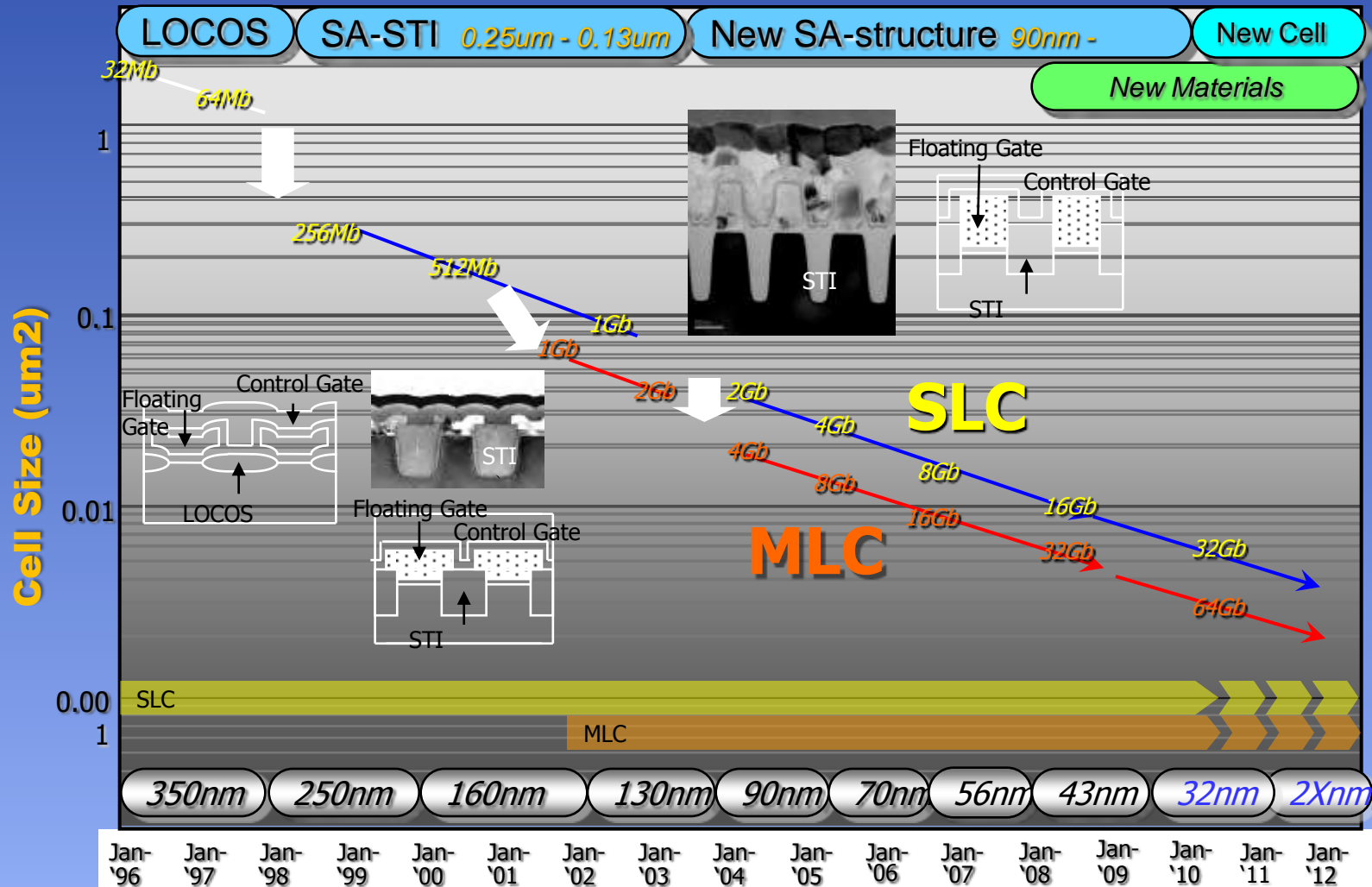




# Top NAND Trends

Douglas Wong, Toshiba America

# NAND Continues to Scale

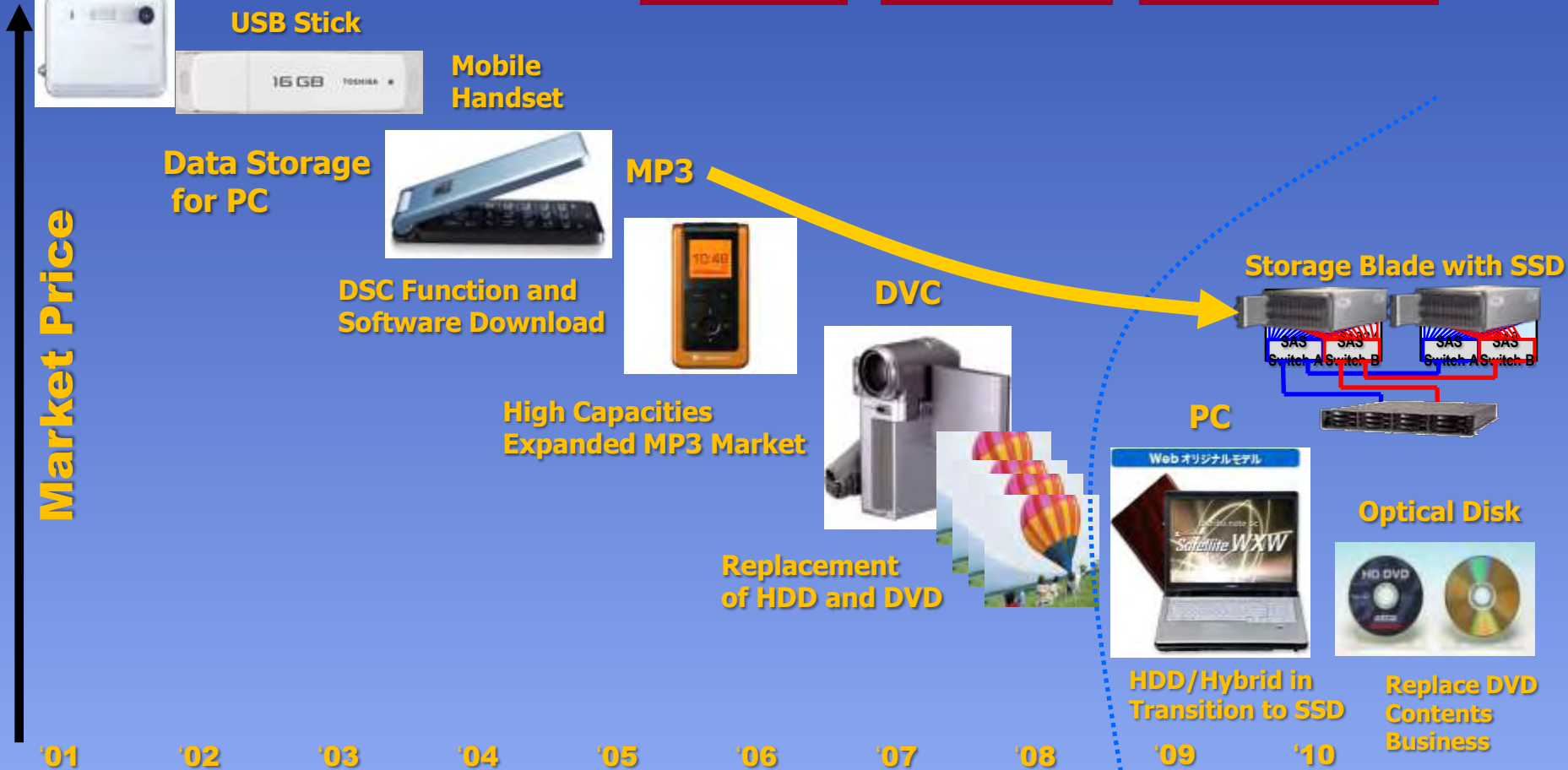


# NAND Bit Cost Reductions Stimulate New Applications

**1 ~ 5GB**

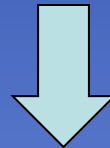
**2 ~ 16GB**

**32 ~ 512GB**



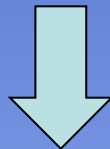
# NAND with built-in Controllers Inevitable

**HDDs with RLL, MFM external controllers**



**IDE HDD**

**Raw NAND Flash**



**NAND with embedded Controller  
(e.g. e-MMC, UFS, etc)**



# NAND Tradeoffs to Consider

- **Performance**
- **Capacity**
- **Bits per Cell**
- **Number of Write/Erase Cycles (Endurance)**
- **Data Retention**
- **Cost**
- **Cell Size/Lithography**

**Each can be optimized for application  
but change tradeoffs**

## A Variety of NAND Flash Choices

**Smaller cell size  
(next gen. litho)**



- Higher capacity chips, lower cost per bit
- Total data written similar (e.g. 2x Density 0.5 Write/Erase cycles)

**SLC versus  
MLC (2 bit/cell)**



- Faster read/write speeds than MLC, half the density per chip
- SLC offers > 10x the number of write erase cycles than MLC, so capacity endurance product is higher



For Additional Information

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