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Basic Information on Using RFIC Foundries

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Our tutorial offers a look at processes available from major SiGe foundries, along with notes on key design and support issues

Foundries for RFIC fabrication are becoming increasingly important as designers move from PC board to module, to fully integrated functionality. The first step is selecting a foundry to work with. This must be done early, since there are many variables in process technology, available design tools, manufacturing capacity, and technical support.

A key design issue is the simulation technology supported and verified by each foundry. Although most EDA tools (both RF and IC design) are supported by all foundries, there are preferences for each, based on the level of cooperation between the software developers, their customers and the foundries.

Another issue in RFIC design is the match between the RF circuit design and the available transistors and passive devices available for each process. Each foundry will have models available for its own devices, which must be used in the creation of the circuit. The limitations on component types, ranges of values, currents, voltages and device performance must be considered in the initial RF "block diagram" design.

Because this is a tutorial article, we'll simply note highlights of the process technologies available from a few major foundries. Rather than try to cover all processes, we've chosen SiGe foundries for this illustrative list.

Jazz Semiconductor

Jazz Semiconductor's (www.jazzsemi.com) SiGe process was first implemented on its proven 0.35-micron, high-volume BiCMOS production technology, and has been optimized to enable low power SiGe devices for today's high-frequency wireless communications and high-speed networking products.

SBC18H2—The company's most advanced SiGe BiCMOS technology features 0.18-micron CMOS gate lengths and SiGe bipolar transistor F_T of greater than 200 GHz for optical-networking and wireless communications applications.

SBC18HX—Offers high performance 0.18-micron bipolar and passive component capabilities combined with industry-standard 0.18-micron CMOS targeted for high-speed networking applications. Low power consumption at peak performance provides significant advantages for high-capacity applications such as OC-192 and OC-768. Peak F_T is155 GHz. SBC18HX comes standard with three bipolar (NPN) transistor types, 1.8 and 3.3 volt CMOS (dual-gate), deep trench isolation, lateral and vertical PNP transistors, MIM capacitors, high-performance varactors, poly, metal and nwell resistors, high-Q inductors and six layers of metal.

SBC18—Provides a next-generation solution for ultra low power, integrated wireless products that require high-performance bipolar transistors with high-quality passives and 0.25-micron CMOS effective density suitable for moderate levels of mixed-signal and logic integration with a peak F_T of 75 GHz to five layers of metal, and a thick top-metal.

SBC35—This is a mature, low-power, cost-effective solution for both networking and wireless applications. Designers have the flexibility of using any combination of three bipolar (NPN) transistors, each of which provides a different optimization for power and speed.

Peak F_T is 62 GHz.

BC35—A 0.35-micron silicon BiCMOS technology for low-cost wireless solutions. With a peak F_T of 30 GHz, this technology offers a balance of cost and performance that makes it attractive for mature wireless products.

IBM

IBM's (www-03.ibm.com/chips/asics/foundry/) silicon germanium BiCMOS technologies offer peak performance for applications requiring high transfer of data, low noise, high linearity and low power consumption such as wireless devices, multi-action mobile telephone systems, and optical networking components. The heart of IBM's SiGe technology is an heterojunction bipolar transistor (HBT) doped with germanium to increase electron transfer. This high-performance material is manufactured using conventional silicon CMOS production tooling, allowing high integration of functions and enabling smaller chip size.

180 nm technologies—BiCMOS 7HP is a SiGe technology with very high performance devices optimized for high performance applications such as high frequency wireless and optical. BiCMOS 7WL is a SiGe technology optimized for mainstream wireless applications with good performance and lower cost.

250 nm—BiCMOS 6HP is a unique and versatile process integrating a 47 GHz high-performance SiGe HBT with a 2.5-V CMOS base, offering high performance transistors with low power consumption.

350 nm—BiCMOS 5HPE integrates a high-speed, 43-GHz SiGe HBT with a 3.3/5.0-V CMOS base, offering high performance transistors with low power consumption.

500 nm—BiCMOS 5HP integrates a high-performance SiGe HBT with a 3.3 V CMOS base. BiCMOS 5PA integrates a high-performance SiGe HBT with a 3.3 V CMOS base optimized for applications requiring high voltage capability and high linearity such as power amplifier designs. BiCMOS 5DM integrates a high-performance SiGe HBT with a 3.3 V CMOS base. This dual metal technology offers increased inductor and capacitor density which is ideal for designs with high proportion of passive elements.

Atmel

Atmel's (www.atmel.com) initial SiGe HBT process has been manufactured in Heilbronn, Germany since 1998. This industry-leading process, still in production, is a high-performance, attractively priced 0.8 µm HBT bipolar technology with F_T of 50 GHz.

Introduced early last year, Atmel offers another process called SiGe2, with F_T of >80 GHz. This 0.5 µm SiGe HBT bipolar process offers designers additional performance at reasonable cost for higher frequency RF and fiber optic applications.

Atmel in Colorado Springs has integrated 0.8-micron SiGe bipolar technology with existing 0.35-micron BiCMOS capability allowing system-level IC design with mixed RF, analog, and digital. Atmel's AT46000 SiGe BiCMOS process is suitable for IC design applications in telecommunications and high-speed data up to 12 GHz. This process offers designers transistor speeds of 50 GHz, at 3.3 volt CMOS with a 5.0 volt I/O option, and a complete digital standard cell library.

The second SiGe BiCMOS process in Atmel's development roadmap is the AT46700. This process was created by replacing the bipolar transistor in the AT46000 with a 0.35 µm NPN. AT46700 offers designers transistor speeds of 70 GHz at 3.3 volt CMOS with a 5.0 volt I/O option as well as a complete digital standard cell library.

Taiwan Semiconductor Manufacturing Company (TSMC)

TSMC's (www.tsmc.com) silicon germanium BiCMOS technology delivers higher performance, faster time-to-market, lower power consumption, more competitive manufacturing costs and superior manufacturing reliability than Gallium Arsenide technology or other similar processes.

Combining the integration and cost benefits of silicon, with the speed of more esoteric and expensive technologies, such as Gallium Arsenide, makes Silicon Germanium an ideal process for wireless/wired communication applications. Products designed for, and manufactured on TSMC Silicon Germanium process demonstrate dramatically improved functionality at a lower cost.

Applications for TSMC's 0.18-micron and 0.15-micron process technologies provide the optimal combination of density, speed and power to serve a broad range of computing, communications and consumer electronics applications. Device applications include high- performance 3D graphics and chipsets, digital TV and set-top boxes, high capacity programmable logic devices, and a variety of advanced wire-line and wireless products.

SiGe is also available in TSMC's 0.35 micron BiCMOS process, with the expected lower F_T and lower power consumption.

Additional Foundries

Among other companies offering SiGe foundry services are: Chartered Semiconductor (www.charteredsemi.com), Freescale Semiconductor (www.freescale.com) and Micrel (www.micrel.com).

Summary

All the the companies mentioned above, and possibly others, offer SiGe RFIC and mixed-signal IC fabrication services that are used by many companies, including some the large well-known IC companies. Each has a different set of capabilities that should be examined carefully during the foundry selection process.

Although SiGe foundries were included here, the required care in selecting a foundry applies to standard bipolar and BiCMOS, GaAs, GaN and other wide band gap processes, and RF CMOS.

Hopefully, this short tutorial note will demonstrate that there is wide range of available capabilities among the various foundry service providers and their processes. All of them are making successful, high-performance products for their customers, but the decision on what foundry to use for your application will hinge on many factors, including financial and business preferences that are not always engineering-related.