Automotive Megatrends and Package Technology Solutions

Presented By: Vikas Gupta, ASE Group

In Collaboration with Heterogeneous Integration Roadmap Technical Working Groups Team

Outline

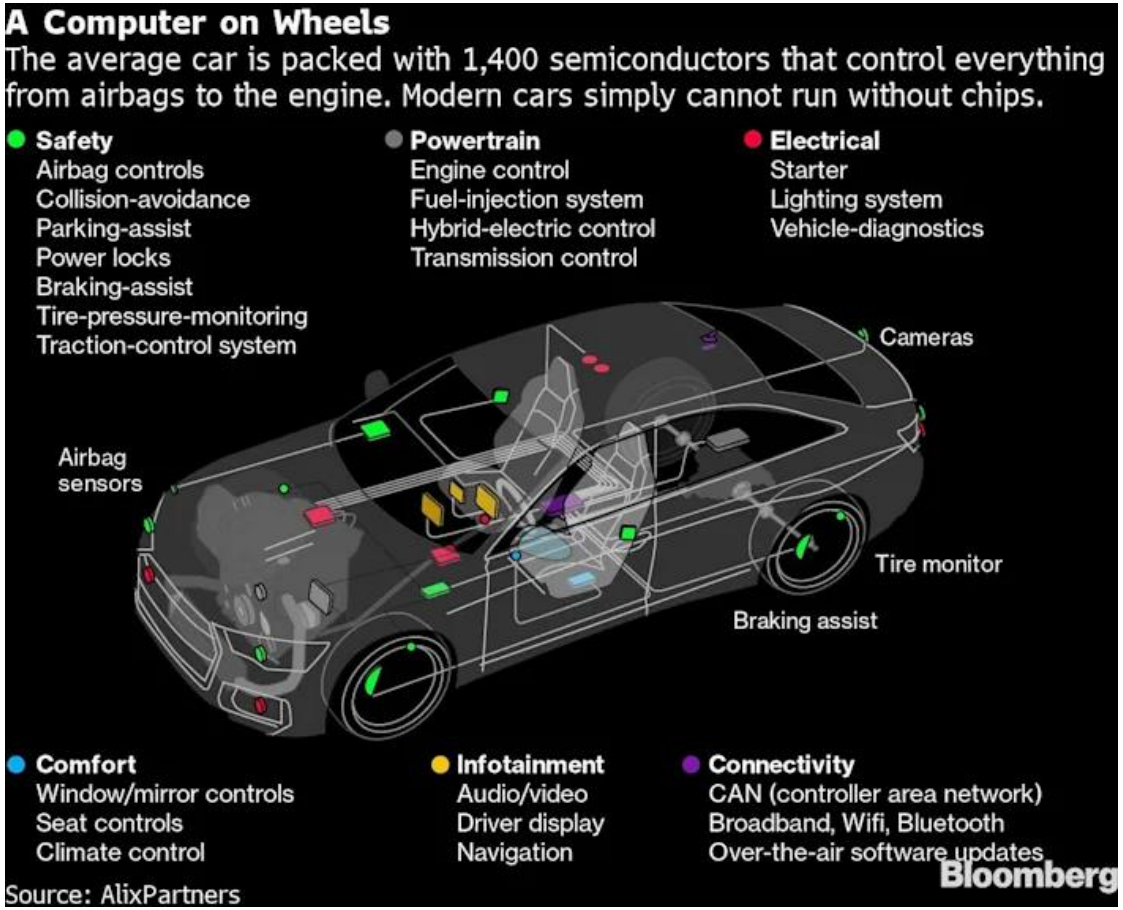
- Heterogeneous Integration Roadmap
- Semiconductors in Automotive Industry
- Automotive Growth Drivers
- Key Megatrends
  - Electrification
  - Autonomous – Sensing
  - Processors
- Reliability
- Summary

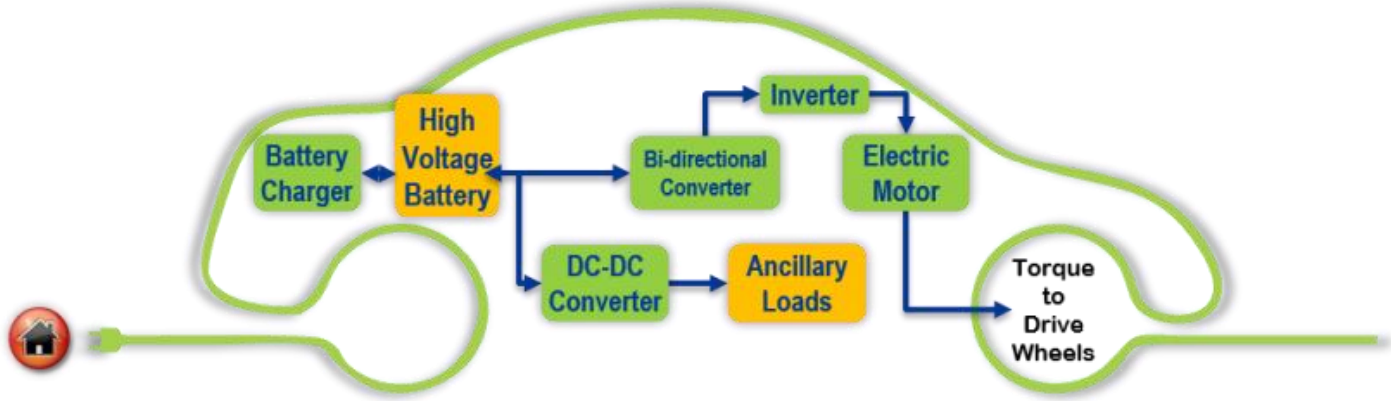
Heterogeneous Integration Roadmap (HIR)

- Sponsored by 3 IEEE Societies (EPS, EDS & Photonics) together with SEMI & ASME Electronics & Photonics Packaging Division
- Comprehensively covering microelectronics technology ecosystem
- Articulates state-of-the-art Advances in Technology & Science, Future directions, Significant roadblocks & Potential solutions
- HIR is the Knowledge Roadmap & Knowledge Supply Chain for the Heterogeneous Future

Launched 10-10-2019
24 chapters, 590 Pages, Free Download
https://eps.ieee.org/technology/heterogeneous-integration-roadmap

Semiconductors in Automotive Industry





- Increasing semiconductor content & value in Automotive
- 80% of Innovations in automotive enabled by semiconductors
- Envisioning Heterogeneous Integration – System, Function, Reliability, time to market?
- How would Adv Packaging Innovations in Mobile (5G & Smart Phone) & High-Performance Computing & Data Centers be made “applicable” to Automotive Future Applications?

Technical Working Group Contributors

- Rich Rice, ASE Group, Rich.Rice@aseus.com
- Veer Dhandapani, NXP, veer.dhandapani@nxp.com
- Sandeep B Sane, Intel, sandeep.b.sane@intel.com
- Shalabh Tandon, Intel, shalabh.tandon@intel.com
- Przemyslaw Jakub Gromala, Bosch, PrzemyslawJakub.Gromala@de.bosch.com
- Marco Munzel, Bosch, Marco.Munzel@de.bosch.com
- Johannes Duerr, Bosch, Johannes.Duerr@de.bosch.com
- Sven Rzepka, Fraunhofer, Sven.Rzepka@enas.fraunhofer.de
- Prof Hongbin Yu, Arizona State University, Hongbin.Yu@asu.edu
- Klaus Pressel, Infineon, Klaus.Pressel@infineon.com
- Vikas Gupta, ASE, Vikas.Gupta@aseus.com
- Andreas Grassmann, Infineon, Andreas.Grassmann@infineon.com

2020 – 2030 Automotive Growth drivers

Autonomous driving (ADAS)

- Sensors & Computing
- More comfort & entertainment

Powertrain efficiency

- Electric Powertrain
- Cleaner thermal engines / pollution control

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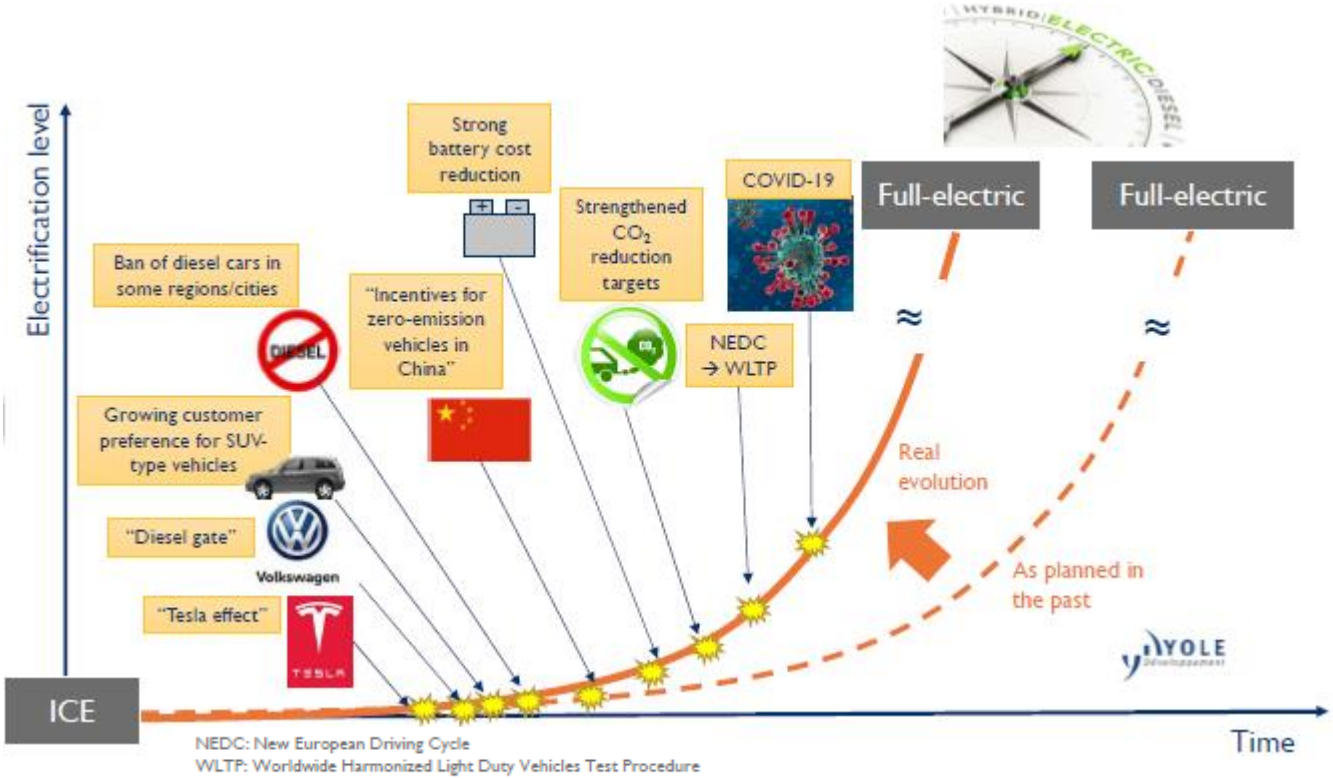
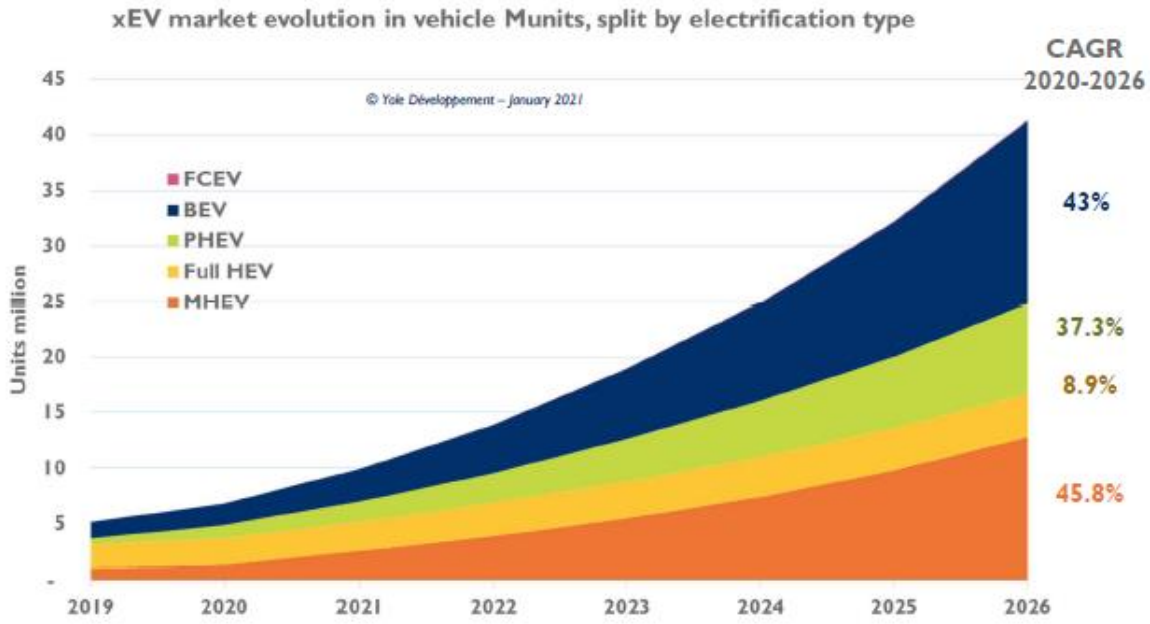
Vehicle Electrification Acceleration





Yole, EE Times, March 2021

- Strategy path for vehicle electrification has been accelerated by several singular events
- To reach significant emission reduction, MHEV and full HEV electrification approaches are not sufficient
- August 5, 2021 - President Joe Biden announced a new national target for electric vehicles to make up half of all new vehicle sales by 2030
- Even hyper cars going electric

OEM Electrification Investments/Targets

$330B investment by 2025
41% increase in last year

35B

GM
~~$27~~ billion investment
- Ultium BEV3 and BT1 EV platforms
- 30 new EVs through 2025
- LG Chem, CATL
- Delphi (800V)

Ford
$30 billion investment
- 40% of all Ford volume to be all-electric by 2030
- Mach-E, F-150, Transit
- MEB platform
- Battery manufacturing strategy

HYUNDAI
$65.8 billion investment
- 28 electrified models
- Hyundai, Kia
- LG Chem, SK Innovation
- Mobis, Vitesco

Yole, EE Times, March 2021

- **Significant increase in EV models across all major OEMs**

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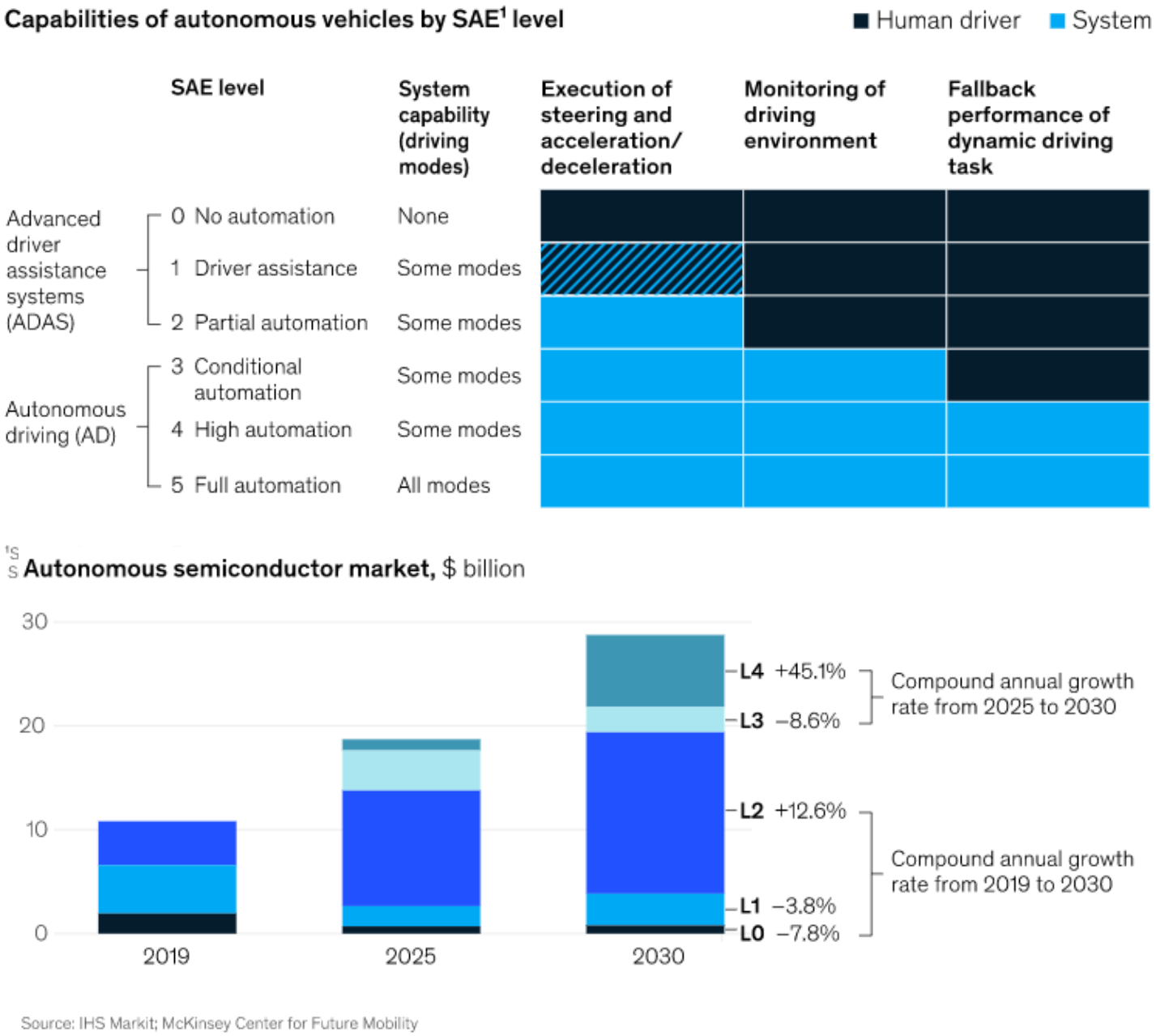
Autonomous Trend

Image Source: Tektronix

High-bandwidth and low-latency networks connecting all sensors, cameras, diagnostic, communications and central processing units will drive advances in artificial intelligence and machine learning



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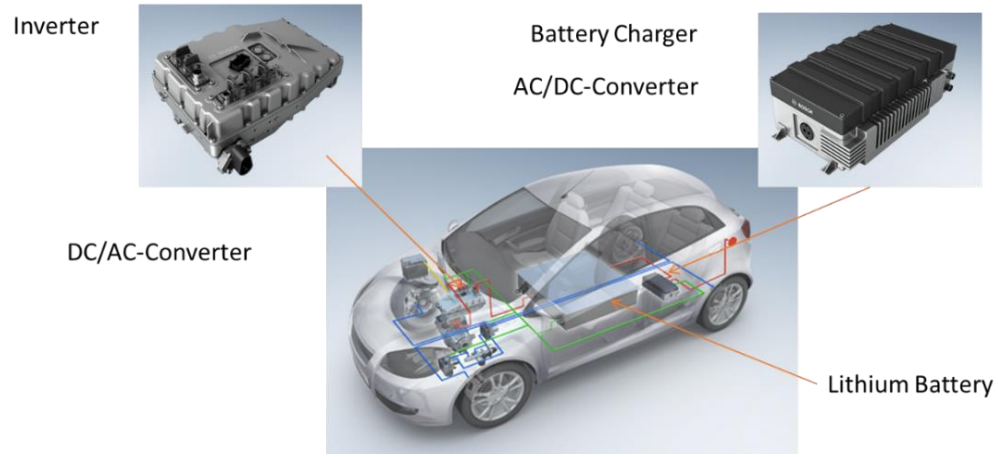
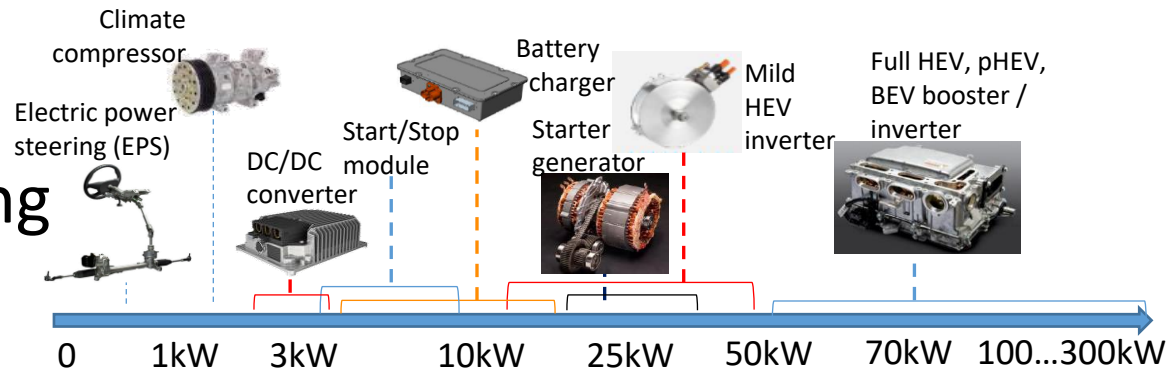
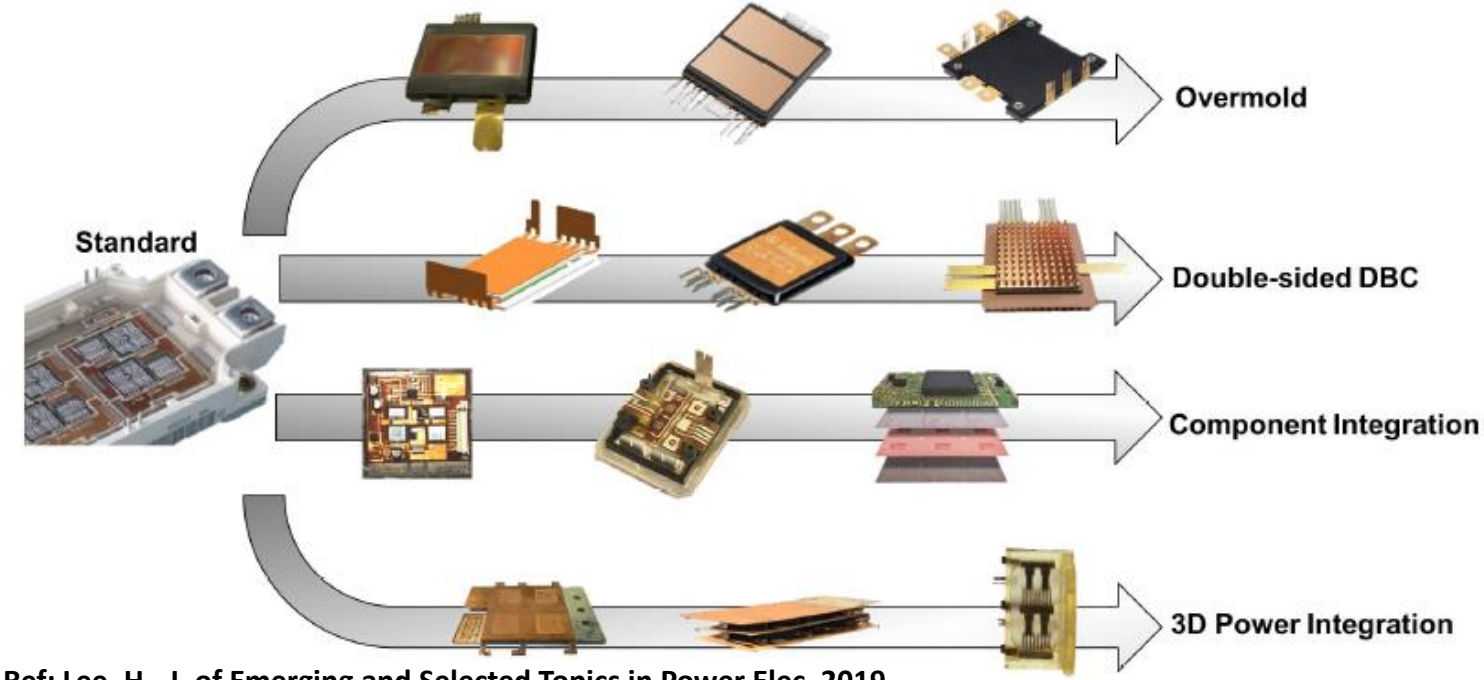
Electrification – Power and Thermal

- Main challenges – longer range and shorter charge times
- Power outputs increase to 350KW or more, requiring costly and next-generation power transistors and diodes.
- Higher voltage to enable faster charging for given battery current limits, lower losses in the vehicle
- Wider implementation of wideband gap devices.
- Need for specialty passives for supporting high energy efficiency

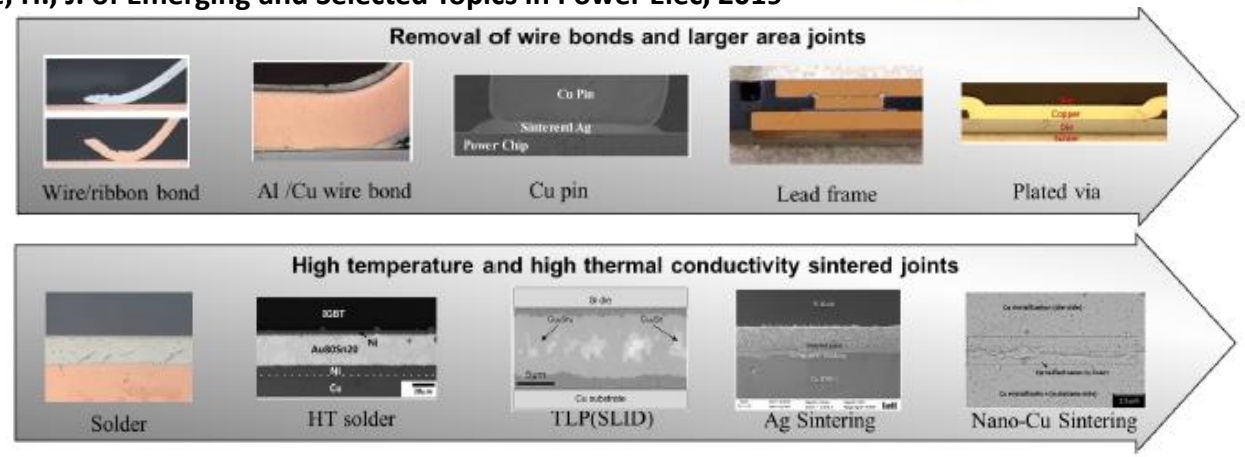




Electrification and Packaging



Ref: Lee, H., J. of Emerging and Selected Topics in Power Elec, 2019



- Key Drivers
  - Lower cost $/kW
  - Higher Power Density kW/kg
  - Smaller Size kW/L
- Enhanced modularity coupled with low inductance, low loss, improved thermal performance through advancement in package designs
- Advances in package interconnections, die-attach and substrate technologies playing a key role in package innovation and performance

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Embedded Technology: ASE a-EASI

Leadframe Base: Good Thermal Dissipation, EMI Shielding

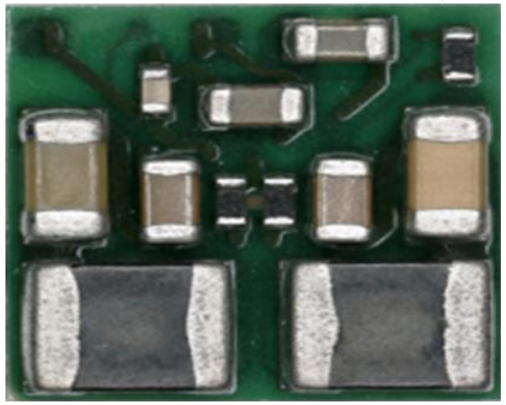
High Tg Prepreg: >2.5KV break-down Voltage

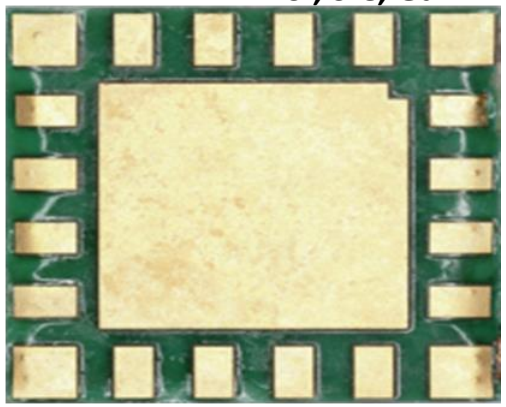
Substrate Copper Layer: 1, 1+1, 1+2

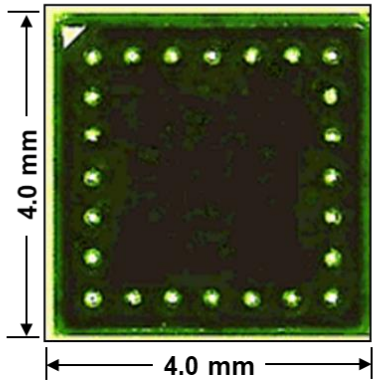
Copper Via: Low Rds_{on} /Inductance & High Current, High thermal dissipation

High Thermal D/A Epoxy Type: Sintering Epoxy, ~100W

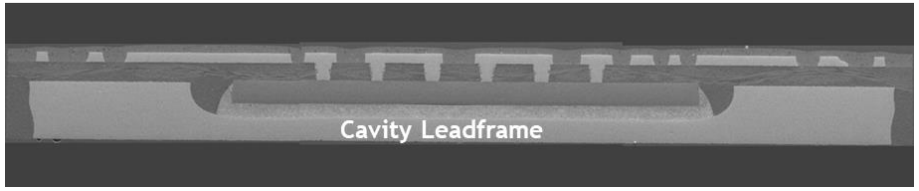
Si, SiC, GaN Dies Embedding



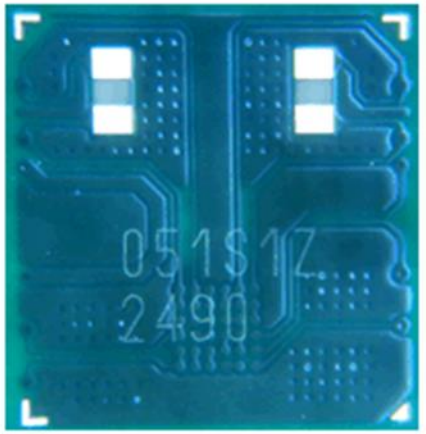




Bottom

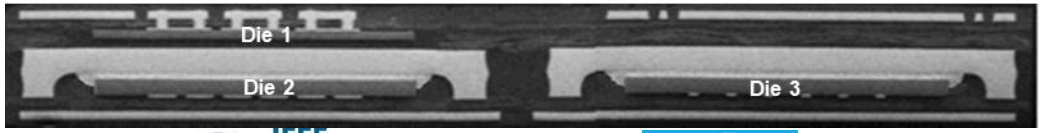


Marking Side



Ball Side

aEASI P1 Structure
5 x 5 x 0.57 mm (excluding Passives)
1 Power Management Chip + 12 Passives
2+1 RDL



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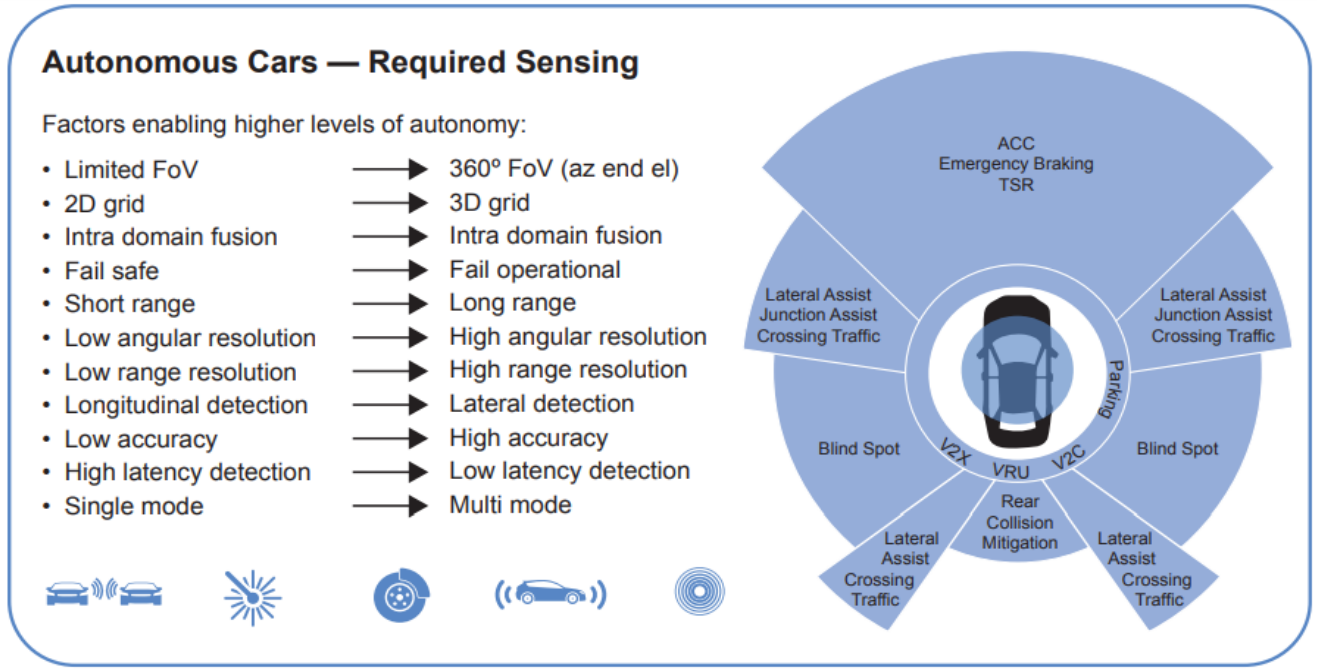
Sensing Technologies



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			

- Key components are:
  - Camera
  - Radar (Chapter update draft completed for 2020 release)
  - LiDAR

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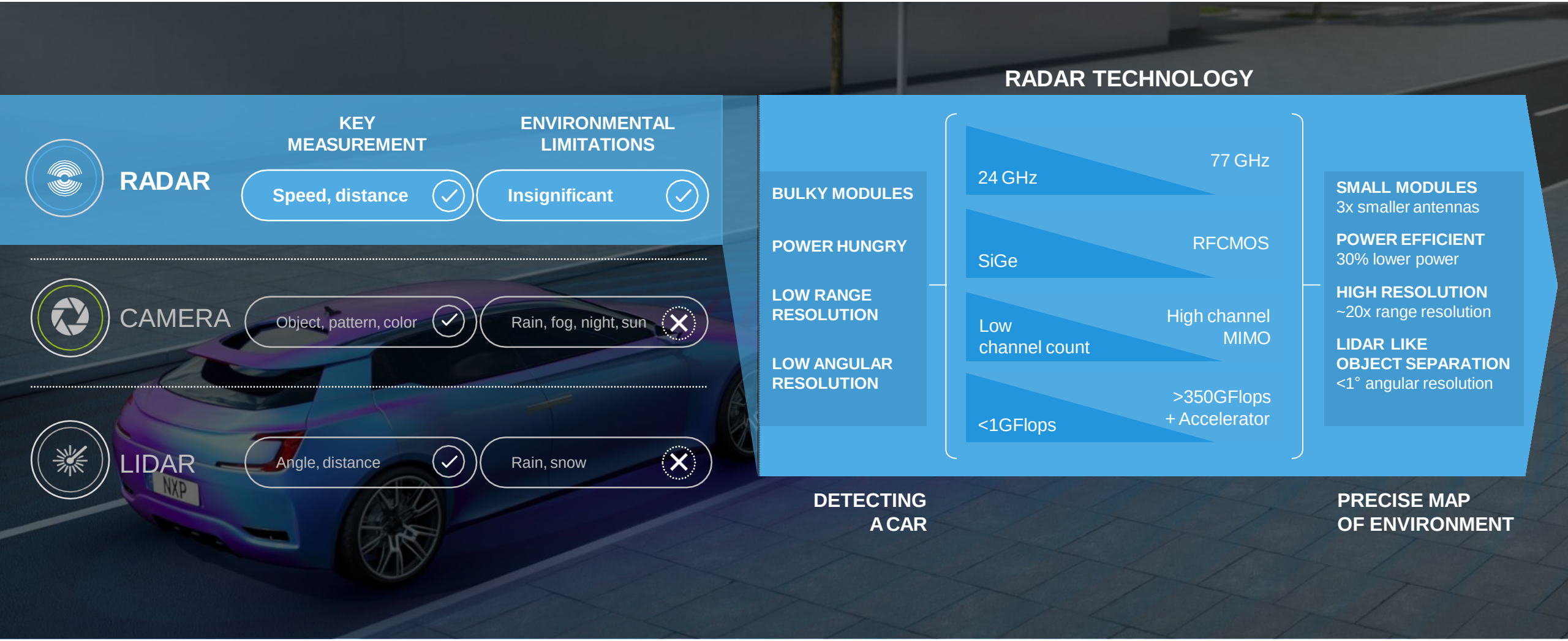
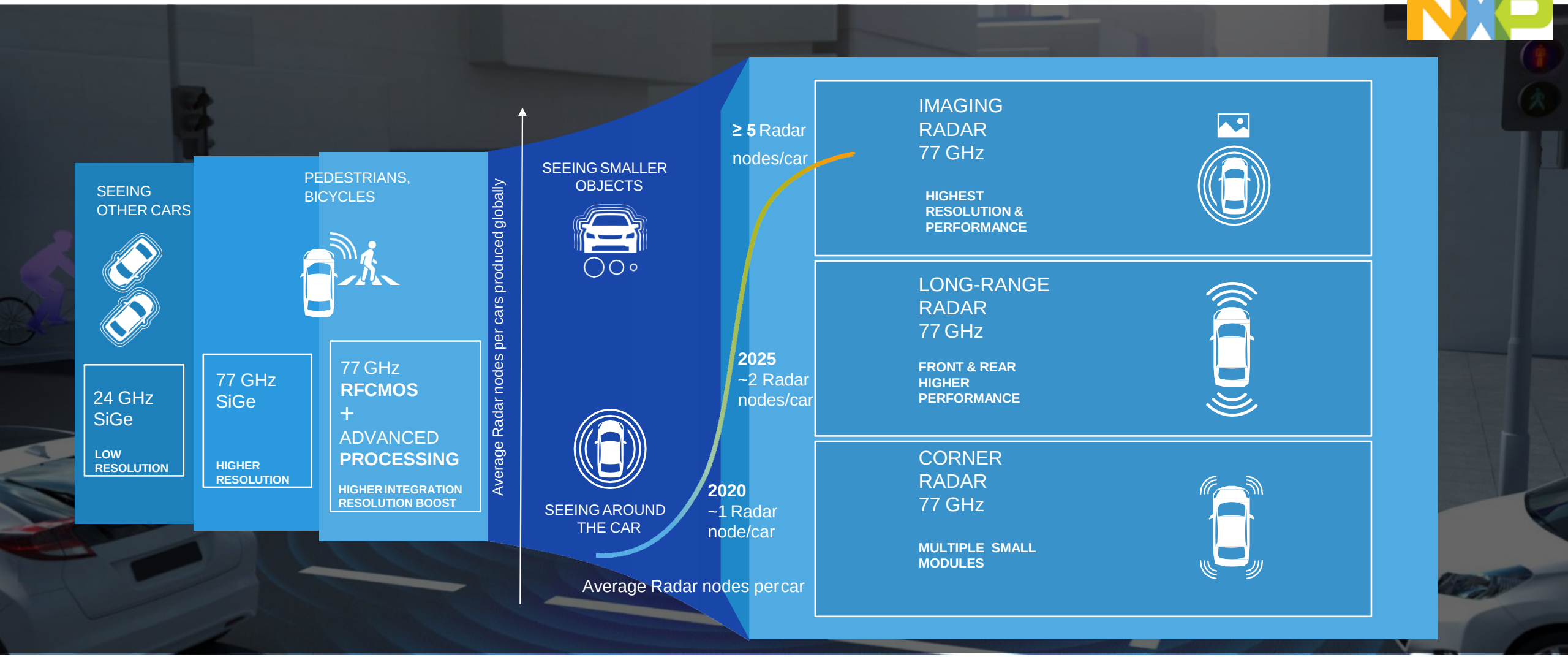
Autonomous Driving: Complementary Sensors L2+ to L5

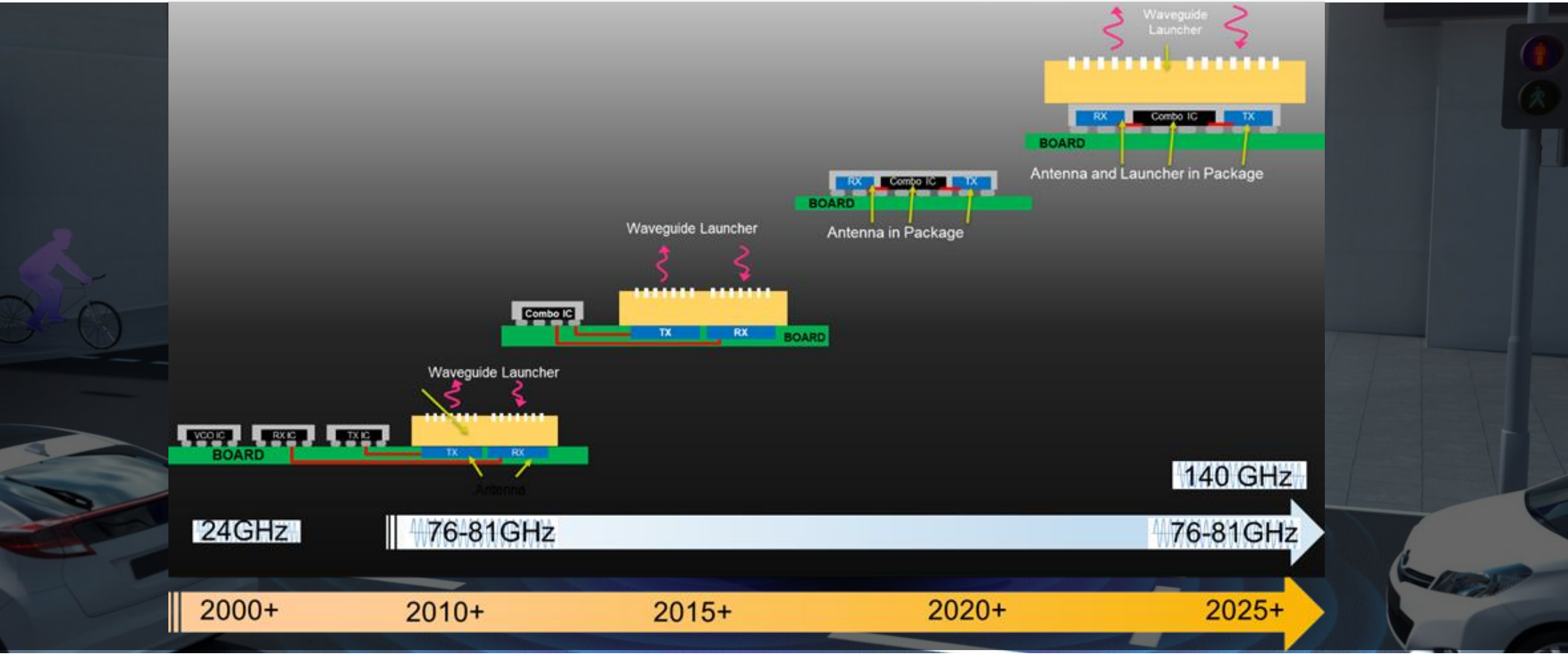


Source: NXP CMI

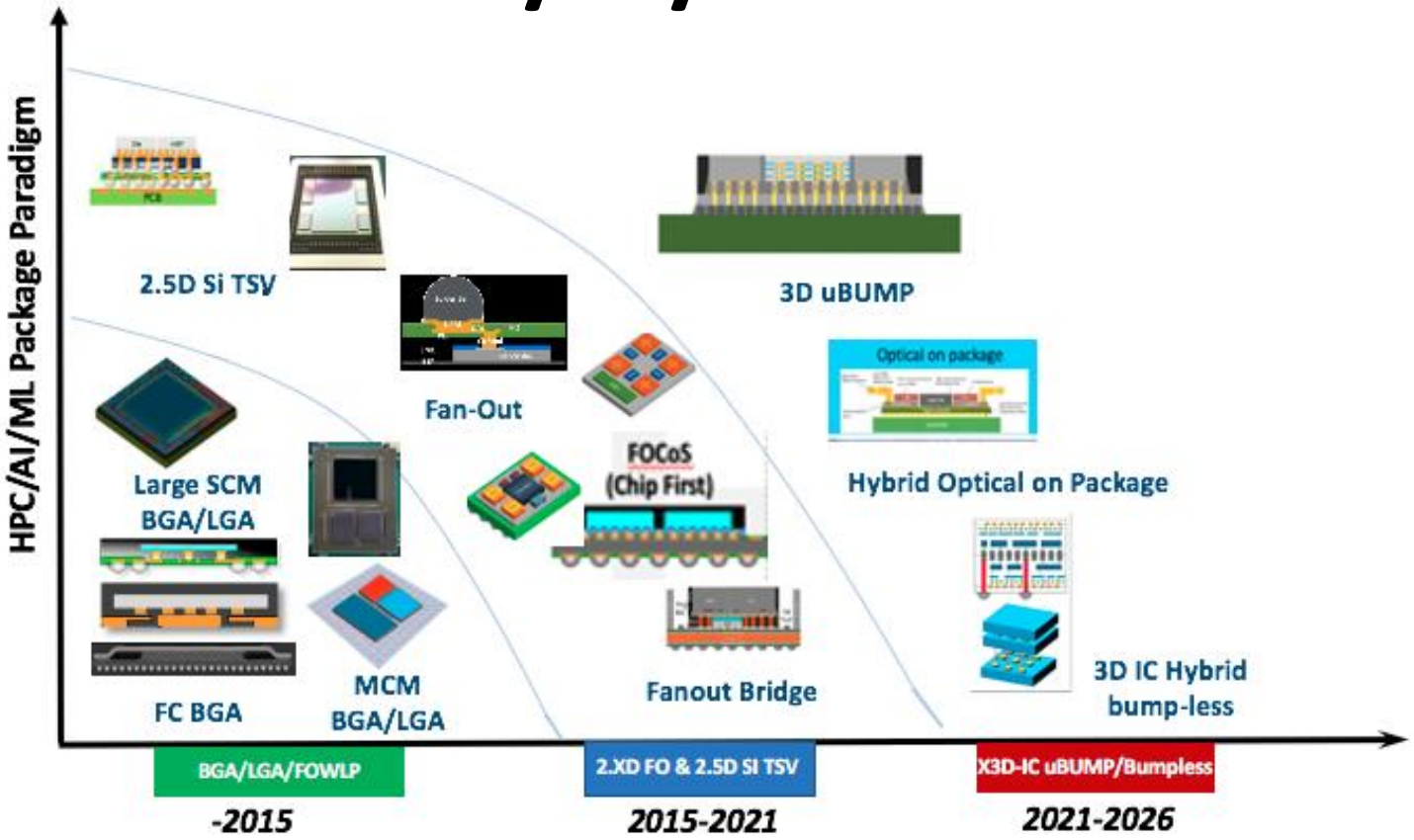
Radar Evolution: From Corner Radar to Imaging Radar



Heterogeneous Packaging Evolution

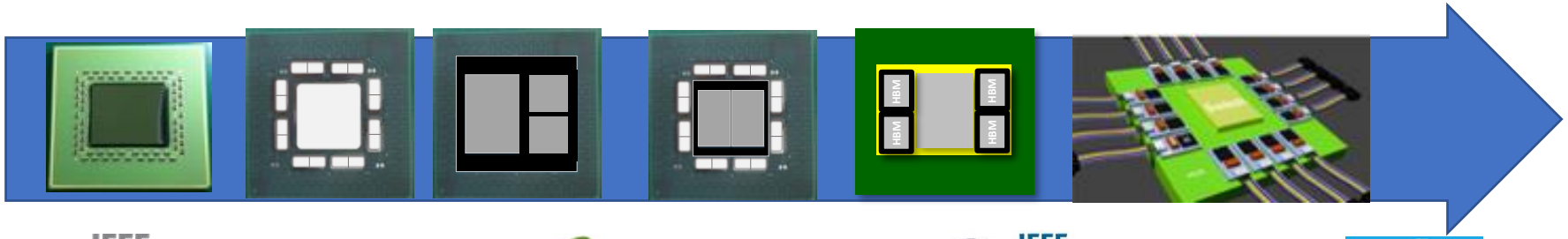


ASE HPC/AI/ML Focus Package Platforms

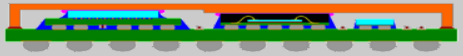


- HPC/AI/ML the prevalent state-of-the-art in device and process technologies
- Require highest processing rates, highest communication rates (low latencies and high bandwidth) and highest capacities
- Automotive processors starting to drive similar requirements; technology adoption accelerating

Courtesy: Lihong Cao, ASE



Automotive Processor Roadmap – Infotainment/ ADAS

	Current	5-year	10 year
	 Grade 2, 3 (AEC Q100), fcBGA-H	 BGA SIP Module, Grade 2, 3	 BGA SIP Module, Mixed Tech
	 WB stacked die, Grade 2, 3 (AEC-Q100)	 Grade 1 (AEC Q100), fcBGA-H, FC-SIP	 fcBGA-H w/ TSI. Optical IO
		 fcBGA-H w/ TSI	

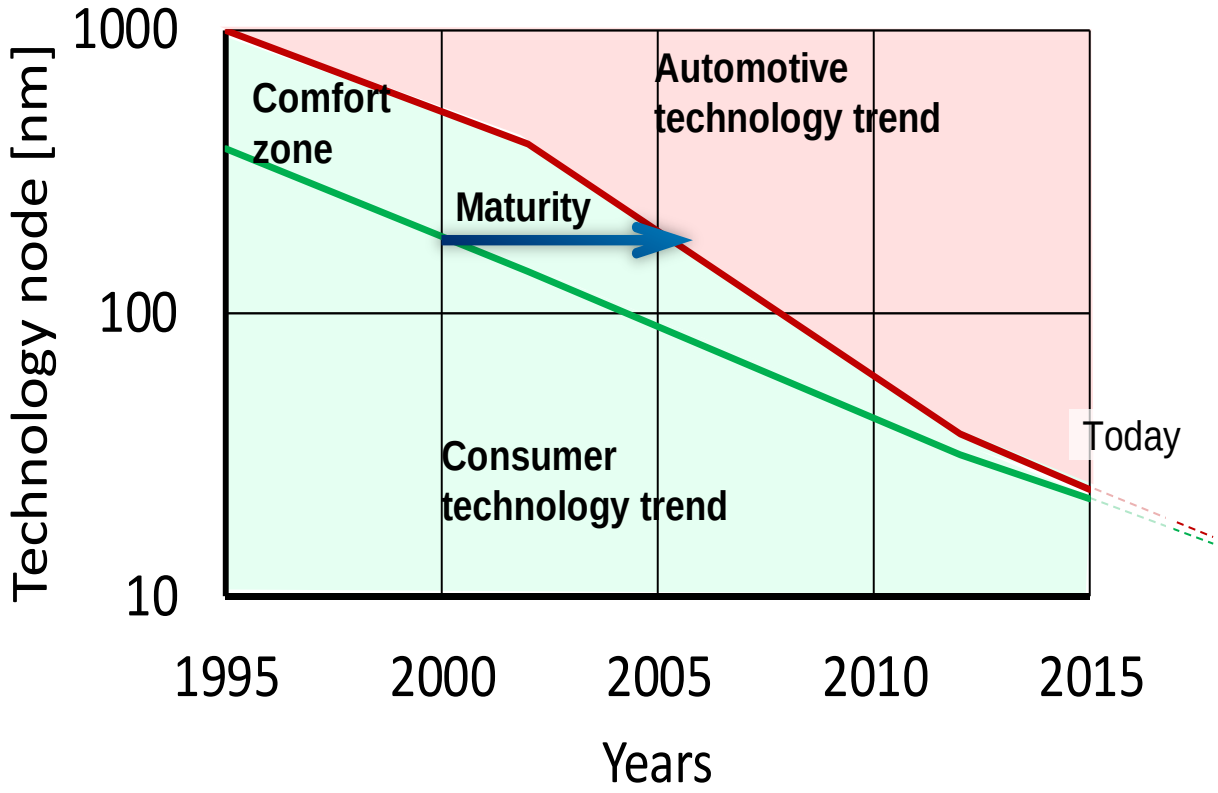
Advanced Si node, increased Graphics and memory BW, Optical IO, Processor Power

Si Node	40nm/28nm/14nm/10nm/7nm		5nm/3nm/2nm
Interface Speed (parallel), opto	High end 128 bit (32bit X 4 channels) →Massive parallelism Mid-end 64 bit (32bit X2 channel)		
Bump pitch	150um/130um/110um		<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?	

Reliability

Reliability Section – our focus

- Major change of the chapter
- Impact of megatrends on automotive reliability
  - **C**onnectivity, **A**utomation, **S**haring, **E**lectrification
- State of the Art
  - Reliability physics
- Anticipated challenges
  - New HW Architecture and SW interaction on HW reliability
  - New qualification criteria/test
  - Model based engineering
  - Digital twin and Prognostics and Health
  - AI/ML : physics enhanced models
  - AI assisted analysis methods
  - Reliability over supply chain, from wafer (chip) to system of systems (CPI, sub-system to system)
- Roadmap



Courtesy: Przemyslaw Jakub Gromala, Bosch

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
  - Electric Power Train
  - Autonomous driving
- Major impacts to system architecture and driver for heterogeneous integration:
  - Highly complex packaging for processors used in autonomous driving
  - Integration of advanced communications
  - Impacts and changes to sensor technology: LiDAR, Radar and camera
  - Power train electrification challenges requiring high voltage management
  - Ensuring higher levels of reliability in all components; convergence of HPC, Communications, Sensing & Power functions into cars

Thank You!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