Automotive MCUs in 28nm FD-SOI with ePCM NVM

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Director of Business Development
Transformational Trends: an Opportunity

Silicon Content ($)

### Premium vs. Average Vehicle

- **Average**
  - Powertrain: $330
  - Chassis: $1,040
  - Safety: $2,030
  - Body: $1,040
  - Infot.: $1,040
- **Premium ICE ADAS L2**
  - Powertrain: $1,040
  - Chassis: $1,040
  - Safety: $2,030
  - Body: $1,040
  - Infot.: $1,040
- **Super Premium BEV**
  - Powertrain: $1,040
  - Chassis: $1,040
  - Safety: $2,030
  - Body: $1,040
  - Infot.: $1,040

### Electrification

- **Average**
  - Battery Mgmt.: $330
  - DC-DC Converter: $330
  - Traction Inverter: $330
  - Other: $330
- **48V Mild Hybrid**
  - Battery Mgmt.: $513
  - DC-DC Converter: $513
  - Traction Inverter: $513
  - Other: $513
- **BEV**
  - Battery Mgmt.: $910
  - DC-DC Converter: $910
  - Traction Inverter: $910
  - Other: $910

### Infotainment & Telematics

- **Average**
  - Audio Amp: $330
  - Dig. Radio: $470
  - Telem.: $540
  - Processor: $470
  - Other: $470
- **Premium**
  - Audio Amp: $330
  - Dig. Radio: $470
  - Telem.: $540
  - Processor: $470
  - Other: $470
- **Super Premium**
  - Audio Amp: $330
  - Dig. Radio: $470
  - Telem.: $540
  - Processor: $470
  - Other: $470

### Autonomous Driving

- **Average**
  - Vision: $330
  - Radar: $330
  - Fusion: $330
  - Other: $330
- **ADAS Level 2-3**
  - Vision: $810
  - Radar: $810
  - Fusion: $810
  - Other: $810
- **ADAS Level 4-5**
  - Vision: $1,243
  - Radar: $1,243
  - Fusion: $1,243
  - Other: $1,243

**BEV:** Battery Electric Vehicle

Source: Strategy Analytics and ST
Automotive at ST
a Business With Solid Foundations

Radical Innovation
anticipating market needs

Enabling
Transformation
emerging trends

High Volume
Applications
gaining market share

Applications and Trends

- Autonomous Driving
- V2X Communication
- Integration & Miniaturization

Core Technologies

- SiC (Silicon Carbide)
- GaN (Gallium Nitride)
- FD-SOI PCM (28nm FD-SOI + PCM)
- BCD10 (90nm)
- 40nm eFlash
- FD-SOI (28nm)
- RF-CMOS BiCMOS
- BCD9 (110nm)
- 90nm eFlash
- VIPower
- LV-PMOS

- ICE Power Train: 33% Share
  Market Leader ASIC/ASSP

- Car Audio: 40% Share
  #1 in Amplifiers, strong in
  Premium Audio, DAB, Tuners

- Passive Safety: 17% Share
  Integrated solutions for
  Airbag and Braking

- Body: 45% Share
  Market Leader in
  Door Control, Lighting
• ST pioneered FD-SOI technology & developed complete Ecosystem

• ST is now Deploying Products

• FD-SOI Key Factors of Merit
  • Power Efficiency
  • Analog / RF Design
  • Robustness
Fully depleted Silicon-on-Insulator (FD-SOI)

Power and energy efficiency

Analog performance for mixed signal and RF design

Robustness for mission critical applications

FD-SOI is unmatched for energy-efficient applications requiring digital and Mixed Signal SoC integration and performance
Phase Change Memory working principle

Storage Mechanism: Material with Variable Resistivity

Resistivity changed via Thermal Cycles (Joule Effect)

- **Amorphous Phase**: High Resistivity (Read “0”)
- **Polycrystalline Phase**: Low Resistivity (Read “1”)

Temperature vs. Time

- **SET pulse**
- **RESET pulse**

**Read speed**: 10ns. **Write cycle**: 1M+ cycles

ST patented technologies:
1. PCM cell structure
2. Custom Material for High Temperature support
Automotive Microcontrollers

Automotive MCU growth contributors:

**Advanced Powertrain:** combining Electric Motors, Thermal Engine and Transmission management

**Electrification:** smart power supporting electrification

**Gateways:** Secure communication interfaces

**ADAS:** safety microcontrollers

eNVM trend: increase memory size due to:
- increased software complexity
- multiple firmware image storage

*Source: Strategy Analytics*
Automotive Requirements and their manufacturing impact

**Testing and Assembly impact**

- **Testing:** Increased Test Time & additional steps
- Packages: high performance (eg: exposed pad)
- Complex Design cycle

**Automotive requirements**

<table>
<thead>
<tr>
<th>Screening</th>
<th>&lt;1 PPM</th>
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<tbody>
<tr>
<td>Burn-In &amp; wide Coverage</td>
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<table>
<thead>
<tr>
<th>Robust design</th>
<th>Margins, Mild optimizations</th>
</tr>
</thead>
<tbody>
<tr>
<td>5V</td>
<td>5V transistors bigger than 3.3V</td>
</tr>
<tr>
<td>165 Tj Vs Mhz</td>
<td></td>
</tr>
<tr>
<td>Design: Leakage, electro migration, ageing</td>
<td></td>
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<tr>
<td>Fast Technology with low Leakage</td>
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<tr>
<th>ASIL B / D Process, ECC, Locksteps</th>
<th>FDSOI – noise immunity (radiation, cross talking, ..)</th>
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<tr>
<td>Safety</td>
<td>Real Time</td>
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<tr>
<td>Multicore Architecture with efficient NVM access</td>
<td>Complex software driving large NVM</td>
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**Wafer and manufacturing Impact**

- Increased design & product costs
- Additional masks
- Advanced technology and options (FDSOI)
- NVM for high density technology
The Evolution of Vehicle Architecture....

ST Technology enablers: FDSOI 28nm with PCM

Distributed Architecture: 9k D-MIPs per Car
- Local Control Units up to 130 ECU/Car (with 8-16-32bit MCU)
- Limited connectivity and in-vehicle data-flow (up to 10 Mbit/s)
- Heavy and expensive harness
- Extremely complex car Software management
- No Car functionalities upgrade

Integrated Real-time Domain Architecture: 90kD-MIPs per Car
- ~5 Domain-Control Units with higher power computation and Non-volatile Memory micros: STELLAR with internal Phase Change Memory (PCM)
- Autonomous Driving Super-computer (MPU ext. Memory) ~100 Trillion Operation per second (EyeQ6)
- Architecture simplification, SW rationalization, harness drastic reduction
- Easy car functionality reconfiguration and SW upgrade
- Enabling High-speed in-vehicle communication
- Over-The-Air Software capability
…from ECUs to Domain Control
example: evolution for the Vehicle Traction

Requirements:
- High density technology
- Real-time
- Working Frequency > 400MHz
- Low power consumption
- >16 MB of high speed access Non-Volatile Memory

Stellar: ST 28nm FDSOI with embedded Phase Change Memory
ST in-house production at Crolles 12 inches

- Achieving Low Power Consumption requirement
- Supporting Higher working Frequency (> 600MHZ)
- High-Speed High-Density Memory assured by our Phase Change Flash Memory

Engine Zone - DOMAIN CONTROLLER
[3 ... 8+ kDMIPs]

ENGINE CONTROL
ICE Engine Management
[0.2 ... 1 kDMIPs]

e-TRACTION
Electric Motor Powertrain
[0.5 ... 1 kDMIPs]

TRANSMISSION
Vehicle transmission control
[1 kDMIPs]

ARM R52
6...32 MB PCM

Vehicle Control Unit
[0.5 kDMIPs]

Vehicle Control Unit
[0.5 kDMIPs]
Increased Data Flows Require Greater Security, Processing Power and Connection Speeds

**Security**
MCUs & Processors with Embedded Security

- Specific Microcontrollers dedicated to automotive, to secure all applications:
  - Power Train
  - Braking
  - Steering
  - Gateway & Connectivity
  - ADAS & V2X
  - Infotainment
- Embedded Hardware Security Module
- Security Level (EAL3/4)
- High data-rate encryption/decryption to manage data streams

**ECU Processing Capability**
Increase required in many automotive domains

- Exponential increase in data to analyze and dispatch
  - x3
  - x15

**Frequency Factor**
ARM R52 vs PowerPC
- More Cores
- 6x Cores 400MHz
- 3x Cores 200MHz
- 1x Core 120MHz

**PowerPC**
- PowerPC 90nm
- PowerPC 40nm

**ARM R52**
- FD-SOI 28nm

**ST's New high-end 32-bit Automotive MCU Family**
will provide the power

- ARM Cortex R52, 6x Cores, 400MHz
- 16/32 Mbyte 28nm FD-SOI with embedded PCM Flash memory
- Sampling 2018
STMicroelectronics Introduces the 1st Safe, Real-Time Microcontrollers for Next-Generation Automotive Domain Architectures utilizing 28nm FD-SOI and on-chip Phase Change Memory (PCM)

- First Arm® Cortex®-R52 automotive microcontrollers with on-chip non-volatile memory for real-time multi-core performance; With full ISO26262 ASIL-D coverage and hypervisor providing new industry reference for functional safety
- 28nm FD-SOI with efficient, high-temperature embedded Phase-Change Memory maximizes performance and reliability while minimizing power consumption
The auto MCU product in 28nm FD-SOI ePCM

F. Arnaud et al, “Truly Innovative 28nm FDSOI Technology for Automotive Microcontroller Applications embedding 16MB Phase Change Memory”, IEDM 2018
Conclusions

• Automotive market is in continuous expansion, with growing silicon content in cars

• ST is an undisputed leader in the automotive market, with a global offer covering all the needs

• ST is pioneering and driving new technologies into the automotive market

• Increased data flows in automotive is demanding higher performances and memory quantity to automotive MCU

• 28nm FD-SOI with embedded PCM NVM memory is the answer to this demand, for offering energy efficient high performance cores with ultra dense NVM memories, qualified up to auto grade-0
ST stands for
life.augmented

Everywhere microelectronics make a positive contribution to people’s lives, ST is there

Thank you