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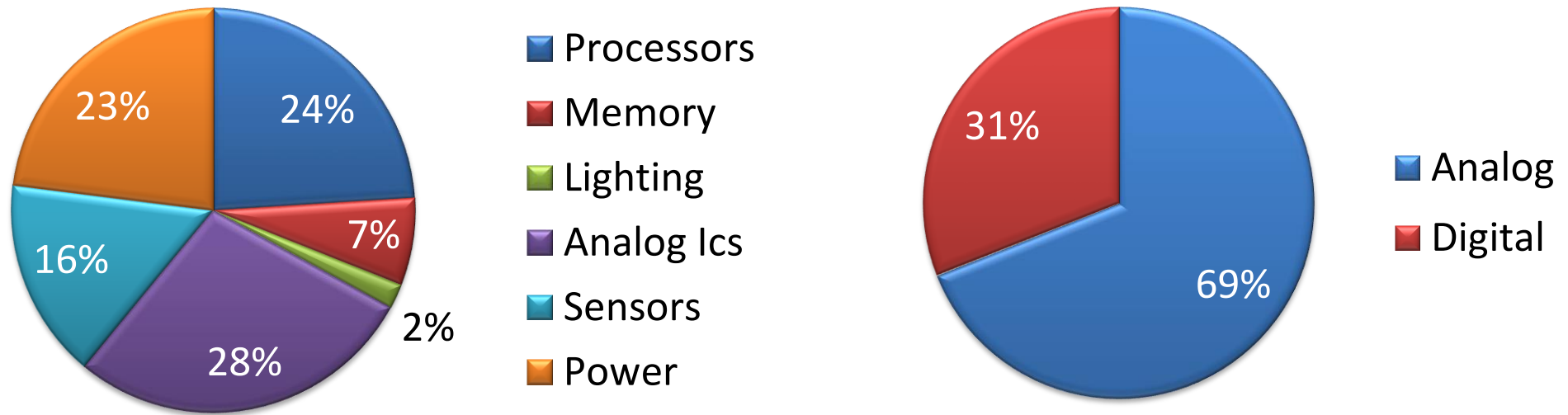
Semiconductor Foundry Opportunity in Automotive

June 2017

Automotive Semiconductor Content

- 2016: $35B* Auto Semi content dominated by Analog

Left pie chart legend:
- Processors — 24%
- Memory — 7%
- Lighting — 2%
- Analog Ics — 28%
- Sensors — 16%
- Power — 23%

Right pie chart legend:
- Analog — 69%
- Digital — 31%

- Analog interfaces the real world with the digital processing of information
  - Computing is primarily a digital function with some analog for Input / output
  - Most other "things" require much greater degree of real-world interface and analog
  - Automotive: sensing, communication, power/actuating are analog interface examples

* Source: MarketsandMarkets

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Fabless

SKYWORKS

BROADCOM.

SEMTECH

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Specialty Analog IC Manufacturing

Proprietary Process Technology

Analog-Accurate Design Kits

Global specialty manufacturing capacity

Enabling fast time to market and high volume assurance of supply

IDM

ON Semiconductor

(intel)

infineon

WE NEVER COMPETE WITH OUR CUSTOMERS

Semiconductor Foundry Landscape

($M)	2005		2010		2015		2016		2016/15 Change	Accumulated Change
A	TSMC	8,217	TSMC	13,307	TSMC	26,439	TSMC	29,488	11%	259%
B	UMC	3,259	UMC	3,965	GF	4,990	GF	5,545	10%	390%
C	SMIC	1,171	GF	3,510	UMC	4,464	UMC	4,582	3%	41%
D	PowerChip	1,587	PowerChip	2,424	SMIC	2,222	SMIC	2,921	31%	150%
E	Chartered	1,132	SMIC	1,555	PowerChip	1,268	PowerChip	1,275	1%	-20%
1	Vanguard	353	**TowerJazz**	**509**	**TowerJazz**	**961**	**TowerJazz**	**1,249**	**30%**	**1125%**
2	Dongbu	347	Vanguard	505	Vanguard	736	Vanguard	800	9%	127%
3	HHNEC	313	Dongbu	495	Hua Hong	650	Hua Hong	712	10%	127%
4	SSMC	280	SSMC	330	Dongbu	585	Dongbu	672	13%	94%
5	He Jian	250	X-Fab	320	SSMC	460	X-Fab	510	54%	146%
11	**Tower**	**102**								

Digital Deep Sub Micron
Specialty Analog

The fastest growing foundry in the world

Source: IC Insights, EE Times, Company Reports

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Market MEGATRENDS driven by Internet of Things Resulting in rapid growth in Specialty Analog applications

GREEN EVERYTHING
Energy Efficiency

WIRELESS EVERYTHING
Seamless Connectivity

SMART EVERYTHING
Embedded Systems

~28% of Revenues

~30% of Revenues

~18% of Revenues

Specialty Analog Technologies

Power

RF

Sensors

TOWERJAZZ
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Market MEGATRENDS driven by ~~Internet of Things~~ Automotive
Resulting in rapid growth in Specialty Analog applications

GREEN EVERYTHING
Energy Efficiency

WIRELESS EVERYTHING
Seamless Connectivity

SMART EVERYTHING
Embedded Systems

EV and Hybrids

Connected Vehicles

ADAS

Specialty Analog Technologies

2x Semi content 5-6x Power Semi

4G, 5G Wireless, WiFi, BT RF Content

Radar, CIS, LiDAR, IR Sensors

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Automotive Semiconductor Systems and Foundry Technology

RF

CIS

Power

Communicating

Wireless Front-End
Wireline in-car drivers

Actuating

Actuators
Drivers

Control
Processors in Digital CMOS
Memory

Sensing

LiDAR
Camera
Radar

Infrastructure

Power Distribution
Battery Management
Engine Systems

Automotive Semiconductor Systems and Foundry Technology

RF

CIS

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CIS Automotive Specialty Foundry Market

Growth driven by

1. Camera proliferation
   - Today
     - Rear View, Lane Departure, Light Beam Control, Driver Monitoring
   - In the future
     - Road Sign Detection, Mirror Replacement, Full surround view
2. LiDAR (autonomous driving)
3. Night Vision (IR)

$M Auto CIS Semi Market

10% CAGR

Source: Marketsandmarkets and internal estimates

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Foundry high-volume CIS technology adapted for Automotive

1. High Dynamic Range is required

Output Signal, Card 2, H7, Gains x1-x4 at I-card=400uA, Test-6 Isf=15uA, SH=1us, Vrst boost = 6V, Vdd = 5V
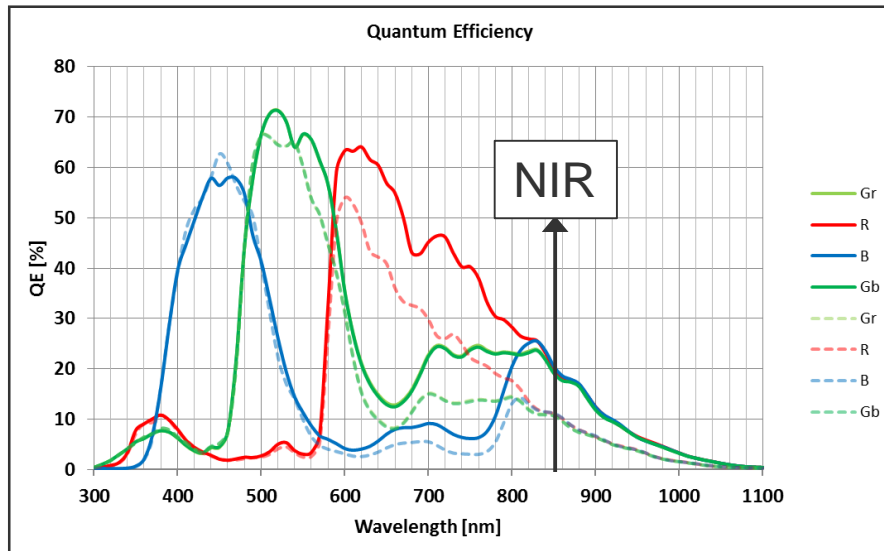
H7 Gx1 GE3_6_5V_14_shift-TG K2 Out Sig G2
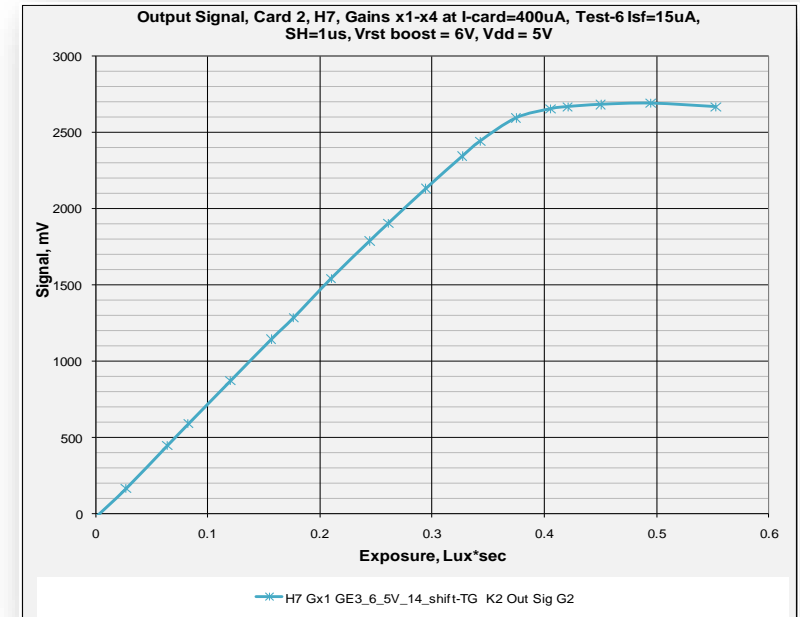
2. High frame rate and global shutter to detect fast movement

3. High resolution VGA -> HD -> 4k

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Improved NIR detection for low-light conditions and LiDAR

1. Enhanced NIR detection can help "see" with limited visible light

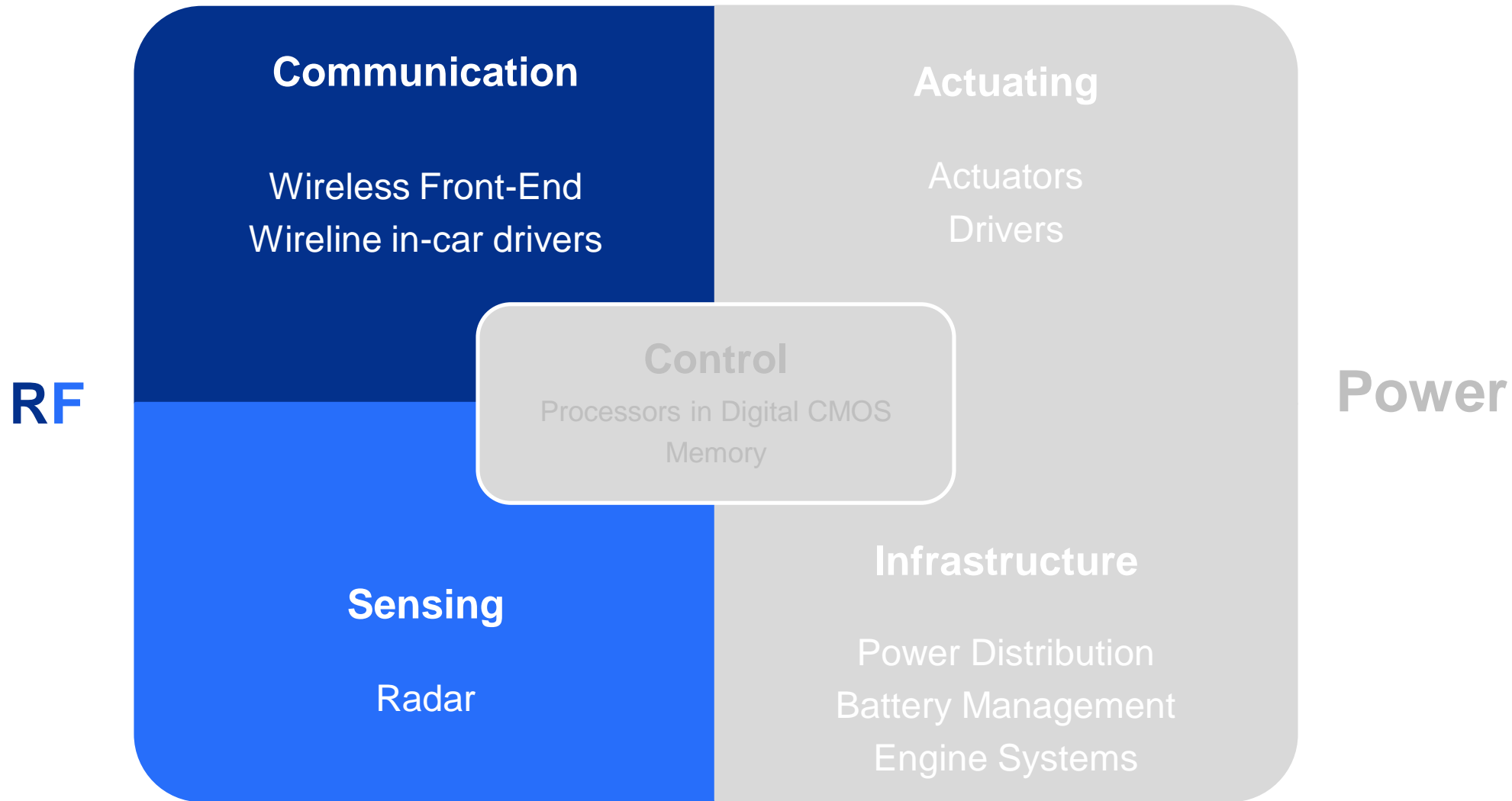Standard

↓

Improved NIR
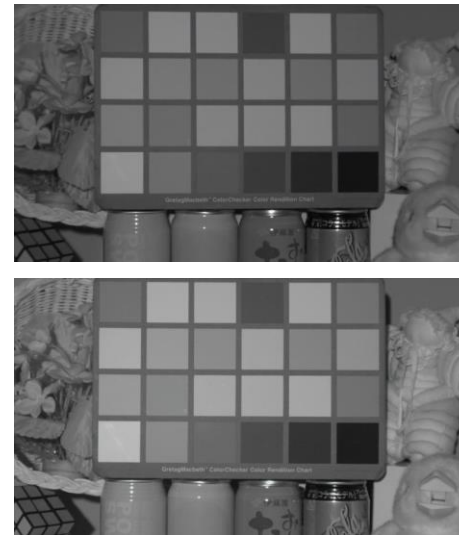
2. IR light is used in LiDAR

Sends IR light, detects time-of-flight (ie: distance), scans scene to reconstruct the 3D scene

CIS Automotive Specialty Foundry Technology: IR for Night Vision

IR detection (room temperature Bolometers) to see in complete darkness (thermal radiation is detected instead of visible light)
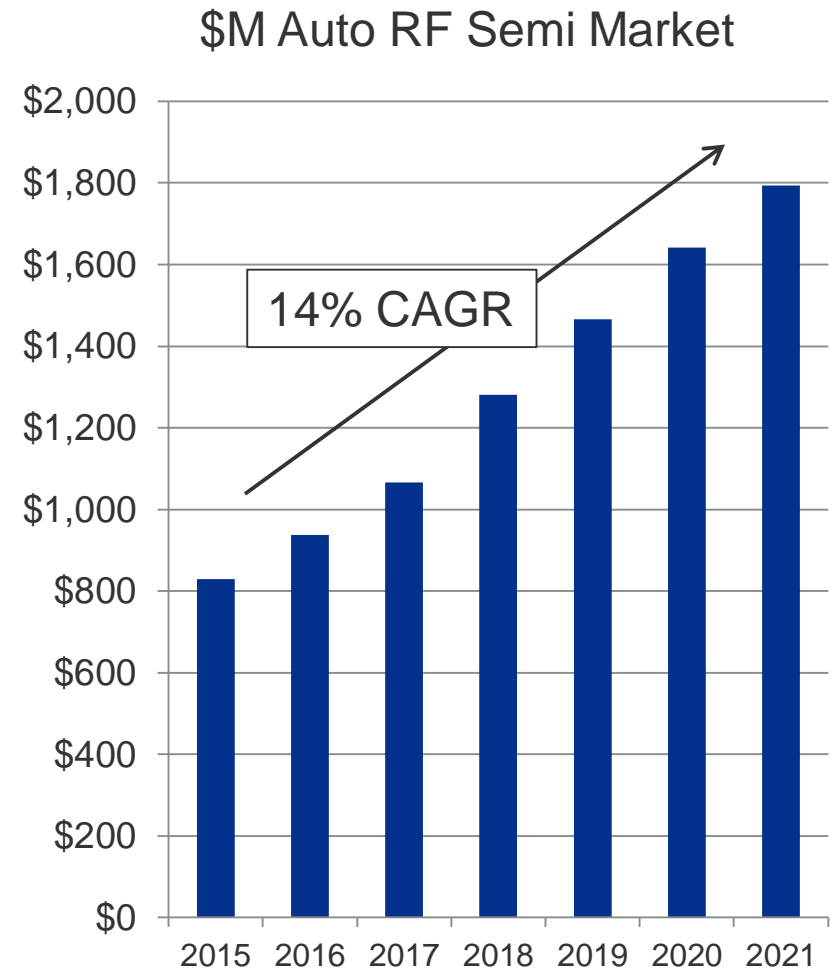
Automotive Semiconductor Systems and Foundry Technology

RF

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Wireline in-car drivers

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Actuators

Drivers

Control
Processors in Digital CMOS
Memory

Sensing

Radar

Infrastructure

Power Distribution
Battery Management
Engine Systems

RF Automotive Specialty Foundry Market

Growth driven by

- Wireless connectivity
  - Built-in 4G->5G cellular, WiFi, GPS
  - Drives more infrastructure (not counted on graph to right)
- Wireline connectivity
  - In-car high-speed data communication
- Radar
  - Up to 7 sensors per car
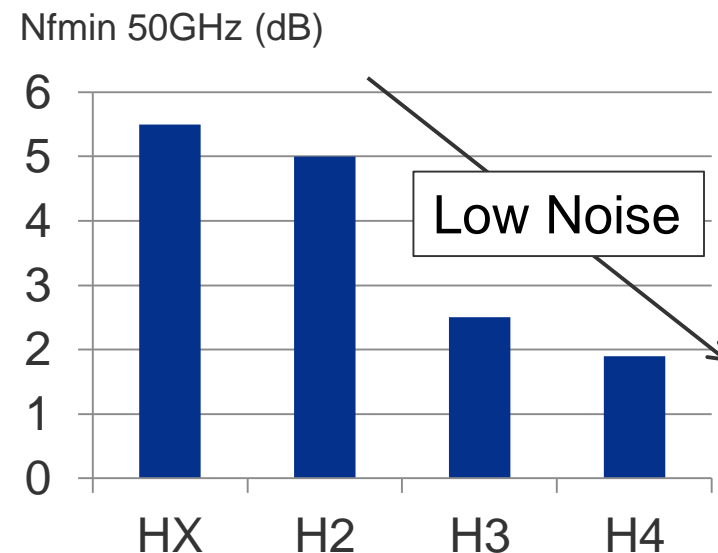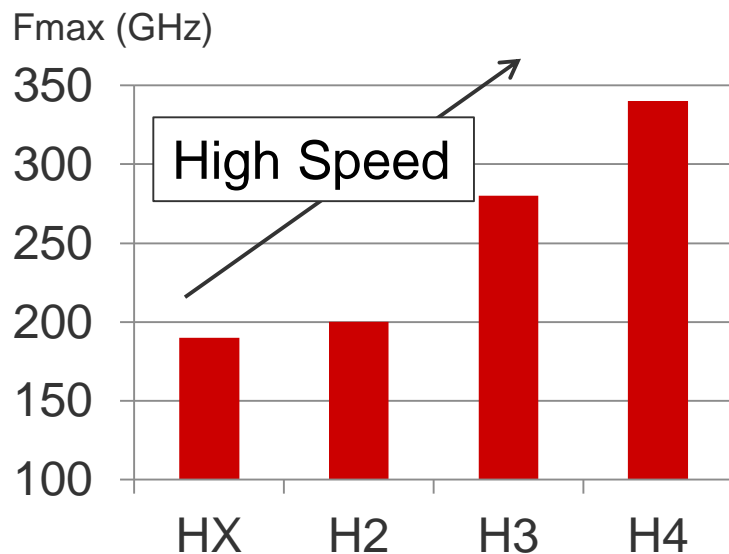 - Collision avoidance, blind spot

$M Auto RF Semi Market

14% CAGR

Source: Marketsandmarkets and internal estimates

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RF Automotive Foundry Technology: Radar

Like LiDAR but using HF radio wave to reconstruct a 3D image

- Main advantage vs. LiDAR: **cost**, maturity, good in poor weather
- Main dis-advantage: less accurate in reconstructing a 3D shape
- Today used for: blind spot detection, collision avoidance
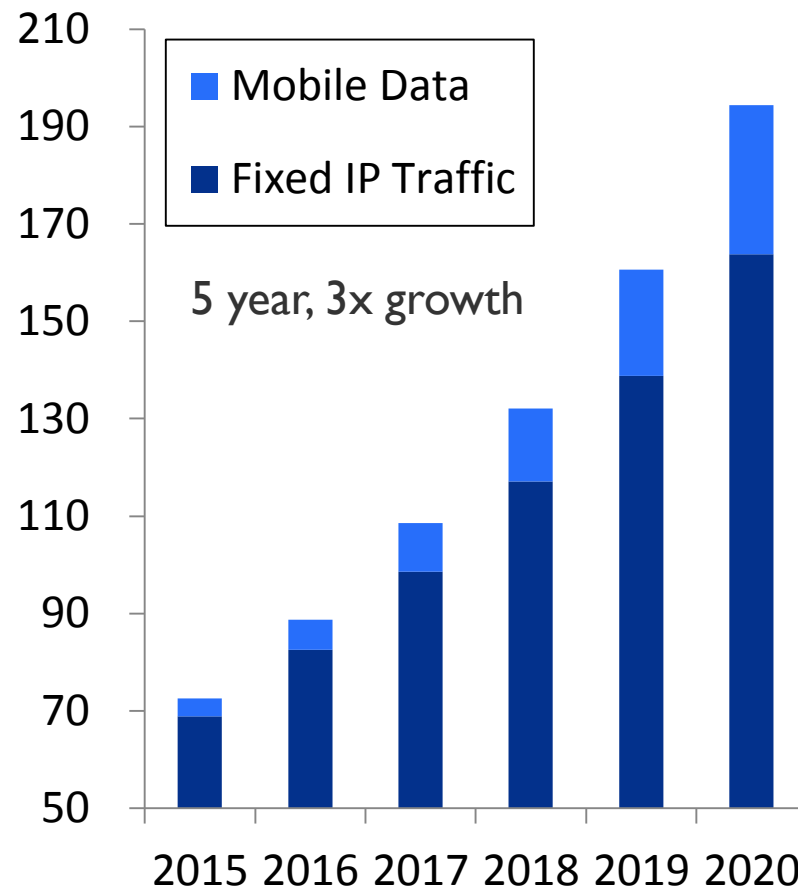- Foundry technology of choice is SiGe: high speed and low-noise

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Autonomous Vehicles will Drive Further Infrastructure Growth

- **Data Traffic Growth* ('15 to '20)**
  - Mobile   53% CAGR
  - Overall   22% CAGR

- **Autonomous Vehicles will add to optical fiber data transport requirement**

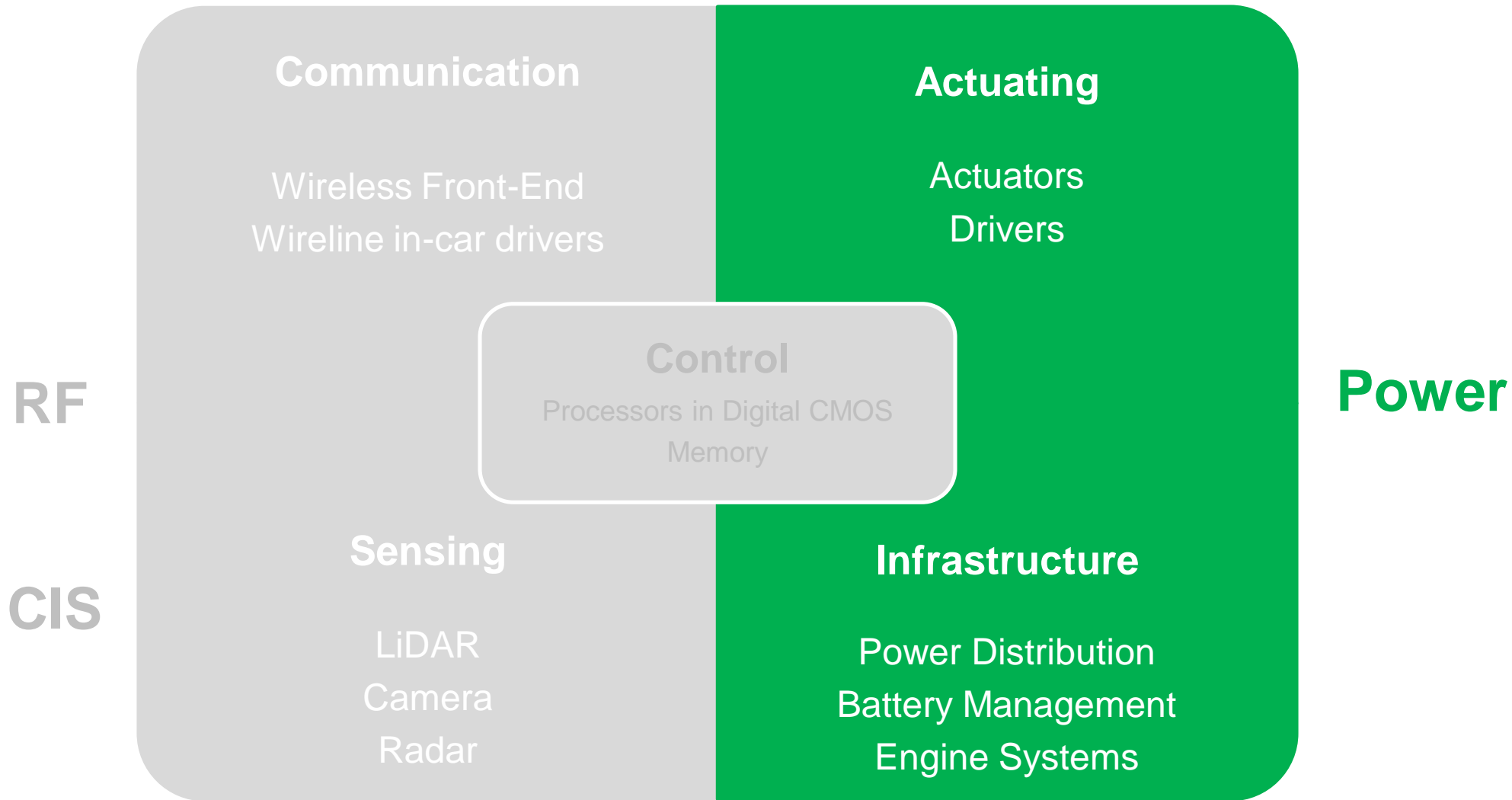- **SiGe is foundry technology of choice for optical fiber connections**

High volume and margin growth in a market where we enjoy > 60% share

Global Monthly Data Traffic in Billions of GBytes

5 year, 3x growth

Legend: Mobile Data (light blue), Fixed IP Traffic (dark blue)

X-axis: 2015 2016 2017 2018 2019 2020
Y-axis: 50, 70, 90, 110, 130, 150, 170, 190, 210

Source: CISCO VNI, 2016

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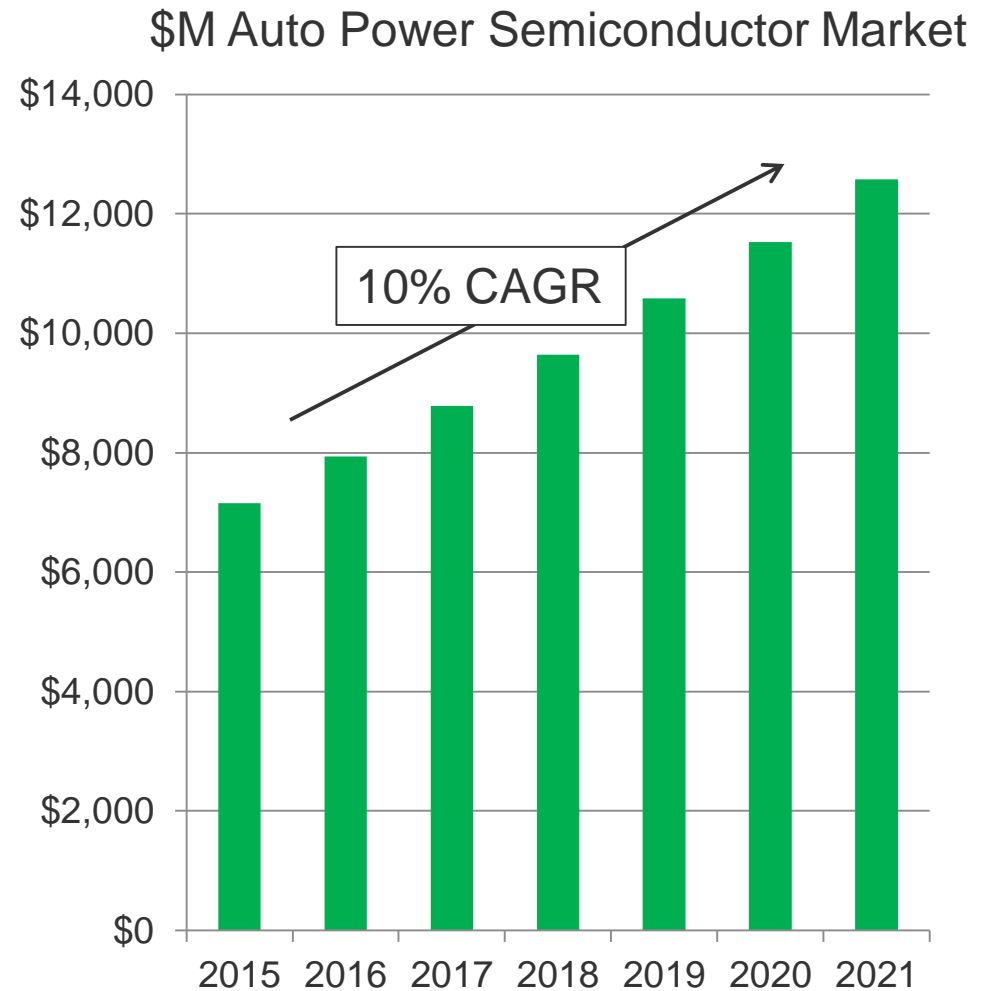Engine Systems

Power Automotive Specialty Foundry Market

Growth driven by

- HEV/EV

  - Battery Management

  - 5-6x Power content vs. standard

Technologies

- Power IC (BCD, High Voltage CMOS)

  - Rugged (SOI)
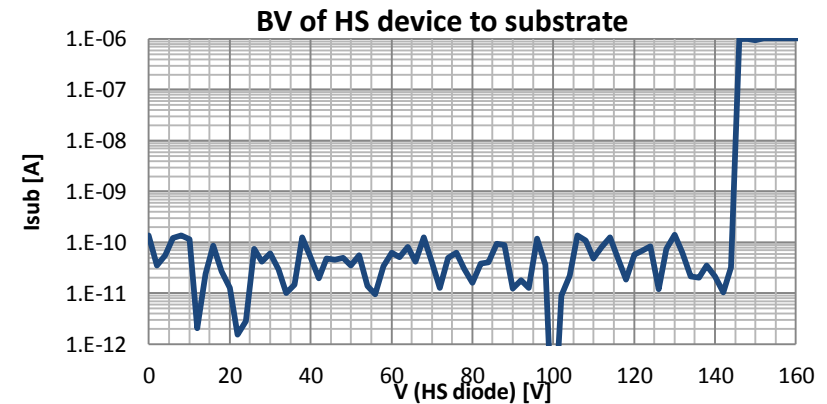
  - Efficient (low Rdson)

- Discrete Power Devices

$M Auto Power Semiconductor Market

10% CAGR

Source: Marketsandmarkets

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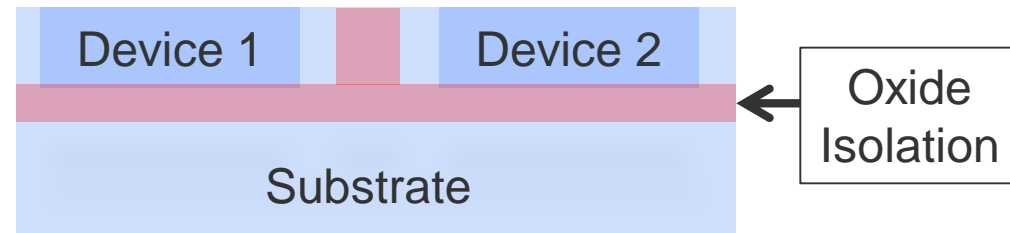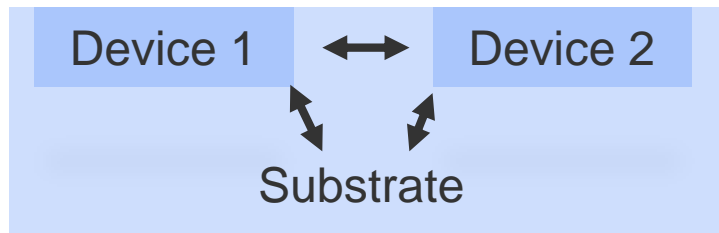The Global Specialty Foundry Leader

Power Foundry Technology for Automotive

Stringent requirements on voltage, reliability and temperature

1. EV requires high-voltage battery management
   - 60V, 0.18um consumer power technology adapted to 140V

BV of HS device to substrate

Plot: I_{sub} [A] (y-axis, from 1.E-12 to 1.E-06) vs V (HS diode) [V] (x-axis, 0 to 160)

2. Temperature and reliability requirements improved with SOI

| Device 1 | ↔ | Device 2 |

Substrate

| Device 1 | | Device 2 | → Oxide Isolation

Substrate

Automotive Semiconductor Content - Outlook

- By 2021, Automotive semiconductor content increases by 33%, continuing to be dominated by the analog segment (Analog ICs, Sensors and power)

2016
$35B

2021
$47B

Legend:
- Processors
- Memory
- Lighting
- Analog Ics
- Sensors
- Power

2016 pie chart:
- 24% (Processors)
- 7% (Memory)
- 2% (Lighting)
- 28% (Analog Ics)
- 16% (Sensors)
- 23% (Power)

2021 pie chart:
- 22% (Processors)
- 7% (Memory)
- 3% (Lighting)
- 26% (Analog Ics)
- 15% (Sensors)
- 27% (Power)

* Source: MarketsandMarkets

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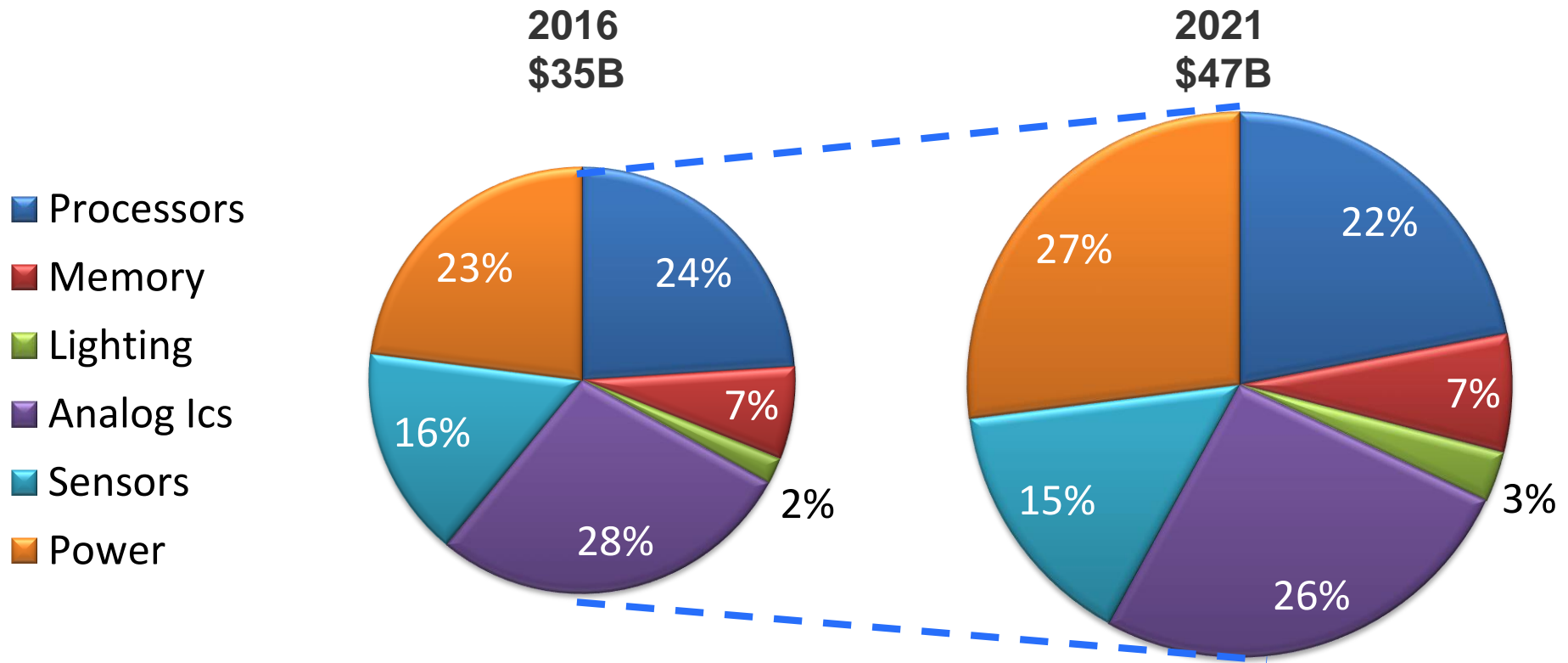
Automotive semiconductor content and opportunity for Foundries

- Automotive semiconductor content remains dominated by analog with ~60-70% share of total and double-digit CAGR

- Growth is driven by:
  - ADAS and Autonomous Driving
    - RF and CIS Technologies for connectivity and sensing
  - Hybrid / EV
    - Power for battery management

- TowerJazz is well positioned to take advantage
  - The #1 Specialty Foundry by Revenue focused on Analog
  - Leader in RF, CIS, Power technology with Automotive Tier 1 customers

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www.towerjazz.com

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