

# Co-operative Business Model for Advancing Compound Semiconductor Technology

Jerry Curtis

Global Communication Semiconductors, LLC  
23155 Kashiwa Court, Torrance, CA 90505  
Phone: 310-530-7274; Email: jcurtis@gcsincorp.com

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## Abstract

The compound semiconductor industry, excluding LEDs, is increasingly following the path previously taken by the much larger silicon semiconductor industry, in the use of wafer foundries to supply their wafer manufacturing needs. This trend is driving the rise of foundry business at companies like WIN Semiconductor Corporation, Advanced Wireless Semiconductor Technology (AWSC), and WaveTek Microelectronics Corporation all located in Taiwan.

These wafer foundries business models are focused on high volume low cost wafers primarily supporting cellular handset PA suppliers. Handset volume dominates the industry, accounting for ~90% of the total wafers produced, with the remaining production being low volume and high technology mix.

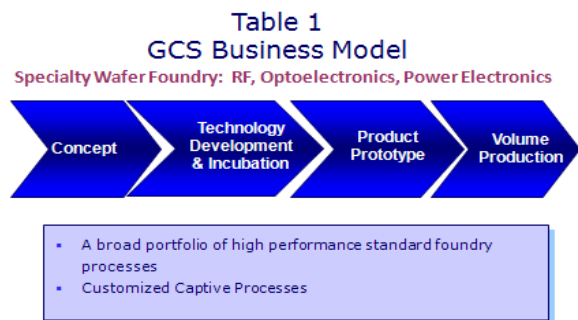
This presentation will discuss the business model for Global Communication Semiconductors, LLC (GCS) and how this foundry model benefits the industry and enables innovation from start-ups as well as established companies by tapping the wafer manufacturing capability and technical expertise of GCS.

## INTRODUCTION

Everyone in the semiconductor industry is familiar with wafer foundries. The success of market leader TSMC (Taiwan Semiconductor Manufacturing Company) in silicon based technology is unmatched. Their success is founded on the business model of driving cost lower and lower through economy of scale, achieved by consolidating demand from many design companies both fabless and IDM. TSMC and other large silicon foundries drive their process development roadmap to provide their customers with leading edge capability which their customers use for new products, largely driven by ever smaller feature size.

In the compound semiconductor industry economy of scale also allows companies like WIN, AWSC, and WaveTek to drive down cost, with WIN being the volume leader. But, unlike the silicon industry or CMOS in particular, performance of customer's designs are greatly influenced by the epi design and the process technology used. The two major market applications that dominate the volume of compound semiconductors produced: cellular handset power amplifiers and Wi-Fi power amplifiers

consume the majority of RFIC's wafers produced but there are many more applications where volume is lower but performance is critical. For these many applications, a co-operative business model, illustrated in Table 1 is used by GCS to serve these low to medium volume applications.



GCS works with our customers from the beginning of their product concept to identify and develop the technology needed to produce their unique product; then GCS produces their product prototype; and then transitions the product to volume production. The breadth and depth of GCS's process technology combined with our experienced and talented engineering team offers our customers unmatched capability to help them develop innovative products for RF, Optoelectronics and Power electronics; as well as other compound semiconductor based products that serve a variety markets. Summary of GCS technology portfolio is shown in Table 2 below.

Technology	Process	Applications
InGaP HBT	High Linearity HBT	Handset, WLAN, Base Station PA
	High Breakdown HBT	Base station driver and small cell PA
	VCO HBT	Low phase noise VCO
InP HBT	SHBT (180GHz ft)	High speed Digital and Analog ICs
	DHBT (ft up to 300GHz)	High speed ,Analog, RFICs
GaAs HEMT	Power PHEMT	High Power and Low Noise Amps
	HFET	Ultra Linear Amps
GaN HEMT	Power HEMT	High V High Power Amps
	HV Switch	1200V Power Electronics
RF Passives	High Q LCR	Filter and Matching/Bias Network Hybrid Integration of Different Dice
THz Diode	High fco Schottky diode	Low loss Mixer
Photo Diode	GaAs, InGaAs PIN, APD	
Laser Diode	DFB, FP, VCSEL	
Photonic IC	Monolithic Integration of Active and Passive Optical components	Optical Fiber Communications Optical Interconnects

## ADVANCING TECHNOLOGY

Historically, compound semiconductor technology was developed by the Defense and Aerospace Industry to serve the needs of that industry, with the technology development being driven by government need and investment. The technology then found its way over time into the commercial market fueling new applications which has helped drive those markets.

This R&D model is still being applied today but the number of defense contractors who have their own Fab, to develop new technology, has decreased. More government investment for new technology is going to IDM compound semiconductor companies like TriQuint and RFMD. These semiconductor companies have their own business interests and in many cases compete against those who might want to use their foundry services to develop products. New technology by its very nature starts as low volume and is difficult to predict when or if the technology will become a high enough volume to attract the interest of the high volume foundries. GCS through partnership with our customers fills this need and at a much lower cost than these customers would incur by establishing their own Fab or adding the new capability to an existing fab. This cooperative business model enables advances in the compound semiconductor market that would otherwise not be possible.

Much of the innovation in high-tech comes from start-up companies who have a new product idea and raise funds, usually from venture capital, to pursue their idea. This is the case for semiconductors in general and for compound semiconductors in particular. More and more of these start-up companies have come to realize that investing in a fab or fab pilot line is costly, increasing the amount of cash they must raise to prove out their product concept. Foundries focused on high volume, low cost are not a fit for these companies due to the high engineering content and expertise required and the low volume. Start-ups, as well as established companies from around the globe are increasingly finding GCS an efficient and cost effective partner to work with them to prove out their ideas and provide a seamless transition to production. Even companies who have invested in a fab or pilot line are discovering that wafer fab at GCS is a superior alternative and some have transferred their technology to GCS, which when combined with existing GCS technology and knowhow can be a winner.

This is in effect like a wafer manufacturing cooperative where combined customer volume lowers the cost for everyone and an established, controlled fab provides high quality wafers and capacity allowing companies to focus their resources on their unique idea or competence while benefiting from the GCS cooperative business model. GCS goes to great lengths to protect our customers own unique technology and IP, as well as their identity. While some customers have chosen to disclose their partnership with GCS, most do not. GCS serves customers who compete with

one another in the market place using their own design expertise and GCS technology to produce performance leading products. GCS customers are both fabless and IDMs with their own fabs but choose to use GCS due to our unique technology, flexibility, and proven capability.

This business model is helping to advance compound semiconductor technology. Many of the products developed by our customers are not intended to become high volume but some are or may become high volume. Since our business model is not based on the traditional ever increasing capital for higher and higher volume, GCS has licensed technology to other foundries when the volume or cost demand becomes such that it no longer fits our business model. In addition, GCS has developed six inch capability, through our partnerships, that can support higher volume as our customers business develops.

## CONCLUSIONS

GCS has developed a unique business model that has been proven to be successful and is providing the industry an efficient and effective way to develop new technology and products. These new technologies and products are helping to advance the compound semiconductor industry in many markets and applications.

## ACRONYMS

IDM: Integrated Device Manufacturer

RFIC: RF Integrated Circuit