
Flash Memory Summit

# Infotainment and Autonomous Vehicles – The challenges of storage

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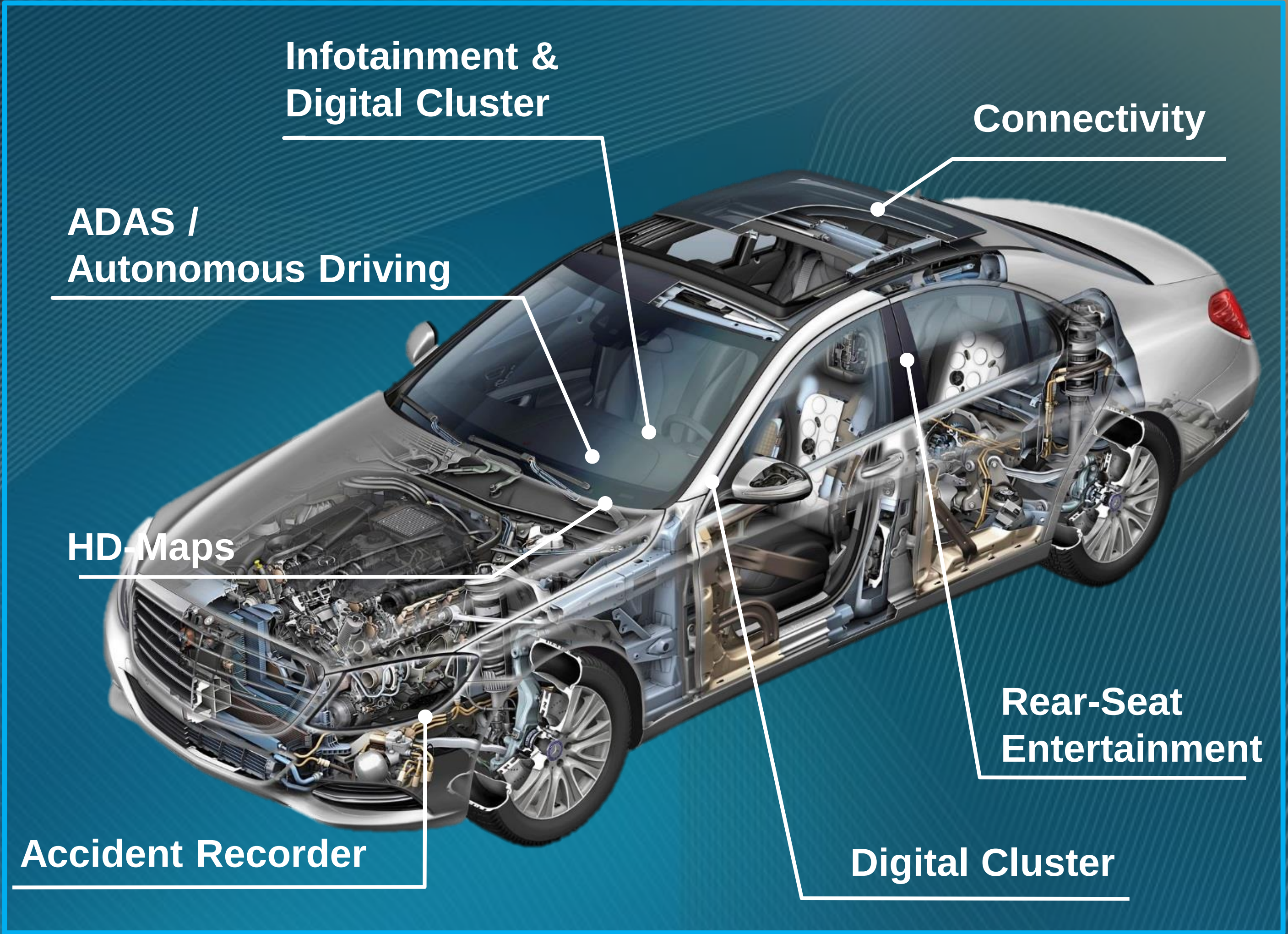
Mercedes-Benz
The best or nothing.

# Storage in a modern Car




| | Flash | DRAM |
|---|---|---|
| Infotainment & Digital Cluster | 64 – 512 GB | 4 – 32 GB |
| Rear-Seat Entertainment | 64 - 256 GB | 4 – 16 GB |
| Connectivity | 4 - 32 GB | 0.5 – 2 GB |
| ADAS / Autonomous Driving | 8 - 32 GB | 4 – 32 GB |
| HD-Maps | 8 - 512 GB | 0.5 – 1 GB |
| Accident recording | 8 - 512 GB | 1 – 4 GB |

In 2025 on Board storage exceeds
50 GB for DRAM and 1TB for Flash

# New needs in Automotive Industry

Intuitive Interaction: MBUX

Images: Daimler AG

Self-Driving Cars

Images: Daimler AG

**Both applications need AI**

- Infotainment needs AI to improve User Experience
- Self-Driving needs AI for example Object detection

# Different requirements for Infotainment and autonomous Driving

## Infotainment

User experience

- Display (Number, Resolution)
- Input devices (Touch, Speech, Gesture)
- User content: Player, Radio
- Fast update cycles
- Combination of On/Off-board content

➡ Strong CPU and GPU
+ Memory capacity

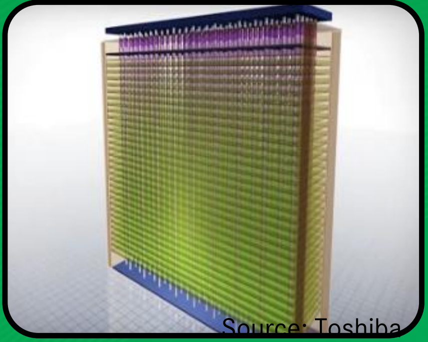
## Autonomous Driving

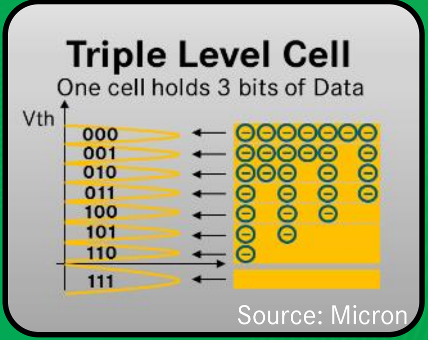
Safety is the first goal

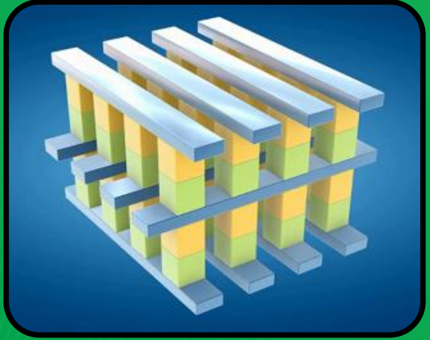
- Redundant Hardware
- Sensor centric system
- Sensor fusion (Camera, Lidar etc.)
- Data storage of sensor data for AI training
- Object detection → Heavy AI workload

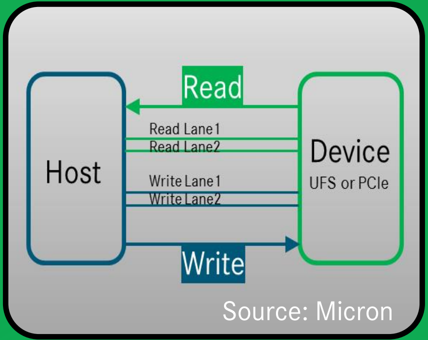
➡ Strong CPU and AI capabilities
+ high RAM Bandwidth

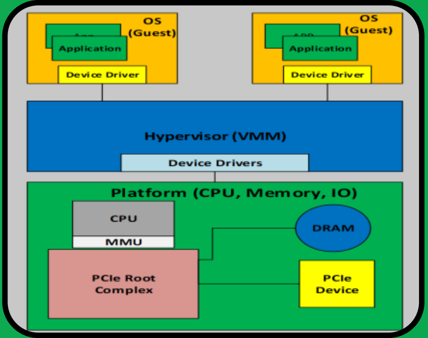
# Our View on NVM Memory Trends






## 3D-Cell Technology

3D is Mainstream now

Capacity increase only possible with 3D technology

## Triple Level Cell Technology

3D allow more electrons per cell

Capacity per die increases

Price advantage over planar technology

QLC questionable for automotive

## Persistent Memory

New memories: X-Point, SCM and MRAM

New memory hierarchy possible

No endurance problem

BUT: Reliability not yet proven

## Emerging NVM Interfaces

eMMC bandwidth no longer sufficient

Move to serial high speed Interfaces: UFS or PCIe

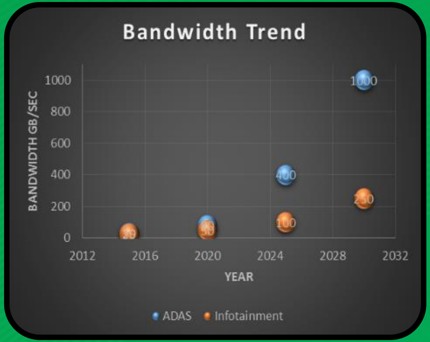
UFS3.0 and PCIe compete in data rate

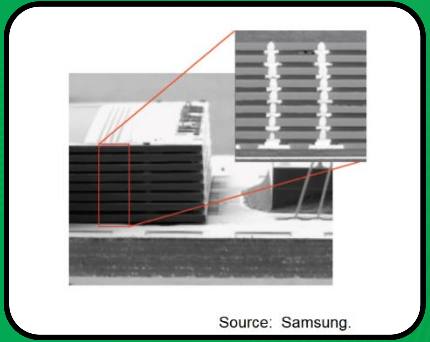
## OS and Hypervisor support

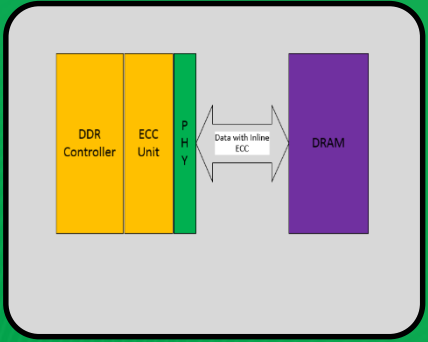
Support for Multi-CPU and OS systems

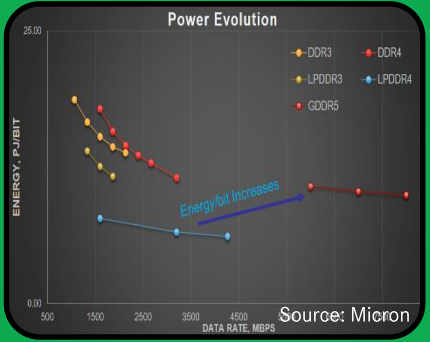
IO-Device support Hypervisor with SR-IOV Passthrough capability

# Our View on volatile Memory Trends




## Bandwidth increases

LPDDR5 in start position, first samples available

LPDDR4x follows LPDDR4

Support of AI cores in AD need more bandwidth
→ GDDR6 or HBM

## Memory density

Memory vendors move from 2znm to 1ynm node

Shortcut to increase density: Multi-Die package

## ECC

Below 20nm node ECC is needed for data reliability

In Autonomous Driving ECC can be a component for safety

ECC can also provided on system level: ECC on Data and Address bus → loss of memory capacity

## Power

*Infotainment:*

Optimize for Power, Standby (Suspend2Ram)

→ LPDDR5

*Autonomous driving:*

Power is not in focus → Bandwidth more important

## Interfaces

LPDDR4 now in the market

Move to LPDDR4x and LPDDR5 in near future

128 bit memory interface standard in IVI

High Bandwidth for AI need GDDR6 and HBM memory

# Match between application and memory technology

## Automotive Applications

1. Fast Startup
2. Central data storage
3. Dashcam video
4. Event Data Recorder
5. OTA Update
6. Sensor Fusion

## Memory technology

| Application | Memory technology |
|---|---|
| 2-5 | **Flash - Floating Gate FET**<br>• Pro: Highest Capacity<br>• Con: Limited write cycles, Read/Write speed |
| 1-6 | **DRAM - Floating Gate FET - volatile**<br>• Pro: High capacity, fast, proven technology<br>• Con: Cost |
| 1;3;4 | **SCM – Bulk resistance**<br>• Pro: Fast, high density, non volatile<br>• Con: Cost vs. Flash, no automotive part avail. |
| 3;4 | **MRAM - Spin transfer torque (STT)**<br>• Pro: Fast, non volatile, automotive<br>• Con: Cost, high write power consumption |
| 4 | **FRAM - Ferro electrical capacitor**<br>• Pro: Write cycles, retention<br>• Con: Cost, limited capacity, speed |
| 1;3;4 | **NRAM - Nanotube (resistance)**<br>• Pro: Fast, high capacity<br>• Con: Very early technology |

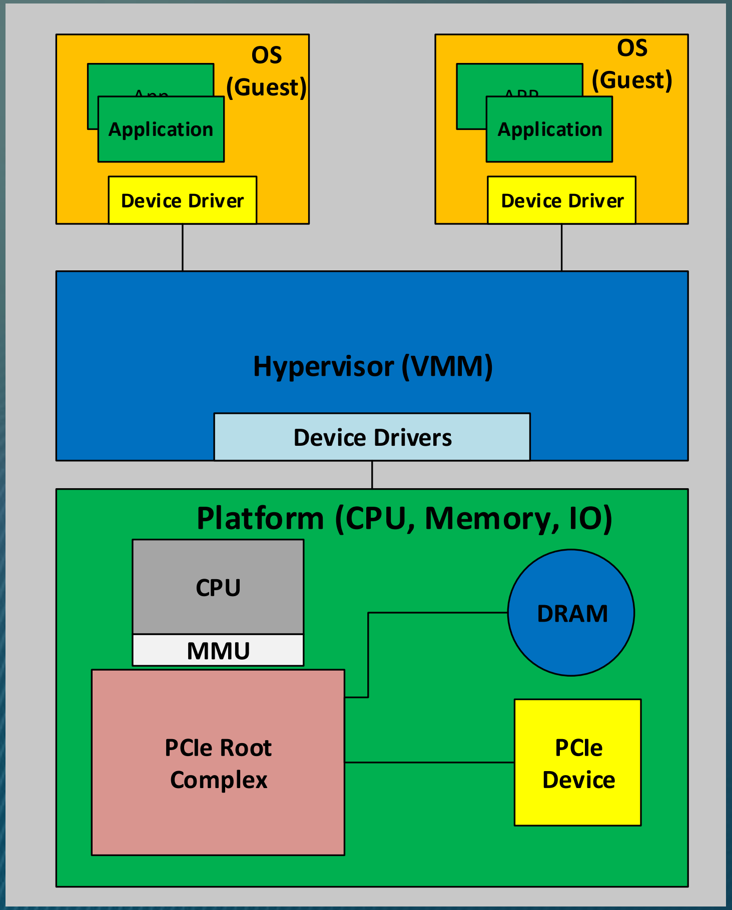
# Technology: Next Generation Memory – Hypervisor support

**What is Virtualization?**
Sharing a single hardware platform among
multiple software operating environments (Operating Systems)

## Hypervisor support for IO-Devices

| | |
|---|---|
| **Emulation** | • Hypervisor emulates Devices by Software |
| **Paravirtualization** | • Device Drivers in Guest OS is modified, OS is aware of Hypervisor |
| **Passthrough** | • Single Guest OS talks directly to IO-Hardware, no device sharing between multiple Guest OS possible |
| **Passthrough with SR-IOV** | • The SR-IOV device provides a dedicated Interface  for each Guest OS (Virtual Function) |

## System SW/HW-View

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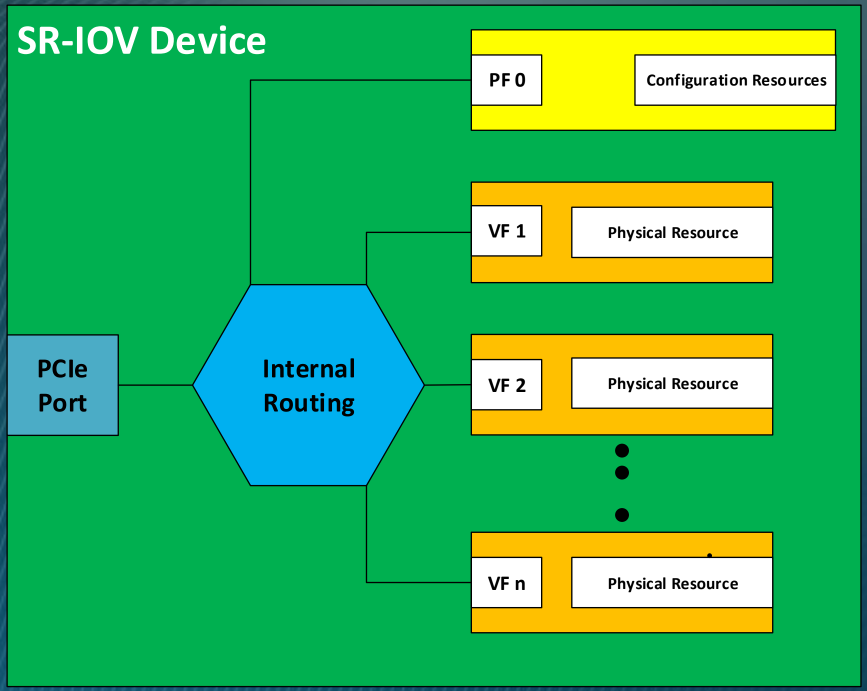
# Next Generation NVM-Memory: SR-IOV Virtualization support

## Technology

- Support on system level needed
  - SoC (SMMU, IOMMU or VT-d)
  - PCIe-switches
  - PCIe-Devices
- Every VF (Virtual Function) can be assigned to one Guest OS (System Image)

## Status today

- SR-IOV is used mainly in servers
- No automotive devices available




## Benefit using SR-IOV Flash devices

- Improved performance (Latency, CPU load)
- Guest OS Standard driver can be used
- Enhanced security, HW-based separation of access

# Summary

- The next generation of cars are autonomous driven CE devices
- Infotainment and autonomous driving pushing the memory technology
- Memory density demand is rapidly increasing
- Automotive needs to take over technology and solutions from IT and Mobile
- Car OEMs move from building cars into an IT-technology providers
- Automotive has the need for the latest memory technology in respect to:

  Density, Interface, Speed and Function (SR-IOV)