Four Key Semiconductor Development Vectors Drive Next-Generation Handset Design

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The wireless communications industry is entering a new era, as the rapidly expanding wireless world becomes data-enabled and generates hundreds of millions of Internet access points worldwide. Emerging wireless communications technologies are going beyond traditional voice services with the potential to dramatically enhance the Internet experience while adding new capabilities like built-in cameras, Bluetooth connectivity and MP3 support. Meanwhile, a growing percentage of handset manufacturers are outsourcing more of the design process so that they can intensify their efforts on branding, distribution, and defining the handset's look and feel. They are partnering closely with semiconductor suppliers who can give them shorter product life cycles, simplified cellular handset architectures, higher levels of semiconductor integration, and more comprehensive product portfolios. All of these dynamics are having an enormous impact on how next-generation mobile terminals are designed and manufactured.

Traditional development priorities for wireless voice terminals included performance, form factor, cost and time-to-market. With the advent of Internet-enabled designs, handset manufacturers now must incorporate multiple feature sets and advanced capabilities, with higher data rates, larger displays and multiple form factors. As the task gets more complex, semiconductor suppliers are taking on more of the challenge, providing complete platform solutions that include not just the RF, baseband and mixed-signal circuitry, but also the protocol stack and user interface software, comprehensive reference designs and development tools.

This paper will explore the four key development vectors for next-generation handset design: process technology (including GaAs developments), packaging advances and new system architectures and comprehensive system integration. These development areas will facilitate the industry's transition to 2.5G services, including packet enhancements for GSM, and 3G services, which will enable high-speed multimedia voice, video and data capabilities.

Process Advances

While CMOS is the process technology of choice for baseband, not everything will get absorbed into CMOS in the foreseeable future – specialty processes are become increasingly important. Bipolar technology is the dominant process for transceiver designs, first with BiCMOS and now SiGe

BiCMOS for improved performance and power efficiency. For PAs, we have migrated from AlGaAs/GaAs HBT to InGaP GaAs HBT, which will be the process of choice for several years. (See Fig. 1).

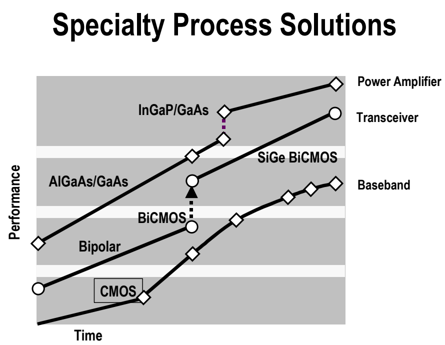

Fig. 1.

Density improvements are the primary focus of process advances. As the die size shrinks, the industry gets a nice compromise of adequate processing speed at low power, plus reduced cost and die size at the higher density. Process improvements have also enabled integration of much more complex functionality while pushing down power consumption. But process developments alone won't get us all the way to next-generation 3G terminal requirements.

Semiconductor Integration

The next area of innovation is in semiconductor integration. There are multiple evolutionary paths. Digital die size is reducing dramatically, while process cost rises and mixed-signal die area remains constant (and gets more expensive as wafer costs increase). RAM requirements are rising, and the deep-submicron processes for RAM and logic have different characteristics. Also, as one goes to higher levels of integration, the digital part of the ARM core shrinks, memory increases, and mixed-signal circuitry stays the same size, so RAM and mixed signal dominate cost and die area. One might explore the integration of RAM and mixed-signal, but may be too challenging and expensive for now.

There are better solutions, such as stacked packaging, in which the processor die is stacked on top of the memory die, or on a low-cost substrate. Indeed, digital integration may be more appropriately supported through advanced packaging than through advanced process technology.

Packaging

The current advanced packaging tend is toward low-cost chip-scale packages that can support digital, mixed-signal and RF applications. Only module-level integration and platform solutions help the new players and shorten the time-to-market for a diverse portfolio of products.

Laminates give benefits in various areas. In addition to enabling integration complexity, these packages are inexpensive and reliable. Laminate modules allow multiple baseband die per package and also provide a foundation for stacked-die and flipchip technology. For RF circuitry, they enable fully integrated radio systems like the CDMA MCM where you traditionally need isolation between transmit and receive and high-quality passives. Semiconductor suppliers can place multiple die and surface-mount components on a laminate.

Packaging advances also influence the debate over single-chip radios. Skyworks has introduced the first in what is expected to be a new category of GSM radios in a single-package that remove discrete-design tasks which can represent eight to nine months of development time. Also, and unlike SoC solutions, the radio in a single package approach preserves roadmap flexibility because the design is conveniently broken into digital and analog functions. Digital moves to the baseband die and analog to the transceiver die, and the mixed-signal device essentially disappears. Each block can continuously shrink along the known roadmap of smaller geometries, unlike SoC approaches that lock RF, analog and baseband on the same die, making it difficult to quickly modify a design or move to smaller geometries since the RF and analog blocks don't automatically scale. (See Fig. 2).

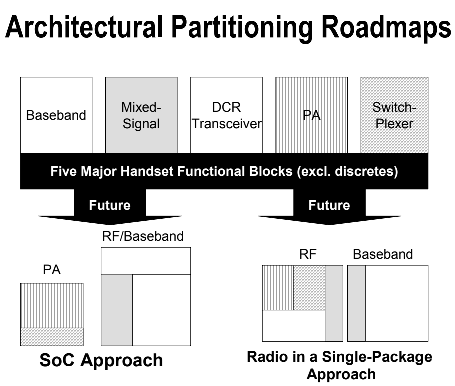

Fig. 2

Advanced packaging allows designers to leapfrog the limitations of silicon-based integration. For instance, in the RF section it is possible to achieve VCO integration, in the digital section one can combine both digital and RF together, and in PAs designers can merge HBT and CMOS die into the same package. Advanced packaging allows the designer to combine optimal process technologies, high-quality discrete passives, and low-cost embedded passives.

Architectural Innovations and System Integration

Next-generation architectures promise reduced internal components and overall system cost, as well as greater flexibility to support multi-mode operation. Developments like direct conversion architectures, intelligent architectures and software-definable radios demonstrate the benefits of architectural innovation.

System integration is the final piece in the puzzle (see Fig. 3). Semiconductor companies now offer complete system solutions that include all the devices from the baseband through the PA, as well as all of the software. They also are working collaboratively with handset manufacturers on board lay-outs. Handset manufacturers are focused primarily on form factor, MMI, plastics and feature/performance definition and feedback. This collaborative model typically reduces handset time-to-market to 6 months, rather than 12.

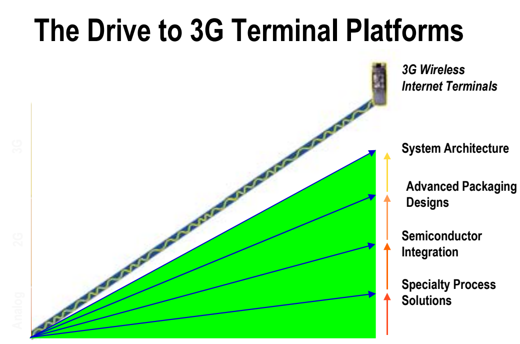

Fig. 3

Meanwhile, as handset manufacturers work more closely with their semiconductor partners, they have streamlined their vendor rosters and now demand more comprehensive product lines. They want the flexibility to start with individual components and then migrate up product integration ladder as required. Early steps include front-end RF modules that can be combined with direct conversion transceivers to encompass the entire RF section. The next step includes comprehensive system-level solutions: integrated front-end modules, RF subsystems and baseband processors, along with protocol stack and user interface software, plus comprehensive reference designs and development platforms.

The industry is moving toward next-generation handsets and services across many technology development vectors. Advances in process technology, packaging, system architectures and comprehensive system integration are driving significant new capabilities. At the same time, a subtle shift in how semiconductor and handset manufacturers work together is opening up new opportunities for innovation, as semiconductor manufacturers concentrate on platform solutions while handset manufacturers address higher-level challenges such as software and product differentiation.

Together, multi-vector technology advances and an evolving design and development model are accelerating the development of next-generation mobile handsets. These trends are presenting significant opportunities for focused semiconductor suppliers who have a comprehensive portfolio of wireless technologies and products, along with the critical mass to drive manufacturing economies of scale while staying at the leading edge of innovation.

ACRONYMS

2.5G and 3G: 2.5-generation and third-generation

ARM: Advanced Risc Machines

BiCMOS: bipolar complementary metal oxide semiconductor

CDMA: code division multiple access

CMOS: complementary metal-oxide semiconductor

DSP: digital signal processor

GaAs: gallium arsenide

GSM: Global System for Mobile Communications

GPRS: General Packet Radio Service

HBT: heterojunction bipolar transistor

InGaP HBT: indium gallium phosphide HBT

MCM: multi-chip module

MHz: megahertz

MMI: man machine interface

PA: power amplifier

PHEMT: pseudomorphic high electron mobility transistor

RAM: random access memory

RF: radio frequency

SAW: surface acoustic wave

SiGe: Silicon Germanium

SoC: system-on-chip

VCO: voltage controlled oscillator