor	√	√		QFN or LQPF
Hittite Microwave	√	√ (to ~ 90 GHz)	√ (~80%)	LP4, ST89
HRL		√	√	
Infineon Technologies	√	√ (to 77 GHz)	√	SMD
MACOM	√	√ to 42 GHz)	√ (mainly – esp. MMW)	QFN, SOT89
Nitronex	√			QFN16
Plextek RFI	√	√	√	
RF Micro Devices (RFMD)	√ (~ 95%)	√ (~ 5%)	√ (small %)	Mainly QFN (3)

Details on a Selection of Players (2)

Player	MW	MMW	Bare Die (chip)	Package/s
Skyworks Solutions	√			MCM, QFN
Sumitomo Electric Device Innovations (SEDI)	√	√ (to 65 GHz)	√ (mainly)	QFN (through Ka-band)
TowerJazz	√		√	
Transcom	√	√ (to 36 GHz)	√ (~ 50%)	
TriQuint Semiconductor	√	√ (to 50 GHz)	√ (~ 50%)	QFN (~ 50%)
TSMC	√		√	
United Monolithic Semiconductor (UMS)	√	√ (to 77 GHz)	√ (~ 50%)	QFN (~ 50%)
Vectrawave	√	√ (to 90 GHz)	√ (~ 50%)	LPA, QFN (~ 50%)
Viasat	√	√ (to 94 GHz)		
Viper RF	√	√ (to 100 GHz)	√	(Various)
WIN Semiconductor	√	√ (to 100 GHz)	√	
Ya Guang Microwave Technologies	√	√ (to 40 GHz)		QFN & similar

Comments on Some of the Selected Players

- **Hittite**: LP4-packaged MMIC (QFN) to at least 36 GHz
 - **NXP** (not summarised in this table) offer a large range of MW SMD-packaged products
 - **Plextek RFI**: now also the European design partner for Cree
 - **RFMD*** supply products in @ least x5 package styles: some ceramic, some plastic. Most are effectively QFN
 - Most **SEDI** products come in bare die format (exclusively where frequencies exceed 36 GHz)
 - **Transcom** products: 8-or-10-lead SMT styles with x2 fixing holes & signal ports (input and output) in co-planar waveguide (CPW) configurations
 - **TriQuint's*** products mainly packaged as SLIM, ST, SLP or VQFN. Broadband LNAs represent exceptions – typically housed in 12-or-17-lead BGA packages
- * *RFMD and TriQuint to merge (announced February 2014)*
- *Overall*: @ least x17 players offer QFN packaged products

Observations on the RFMD/TriQuint Merger Announcement

- RFMD's and TriQuint's total annual revenues are of similar magnitudes (~\$964M & ~\$892M for 2013)
- RFMD net loss \$53M, TriQuint net profit \$19M
- Projected 2014 combined revenues should be around \$1.9bn or even \$2bn, hopefully with @ least a modest profit (savings of around \$120M are expected)
- Maybe the likelihood of @ least one eventual plant closure?
- At present RFMD+TriQuint may appear somewhat top heavy @ board level.....

Possible Future MMIC Technologies

Many developments are taking place, for example:

- **Graphene**-based technologies (RF transistor structures already demonstrated e.g. HRL)
- **Tunnelling transistors** (reference 4 here)
- **3D MMICs** (University of Manchester is involved. Demonstrated by AMCOM four years' ago)
- With the exception of 3D MMICs it will be well into the 2020s & beyond before any such technologies gain significant market share

Concluding Points

- **MMICs will remain vital** for the entire RF/microwave/millimeter-wave industry – with important changes in emphasis
- Of the ~ 60 mostly American-owned current players 43 supply GaAs-based products & 21 SiGe. x13 offer both GaAs-based & SiGe-based
- GaN-based & SiGe-based MMICs are increasing rapidly
- Eight of the players use the fabless business model – using foundries such as IBM Microelectronics, TriQuint, TSMC & WIN Semiconductor
- Most packages are QFN or similar SM

Some References

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<http://www.apt.int/sites/default/files/Upload-files/ASTAP/Rept-4-Technology%20Trends%20above%20100GHz.pdf> (page 14)
4. Alan Seabaugh, "The Tunneling Transistor", IEEE Spectrum, October 2013, pp 31-34, 56