MultiChip Packaging for Mobile Telephony

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Abstract: This paper presents product level considerations for multichip packaging as a cost effective alternative to single chip packaging in the design and manufacture of mobile telephony products. Important aspects include component functionality and complexity, acquisition and logistics costs, product modularity and integration. Multichip packaging offers unique solutions and significant system level cost savings in many applications including RF modules, digital matrix functions and product options such as security, data storage, voice recognition, etc.

Introduction: Throughout the 1980s and 1990s, promotion of conventional microelectronic assembly solutions such as hybrids and multichip modules focused on performance aspects of these technologies. As the new millenium approached many began to recognize that the true value of these microelectronic assembly options lie in miniaturization and integration of specific funtional combinations into a single package.

As we move into the age of telecommunications dominance of the electronic products sector of the global economy, high volumes of complex products create greater opportunity for the application of multichip package alternatives by driving cost curves lower and lower. This builds on the growing demand for greater bandwidth, data capacity and speed expectations in the market place as well.

Key driving forces for functional integration and miniaturization as well as performance come from rapid growth in the internet as both a communication mode and a primary conduit for business exchange. For example, late in the year 2000 data traffic volume carried by the global communications network exceeded the volume of voice traffic for the first time.

Mobile Telephony Applications: The variety of mobile or wireless telephony applications ranges from pagers and cellular handsets to email appliances and wireless internet tools. Each product, as well as each geographic and/or cultural market segment creates unique customer expectations.

Pagers generally present the most simple application and may frequently be integrated into essentially a single, or at most two, basic functional modules. These include the RF function and the data conversion function, which may include text messaging.

Email appliances come next in product simplicity, requiring the same basic functionality as pagers with the addition of a keyboard or stylus input function as well as RF transmission capability.

Wireless internet access functions add significant programmability and higher performance two way transmission requirements to the product. Input and navigation functions become slightly more complex (or at least varied) in comparison

to email appliances, but the limited browsing capability imposed by a portable form factor keep overall product complexity in line with the typical email specific product. Future products may need to incorporate some sort of finger print recognition capability for internet procurement applications.

Clearly the most complex and diverse module applications lie in cellular handsets where functional requirements of all the previously described applications essentially come together. The cellular handset requires two way RF capability, complex digital multiplexing, input functionality and power control such as overvoltage protection circuitry. Cell phones of the future will likely add voice control, perhaps voice recognition for security purposes, and perhaps even global positioning system (GPS) capability.

Considering the high volumes expected in these markets, the opportunity for cost effective manufacture looks good. And clearly, each of these applications demands certain price targets be met in order to create the expected product demand in the marketplace.

Module Partitioning: Prime targets for early adoption of module implementations focus on the RF functions and some of the more complex digital sub-systems, particularly in cell phone handsets.

RF modules hold special appeal due to the complexity and expense of attempts to integrate at the semiconductor level. For example, high frequency GaAs drivers for the antenna cannot be easily integrated at the chip level with the control circuitry usually designed in silicon. An additional advantage of modularizing the RF front end comes from the test ability to fully characterize and trim the analog functions of the module prior to assembly into the hanset itself. And further, the ability to incorrporate dual band, or even triple band transciever capability into a module enahnces product market applicability (See Figure 1.). This generally results in significantly higher final product assembly yield and thereby reduced trouble shooting and rework expense.

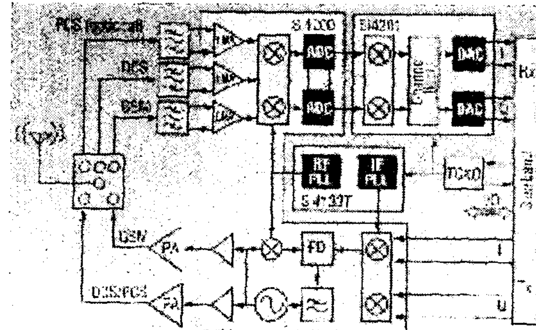

Figure 1. Three chip triple band GSM transceiver module block diagram (Silicon Technologies).

The relatively high complexity of the digital partition in a cell phone creates a second module opportunity for significant reduction in the total pincount for this part of the product. A typical handset requires three (3) to five (5) separate chips to fully manage the digital functions. In miniaturized form factors this results in up to 400 or 500 input/output points on the cell phone printed wiring board (PWB). Incorporating these chips into a single module may reduce this I/O count to as little as 200 to 250 in a slightly smaller footprint. The ultimate impact? A dramatic reduction in PWB complexity and thereby cost.

As wireless internet access continues to grow in importance, both independantly and as a cellular handset option, digital functions such as personal management functions like appointment calendars, phone directories, website URLs, etc. will create additional demands for functional integration. For purposes of internet purchases security requirement

generate an expectation from customers that systems protect their identity and credit. Tools such as finger print recognition, voice printing or eye retina identification systems will find their way into both stationary and portable systems. These present additional module opportunities.

One final, yet major modularization opportunity lies in knowing the location of a device through interaction with the GPS network. This function provides major opporutnity for high volume usage through recovery of lost or stolen property, coordination with mapping information to identify convenient locations fto users for items such as restaurants, hotels, shortest or best traffic routes to selected destinations, etc. A GPS receiver remains somewhat complex today, but continued integration of the digital functions will soon allow design and manufacture of a simple module for easy integration into multiple application environments.

Additional module application opportunities come from the base station and routing network arena where bandwidth and capacity limitations cause mobile telephony frustration on the part of end users. Examples include vector modulators (See Figure 2.), optoelectronic repeaters, power amplifiers, etc.

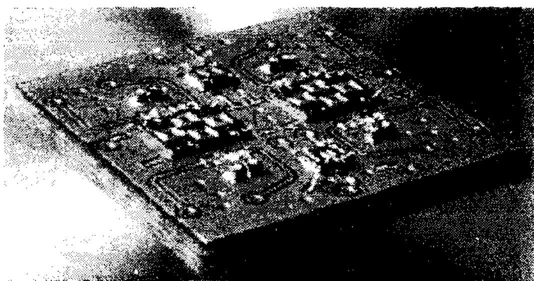

Figure 2. Eight chip base station vector modulator BGA form factor MCM (Alpha Industries).

In summary, candidates for modularization in portable products, and mobile telephony in particular, abound. RF modules, digital matrices, personal digital assistant functions, security systems, GPS location and integration, etc. can be expected to support strong growth of module designs in the foreseeable future.

Benefits of Modularization: The use of modules will soon drive even more rapid market growth in those markets that take advantage of them. Key benefits include: accelerated time to market, and more importantly, time to volume production; simplified product modularity/partitioning, engineering design changes, functional enhancement and modeling; lower cost through simplified PWB structures, higher assembly and test yields, and reduced logistics overhead; and improved product reliability.

Time to market acceleration results from removal of any need to specially design key functions into a product. Only the interface between a specific, standardized module and the rest of the product functions remains necessary. This also impacts time to volume production by removing much of the prototype touble shooting and design problem resolution from the product introduction cycle.

Having standardized modules avialable for these common functions greatly simplifies the design process and allows product designers to focus their energy on tailoring their products to their customer's needs rather than on making certain that isolated product functions work properly. Engineers can also focus effort on designs capable of incorporating multiple options, completely at the discretion of the ultimate customer. And in many cases perhaps even enabling easy upgrade options that customers may implement themselves. Finally, knowing the performance specifications and limits of each module eases the design modeling

and problem resolution process by providing designers with known boundaries for each function, as opposed to having to deal with multiple individual components that do not necessarily behave in predictable wasy when integrated into a complete function. The module designer and producer resolves these issues before the product designer ever needs to deal with them.

Cost reduction remains the ultimate judge of the value of any design approach, and modules may positively impact cost in several ways. The most obvious impact comes at the PWB level where modules allow the highest density interconnect structures to be focused only where needed. This results in larger pitch integrated components (modules) than possible using individual integrated circuits (ICs) directly on the PWB (See Figure 3.). These simplified PWBs cost far less and result in higher assembly yields as well. In addition, since module procurement results in essentially "know good functions," assembly yield is further enhanced through the elimination of defective interactions between individual IC components. This also significantly improves final product reliability since most infant failures and marginal performance interactions (among components) disappear.

The final cost impact comes from the logistics arena where the simple cost to create and manage a part number in the manufacturing resource planning system at a major corporation can run into the US $100,000 to US $150,000 range. For a major OEM the use of a single module in a product design, as opposed to five or six individual ICs, may result in an information systems cost savings of as much as $500,000 per year!

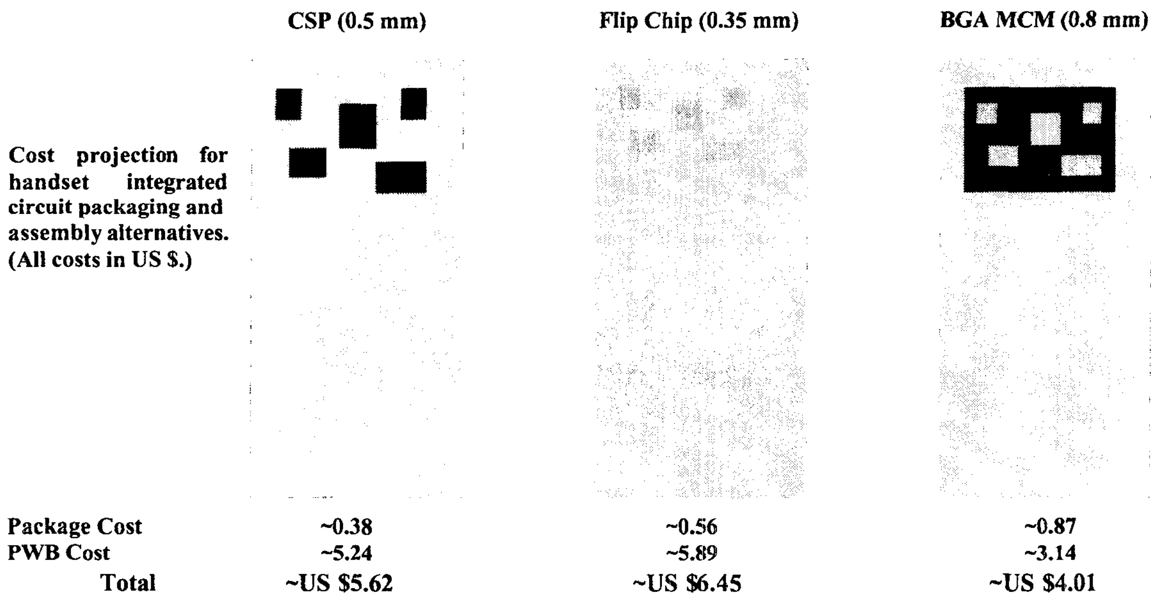

Figure 3. Potential cost savings estimate using multichip packaging versus chip scale (CSP) or flip chip alternatives.

Biography: Charles E. Bauer, Ph.D. is Senior Managing Director of TechLead Corporation, a technology management company specializing in the electronics packaging, interconnection and assembly industry. Dr. Bauer focuses in the area of

strategic technology planning and selection, particularly the interaction between markets and technology applications. His nearly 20 years of experience spans the range from printed circuit board and hybrid fabrication through complex IC metallization, multilayer packaging, multichip modules and flat panel display packaging and assembly.

Recent target technology areas include ball grid array and flip chip, and chip scale packaging (CSP) as well as high density substrates, both organic and inorganic. Dr. Bauer lectures throughout Asia, Europe, South America, Australia/New Zealand and the USA on these topics from both a technical and market perspective.