MMICs: state of the industry in 2013 and future prospects

Engalco Research gives an overview of monolithic microwave integrated circuits of various types, and the main players and trends in the sector.

Globally, approaching 60 companies are involved in designing and/or manufacturing monolithic microwave integrated circuits (MMICs). These firms have their headquarters and main operations located variously worldwide, although the majority are in the USA (the countries of major operations are considered in more detail below).

Many of the smaller companies are dedicated exclusively to the design or manufacture of MMICs, and most players operate foundries active in at least one or two of the compound semiconductor technologies. Several of these players are fabless, i.e. they design and market MMICs that are actually manufactured at a MMICs foundry.

Many players (especially manufacturers) are now addressing China, both in terms of sales outlets and increasingly also local manufacturing. Additionally, China is rapidly developing its own indigenous MMIC industry. One example is the strongly growing Ya Guang Microwave Technologies. It is very likely that there will be some substantial consolidation within the industry in the future.

Figure 1 shows the proportions of players that are involved in using specific types of semiconductor materials to fabricate MMICs (in 2013).

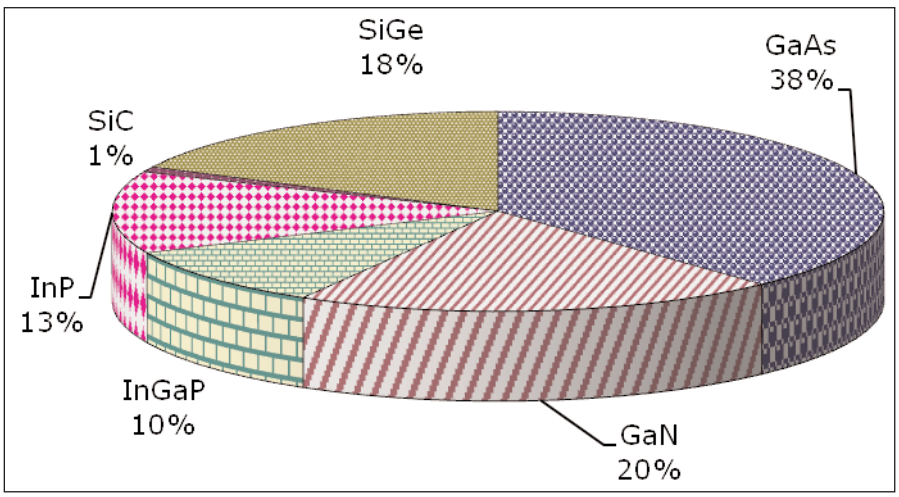

Figure 1. Proportions of players involved in each type of semiconductor substrate for MMICs (2013).

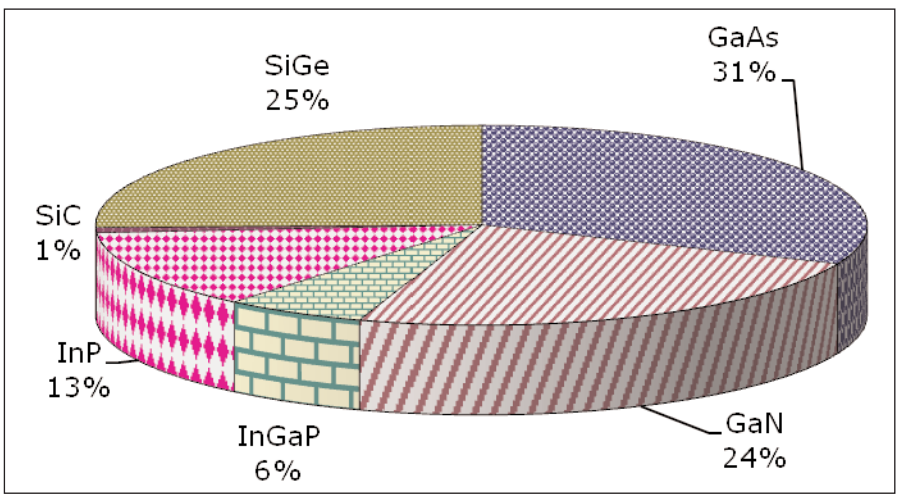

Figure 2. Proportions of players involved in each type of semiconductor substrate for MMICs (2018).

It can be seen that the majority (38%) continue to utilize GaAs — then GaN with 20% followed closely by SiGe with 18% of the total. The total number of GaAs-MMIC suppliers is 44. It is very important to appreciate that several of the players are involved with more than one semiconductor material – notably GaAs and GaN — and these are currently expanding their GaN portfolio.

These data are forecasted for 2018 in Figure 2.

Compared with the 2013 data, GaAs MMIC implementations have decreased by 7%, GaN has increased by 4% and SiGe has increased by 7%.

A brief perusal of the trade press reveals that some people dare to make statements such as: "GaAs is

dead, GaN is here from now onwards". *This kind of statement is totally incorrect regarding GaAs* — although absolutely right about GaN. For most applications, GaN MMIC power amplifiers (PAs) offer much more output power at substantially higher efficiencies than comparable GaAs MMIC PAs. However, it is always very important to remember:

- GaAs MMICs operate with DC supply rails of about 8V to 15V or so;
- BUT GaN MMICs require DC supply voltages of more like 30V or even 45V;
- AND this means that no GaN-based MMIC can ever be a plug-in replacement for a GaAs-based chip.

Meanwhile high-level PAs are regularly being offered today, implementing discrete GaN transistors (e.g. from MACOM).

SiGe BiCMOS is rapidly increasing in importance for short-range, Gigabit-data-rate millimeter-wave radios, with the global market for such MMICs forecasted to reach a value of $220m by 2018. Since the 2012 market was estimated to be about $20m this represents an 83% average year-on-year growth rate i.e. an overall market value increase by a factor of 11.

Players *exclusively* offering SiGe MMICs as well as those offering both GaAs MMICs and SiGe MMICs are identified in Table 1.

It can be seen from Table that a total of 21 players offer SiGe-based MMICs and 13 will supply either GaAs-based or alternatively SiGe-based MMICs.

RFMD and Skyworks are leading suppliers. Whilst the majority of operations are located in China or the USA, there are also important companies outside of these countries. The numbers involved are indicated in Figure 3.

In Japan companies such as Mitsubishi Electric, New Japan Radio, Sumitomo Electric and Toshiba are all influential in this business. Taiwan has Taiwan Semiconductor Manufacturing Company (TSMC — a very important silicon player that also operates a SiGe foundry) and the world-leading GaAs-based foundry WIN Semiconductor.

Most players offer MMIC products operating strictly somewhere within the microwave range of frequencies (500MHz to 18GHz) and some of these players offer both microwave (MW) and millimeter-wave (MMW: above 18GHz). It would appear that only Gotmic (Sweden), IHP of Germany and HRL (USA) offer exclusively millimeter-wave MMICs. This entire scenario (also bare die and package options) is summarized in Table 2. ►

Table 1 GaAs and SiGe MMIC Suppliers (Source: Engalco) — not intended to be a comprehensive listing but includes the main players.

Name	GaAs	SiGe
Avago Technologies1	√	√
BeRex		√
Freescale	√	√
GigOptix*	√	√
Hittite Microwave*	√	√
IBM Microelectronics		√
Infineon		√
MACOM	√	√
MAXIM		√
Mini-Circuits*	√	√
NXP Semiconductor		√
Plextek RFI*	√	√
RF Integration*	√	√
RFMD	√	√
Skyworks Solutions	√	√
Tahoe RF Semiconductors*		√
Tower Jazz		√
TSMC		√
Vectrawave*	√	√
ViaSat	√	√
Ya Guang Microwave Technologies	√	√

* Fabless players (use various foundries).
1 Avago Technologies use the Tower Jazz SiGe foundry.
2 Anadigics is omitted because this company focuses exclusively on GaAs MMICs.
3 TriQuint Semiconductor may possibly be involved with SiGe MMICs, although this situation is at present unclear.

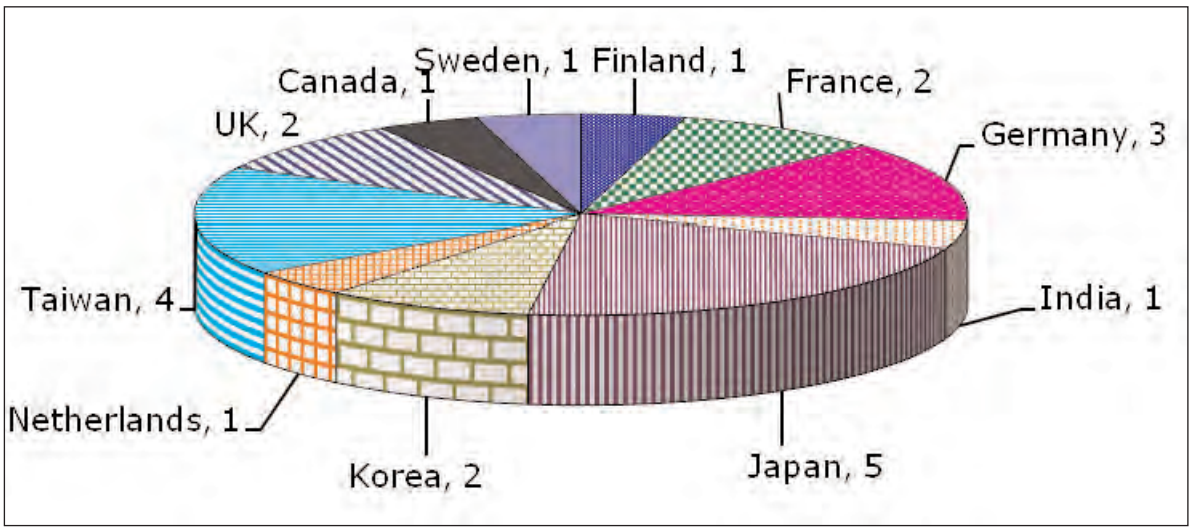

Figure 3. Number of players that have *main* operation outside China or the USA (2018).

Table 2 Players identified as offering MW, MMW, bare die and/or packaged MMICs (Source: Engalco).

Player	MW	MMW	Bare die (chip)	Package/s
Agilent Technologies	√	√	√	
AMCOM Communications	√ to 10GHz			SD-R, WM-R
Anadigics	√			(e.g.) MSL-3
Astra Microelectronic Technologies	√		√	
Auriga Microwave	√	√	√	
Avago Technologies	√ (mainly)	√ (a few bare die)	√	Mainly SMT
BAE Systems Electronic Solutions	√	√	(no	commercial information)
BeRex	√			SOT89 & SOT363
Bowei	√			SMT
Cree	√		√	Screw-down (GaN PA)
Custom MMIC Design Services (CMDS)	√	√ (to 77GHz)	√	
Fraunhofer IAF	√		√	
Freescale Semiconductor	√	√		QFN or LQPF
Gain Microwave	√		√	
GCS	√	√	√	
GigOptix (previously Iterra)	√	√ (to 40GHz)	√	
GotMic		√ (to 105GHz)	√	
Hittite Microwave [1]	√	√ (to ~90GHz)	√ (~80%)	LP4, ST89
HRL		√	√	
IBM Microelectronics	√ (mainly)		√	
IHP		√ (to 300GHz)	√ (mainly)	
Infineon Technologies	√	√ (to 77GHz)	√	SMD
MACOM	√	√ (to 42GHz)	√ (mainly, MMW)	QFN, SOT89
Maxim	√			QFN (to 48-lead), some SOT & WLP
METDA	√	√	√	BGA, SMT
Microsemi	√			SMT [2]
Microwave Technology (MwT)	√		√ (50%)	Some QFNO
Mini-Circuits	√			SMT
Mitsubishi Electric & Electronics	√			SMT (typ. 30-lead)
New Japan Radio	√			QFN, SMT
Nitronex	√			QFN16
Northrop Grumman	√	√	(no	commercial information)
NXP Semiconductor	√			SMD (mainly SOT)
Ommic	√	√	√ (mainly)	Some QFN & other
Plextek RFI	√	√	√	
RENESAS	√			Plastic QFN (typ.16-lead)
RFHIC	√			QFN [3], up to SOIC89
RF Integration	√		√	
RF Micro Devices (RFMD)	√ (~95%)	√ (~ 5%)	√ (small %)	Mainly QFN [3]
Skyworks Solutions	√			MCM, QFN
Sumitomo Electric Device Innovations (SEDI) [4]	√	√ (to 65GHz)	√ (mainly)	QFN (through Ka-band)
Tahoe RF Semiconductors	√		√	LCC [5]
Teledyne Scientific and Imaging LLC	√			324-pad µBGA
TLC Precision Wafer Technology	√	√ (~95%. to 100GHz)	√	
Toshiba	√			SOT (x1 product)
TowerJazz	√		√	
Transcom	√	√ (to 36GHz)	√ (~ 50%)	[6]
TriQuint Semiconductor [7]	√	√ (to 50GHz)	√ (~ 50%)	QFN (~ 50%)
TSMC	√		√	
United Microelectronics Corp (UMC)	√	√	√	
United Monolithic Semiconductor (UMS)	√	√ (to 77GHz)	√ (~ 50%)	QFN (~ 50%)
Vectrawave	√	√ (to 90GHz)	√ (~ 50%)	LPA, QFN (~ 50%)
Viasat	√	√ (to 94GHz)		
Viper RF	√	√ (to 100GHz)	√	(Various)
WIN Semiconductor	√	√ (to 100GHz)	√	
Ya Guang Microwave Technologies	√	√ (to 40GHz)		QFN & similar

Notes relating to the data in Table 2:

[1] Hittite offers a MMIC in an LP4 package (QFN) operating to at least 36GHz.

[2] This applies to Microsemi's range of SMT-packaged MW amplifiers.

[3] RFMD supplies products in the following package styles: ceramic micro-X, plastic micro-X, MCM, QFN, SOIC8 and SOT89 (3-lead).

[4] Most of SEDI's products come in bare die format (always for frequencies exceeding 36GHz). Several SEDI products remain labelled with the earlier Eudyna name.

[5] LCC = leadless chip carrier.

[6] Transcom offer many of their products in unusual package formats. All comprise 8-or-10-lead SMT styles with two fixing holes and signal ports (input and output) in co-planar waveguide (CPW) configurations.

[7] TriQuint's choice of packages mainly comprise: SLIM, ST, SLP or VQFN. Broadband LNAs represent exceptions – typically housed in 12-or-17-lead BGA packages.

A total of 17 players offer products in the QFN (or similar) package format — including Hittite's LP4. It is important to note that several of the major players, e.g. Avago, RFMD, Transcom, TriQuint and UMS, offer about a half or more of their products in either QFN or at least SMT formats. SM-packaged MMICs (mostly QFN) represent an increasingly significant portion of the total available on the market. With the relentless advance of integrated microwave assembly technology, individually connectorized MMIC-based components such as amplifiers and oscillators are already giving way to SM-packaged products, and this trend will doubtless continue.

Another important feature that can be deduced from Table 2 is the relative numbers of players involved in microwave products, millimeter-wave products — or indeed both categories. A total of 53 players are in the first category and 29 players in the second. This means that just below a half of all the MMIC players offer millimeter-wave products as well as microwave products.

Most of the millimeter-wave players offer products operating to at least 42GHz (important, as this encompasses the rapidly growing K/Ka-band SATCOM application sector) and the small German operation IHP can supply at least one product operating to 300GHz. An important subset of these players offer millimeter-wave chips operating in the increasingly significant unlicensed 60GHz band, the E-band and the 76–81GHz adaptive cruise control (ACC) band (W-band).

Concluding remarks

The following conclusions can be drawn:

- Monolithic microwave integrated circuits (MMICs) remain vital to the RF/microwave industry — with ever-expanding applications.
- Out of the approximately 60 MMIC players identified operating worldwide — mainly American-owned — 44 supply GaAs-based MMICs, 21 supply SiGe-based MMICs and 13 offer both types.
- The market for SiGe-based MMICs is growing strongly — notably for millimeter-wave applications including short-range Gbit/s links.
- Another important end-user area for SiGe-based MMICs is for W-band adaptive cruise control (ACC).
- The market for GaN-based MMICs is growing strongly although the number of players offering these types of MMICs is growing slowly.
- At least seven of the players operate using the fabless business model — Hittite Microwave and Plextek RFI are prominent examples. Foundries include IBM Microelectronics, TriQuint Semiconductor, TSMC and WIN Semiconductor.
- Most packages are QFN or similar — although many products are offered in bare die form, often as an option. ■

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