Market Drivers and Packaging Trends for Automotive Electronics

E. Jan Vardaman, President and Founder

TRACK INNOVATION

IDENTIFY TRENDS

ANALYZE GROWTH

INFLUENCE DECISIONS

RELEVANT, ACCURATE, TIMELY

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What's Driving Automotive Electronics?

Vehicle Sensors

Lane departure system
Night vision
Front object CCD camera
Front airbag sensors
ASCD
Nightime pedestrian warning
Drowsiness sensors
Front object laser radar
Nightime pedestrian warning IR sensor
Active park assist
Tire pressure sensor
Rear object monitor CCD camera
Rear camera
Side curtain sensor
Blind spot detection
Cross traffic alert
Central computer
Rear object laser radar
Wheel speed sensor
Tire pressure sensor
Collision sensor
Side airbag SRS
Adaptive cruise control
Steering Angle sensor
Automatic brake actuator
Wheel speed sensor

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Advanced Driver Assistance Systems (ADAS)

- **From increasing number of safety features to autonomous driving……**
- **Drives increased use of sensors including CMOS image sensor for camera modules, collision sensors, object detection, etc.**
- **Increased processing capability**
- **Greater use of communications functions**
- **System design and co-design**

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Driver Assistance Systems

CROSS-TRAFFIC ALERT
BLIND-SPOT DETECTION
LANE-CHANGE ASSISTANCE
SELF-PARKING
SIDE IMPACT
LANE-DEPARTURE WARNING
PARKING ASSISTANCE/ VISION
PARKING ASSISTANCE
BRAKE-ASSISTANCE/ COLLISION AVOIDANCE
ADAPTIVE CRUISE CONTROL
SIDE IMPACT
SELF-PARKING
LANE-DEPARTURE WARNING
LANE-CHANGE ASSISTANCE
BLIND-SPOT DETECTION
CROSS-TRAFFIC ALERT
RADAR APPLICATION
ULTRASONIC

Figure 2 Several driver-assistance systems are currently using radar technology to provide blind-spot detection, parking assistance, collision avoidance, and other driver aids (courtesy Analog Devices).

Source: Analog Devices.

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Levels of Driver Assist and Car Automation

- **Increasing degree of automation means**
  - More sensors
  - Sensor fusion
  - Greater computing power and intelligence
  - Greater automotive network bandwidth needs
- **Infineon calculates added value in automotive electronic content**
  - Adding partial automation adds $100-150 of semiconductor content to existing $330 in today's cars
  - Highly automated adds as much as $550

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Automotive Sensor Packages

Sensor modules market value for autonomous cars from 2015 to 2030 (in $B)

(Source: Sensors and Data Management for Autonomous Vehicles report 2015, October 2015)

(in $B)

0, 5, 10, 15, 20, 25, 30, 35

2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030

TOTAL SENSOR MODULES IN $M

- Dead reckoning sensors
- LIDARs
- Micro bolometers
- Stereo cameras
- Cameras for surround
- Cameras for long distance
- LR radars
- SR radars
- Ultra sound sensors

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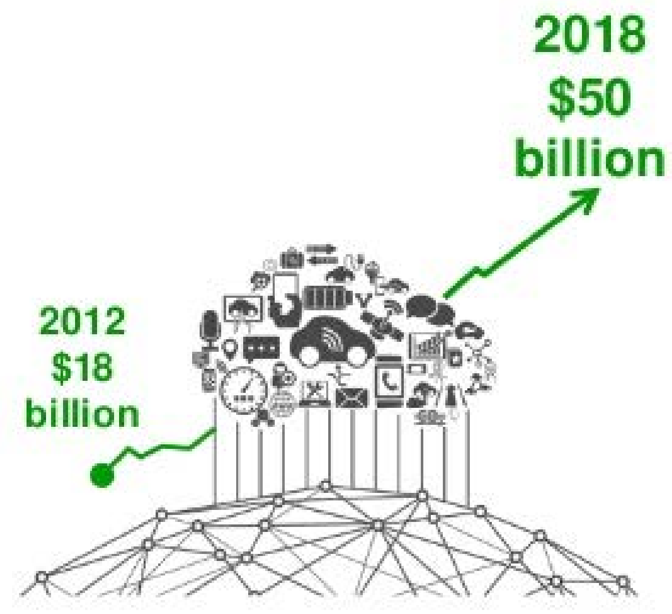
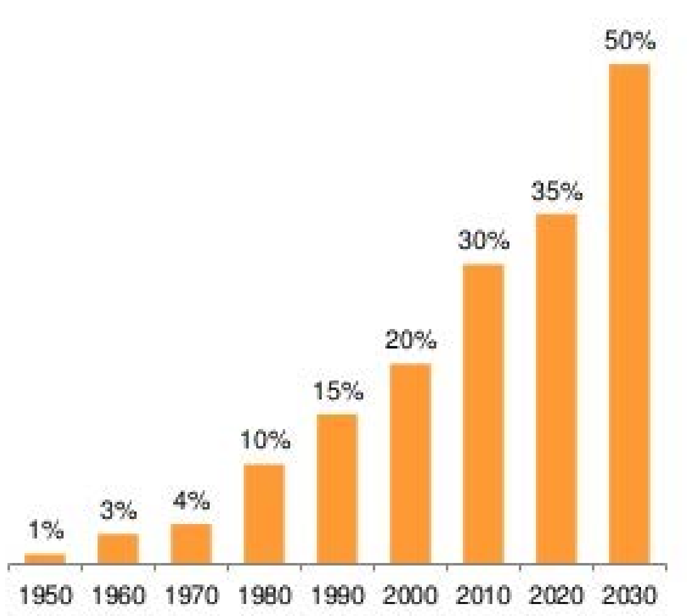
Automotive Sensor Packages

Cars transforming into mobility platforms





Automotive Electronics sustaining growth opportunities

Page 8

Source: PWC analysis

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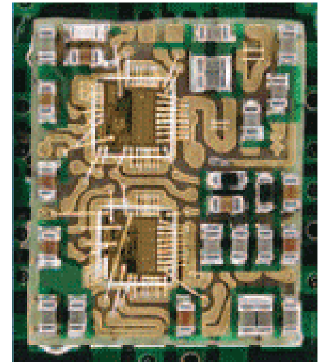
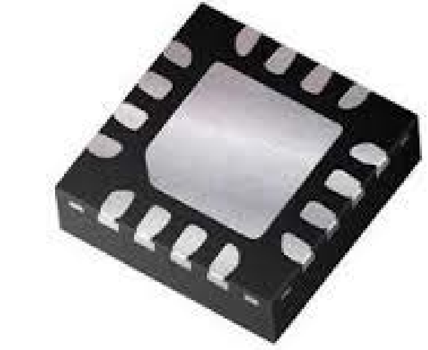
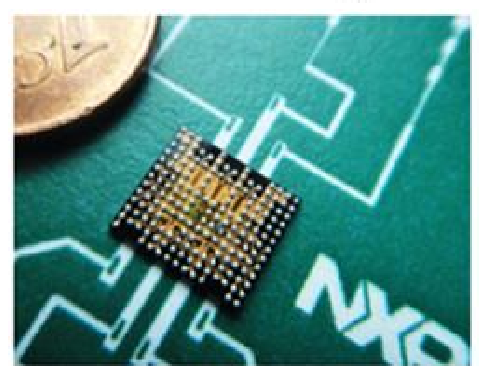
Automotive Packaging Developments

- **Increased connectivity and safety features**
  - Variety of sensors
  - Many types of packages
- **Variety of automotive packages**
  - Laminate packages (flip chip and wire bond)
  - Leadframe packages (QFP, QFN, etc.)
  - WLP
  - FO-WLP
- **Future package requirements**
  - Increased use of SiP solutions in a variety of package formats
  - Co-design becomes increasingly important







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Packages for Automotive Electronics

Infotainment
- Audio Drive IC
- QFP PKG /CNA RDL

Chassis
- Brake system
- QFN PKG /CNA RDL

ADAS system
- RADAR Sensor
- FO-WLP

Powertrain
- Engine Motor IC
- QFP PKG /CNA RDL

Safety
- Airbag
- QFN PKG /CNA RDL

Source: Nepes.

- **Key areas with different requirements**
- **Variety of packages**

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Traditional Safety Feature Sensors

- **Air bag inflation sensors**
- **Tire pressure sensors**

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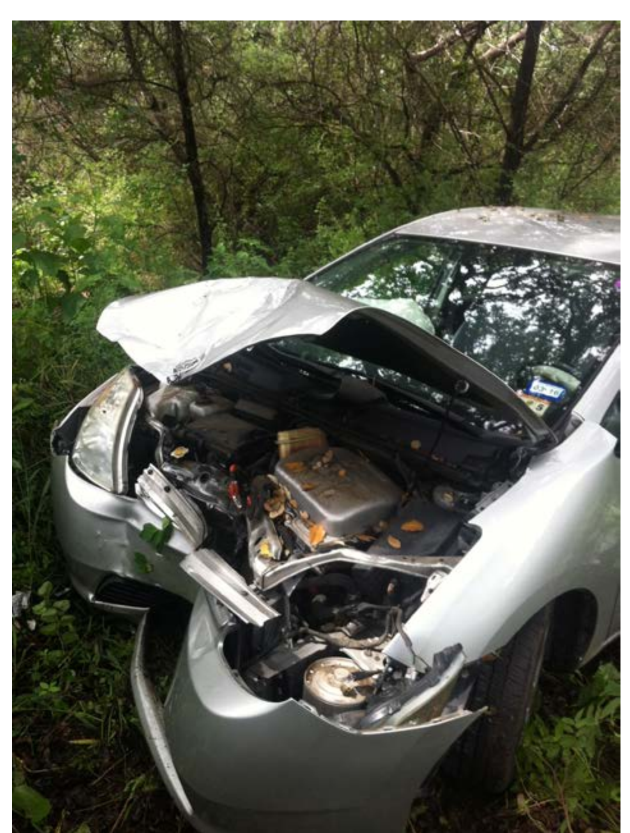
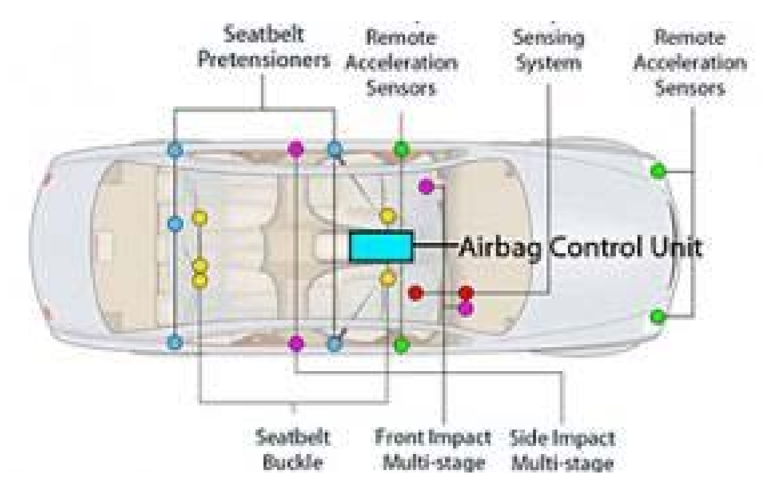
Air Bag Sensors and Control Units

- **Air bag module (Toyota Prius)**
  - Accelerometers
  - CPU with memory
  - Power controllers
  - Impact trigger
  - Serial EEPROM





Central airbag sensor

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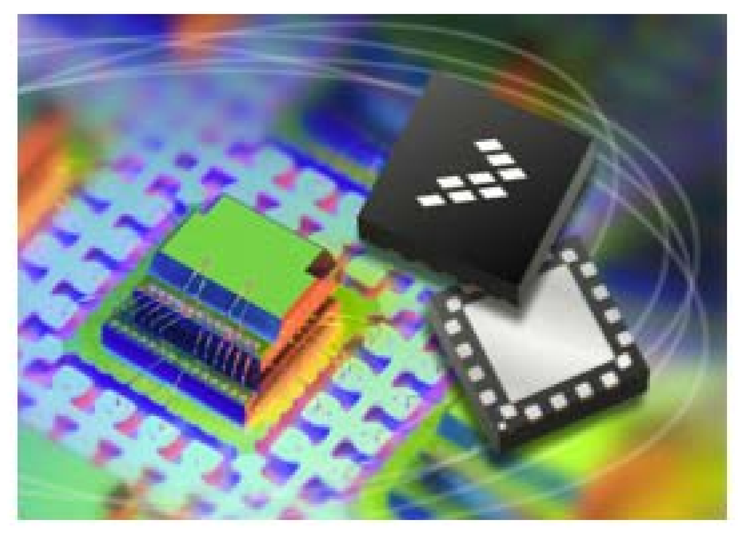
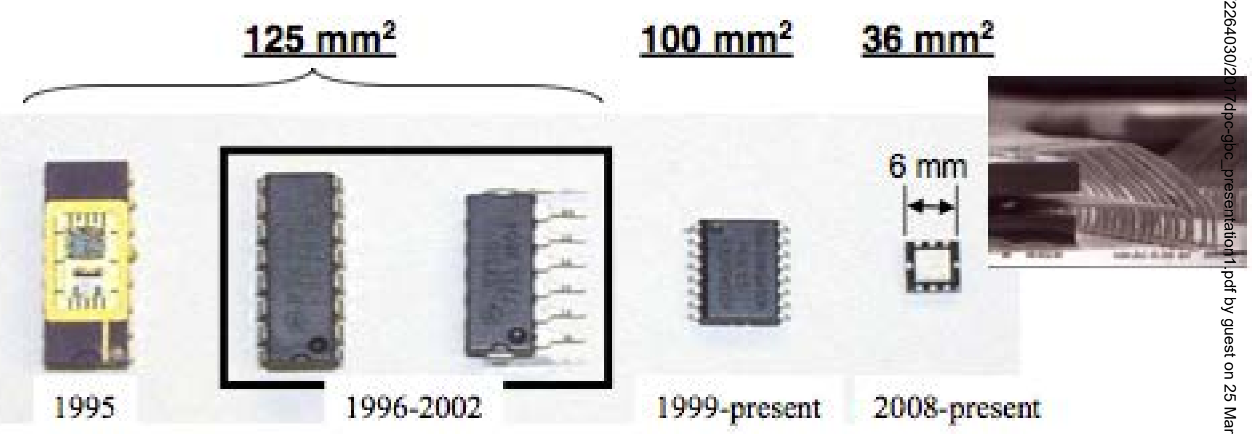
Freescale Impact Detection Sensors: Size Trend

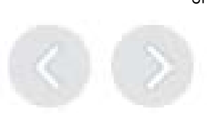
- **70% shrink** over 13 years.
- Automotive safety function:
  - XY, and Z-axis over-damped transducer
  - Control / logic / signal conditioning die
- **Packaging solution**:
  - Multi-die package
  - Stacked die QFN
  - **AEC Grade 1**





Source: Freescale.

© 2014 Freescale Semiconductor, Inc.



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Block Diagram of Infineon SP37 Tire Pressure Monitoring System

Power Supply Management

Pressure Sensor

Acceleration Sensor

Temperature Sensor

Voltage Sensor

ADC

8-bit µC

RF Transmitter

Flash Sensor Calibration Data & Application Firmware

ROM Firmware Library

LF Receiver

Source: Infineon.

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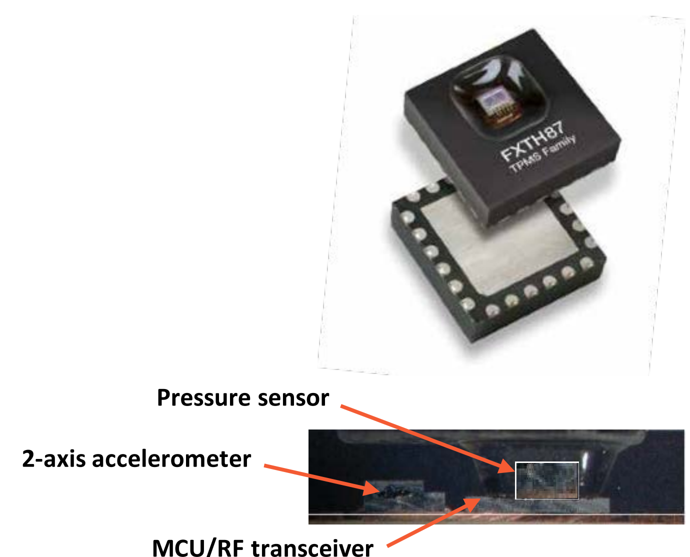
Tire Pressure Monitoring System (TPMS)



Source: NXP.

NXP FXTH87 TPMS
- Pressure sensor
- XY-axis or Z-axis accelerometer
- 8-bit MCU
- RF transmitter

- **QFN24**
- **7.0 mm x 7.0 mm x 2.2 mm**

Expected to operate 10 years on a single coin cell battery

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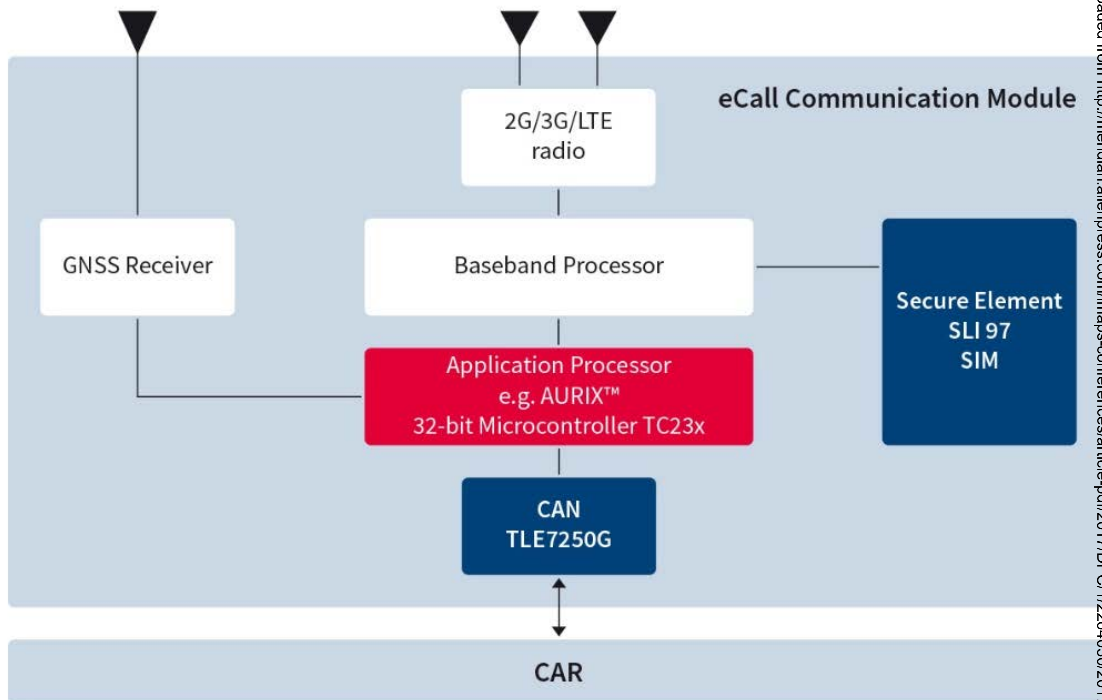
Infineon eCall

- **In-car emergency eCall speeds up assistance for drivers involved in accidents**
  - Car's position and other relevant data automatically transferred to rescue services
- **Mandated in all EU cars starting in this year**
- **Leadframe package**



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System Cost for Radar Significant Decrease

System cost for Radar have been significantly reduced with innovative packaging and SiGe/CMOS

Innovations for Driver-, Road- and Pedestrian Safety

Key Innovation Steps

Technology & Device

Package

System Architecture

Vision "Zero" + Autonomous Driving

ATLAS IC
1st SiGe 77GHz Transceiver

Mid Range Radar
1st 77GHz product in eWLB package

Dual Chip Radar Solution
1st complete System solution: 400 GHz RF, µC, Power Supply

Long and mid range
Next Gen. of Dual Chip Radar Solution
600 GHz RF, AURIX™ 3rd Gen, Power Supply

Mid and short range
Single Chip Radar Solution (CMOS)

2009 | Today | > 2022

Source: Infineon CEO SEMI's Semicon Europa's Fab Managers Forum in Dresden, Germany reported by Semiconductor Manufacturing & Design

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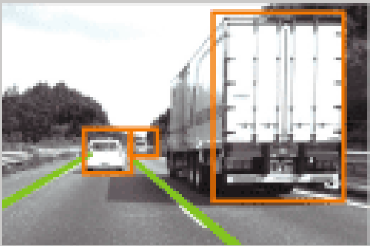
Applications for Image Sensors

Front Collision Warning
Lane Recognition



Pedestrian Detection

Infineon 3D camera chip
(in cabin monitoring driver/passenger)

Source: Renesas, Infineon, and Lexus.

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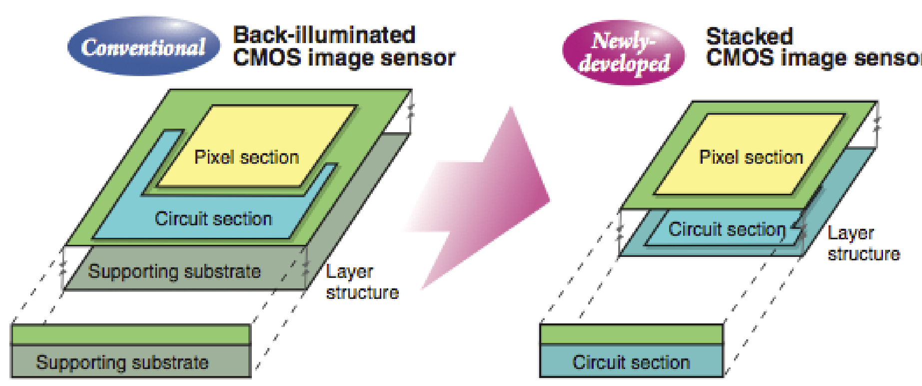
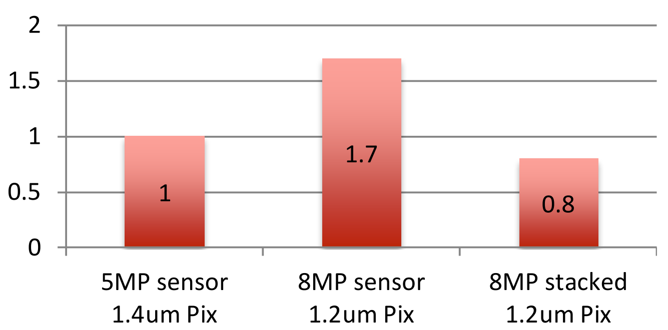
Sony Image Sensors: Stacked Die with TSVs Today



Source: Chipworks.

- **Advantages**
  - 30% reduction in size
  - Decouples image sensor and processing and device technology
  - 90nm for CIS plus 65nm processor
  - Reduces power
- **Sony proven track record in smartphones**
  - Wants to apply to automotive



Traditional → Stacked
Normalized Power

Source: Sony.

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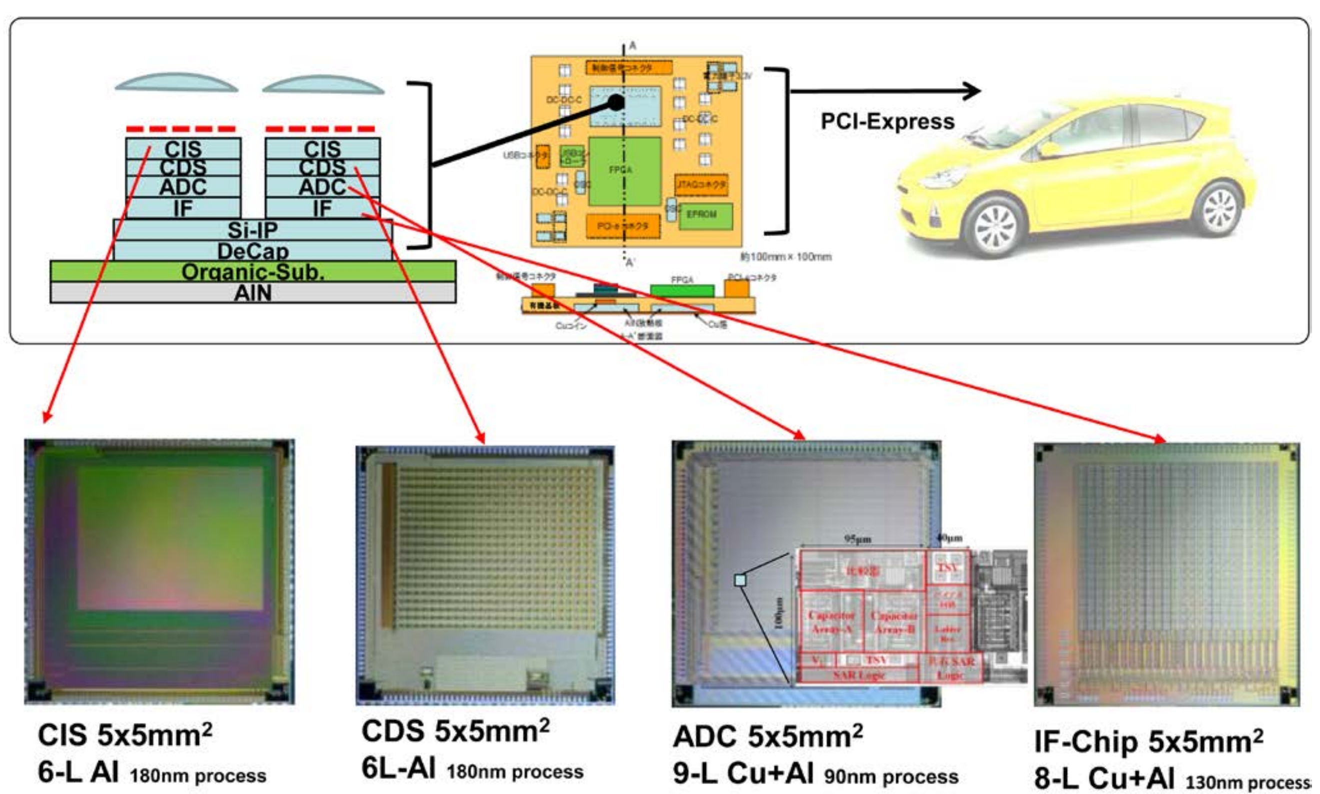
CMOS Image Sensor + Digital



Source: ASET.

- Automotive safety features require fast signal processing for camera module
- Demonstrator vehicle from Japan ASET National Program with TSV for image sensor and logic on silicon or glass interposer

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NXP CONNECTS THE CAR - SMART RECEPTION & SENSING

Sense | Think | Act

Signal Processing

ADAS

- Wheelspeed & Angular
- Radar
- Camera
- LIDAR
- V2X

COMMUNICATION

- Smart Car Access (NFC)
- AM FM DIGITAL SDR Radio (NFC)

Big Data

Sensor Fusion

Maps

Entertainment APPS

Light (Matrix, Laser)

Display

Vehicle Control
- Brake
- Steer

Amps

NXP Ethernet
NXP FlexRay
NXP CAN
NXP Solutions

NXP

Supported by automotive qualified Transistors, Diodes, Power MOSFETs and Logic devices

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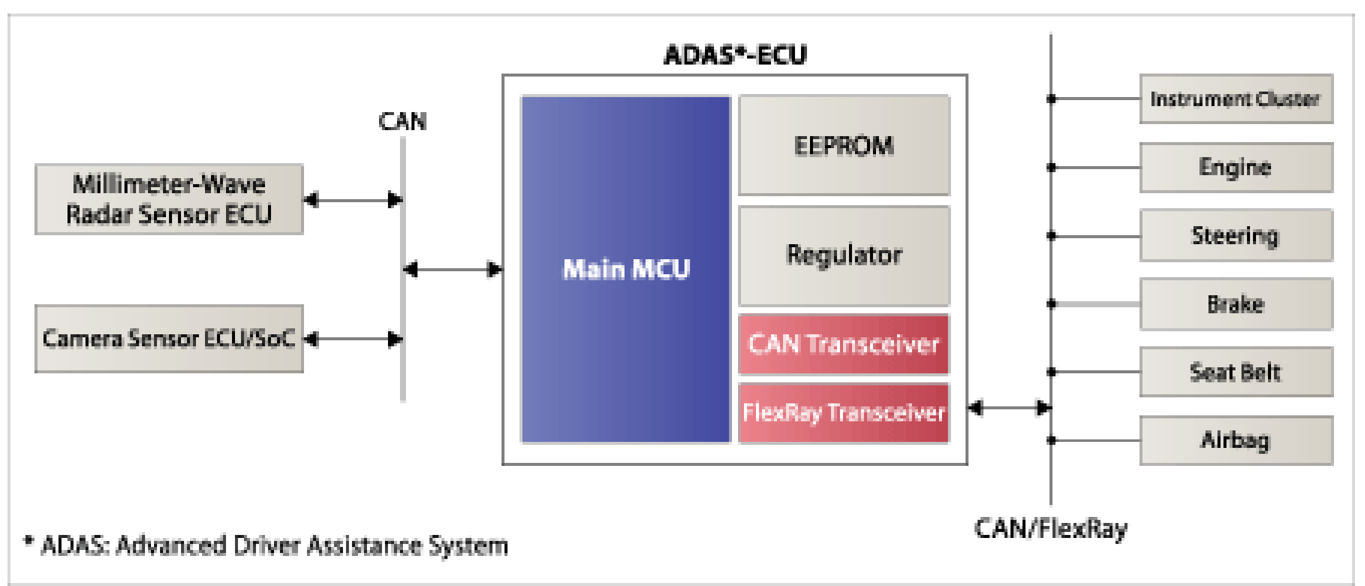
Sensor Fusion/ADAS Control ECU



Source: Renesas.

- **Results from radar and camera sensors are fused with vehicle acceleration, braking, and handling systems to avoid and reduce the possibility of accident in advance.**

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Renesas R-Car

- CPU plus image processing
- Automotive computing platform for driving safety systems
- Infotainment systems

Source: Renesas.

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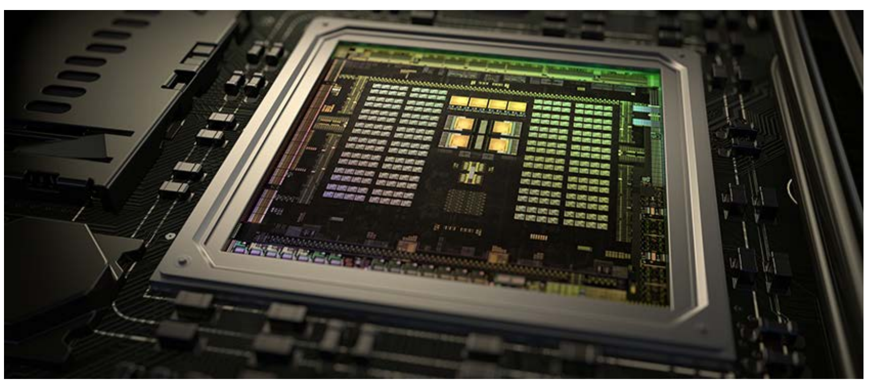
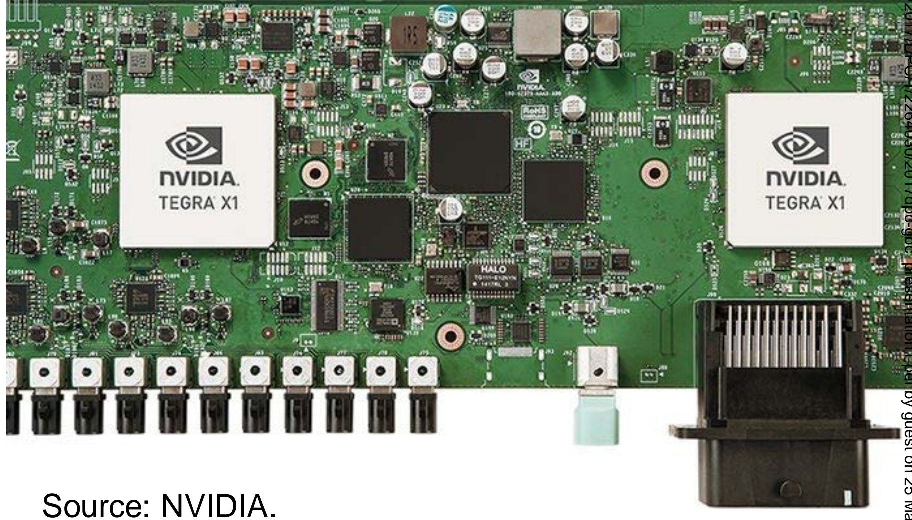
NVIDIA's Tegra's X1: NVIDIA Drive CX Cockpit Computer

- **DRIVE CX**
  - Cockpit computer solution with hardware and software
  - Enables advanced graphics and computer vision for navigation
  - Infotainment
  - Digital instrument cluster
  - Surround-Vision vision provides undistorted top-down 360 degree view of car in real time (no more blind spots)
- **DRIVE PX**
  - Auto-pilot development platform
  - Based on Maxwell GPU architecture
  - Provides parallel computing algorithims, neural computing, and graphics for ADAS
  - With 2 Tegra chips provides inputs for up to 12 cameras





Source: NVIDIA.

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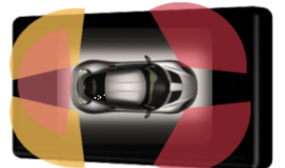
Automotive Packaging Reliability Requirements

DIS	Chassis & Safety	ADAS	Body	Powertrain
Grade 3 & 2	Grade 1	Grade 1	Grade 1	Grade 1 & 0
-40°C to +105°C	-40°C to +125°C	-40°C to +125°C	-40°C to +125°C	-40°C to +150°C



Package STRESS	ABV	TEST METHOD			Duration			
		Standard	Condition	Unit	Grade 3	Grade 2	Grade 1	Grade 0
Temperature Cycling	TC	AEC-Q100, JESD22-A104	-50 ~ +175C	cycles				1000
			-50 ~ +150C		500	500	1000	2000
High Temperature Storage Life	HTSL	AEC-Q100, JESD22-A103	+175C	hours			500	1000
			+150C		500	500	1000	2000

Source: Freescale.

- Automotive harsh environment testing
- Increasing number of semiconductors are being used in automotive that are not designed for automotive
- Zero defect quality and 15+ year reliability at the ECU level

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Conclusions

- **Increased number of safety features in cars including many sensors**
  - Multi-die packages or system-in-package (SiP) to integrate functions closer together
  - Smaller form factor packages with improved performance
  - Designing system-level solution
- **Variety of packages including SiP**
  - Laminate packages (both flip chip and wire bond)
  - Leadframe (Movement from QFP to QFN)
  - WLP
  - FO-WLP
- **New developments in packaging**
  - Lower cost
  - Higher integration
  - Improved reliability (to meet automotive specifications)

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