HETEROGENEOUS INTEGRATION ROADMAP

IEEE Heterogeneous Integration Roadmap Symposium

Automotive TWG Update

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Chapter Outline

This Chapter is organized into 5 sections:

- Connectivity and Communications
- Processor Roadmap
  - ADAS
  - Infotainment
  - Other MCU
- Autonomous Driving Sensors with general discussion about RADAR, and LiDAR. *Roadmaps for RADAR and camera sensors will be addressed in subsequent revisions*
- Functional safety and reliability
- Electric Powertrain challenges

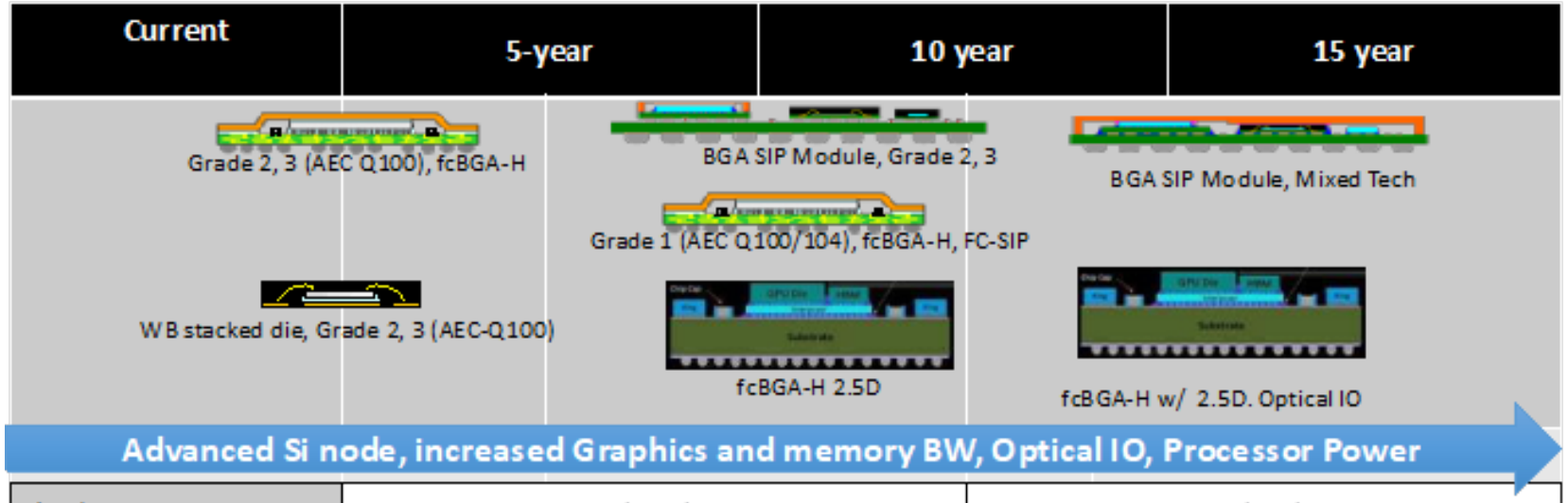
Executive Summary

- Automotive is one of the highest volume growth markets for semiconductor and advanced packaging in the coming decades
- Two major focus areas for new vehicles: causing major disruption
  - Autonomous driving
  - Electric Power Train
- Major impacts to system architecture and driver for heterogeneous integration:
  - highly complex packaging for processors used in autonomous driving,
  - integration of advanced communications,
  - ensuring higher levels of reliability in all components Coming convergence of HPC, Communications, Sensing & Power functions into cars
- Impacts and changes to sensor technology: LiDAR, Radar and camera
- Power train electrification challenges requiring high voltage management

Processor Roadmap

- CPU and GPU: 14nm FinFET → 7nm FinFET
- ADAS Processor: 28nm HK and POlySi → 22FDX and 12FDX, advanced CMOS
- More and more Artificial intelligence cores being integrated
- ADAS will drive more computational power needs – achieving zero defects will be a challenge

Processor Roadmap



Si Node	40nm/28nm/14nm		10nm/7nm/5nm
Interface Speed (parallel), opto	High end 128 bit (32bit X 4 channels) → Massive parallelism Mid-end 64 bit (32bit X2 channel)		
Bump pitch	150um		<100um
Mounting structure	PCB Attach		SIP/Module
Reliability	AEC Q100 Grade 3/2/1	AEC Q100 Grade 2/1 AEC Q006 Grade 1	AEC Q100 Grade 1 AEC Q-104 for SIP
Safety	ASIL-B	ASIL-D?	

Sensing Technologies

- Key components are:
  - LiDAR
  - Radar (will be covered in future revs)
  - Camera (will be covered in future revs)

Sensor Objective	Camera	RADAR	LiDAR	Ultrasound
Adaptive Cruise Control		X	X	X
Emergency Braking	X	X	X	X
Pedestrian Detection	X	X	X	X
Collision Avoidance		X	X	X
Traffic Sign Recognition	X			
Lane Departure Warning	X		X	
Cross Traffic Alert	X	X	X	
Surround View	X			
Blind Spot Detection	X	X	X	
Park Assist	X	X	X	X
Rear Collision Warning	X	X	X	X
Rear View Mirror	X			
Drowsiness Detection	X			

LiDAR Detector Roadmap

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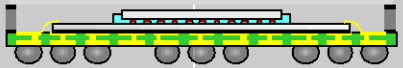
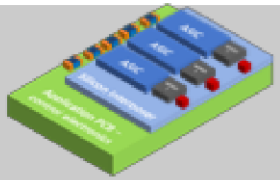
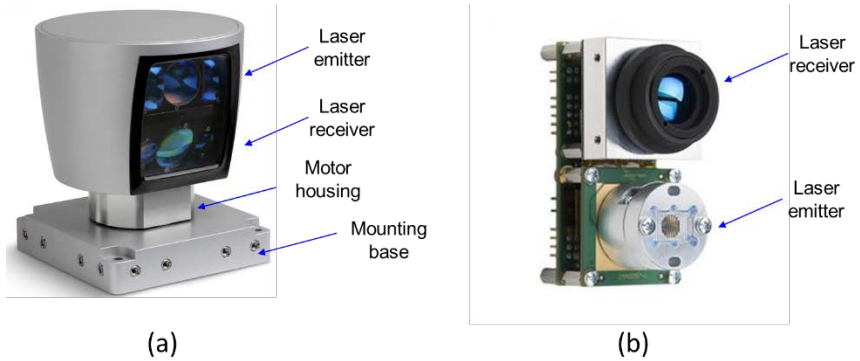
Packaging Architecture	Current	5-Year	10-year	15-year
LiDAR Module/SiP	 LiDAR SiP Stacked die, FBGA, AEC Grade 1, 2		 LiDAR Integrated Sensor, AEC Grade 0	 LIDAR Integrated Sensor, AEC Grade 0, High Density Si Interconnect
LiDAR Detection Range : Short Range (100m) to Long Range (100-250m)				
Package	Detector: C2W, bumped, FC, W/B ASIC: W/B, F/C Package: LFBGA, QFN, LGA, SiP	Detector: FC, PoP, W/B ASIC: W/B, F/C Package: LFBGA, QFN, LGA , MLP, WLCSP		Detector: FC ASIC: FC Package: WLCSP, FO WLP
Detector/ASIC per pkg Footprint	1 Detector / 1 to 3 ASIC 10x10mm	1 Detector / 1 to 2 ASIC 9x9mm	2-4 Detector/ 3 to 4 ASIC 8x8mm	>4 Dectector/ASIC
Substrate	Laminate, Leaded, Ceramic	Laminate or Ceramic	Laminate or Ceramic	Laminate w/high density Interposer
Optical Grade Window or Filter	Filter, Glass, or Plastic	Filter, Glass, or Plastic	Filter, Glass, or Plastic	Filter, Glass, or Plastic
Ball Pitch	0.8mm	0.7mm	<0.7mm	<0.7mm
Reliability	AEC Q100 Grade 1, 2	AEC Q100 Grade 0		>AEC Q100 Grade

IEEE IEEE photonics Society semi IEEE ELECTRONICS PACKAGING SOCIETY ASME ELECTRON DEVICES SOCIETY

LiDAR Sensor - Status

LiDAR System	Range	Reliability	Cost	Size	Systems per car
Mechanical	Long	Good	Mid to high	Bulky	1
MEMS Based	Medium to long	Good	Low	Compact	1-4 or more
Flash	Short	Very good	Low	Compact	1-4 or more
Optical Phase Array	Advantages: solid state design with no moving parts Disadvantages: loss of light that restricts the range				



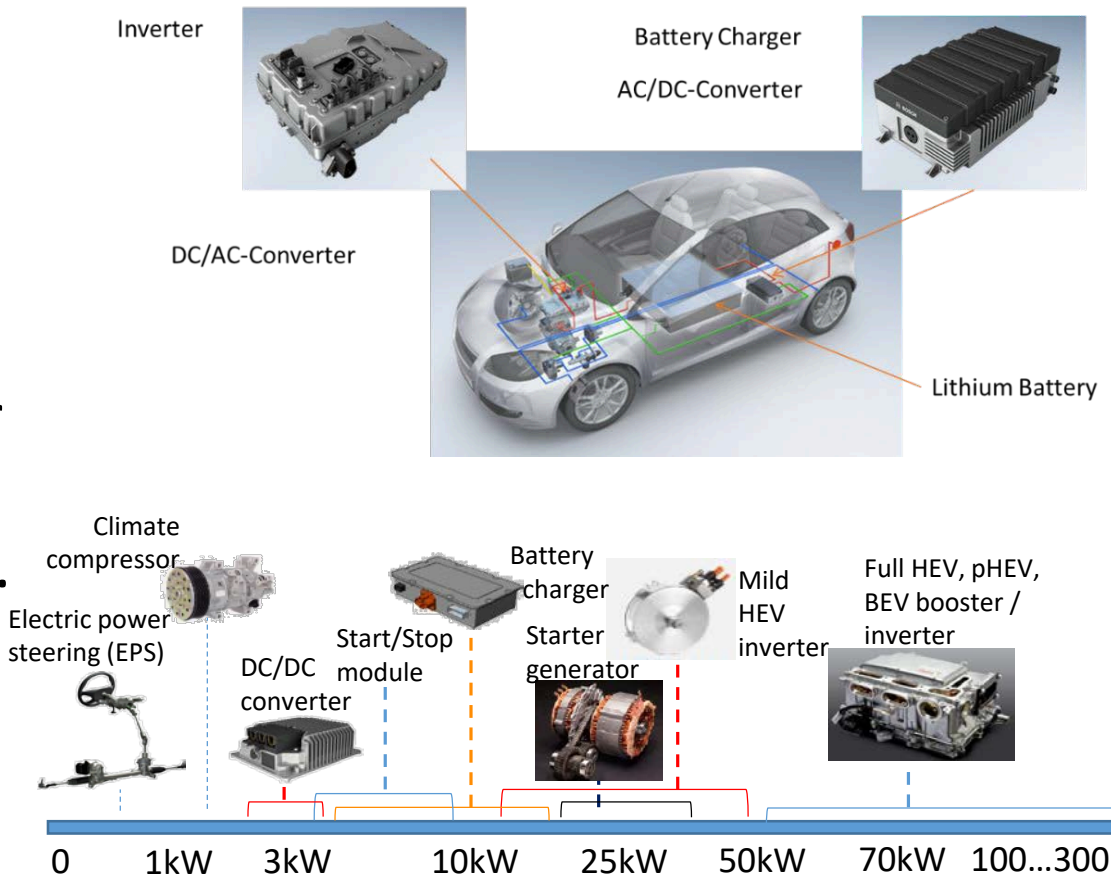
Two LiDAR systems from (a) Velodyne and (b) LeddarTech

Reliability

- Developing the required *infrastructure, sensors,* electronics *hardware;*
- Studying and characterizing the *failure mode and mechanism effect* by thorough *analyses* (FMMEA) for both *PoF and DD approaches;*
- Providing appropriate solutions to *data acquisition, management,* and secure data *transfer;*
- Performing the data fusion for integrating global *health assessment, diagnostics, and prognosis* score per application;
- Establishing a highly efficient digital twin for electronic control units based on precise *metamodeling and model order reduction* (MOR) schemes that can be executed in each of the individual cars locally (or in cloud) assisted by self-learning capabilities provided by cloud services

Electrification – Power and Thermal

- The primary impact will be on batteries
- Apart from MCUs for supervisory and control functions, specialty components will include power transistors such as IGBTs.
- Power outputs can increase to 100KW or more, requiring costly and next-generation power transistors and diodes.
- Need for Specialty passives for supporting high energy efficiency



Summary

- Complexity of automotive electronics is evolving rapidly with diverse platforms and functions
- Addressing performance demands and new use cases is a huge challenge
- Component and system reliability advancements must keep up
- Heterogeneous integration of system and subsystem modules will be a key enabler to achieving the goals of transportation of the future
- Auto TWG chapter status: we have completed a first revision, but will need updates on various sections including radar, camera sensor and power modules

Connectivity to other Chapters

- Computing – HPC & 2.5D/3D chapters
- Connectivity – 5G and RF chapter
- LiDAR – Integrated Photonics chapter
- EV and HEV – Integrated power package chapter
- Various – SiP chapter
- Reliability chapter
- Thermal chapter – high temperature need for under-hood electronics, cooling solutions for WBG devices