Storage & Electronic Devices Solutions Company Business Strategy

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Storage & Electronic Devices Solutions Company Representative Executive Officer
Corporate Senior Executive Vice President
Toshiba Corporation

July 6, 2016
I. Introduction

II. SDS Company Overview

III. Memory and Storage

IV. Discrete and System LSI

V. Closing
Completion of Business Structural Reforms

Redefine focus businesses, withdrawal from non-focus areas

Discrete: Termination of white LED business
System LSI: Withdrawal from CMOS image sensor business
HDD: Acceleration of enterprise development,
     Shift of resources to SSD

Establishment of “Japan Semiconductor”, a new wafer fab company

Reduction in headcount (4,590 in total) in non-memory

Early retirement, 2,058; moved to Sony Group, 1,100;
re-allocation to other divisions, 1,112; reduction overseas, 320

Committed to return to the black in all of
Discrete, System LSI and HDD in FY16
Ⅰ．Introduction

Ⅱ．SDS Company Overview

Ⅲ．Memory and HDD

Ⅳ．Discrete and System LSI

Ⅴ．Closing
Storage & Electronic Devices Solutions (SDS) Company

- Shared Services
- Electronic Devices & Storage Sales Center
- Discrete Semiconductor Division
- Mixed Signal IC Division
- Logic LSI Division
- Memory Division
  - SSD Division
  - Image Sensor Division
- Storage Products Division
- Center for Semiconductor R&D
Production Sites

Himeji Operations
- Semiconductor
  Wafer Fab 6"
  Assembly
  ■ Discrete

Buzen Toshiba Electronics Corp.
  Assembly
  ■ Discrete

Japan Semiconductor Corp.
  Oita Operations
  Wafer Fab 6”, 8”
  ■ System LSI
  ■ Discrete

Kaga Toshiba Electronics Corp.
  Wafer Fab 6”, 8”
  Assembly
  ■ Discrete

Japan Semiconductor Corp.
  (established in April, 2016)
  HQ and Iwate Operations
  Wafer Fab 8”
  ■ System LSI

Toshiba Memory Advanced Package Corp.
  Assembly
  ■ Memory

Yokkaichi Operations
  Wafer Fab 12”
  ■ Memory

Toshiba Semiconductor (Thailand) Corp.
  (TST)
  Assembly
  ■ Discrete

Toshiba Information Equipment (Philippines) Inc.
  (TIP)
  ■ HDD, SSD

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Market Projection: Focus Areas

Enterprise storage, automotive and industrial should lead the mid-term markets

**Semiconductor**

Market CAGR (15-18): +1%

Focus Area CAGR (15-18): +6%

<table>
<thead>
<tr>
<th>Year</th>
<th>Others</th>
<th>PC</th>
<th>Tablet</th>
<th>Smart phone</th>
<th>Automotive</th>
<th>LCD TV</th>
<th>Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY15</td>
<td>100</td>
<td>100</td>
<td>96</td>
<td>96</td>
<td>96</td>
<td>22</td>
<td>22</td>
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<tr>
<td>FY16</td>
<td>93</td>
<td>93</td>
<td>94</td>
<td>94</td>
<td>94</td>
<td>24</td>
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</tr>
<tr>
<td>FY17</td>
<td>94</td>
<td>94</td>
<td>96</td>
<td>96</td>
<td>96</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>FY18</td>
<td>96</td>
<td>96</td>
<td>96</td>
<td>96</td>
<td>96</td>
<td>28</td>
<td>28</td>
</tr>
</tbody>
</table>

**HDD**

Market CAGR (15-18): ▲3%

Focus Area CAGR (15-18): +15%

<table>
<thead>
<tr>
<th>Year</th>
<th>2.5&quot;</th>
<th>3.5&quot;</th>
<th>Nearline</th>
<th>Trad</th>
</tr>
</thead>
<tbody>
<tr>
<td>CY15</td>
<td>27.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CY16</td>
<td></td>
<td>24.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CY17</td>
<td></td>
<td>24.5</td>
<td></td>
<td></td>
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<tr>
<td>CY18</td>
<td></td>
<td>24.8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Toshiba


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## FY16 Market Outlook

### Semiconductors

- Possible slowdown in 2nd half, -0.4% YoY
- Healthy automotive market, industrial demand expected to recover gradually
- NAND demand has been tight, thanks to larger memory density of Chinese smart phones
- Price decrease rate slowing, especially in retail market, thanks to strong NAND demand
- SSD demand grow both in PC and Enterprise

### HDD

- Sluggish PC market, but supply requests to Toshiba have been increasing lately
- Nearline HDD demand continues to grow
FY16 Sales and Profit Plan

Return to black in all businesses, V-shaped recovery, back on the right track for growth

- **Memory:** Enhance BiCS (3D flash memory) and SSD business
- **Discrete:** Grow three focus areas: RF switches, power devices, couplers
- **System LSI:** Promote ASIC for industrial markets, etc., fully utilizing image recognition and motor control technologies
- Engage with major industrial and infrastructure-related customers based on system design technology

- **HDD:**
  - Expand enterprise business

Sales CAGR (16-18) +8%

<table>
<thead>
<tr>
<th>Year</th>
<th>Sales Revenue (billion yen)</th>
<th>Operating Profit, FCF</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY15</td>
<td>846</td>
<td>345</td>
</tr>
<tr>
<td>FY16</td>
<td>1,430</td>
<td>332</td>
</tr>
<tr>
<td>FY18 (Provisional)</td>
<td>1,680</td>
<td>130</td>
</tr>
</tbody>
</table>

* Devices, etc *

- HDD
- Memory
- FCF

▲ Aim for further improvement

* Discrete, System LSI and NuFlare Technology
FY16 Sales and Profit Plan

Committed to return to the black in profit and free cash flow in all businesses

Sales revenue

<table>
<thead>
<tr>
<th></th>
<th>FY15</th>
<th>FY16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memory</td>
<td>846</td>
<td>747</td>
</tr>
<tr>
<td>HDD</td>
<td>386</td>
<td>352</td>
</tr>
<tr>
<td>Devices, etc</td>
<td>345</td>
<td>332</td>
</tr>
</tbody>
</table>

(billion yen)

OP / OP margin % / FCF

<table>
<thead>
<tr>
<th></th>
<th>FY15</th>
<th>FY16</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROS</td>
<td>-6%</td>
<td>2%</td>
</tr>
<tr>
<td>▲</td>
<td>63</td>
<td>49</td>
</tr>
<tr>
<td>▲</td>
<td>46</td>
<td>170</td>
</tr>
<tr>
<td>▲</td>
<td>100</td>
<td>5</td>
</tr>
</tbody>
</table>

(billion yen)

FY15 Breakdown of major costs
- Structural reform ▲63
- Asset write-downs ▲49
- Revaluation of inventories ▲46

FCF ▲57 ▲100
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Ⅲ．Memory and HDD
Ⅳ．Discrete and System LSI
Ⅴ．Closing
Toshiba Everywhere: Broadest Storage Portfolio

- **Smart phones**
  - Raw NAND
  - eMMC™
  - BGA SSD (PCIe)

- **Tablet PCs**
  - UFS
  - MCP Memory

- **Automotive**
  - eMMC™

- **Note PCs**
  - Client SATA SSD (2.5-inch & M.2)
  - Client NVMe/PCIe SSD (2.5inch & M.2)

- **Desktop PCs**
  - 2.5-inch Mobile SSHD SATA
  - 2.5-inch Mobile HDD SATA
  - 3.5-inch Desktop HDD SATA

- **Servers/Storage**
  - High Performance NVMe/PCIe SSD
  - Enterprise SAS SSD
  - Enterprise SATA SSD

- **Data Centers**
  - Enterprise HDD
  - Performance (15K/10Krpm) SAS
  - Capacity (7.2Krpm) SAS/SATA

Toshiba Everywhere: Broadest Storage Portfolio

- **Client SATA SSD** (2.5-inch & M.2)
  - Client NVMe/PCIe SSD (2.5-inch & M.2)

- **High Performance NVMe/PCIe SSD**
  - Enterprise SAS SSD
  - Enterprise SATA SSD

- **Enterprise HDD**
  - Performance (15K/10Krpm) SAS
  - Capacity (7.2Krpm) SAS/SATA

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NAND Market Overview

Smart phones and data centers lead market growth: about 40% bit growth (CAGR) expected

NAND Market Projection (GB base)

Market Trends
- High single digit growth in amount
- Expect replacement demand from HDD

Key Market Drivers
- Higher memory density in smart phones
- Data center demand increases
- Market expansion on price erosion

Source: Toshiba
Memory Business Strategy

Accelerate BiCS development and production to meet expanding storage demand and stay price-competitive

Sales Revenue

(billion yen)

<table>
<thead>
<tr>
<th>Year</th>
<th>OP Margin</th>
<th>FY15</th>
<th>FY16</th>
<th>FY17 (Provisional)</th>
<th>FY18 (Provisional)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>846</td>
<td>747</td>
<td>850</td>
<td>950</td>
</tr>
</tbody>
</table>

CAGR(16-18) 13%

NAND production plan (GB output base)

- FY15 = 100
- FY16: 3D
- FY17: 2D, 3D
- FY18: 2D, 3D

Mass production started BiCS2
Samples by Sep’16 BiCS3 (Next BiCS)

OP margin rates in Memory have been fluctuating but always between 10–30% in FY03-15 (except for FY08, on impact of Lehman collapse)

Yokkaichi Operations

Y5
New clean room

Y4
Y3
N-Y2

Toshiba Corporation

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Capex (Commitment basis)

Total 860 billion yen capex (FY16-18), utilizing operating CF, internal resources and leasing

Major investments

<table>
<thead>
<tr>
<th>Yokkaichi</th>
<th>Y5-Ph2</th>
<th>N-Y2</th>
<th>New clean room</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process</td>
<td>A19nm</td>
<td>15nm</td>
<td>BiCS FLASH™</td>
</tr>
</tbody>
</table>

(billion yen)

- FY13: 200
- FY14: 220
- FY15: 201
- FY16: 285
- FY17
- FY18

- July, 16: Completion of new Y2 cleanroom
- FY16: Site preparation for new cleanroom
- FY17: Construction of new cleanroom

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Price-competitiveness of Memory

**Further integration and cost competitiveness through deepening 3D technologies**

**Deepening 3D Technology**

- Super-stacking technology (technology needed for more than 100 layers)
- Vertical shrinkage technology
- Die shrinkage technology (effective layout of peripheral circuits and memory arrays)

**3D Manufacturing Innovation**

- Die shrink and cost reduction through Nano-ImPrint Lithography (NIL)
- High productivity production technology (deposition and etching processing)
- High efficiency production (multi-clean room production)

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*ReRAM: Resistive Random Access Memory*
Yokkaichi’s Utilization of Big Data

Improving productivity through highly automated clean room operations

- Process and analyze a flood of data to improve productivity, production yields and reliability
- Timely visualization of analysis results

Manufacturing equipment → Database (1.6 billion data points daily) → Data analysis → Control

Analysis and review by engineers

Introduced AI-based analytical tool this year

- Apply machine learning technology to analyze big data that people cannot process
- Closely work with Corporate R&D Center and INS Company

Example of visual inspection analysis
Analyzing several hundreds of thousand images daily
Automatically sort failure modes
Expansion of UFS Market

Smart phone storage trend

<table>
<thead>
<tr>
<th>Model</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-end Smart phones</td>
<td>eMMC™</td>
<td>UFS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>32GB-128GB</td>
<td>32GB-128GB</td>
<td>64GB-128GB</td>
<td>64GB-256GB</td>
</tr>
<tr>
<td>Mid-end Smart phones</td>
<td>eMMC™</td>
<td>UFS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>16GB-64GB</td>
<td>32GB-64GB</td>
<td>32GB-128GB</td>
<td>64GB-128GB</td>
</tr>
</tbody>
</table>

eMMC™: embedded MultiMedia Card
UFS: Universal Flash Storage

Higher memory density and better performance in smart phones

eMMC™/UFS performance

(Comparison with other Toshiba products)

<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8.2K</td>
<td>8.5K</td>
<td>315</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>25K</td>
<td>15K</td>
<td>610</td>
<td>155</td>
</tr>
</tbody>
</table>

- eMMC™ Ver.5.1
- UFS Ver.2.0

Comparison of 64GB UFS 1-day access pattern performance

World’s fastest due to a new concept-based NAND controller

Toshiba’s current product
Toshiba’s new product (available Aug’16)
Competitor A
Competitor B

High speed (Latency)
Data Center SSD market to grow to over ¥1 trillion thanks to expanding cloud services; growing sales as a total storage solutions supplier

Data center floor space

- **Storage Strategy (SSD/HDD)**

SSD demand for data centers

**SSD/HDD Sales Plan**

- **Source:** Forward Insights
SSD Market Projection

Promising market to lead NAND demand

Market by GB

Source: Toshiba

Enterprise

- **SAS**: For high end servers. Fully utilizing relations with HDD customers; continue to offer No.1 performance products.
- **PCIE**: For high end data centers, replacing SATA. Launch products with new features, North America development center.
- **SATA**: Customer support in North America.

PC, Tablet, Retail

- **PCIE**: PCIE increasing even in price-competitive market. Grow market share with optimized in-house controllers.
- **SATA**: Existing controller, from 3rd party.

Cost-effectiveness

CAGR (15-19) 50%
Strengths of SSD for Enterprise & Data Centers

Apply cutting-edge technologies to retain performance competitiveness against competitors

Next gen. SAS-SSD: available in Q1’17
Next gen. PCIe-SSD: available in Q1’17

TSV* Technology

- Low power consumption
- High-speed data transfer

*Through Silicon Via

NAND Cell Technology

- pMLC*, TLC
- Larger density, higher speed

※Pseudo MLC

New feature proposals

- Early compliance with next-gen. high speed interface spec (SAS 24G/Multi Link, PCIe Gen4)
- Host control of SSD operation, better performance management and reliability (Host Managed I/F, Multi Stream, etc)

America’s Storage Development Center

Accelerate qualification, feedback key data center customers’ requirements to product development (Folsom, California)
Nearline HDD Market and Strategy

Nearline HDD market to continue to grow, Long relations with major enterprise customers

- Qualified by 11 of 16 major enterprise customers; highly praised for performance and reliability
- Continue to launch high quality, large density products for major data center customers
- Maintain a long-term partnership with key components suppliers from the early stage of development

Nearline HDD Market in Units

New product launch plan

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2/4TB</td>
<td>6TB</td>
<td>8TB</td>
<td>10TB</td>
<td>He 14TB</td>
<td>He 16TB</td>
</tr>
</tbody>
</table>

Source: Toshiba
Future of Nearline HDD

Recording density improving >15%/Y, Realizing better bit cost over SSD

Bit cost comparison (vs SSD)

Recording density +>15%/Y

Cope with shrinking HDD market by shifting resources to SSD business

Source: Toshiba

MAMR: Microwave Assisted Magnetic Recording
HAMR: Heat Assisted Magnetic Recording
TDMR: Two-Dimensional Magnetic Recording
PDW: Pattern Dependent Write Control
DSA: Dual Stage Actuator

Cope with shrinking HDD market by shifting resources to SSD business

Source: Toshiba

MAMR: Microwave Assisted Magnetic Recording
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Cope with shrinking HDD market by shifting resources to SSD business

Source: Toshiba
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Ⅲ. Memory and HDD

Ⅳ. Discrete and System LSI

Ⅴ. Closing
Discrete and System LSI: Sales by Application

Focus on automotive and industrial
Grow business through solutions for major markets

Sales revenue by application

Automotive
- Sales CAGR (15-18) +10%
- Products:
  - Image recognition LSI for automotive camera
  - FRD for inverter
  - Power IC for EPS
  - MCU for ECU etc.
  - FRD: Fast Recovery Diode

Industrial & Energy
- Sales CAGR (15-18) +13%
- Products:
  - Train
  - Smart meter
  - PV inverter
  - Server
  - UPS
  - PLC

Other
- 56% FY15: 294 Byen
- 43% FY18
Solutions for Automotive Markets

Focus on automotive, fully utilizing Toshiba’s unique technologies

Safety...video and image

Application ADAS, Driver’s info, etc.
Product Imaging IC, Comms IC, Power, Small signal

Information...storage

Application GPS, HUD, etc.
Product eMMC™, SD card, HDD, Power, Small signal

Driving

Motor Control
Application Inverter, Pump, etc.
Product Analog IC, MCU, Coupler, Power, Small Signal

Engine Control Unit
Application Engine, EPS, etc.
Product Analog IC, MCU, Power, Small Signal
Image Recognition LSI for Automotive

Oct’15  Denso Corp. deployed our image recognition LSI in its front-camera-based active safety system

May’16  Recognized by The Institute of Image Info. and Television Engineers in Japan (subject: Co-occurrence Histograms of Oriented Gradients)
### Solutions for Industrial Markets

**A range of unique products for various industrial applications**

<table>
<thead>
<tr>
<th>FA and Robotics</th>
<th>Wireless</th>
<th>Power Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ASIC/FFSA:</strong> Custom LSI to offer highly efficient production system <strong>ApP Lite™/MCU:</strong> Products suitable for industrial IoT and motor control</td>
<td><strong>BLE Smart Mesh:</strong> Low power consumption wireless communications connected to Mesh network for mail security system, FA, building energy management system</td>
<td><strong>MOSFET:</strong> Broad lineup with many voltage specifications, used in various applications (especially power supply)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Smart Grid</th>
<th>Transportation /Power Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MCU + Analog IC:</strong> ASSP/solution tailored for smart meter (electric power meter, etc.), micro inverter (photovoltaic)</td>
<td><strong>IGBT:</strong> Available for trains, construction machinery, power converters, industrial inverters and specialized power supply</td>
</tr>
</tbody>
</table>

**Miscellaneous:**
- ASIC : Application Specific IC
- FFSA™ : Fit Fast Structured Array
- ApP Lite™ : Application Processor Lite
- ASSP : Application Specific Standard Product
- BLE : Bluetooth® Low Energy
- IGBT : Insulated Gate Bipolar Transistor
Strengths in Discrete

**Power Device**
- Broad product offering
- **High performance MOSFET** (low ON resistance and low switching loss) enables efficiency of power supply
- **IGBT and SiC** for railways and industrial

**RF Switch**
- Original process realized the **industry’s best reduction in insertion loss**
- Aiming to expand share in the smart phone market where the number of switches is rapidly increasing

**Photo Coupler**
- **Major player in the market** (24% share/15)
- Focus on **high performance IC couplers** for industrial and automotive markets
- World’s smallest MOSFET coupler for tester application (for surface mounting at high density)

**Better ON Resistance performance in low voltage MOSFET**

- Benchmark (competitor)
- Toshiba (new (9th) gen)

**ON Resistance (mΩ⋅nC)**

<table>
<thead>
<tr>
<th>Voltage (V)</th>
<th>0.1</th>
<th>10</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON Resistance (mΩ⋅nC)</td>
<td>Benchmark (competitor)</td>
<td>Toshiba (new (9th) gen)</td>
<td></td>
</tr>
</tbody>
</table>

**Source:** Toshiba

**CY15: 3.1 switches/phone**

**CY18: 7.0 switches/phone**
Strengths in System LSI

Focus on advanced technology to boost IoT

- Cutting-edge wireless LSI
  *Bluetooth®, BLE, WLAN, etc.*
  Recognized by the New Technology Development Foundation in Japan (subject: high-speed and safe wireless technology)

- Chip set for Google Ara modular system
  Design capability to materialize its concept as real chips incorporating advanced technology

Focus on steadily growing industrial & automotive markets

- Image recognition LSI

- Power supply and motor control LSI
  - **FFSA™**: Enter the market with products with FPGA’s and ASIC’s advantages
    - TAT from specification determination to mass production (40 nm’s case)
    - |        |          |
      |ASIC    | 12 months|
      |FFSA™   | 8 months |
    - New ASIC methodology reduces customers’ development steps
Japanese Semiconductor

Oita Operations and Iwate Toshiba Electronics: Merged in Japan Semiconductor on April 1

Company name: Japan Semiconductor Corp.
Business facilities: HQ/Iwate Operations, Oita Operations, Kawasaki Branch Office (Foundry Business Dept) Taiwan and US offices (planning)
Date of Establishment: April 1, 2016
Capital: 15 billion yen
Representative: Kazuya Mori, President & CEO
Employee: 2,030

Strengths:
- Automotive-grade quality based on IDM’s experience
- Cost-competitiveness and short development turn around time
- World leading analog technology (unlike digital, tuning is critical in analog)

Products:
Mixed Signal IC, MCU, ASIC, Linear sensor and Discrete

Aiming to win foundry business equal to 30% of production in FY18
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V．Closing
Use advanced manufacturing technology to bring cutting-edge products to innovative markets

Contribute to creating the infrastructure of the Information (Big data) Society and Eco-Friendly Society
Forward-looking Statements

- This presentation contains forward-looking statements concerning future plans, strategies and performance of Toshiba Group.
- These forward-looking statements are not historical facts, rather they are based on management’s assumptions and beliefs in light of the economic, financial and other data currently available.
- Since Toshiba Group promotes business in various market environments in many countries and regions, its activities are subject to a number of risks and uncertainties that, without limitation, relate to economic conditions, worldwide mega-competition in the electronics business, customer demand, foreign currency exchange rates, tax rules, regulations and other factors. Toshiba there wishes to caution readers that actual results might differ materially from our expectations.
- Toshiba’s fiscal year (FY) runs from April 1 to March 31. All figures are consolidated totals for the 12 months, unless otherwise indicated.