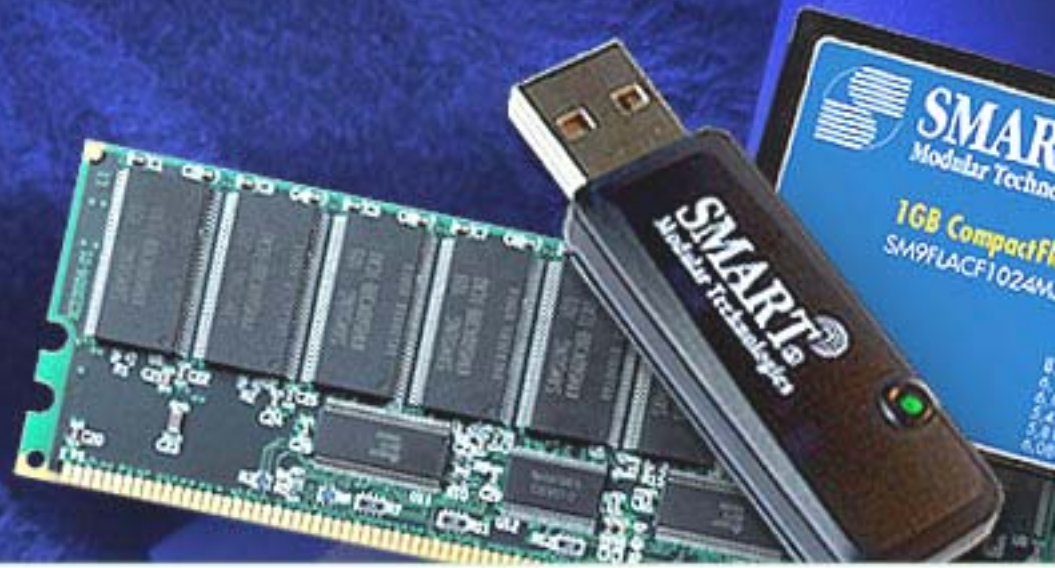




SMART[®]
Modular Technologies

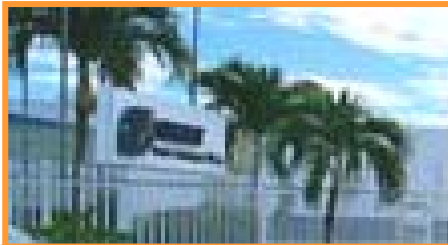


DDR2 Module Trends

Arthur Sainio

September 2004

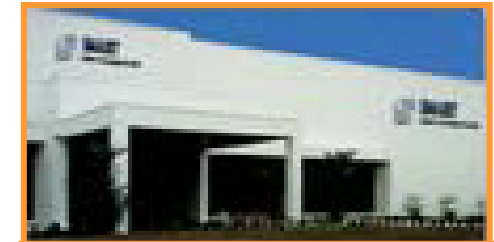
SMART Modular Overview



Puerto Rico
83K sq. ft. (1996)



Fremont, California
130K sq. ft. (1988)



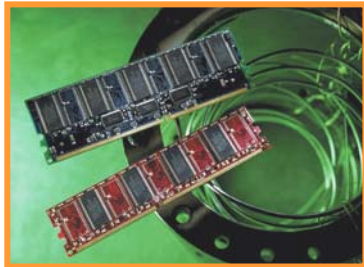
Malaysia
86K sq. ft. (1998)

- Leading Memory Module Supplier
- Founded in 1988
- ~\$800M Revenue in 2003
- 1400 Employees
- 379K sq. ft. of mfg capacity
- *In business for over 16 years*

Other Sites

2001	Bangalore, India	10K
2002	Sao Paulo, Brazil	25K
2003	Dominican Republic	45K
-----	TOTAL	379K

Product Portfolio Overview



Memory Modules

Technologies / Form Factors Offered

- SDRAM, DDR (I, II), Flash, SRAM, RLDRAM, FCRAM
- DIMM, SO-DIMM, SIMM, Mini-DIMM, μ SO-DIMM



Memory Cards/Drives

Technologies

- ATA PC Card I & II, Linear Type I and II
- CF Card
- USB Flash Disc
- IDE Drive
- Embedded USB Flash Drive

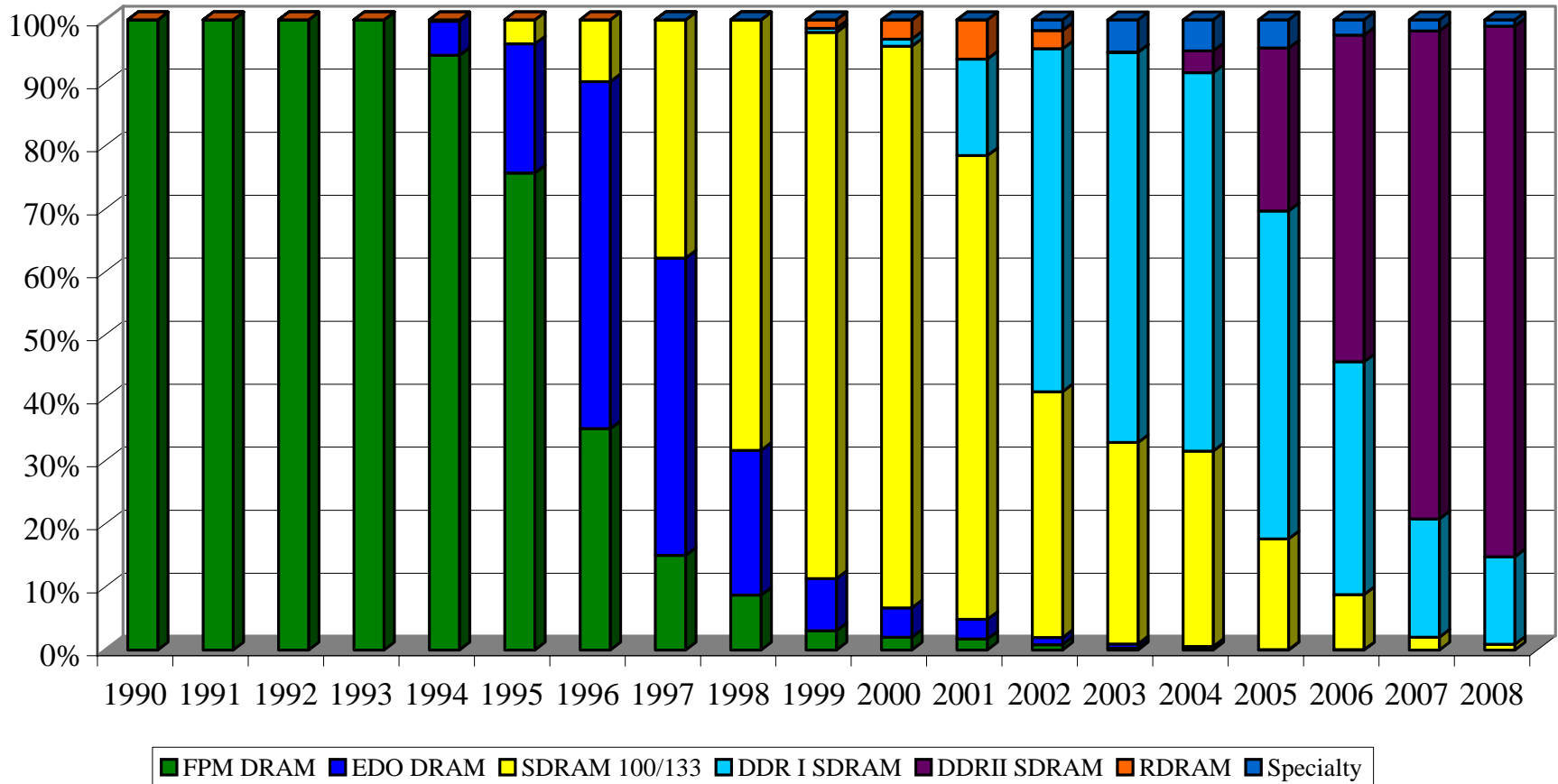


Communications

Products

- Analog modems, FireWire (IEEE 1394)
- Bluetooth: CF Card, RS232C, MiniModule, USB, Printer Adaptor
- Combo WiFi and Bluetooth: CardBus 32, MiniPCI
- PMGTM: MMT (IXI), Module (IXI)

DRAM Technology Lifecycles



Source: Semico, June 2004

DDR & DDR2 Market Observations



- Focus on faster DDR speed grades
 - DDR333 & 400
 - 512Mb is mainstream
- DDR TSOP > BGA
 - PC2700/3200 unbuffered DIMMs use TSOPs
 - PC2700/3200 registered DIMMs using BGAs
- PC3200 RDIMM Demand Growing
 - Some high-end HPC systems
 - Some networking applications
- DDR2 demand growing
- OEM production in Q3'04
- Challenges for increased market adoption
 - Diminishing Price Premiums
 - High Volume BGA packaging
 - High-Speed Testing
 - Transition to Pb-free

- **200-pin SO-DIMM**
 - Notebook and desktop PC markets
 - No requirements for registers or error correction.
- **244-pin Mini-DIMM**
 - Blade server and networking applications
 - Registered and Unbuffered ECC
- **214-pin Mezzanine Micro-DIMM**
 - Smallest form factor systems
 - Subnotebooks, PDAs
 - No requirements for registers or error correction.
- **240-pin Unbuffered DIMM**
 - Desktop PC markets
 - ECC version for networking and datacom applications
- **240-pin Registered DIMM**
 - Servers, workstations and HPC
- **240-pin FB-DIMM**
 - Industry standardization in progress
(For servers, workstations and HPC)

DDR2 Modules: One Size Doesn't Fit All



- DDR2 features are compelling for many OEM applications:
 - Lower power
 - Higher performance
 - BGA packaging (space savings and performance)
 - Better thermal performance
- However, standard module form factors and configuration are not always a good fit
- Number of JEDEC-standard gerbers has more than doubled from DDR to DDR2!
- But the trend is for even greater module diversification based on specific application requirements

More Diverse Application Drivers



- Blade Servers
 - Edge Servers
 - Application Servers
- Communications
 - Internet backbone switches /routers
 - Gateways
 - Edge Routers
- Embedded Computing
- Industrial Control/Automation
- Instrumentation
 - Automated Test Equip.
 - Scientific Instrumentation

More Diverse Module Application Specifications



- ECC needed for data-sensitive applications: (financial transactions, packet data transfers. Etc.)
- 1 to 4 memory sockets per system
512MB-2GB per socket
- Small form-factor registered modules for 4-socket systems
- Smaller, more compact, ultra low height form factors
- Lower power using x8-based devices on the module (vs. x4)
- Vertical and angled sockets for meeting <1U space constraints
- Robust sockets for meeting shock and vibration requirements

Advantages of Greater DDR2 Module Diversification



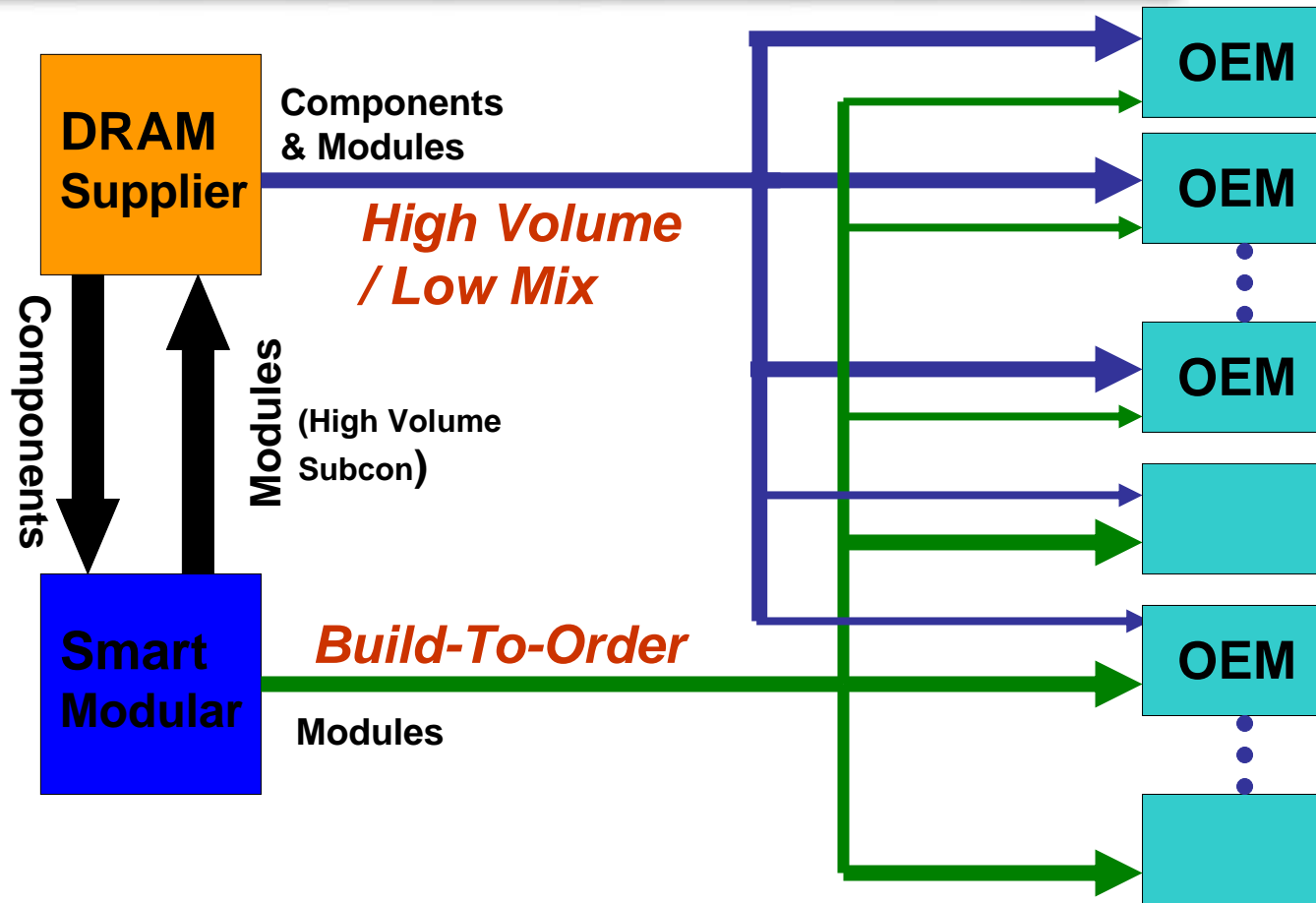
- ✓ More Types = Exact Fit for Each Application
- ✓ Achieve Higher Density
- ✓ Save Board Space
 - Using low profile DIMMs w/vertical sockets
- ✓ Reduce DIMM / Processor Spacing
 - Higher speed DIMMs are closer to the processor(s) for better timing margins
- ✓ Improve System Air Flow and Cooling by Using the Best Fit Module Type
- ✓ Performance and density are highly cost-effective

Critical Success Factors

Verification Activity
ATE at-Speed Test (Incl. SPD verif.)
Complete Post Layout Simulation
PLL Selection & Tuning
Environmental Testing
Signal Integrity
Application Testing
Reliability Testing
Multiple DRAM Supplier Validation

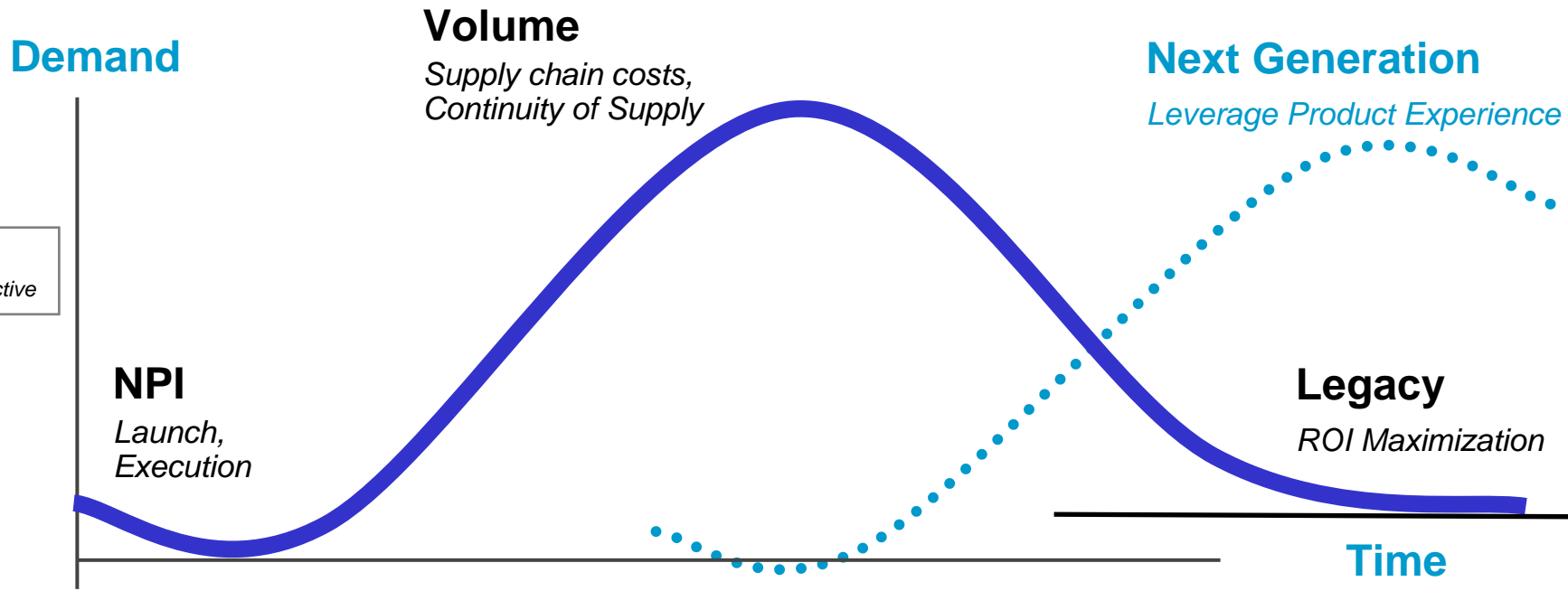
- Each system/application behaves differently
- A DIMM is just not a memory stick anymore
- Extensive checklist of verification activities to insure success

SMART's Business Model Supports Module Diversification



***BTO is Extremely Important in a High Mix Market
SMART Can Support High Mix & High Volume***

SMART's Business Model Supports Product Lifecycle Management



SMART	<ul style="list-style-type: none"> • NPI, Proto-type, Launch • Supply chain planning • DFx (SC/Manuf/Test) 	<ul style="list-style-type: none"> • Supply Chain Management • Product Life Extension • Supplemental mix mgt. 	<ul style="list-style-type: none"> • Legacy Product Management • E/O Management • Warranty disposition
Customer Benefit	<ul style="list-style-type: none"> • Time-to-Market • Cost to Market • Critical 1st Phase Execution 	<ul style="list-style-type: none"> • Backfill, Supply Continuity • Market Competitiveness • Resources for Next Gen 	<ul style="list-style-type: none"> • Customer Satisfaction • ROI • Optimized Bottom-line execution

Thank You!