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Chips that Rip

SiGe Activates the Next Generation of Broadband Communication Devices

ON Semiconductor™

http://onsemi.com

APPLICATION NOTE

New broadband communication applications and devices promise much. To fulfill their promise, manufacturers must find integrated circuit (IC) technology that continues to push performance higher while driving total cost per gigabit lower. Broadband communication has unique characteristics that are fast pushing traditional CMOS technology to its limit. The race is on to find new materials that will deliver high performance for high–frequency applications while maintaining the manufacturability and price point required for cost–effective mass production. Several new materials show promise. Gallium arsenide (GaAs), indium phosphide (InP), and silicon germanium (SiGe) materials deliver significant performance advantages over CMOS. ON Semiconductor has carefully evaluated the benefits of each and selected SiGe for its next generation of broadband communication ICs. With ultra–low noise performance, solid speed and power characteristics, ease of multi–channel integration and wide support for traditional silicon processing techniques – ON Semiconductor believes that the best choice for next–generation broadband IC products is SiGe.

Keeping Talk Cheap – The Market for Low–Cost, High–Functionality Communication ICs

Stand near any airport arrival gate or baggage claim area and you'll see the future before your eyes. Wireless phones sprout from pockets like weeds after a spring rain. Wildfire adoption of wireless and optical communication technologies is driving demand for new chip capabilities. Broadband applications that can put data, voice and high–bandwidth, delay–sensitive services like videoconferencing into the palm of a hand need gigahertz speeds and miniscule footprints.

Demand for applications and services naturally creates a market for devices that can deliver them. Networking equipment manufacturers are pitted against each other to deliver more bandwidth through a dizzying range of core and access networking products, including:

- Various Digital Subscriber Line (xDSL) systems
- Cable modems
- Asynchronous Transfer Mode (ATM) switches
- Passive Optical Network (PON)
- Smart ATM+Internet Protocol (IP) networking switches, routers and access concentrators
- High–speed optical switches and terabit routers
- Gigabit Ethernet links
- Dense Wave Division Multiplexing (DWDM) metro–area equipment
- 3G Wireless voice and data networks
- Point–to–Point Microwave Communications Equipment
- Storage Area Network (SAN) solutions
- Network Attached Storage Equipment

Not Just Any Chips

The steeply rising broadband equipment market, therefore, results in projectile estimates for broadband integrated circuits (ICs). Not just any ICs, however. As demand for communication speed and distance intensifies, so does the need for new semiconductor materials that can cost–effectively meet the unique demands of broadband communication devices.

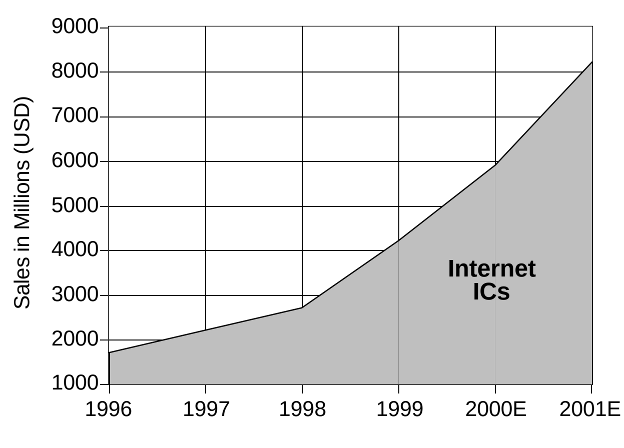

Figure 1. Internet IC Sales

One such unique demand is high scalability. While today's conventional Complementary Metal–Oxide Semiconductors (CMOSs) aren't going away anytime soon, they do have limits. As networked communication technologies, such as Synchronous Optical Network (SONET), push data transport speeds toward 40 gigabits per second (Gbps), CMOS can't keep up. In fact, according to the Semiconductor Industry Association of San Jose, Calif., within the next ten to twelve years, most known semiconductor technologies will be approaching – or will have reached – their limits.

In addition to having high scalability, broadband communication ICs must minimize noise and distortion levels that interfere with radio frequency (RF) transmission, reception, and reliability. To assure high performance at high speeds, ICs for broadband must also be reliable – that is, they must be able to resist degradation over time. Finally, they must be manufacturable. Too–fragile materials result in high defect rates and low cost–effectiveness. Too–temperamental materials limit the number of functions that can be integrated on a chip. Ideally, broadband communication ICs must be robust enough for standard CMOS fabrication and able to integrate with existing CMOS circuits.

New Materials. New Options. New Trade–Offs.

Conventional CMOS devices have been the subject of research and development for almost 50 years. Today, they are the workhorse ICs found in virtually every computing device made. Easy to manufacture with standard fab processes and highly cost–effective, CMOS will remain the mainstay for many applications. However, communication requirements for RF or efficient light–emitting properties spurred research into new materials and combinations. These new combinations are formed from elements found in columns III and V of the periodic table, hence they are known as III–V compounds. Two examples are gallium arsenide (GaAs) and indium phosphide (InP). New semiconductor manufacturing processes also enable new materials to be layered onto existing semiconductor crystals, which are usually silicon.

The three most common compounds in usage today are GaAs, InP, and SiGe. Each has its advantages. Each also has associated drawbacks that may limit use for certain types of applications.

Gallium Arsenide – Fast but Finicky

High–speed gallium arsenide (GaAs) is already used in power amplifiers and switches for certain wireless applications, such as satellite communication and wireless local area networks (LANs). GaAs also is suited for line amplifiers in cable TV infrastructure, cable modems, and set–top boxes. Its RF characteristics ensure that GaAs maintains its reliability as wireless devices move to high frequencies (1.8/1.9 GHz). However, the high cost of GaAs make it more suitable for niche applications such as antenna switches and power amplifiers where the cost per device can be recouped over a large installation or many users. A second drawback of GaAs is that it is a bit finicky. It is not conducive to applications that require high levels of integration to combining multiple functionality on a single chip. Finally, the thermal properties of GaAs are three times worse than traditional silicon, so heat removal can be a challenge. Therefore, for broadband communication that requires multiservice capabilities, GaAs is not the best choice.

Indium Phosphide–Small and Super–sensitive

Ultra–high speed and highly sensitive at detecting and emitting light–indium phosphide (InP) will be used for high–performance applications. These applications will be found in 40 Gbps fiber–optic systems and high–frequency transceivers. InP is expensive, making it impractical for large–scale applications. It also presents manufacturing challenges.

Today, InP substrates are smaller than conventional CMOS substrates, which means they require special fabrication processes and yield significantly less usable material per wafer. Their high sensitivity also has a negative side – InP compounds must be highly precise in composition, and like other III–V materials, the wafers are extremely fragile. InP compounds that vary even slightly compromise reliability. And small fragile wafers significantly limit production yields – contributing to their already higher cost. TRW recently has announced the first high–volume production line for InP fabrication, which may ease the manufacturing issues for OEM customers, but there is still much work to be done to approach the cost effectiveness and reliability of CMOS.

Silicon Germanium–Broadband's Best Bet

Silicon germanium (SiGe) represents the best balance of cost, performance, manufacturability and power manage–ment requirements for broadband communication applications. ON Semiconductor is leveraging the material's properties to deliver the next generation of broadband communication ICs.

SiGe is less costly than either InP or GaAs while delivering comparable – or better – speed and scalability.

By layering germanium into a silicon transistor, manufacturers can dramatically improve an IC's operating frequency, current, noise and power capabilities. SiGe enables data rates today above 10 GHz and is expected to increase its range well beyond that within two years.

At the same time, SiGe is also noted for its low–noise characteristics that result in very little distortion. High–frequency capabilities with low noise make SiGe ideal for wireless and optical networking communications systems and devices such as Transimpedance Amplifiers.

SiGe can be integrated on Bi–CMOS process technologies. This allows the integration of high–speed SiGe transistors and high density CMOS on the same chip – thus enabling the system engineer to integrate powerful new circuits that deliver expanded functionality on ever–shrinking board space.

Other Possibilities

There is also a wide range of other inorganic compounds used, but not commonly. These include silicon carbide, gallium nitride, and cadmium sulfide and others. Compound semiconductors made of three elements have also been tested for broadband communication applications, but lack the strong combination of manufacturability, reliability and scalability that make them good options for wireless–communication applications.

Putting SiGe into Action

ON Semiconductor selected SiGe for its next generation of broadband communication IC products. As a market leader in clock management and high performance digital products, ON Semiconductor is the preferred supplier to the world's leading communication equipment companies including Alcatel, Cisco Systems, Nortel and Sun. SiGe technology enables the company to extend its expertise into OC–192 and beyond.

ON Semiconductor is the first company to deliver this class of SiGe–based products to customers. GigaComm™ combines SiGe process technology with ON Semiconductor's low–skew design expertise and innovative packaging to support the next generation of ultra–high speed communications. GigaComm products support application–specific solutions for optical networking, cross connects and high–speed serial backplane interfaces that are ideal for OC–192, Gigabit Ethernet, 10–Gigabit Ethernet, Fibre Channel and Very Short Reach (VSR) intraconnect applications.

GigaComm Technology

ON Semiconductor's GigaComm ICs product family requires smaller board areas, has better thermal response and higher–frequency performance and is in lower–profile packaging. It supports the following:

- 40 ps typical rise and fall times
- Higher channel densities – up to 12 Gbps operation
- Operating voltage range of 2.375 to 3.6 with minimal power dissipation over frequency
- Low power consumption – 25 mA differential receiver
- Any level input structure to accept LVDS, PECL, CML and single–ended CMOS

GigaComm products are the first SiGe–based products that support next–generation high–speed communications applications for clock distribution, multiplexing, translation and specific applications such as laser drivers.

The Road to the Future is Paved with SiGe

Broadband communication applications are today's applications. As market demand pushes semiconductor technology into barely explored territory, one thing is certain – manufacturers today must have access to ICs that can begin delivering on the promise of wireless and optical technologies while still leveraging the industry learning curves and expertise in silicon manufacturing processes. SiGe–based ICs meet both of those requirements. SiGe products from ON Semiconductor add further value with low jitter/low skew features and minimal power consumption to give manufacturers a jump–start in fast–moving markets.

For more information about its GigaComm products or SiGe technology, visit the ON Semiconductor web site at **http://onsemi.com/gigacomm**.

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ASIA/PACIFIC: LDC for ON Semiconductor – Asia Support
Phone: 1–303–675–2121 (Tue–Fri 9:00am to 1:00pm, Hong Kong Time)
Toll Free from Hong Kong & Singapore:
001–800–4422–3781
Email: ONlit–asia@hibbertco.com

JAPAN: ON Semiconductor, Japan Customer Focus Center
4–32–1 Nishi–Gotanda, Shinagawa–ku, Tokyo, Japan 141–0031
Phone: 81–3–5740–2700
Email: r14525@onsemi.com

ON Semiconductor Website: http://onsemi.com

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