Expanding Flash Memory Capacity through Stacking Methods

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High-Density Flash Packaging

- Flash Stacking
- Flex Integrated Modules

Flash Stacking Benefits

Benefits

Highest Density NAND Solution

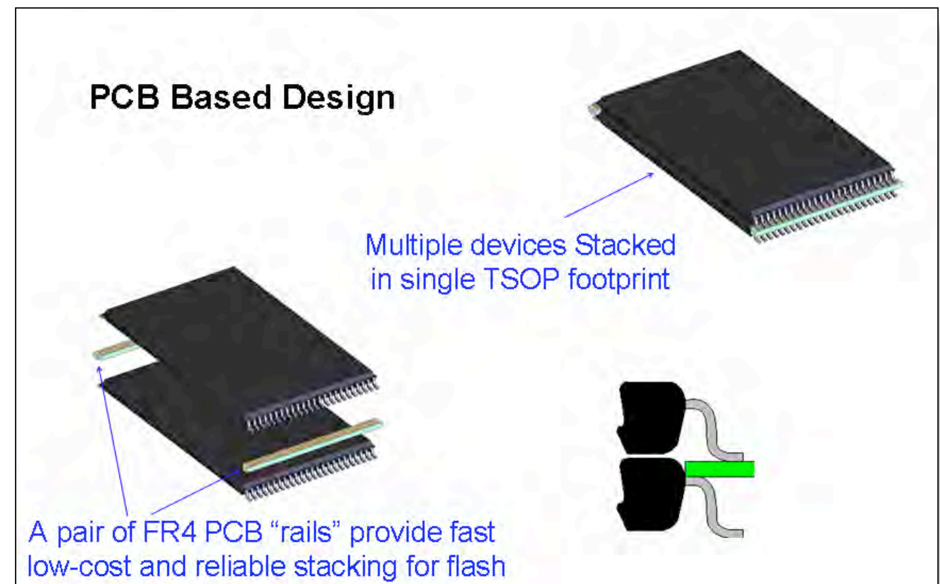
- Stacking multiple lower density devices in a single TSOP footprint

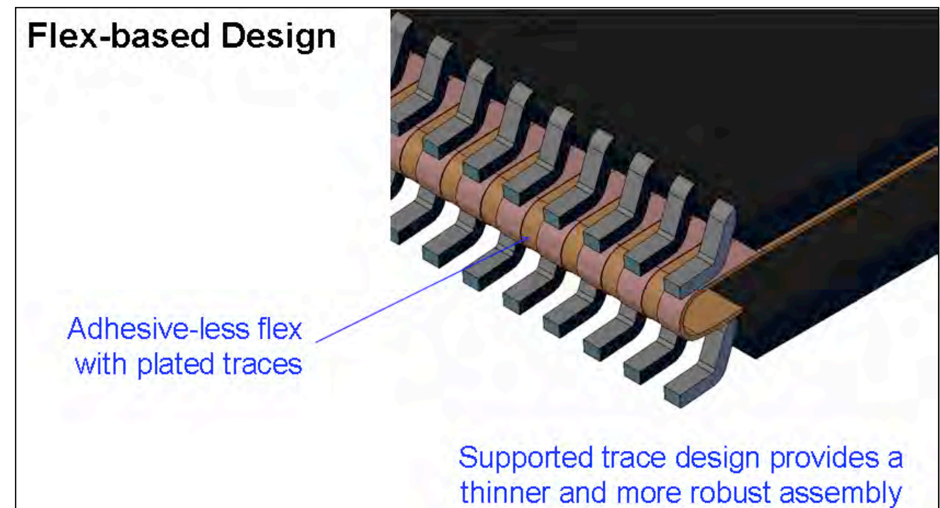
Component supply flexibility

- Supports commodity NAND devices from multiple vendors

Product Agility

- Enables higher capacity SKUs with minimum design changes and manufacturing cycle time for UFD, MP3, Memory Card, etc…





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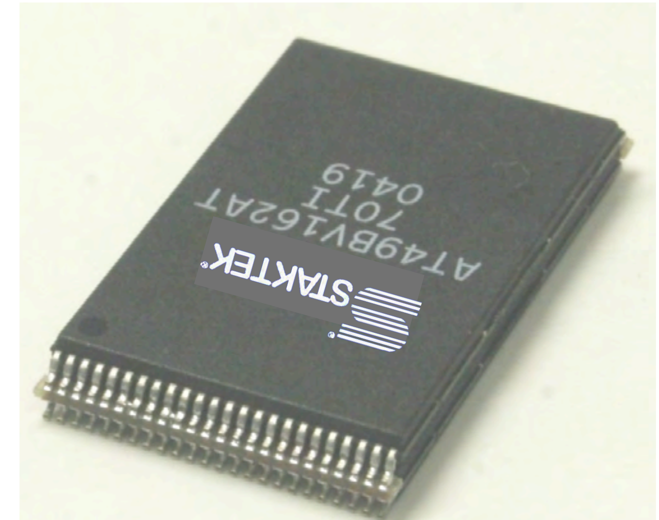
FlashStak™ X-2

- **Doubles the NAND storage capacity**
  - Stacks two NAND TSOP devices
- **Mechanically Rugged and Reliable like a single TSOP**
  - Extensive stack qualification and testing
  - Stack fits into a standard TSOP footprint
- **Flexible and Just-in-Time Component Support**
  - Supports commodity 1CE and 2CE flash devices
  - 24 hour manufacturing cycle time (typical)
- **Low Profile Stack**
  - Virtually the same height as two TSOPs
- **Proven and standard assembly process**
  - Based on proven Value Stakpak® IP
  - 2GB products shipping since Q4’05



Double the Density of a Commodity Flash Device

FlashStak X-4

- **Quadruple the NAND storage capacity**
  - Supports up to 32Gb in a single stack with 4 x commodity 8Gb devices
  - Supports up to 64Gb in a single stack with 4 x 16Gb devices
- **Mechanically Rugged and Reliable like a single TSOP**
  - Extensive stack qualification and testing
  - Stack fits into a standard TSOP footprint
- **Flexible and Just-in-Time Component Support**
  - Stacks up to 4 JEDEC standard TSOP devices (single or dual CE)
  - 24 hour manufacturing cycle time (typical)
- **Low Profile Stack**
  - 4.62mm MAX Height
- **Proven and standard assembly process**
  - Based on proven Value Stakpak® IP

Stacking dimensions*:

L x W = 20.3mm x 12.9mm MAX

2-High = 2.34mm MAX Height

3-High= 3.48mm MAX Height

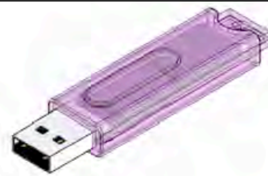
4-High= 4.62mm MAX Height

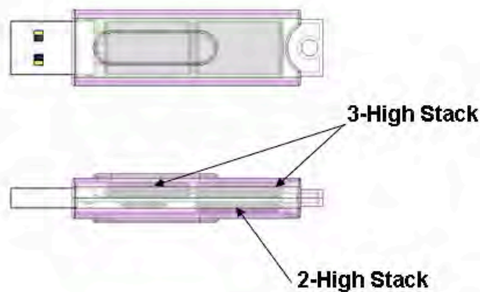
Quadruple the Density of a Commodity Flash Device

Flash Stacking Applications

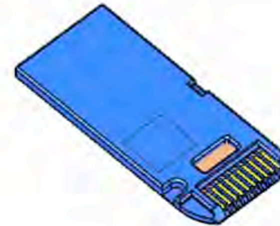
High-Capacity USB Key

8GB w/1Gb devices
16GB w/2Gb devices

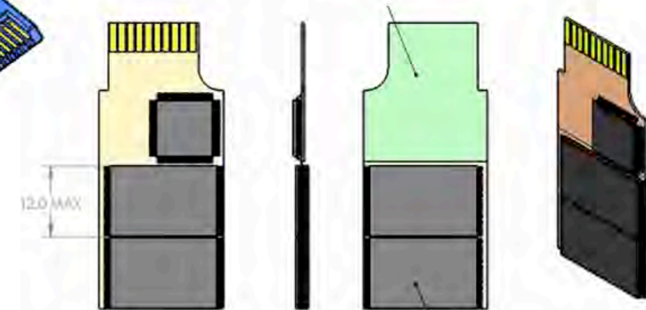




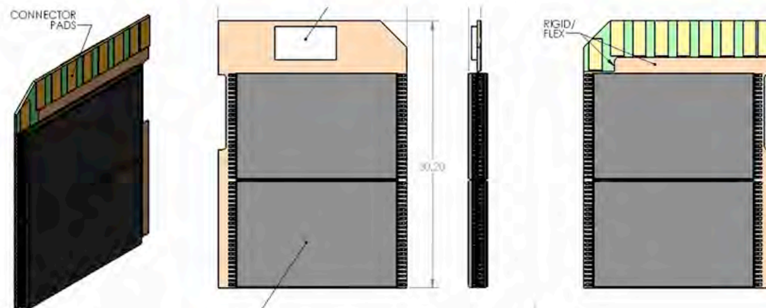
High Density Memory Stick



Double the capacity of conventional modules due to volumetric efficiency



High Density SD/MMC Card

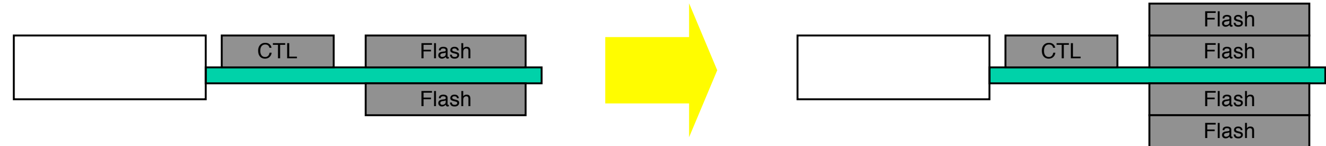


2X devices in the same volume

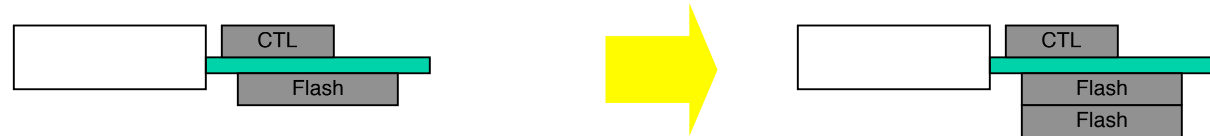
- **Small Form-Factor Memory products**
- **Portable electronic products requiring high capacity embedded Flash**
  - MP3/Medial player
  - Digital still camera
  - Camera Phone
  - Ultra-Mobile PC w/integrated Flash drive

Flash Stacking can be enabled with minimal re-design

High Capacity USB Flash Drive

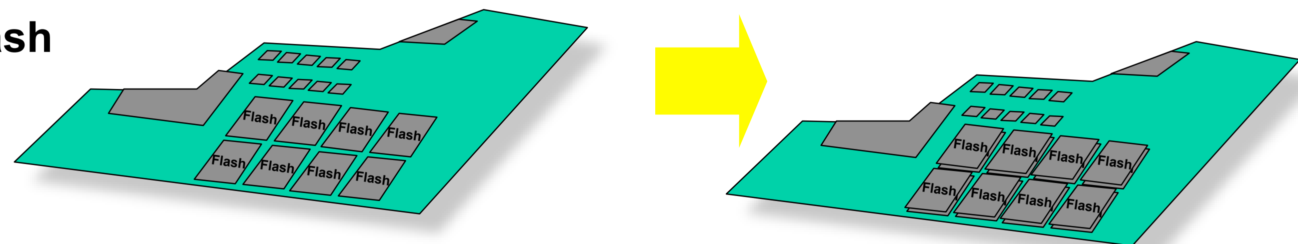


Small USB Flash Drive



Personal MP3 Player

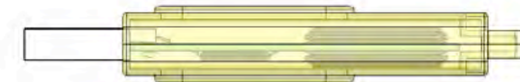
Ultra Mobile PC – Flash on Motherboard



Doubling the Capacity With Minimum Device Design Changes

Case Study: 4GB USB Flash Drive

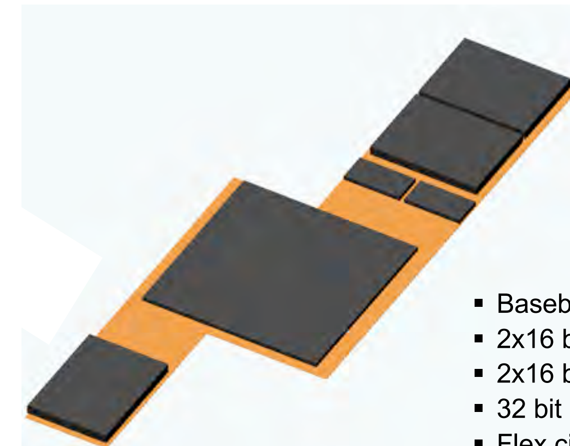
- PNY's first commercial 4GB USB Flash drive using FlashStak X-2
- Product derived from existing 2GB drive using two single 8Gb TSOP devices
- Two 16Gb stacks were fitted in the existing housing with only minor modifications
- Stacks shipping in volume since Q405



Flex Integrated Module (FIM) Overview

Description

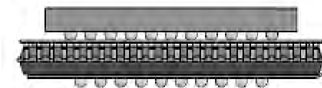
- **System Stakpak®** is a Flex Integrated Module (FIM)
- Integration of heterogeneous ICs and packages within a folded flex module
- Enables complex or economical form-factor optimized sub-systems
- Leverages Staktek's extensive experience and IP with flex circuit assembly
- Complementary to SiP and PoP packaging
- Supports sub 2mm low-profile applications



- Baseband Processor
- 2x16 bit DRAMs
- 2x16 bit Flash
- 32 bit SRAM {Cache}
- Flex circuit
- Ball Attach

Benefits

- *Best-in-class* silicon selection
  - Optimal feature set for targeted application
- Increased design flexibility
  - Time to market
- Enhanced yield
  - Cost efficiency



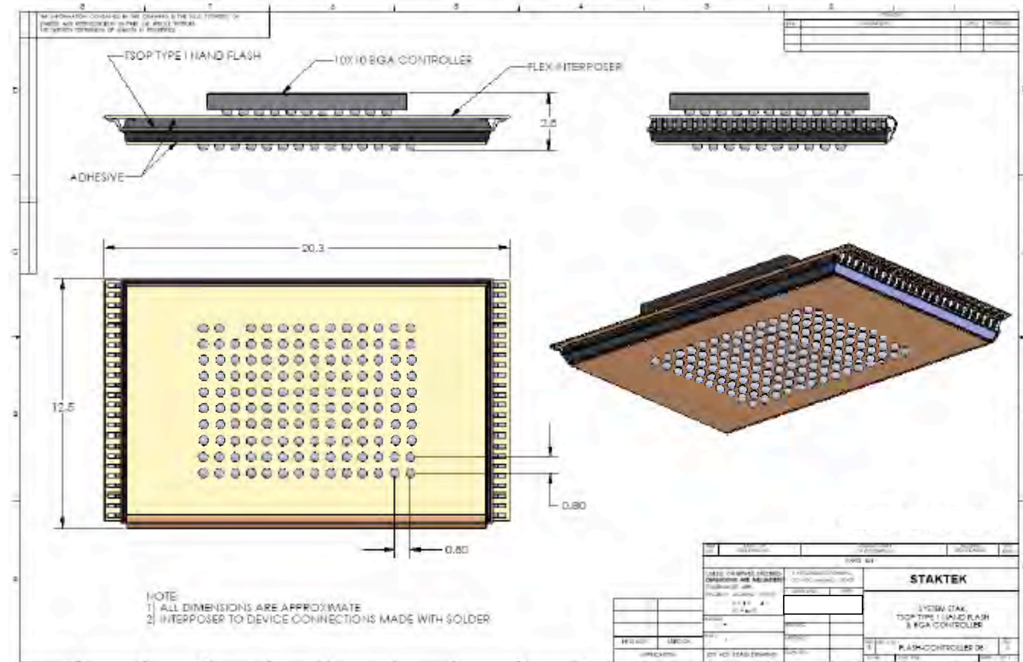
- Controller (BGA)
- Flash (TSOP)
- Flex circuit
- Ball Attach

System StakPak® Advantages

- Best-In-Class silicon selection
  - Integrate the devices YOU choose for optimal functionality/performance regardless of available packaging formats.
  - Use ANY off-the-shelf package formats (including bare die, CSP, SiP, PoP,TSOP,TBGA, etc.) without modification.
  - Integrate STANDARD packaged parts to shorten supply chain, minimize inventory, simplify forecasting and increase sourcing flexibility.

- Increased design flexibility
  - Exploit scalable flex circuit wiring resources for COMPLEX ROUTING requirements.
  - Integrate DISCRETE COMPONENTS within the module package.

- Enhanced yield
  - PRE-TEST individual packaged components.
  - Conduct ON-MODULE PRE-TEST of selected critical components.
  - REWORK defective components on-module, post-functional test.

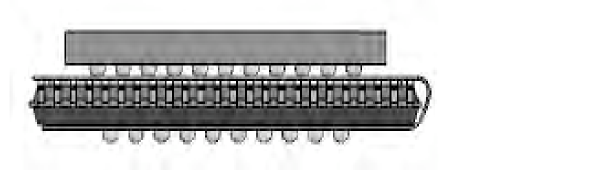


- FIM example – TSOP Flash + BGA Controller

Summary

- FlashStak™ Solution
  - Double and quadruple TSOP stacking solution for NAND Flash devices
  - Create products with higher memory capacity
  - Many products will require minimal redesign to accommodate stacked Flash
  - Based on reliable, proven designs and production processes

- System StakPak® Solution
  - Rapidly integrate Best-in-class flash and controller solutions into single low-profile package
  - Maintain design/supply-chain flexibility
  - High-yield solution



Speaker BIO

- Bert Haskell – Director of Marketing, CEBU, Staktek, Inc.

- 20 years experience in the electronics industry
  - Manufacturing Engineer (Eastman Kodak)
  - R&D Management (MCC, SDC)
  - Product & Technology Marketing (AMD, Motion Computing, Staktek)

- Over 30 publications, 5 patents

- Author: "Portable Electronic Product Design and Development", McGraw-Hill 2004

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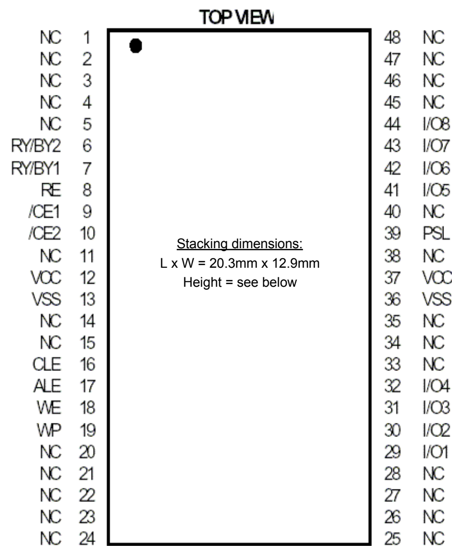
Appendix: Additional information

- For reference only (not part of presentation)
  - FlashStak™ 2-X: 2 Product SKUs
  - FlashStak™ Reliability Test Conditions

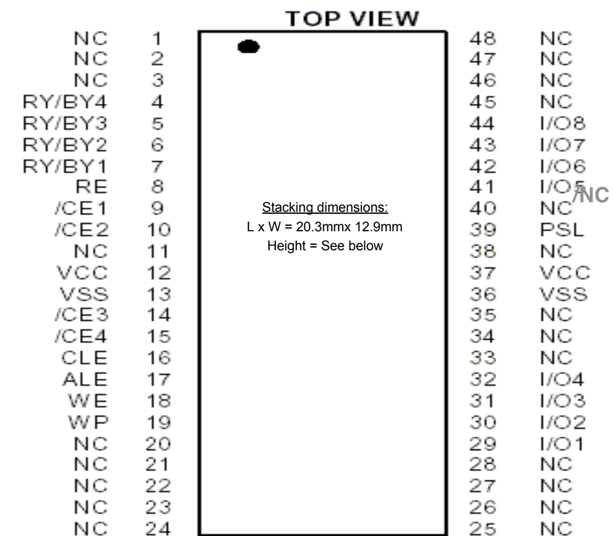
FlashStak™ 2-X: 2 Product SKUs

2CE FlashStak



Vendor	Density	Single CE part#	Stack Height (mm)	Status
Hynix	4Gb	HY27UG084G2M-TXXX	2.21	Production-ready
	8Gb	HY27UH088G2M-TXXX	2.21	Production-ready
Micron	4Gb	MT29F4G08BABWP-XX	2.27	Production-ready
Samsung	256Mb	K9F5608D0D-PCB0	2.25	Production-ready
	4Gb	K9K4G08U0M-XXXX	2.25	Production-ready
	8Gb	K9K8G08U0M-XXXX	2.25	Production-ready
Toshiba	8Gb	TC58NVG3D4CTG00	2.45	In production
	16Gb	TH58NVG4 D4CTG00	2.45	Production-ready

4CE FlashStak



Vendor	Density	Dual CE Part#	Stack Height (mm)	Status
Micron	8Gb	MT29F8G08FABWP-XX	2.20	Sampling
Samsung	8Gb	K9W8G08U1M-XXXX	2.32	Sampling
	16Gb	K9WAG08U1M-XXXX	2.32	Sampling

Others currently being developed under NDA

FlashStak™ Reliability Test Conditions

Test	Reference	Conditions
HAST	JESD22-A110	96 hours at 130C, 85% relative humidity using continuous bias.
Temperature Cycle (Component Level)	JESD22-A104	Condition B, soak mode 1 for 1000 cycles at -55C to 125C
Temperature Cycle (Module Level)	JESD22-A104	Condition J, soak mode 2 for 1000 cycles at 0C to 100C. 30 minute cycles with a temperature change rate of 10C/minute.
Constant Acceleration	Mil-Std-883, 2001	Condition A: 5000g
Vibration	JESD22-B103	Four sweeps of 20g peak sinusoidal vibration from 20 to 2000Hz in each of the three mutually perpendicular axes for a total of 12 sweeps
Precondition	JESD22-A113	Use appropriate soak and reflow profile depending on device MSL
Mechanical Shock	JESD22-B104	Condition B; 5 shocks at 1500g with 0.5ms durations in each of the three mutually perpendicular axes for a total of 30 pulses.
Solderabililty	JESD22-B102 J-STD-002	Reflow test or Dip & Look method
Solder Analysis	J-STD-001	Solder impurities per J-standard
Lead Inspection	Internal	Verification of lead inspection equipment accuracy and repeatability for pitch and coplanarity using a known golden standard.
Ionic Contamination	IPC-TM-650, Method 2.3.25	Liquid solution of 75% IPA and 25% DI water. Resistivity measured in Megaohm-cm and converted to equivalents of NaCl mg per square inch