Packaging for Portables; Going Vertical & Getting Small

3D packaging continues electronics footprint reduction

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Outline

• UBM TechInsights; what’s all this Teardown stuff?

• Portable Electronics as Product drivers; Handsets set the pace for (selective) 3D packaging; a few examples from “The Boneyard”.

• A little trip down memory lane in 3D packaging.
Background

• UBM TechInsights Austin, formerly known as Portelligent.

• Company focus: Technical Intelligence and Intellectual Property Services: Along with Chip-level Reverse Engineering, we produce Teardown Reports & related research on Wireless, Mobile, and Personal Electronics.
  • A Teardown covers system architecture, physical implementation, Bill-of-Materials (BOM), estimated Cost of Goods Sold (COGS), and system metrics.

• Cell Phones, Smart Phones, PDAs, Digital Cameras, Wireless Networking, Game Boxes, Multimedia, are primary areas of systems coverage.

• Teardown analysis activities cover a decade of industry change and hundreds of product analyses.
Portables drive 3D Packaging

- Mobility rules, and consumers continue to expect more stuff in less space.
- Advances in power efficiency mean many more mm$^2$ of silicon can be put into small form-factor devices without exceeding battery life constraints or thermal dissipation limits.
- Handsets and ‘pocketable’ electronics lead the charge for more technology in less volume.
- Other consumer products are also pushing high-volume, high-density 3D packaging as well, though application is selective.
Apple iPad 3G Tablet Computer

Product Description:
As a follow on to the Apple WiFi model, the cellular-data enabled iPad 3G was released to market on April 30, 2010. As with the WiFi version of the iPad, it appears to be an oversized - but more capable - iPod Touch, and features WiFi 802.11n, Bluetooth 2.1 + EDR connectivity and the added 3G capabilities for true cellular data portability. The large 9.7” TFT-LCD display (16M colors, 1024 x 768 pixels) uses IPS (in-plane switching) technology to enhance the viewing angle. The display is overlaid with a multi-touch capacitive touchscreen containing a fingerprint-resistant oleophobic coating. The large two-cell battery (3.75V, 6.61Ah) provides a claimed use time of 10 hours and standby time of 730 hours.
iPad 3G Component Arrangement
iPad 3G Teardown
iPad 3G Main Board (Side 1)

- Apple / Samsung #A4 / #APL0398 ARM Applications Processor
- Samsung #K9LCG08U1M Multichip Memory – 8 GB MLC NAND Flash
  **Die#1** - Samsung, MLC NAND Flash - 4GB (qty. 2)
- Samsung #K4X2G643GE Multichip Memory - 256MB Mobile DDR SDRAM
  **Die#1** - Samsung, Mobile DDR SDRAM - 128MB (qty. 2)
iPad 3G Wireless Board (Side 1)

**Infineon**
- #PMB8878
  - Digital Baseband Processor
  - **Die#1**: PMB8877, GSM/EDGE Baseband Processor
  - **Die#2**: M8802, WCDMA Baseband Processor

**Numonyx**
- #PF36MY1EE
  - Multi-Chip Memory
  - **Die#1**: Numonyx, NOR Flash Memory - 16 MB
  - **Die#2**: Elpida, Mobile DDR SDRAM Memory - 16 MB

**Skyworks**
- #SKY77340
  - Quad-band GSM/EDGE Power Amplifier
  - **Die#1**: Skyworks, Power Amplifier Controller
  - **Die#2**: Skyworks, Power Amplifier Band 2
  - **Die#3**: Skyworks, Power Amplifier Band 1

**TriQuint**
- #TQM666032B
  - Band II W-CDMA PA w/ Duplexer
  - **Die#1**: TriQuint, Power Amplifier
  - **Die#2**: TriQuint, Bias Control
  - **Die#3**: TriQuint, Power Detector
  - **Die#4**: Infineon, BAW Filter
  - **Die#5**: Infineon, BAW Filter

Grid = 1cm
iPad 3G - Some Metrics

<table>
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<tr>
<th>General Area</th>
<th>Assembly Name</th>
<th>IC Die Count</th>
<th>IC Package Count</th>
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- Substrate Tiling Density and Die/Package Area ratios reflect impact of stacking and 3D.
Motorola Droid X Smartphone

Product Description:
The Motorola Droid X is a top tier offering for Verizon subscribers. This dual-band (850&1900 + EVDO) CDMA phone features a 4.3 in. multi-touch, touchscreen LCD. The Android-based phone also provides the user with a 8MP CMOS camera with auto focus and flash. The Droid X utilizes three microphones to facilitate noise cancelling. The phone provides Bluetooth and WiFi connectivity as well as GPS and FM radio. Wired connectivity is made available via a USB port. A microSD card slot allows for additional storage. The Li-ion battery supplies a reported eight hours of active time and 220 hours of stand-by.
Droid X Component Arrangement
Droid X Teardown
Droid X Main Board (Side 1)

**TriQuint**  
#TQM613029  
CDMA 850MHz Power Amplifier / Duplexer Module  
**Die#1**: TriQuint, CDMA 850MHz Power Amplifier  
**Die#2**: TriQuint, Bias Control / Power Detector?

**Avago**  
#AFEM-7758  
CDMA 1900MHz Power Amplifier / Duplexer Module  
**Die#1**: Avago, CDMA 1900MHz Power Amplifier w/ Control  
**Die#2**: Avago, Transmit Switch

**Qualcomm**  
#QSC6085  
Baseband Processors + CDMA Transceiver  
**Die#1**: Qualcomm, Digital Baseband  
**Die#2**: Qualcomm, CDMA Transceiver  
**Die#3**: Qualcomm, Analog Baseband / PM

**Micron**  
# NANDA9R4N4  
Multichip Memory  
**Die#1**: Micron, Mobile DDR SDRAM Memory – 64 MB  
**Die#2**: Micron, SLC NAND Flash EEPROM Memory -128 MB
Droid X Main Board (Side 2)

**Toshiba**
- #YCC0A211278LJ
  - Multichip Memory - 512 MB Mobile DDR SDRAM, 1 GB MLC NAND Flash
  - **Die#1** - Elpida, Mobile DDR SDRAM Memory - 256 MB (QTY 2)
  - **Die#2** - Toshiba, MLC NAND Flash Memory - 1 GB

**Toshiba**
- #THGBM2G6D8EBA1E
  - Multichip Memory Package - 8 GB MLC NAND Flash, Memory Controller
  - **Die#1** - Toshiba, MLC NAND Flash Memory - 4 GB (QTY 2)
  - **Die#2** - Toshiba, Memory Controller

**TI**
- #OMAP3630
  - Applications Processor
## Droid X - Some Metrics

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<th>General Area</th>
<th>Assembly Name</th>
<th>IC Die Count</th>
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- Substrate Tiling Density and Die/Package Area ratios on Main Board higher still versus iPad 3G example.
Droid X - Substrate Cross Section

PCB Construction: 3+(1+2+1)+3 Buildup / Stacked Via

- Four-layer 1+2+1 drilled/microvia core formed [double-sided core+microvias and thru-hole drill] followed by;
- Hole-fill and addition of first microvia layers top and bottom followed by;
- Second hole-fill and addition of microvia layers top and bottom followed by;
- Third hole-fill and addition of microvia layers top and bottom to complete 10-layer board
- Via-in-pad construction allowed.
- PCB Vendor: Compeq
- PCB Thickness: 1.0mm
- Cross-Section Location: TI OMAP3630 / Toshiba YCC0A211278LJ
Apple iPhone 4

**Product Description:**

Apple released their fourth-generation iPhone 4 (not to be confused as being 4G capable) in late June 2010, coinciding with their latest iOS upgrade to 4.0. Operating on quad-band GSM + EDGE and quad-band W-CDMA + HSDPA / HSUPA (850/900/1900/2100 MHz) networks, the iPhone 4 is enhanced with higher resolutions for both display (960 x 640 up from 480 x 320) and main camera (5MP up from 3MP) with HD video recording capability. Apple also introduced a front-facing VGA camera for making conference calls from iPhone-to-iPhone via their new FaceTime chat application. The 3.7V/1420mAh Li-polymer battery provides a claimed 14 hours of GSM talk time, but only 7 hours for W-CDMA; standby time is rated at 300 hours. Other features include WiFi 802.11b/g/n (802.11n is 2.4GHz only), Bluetooth 2.1 with EDR, and A-GPS with navigation.
iPhone 4 Component Arrangement
iPhone 4 Teardown

- Display/Touchscreen/Display Window
- Main Enclosure
- Battery
- Main Board
- Battery Cover
- Home Key Flex
- Docking Flex
- 5MP Camera
- VGA Camera
- Earpiece
- Sensor Flex & WiFi/BT/A-GPS Antenna
- User Interface Flex
- Key Covers
- MicroSIM Ejector Lever
- Main Antenna & Speaker Assembly
- Moisture Sensor
- Clamps, Clips, & Gaskets
- MicroSIM Holder
- Screws & Washers
iPhone 4 Main Board (Side 1)

**TriQuint**

* #TQM666092  
  W-CDMA Band II PA w/ Duplexer  
  *Die#1*- TriQuint, Power Amplifier  
  *Die#2*- TriQuint, Bias Control

**Skyworks**

* #SKY77452  
  W-CDMA PA Band VIII w/ Duplexer  
  *Die#1*- Skyworks, Power Amplifier  
  *Die#2*- Skyworks, Bias Control

**TriQuint**

* #TQM676091  
  W-CDMA Band I PA w/ Duplexer  
  *Die#1*- TriQuint, Power Amplifier  
  *Die#2*- TriQuint, Bias Control

**Skyworks**

* #SKY77459  
  W-CDMA Band V PA w/ Duplexer  
  *Die#1*- Skyworks, Power Amplifier  
  *Die#2*- Skyworks, Bias Control

**Elpida**

* #ECK4265J1PB-50-F  
  Multi-Chip Memory - 512MB Mobile DDR SDRAM  
  *Die#1*- Elpida, Mobile DDR SDRAM - 256MB (qty 2)

**Apple / Samsung**

* #A4 / APL0398  
  ARM Applications Processor
**iPhone 4 Main Board (Side 2)**

**Micron (formerly Numonyx)**
- #PF36MY1EF
- Multi-Chip Memory
  - **Die#1**: Intel, NOR Flash Memory - 16MB
  - **Die#2**: Elpida, Mobile DDR SDRAM Memory - 16MB

**Apple / Dialog**
- #338S0867 / D1815A
- Power Management

**Apple / Cirrus Logic**
- #338S0589 / CLI1495B0
- Audio CODEC

**Apple / TI**
- #343S0499 / F761586G
- Touchscreen Controller

**Infineon**
- #X-GOLD 616 PMB9801
- GSM / W-CDMA Baseband

**Samsung**
- #K9PFG08U5M
- Multi-Chip Memory - 32GB MLC NAND Flash
  - **Die#1**: Samsung, MLC NAND Flash - 4GB (qty 8)
## iPhone 4 - Some Metrics

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<tr>
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- Substrate Tiling Density and Die/Package Area ratios on Main Board among the highest we’ve ever seen.
### iPhone 4 - Substrate Cross Section


**Construction: 4+2+4 Full Sequential Buildup**
- Two-layer starting core fabrication followed by;
- 4X sequential addition of (filled) microvia layers added top and bottom to form 10-layer PCB.
- Via-in-pad construction
- PCB Vendor: Ibiden
- PCB Thickness: 0.75mm
- Cross-Section Location: A4 Applications Processor + Memory PoP (top side) & 32GB NAND Flash Memory (bottom side)
Some 3D Packaging Nostalgia

- Without peeking ahead, can you *accurately* identify these?
Some 3D Packaging Nostalgia

A Memory Module from the Saturn V flight control computer - One of up to eight such modules per LVDC, the Core Memory module shown provided 4,096 word locations of 28 bits each, or roughly 115Kbits per module
Some 3D Packaging Nostalgia

- Saturn V Rocket Launch Vehicle Digital Computer (LVDC)….
Space-Race Era Packaging

- Stacked Boards, Surface Mount Technology, Underfill, Multichip Packages, Flip-chip Die attach → *ca. 1965 via IBM (Federal Systems Div.)*
Space-Race Era Packaging

- RCA 110 Saturn Ground Support Launch Computer Boards – 3D was *not* critical in all applications!
Summary

• Memory / Processor-Memory components remain the most vibrant area for application of 3D stacking.
• MCPs, SiPs, PoP usage reflects a mix of design philosophy and technology accelerator towards monolithic implementations.
• Selective use of 3D packaging in high-function mobile/personal/consumer electronics keeps electronics footprint small, freeing up space for all the things that do not shrink very well (especially the battery)
• Today’s technologies have a long history – as usual we’re standing on the shoulders of giants (and while the Space Race was one driver of packaging technology advancement, it didn’t create Tang!)

Thanks for listening - questions?