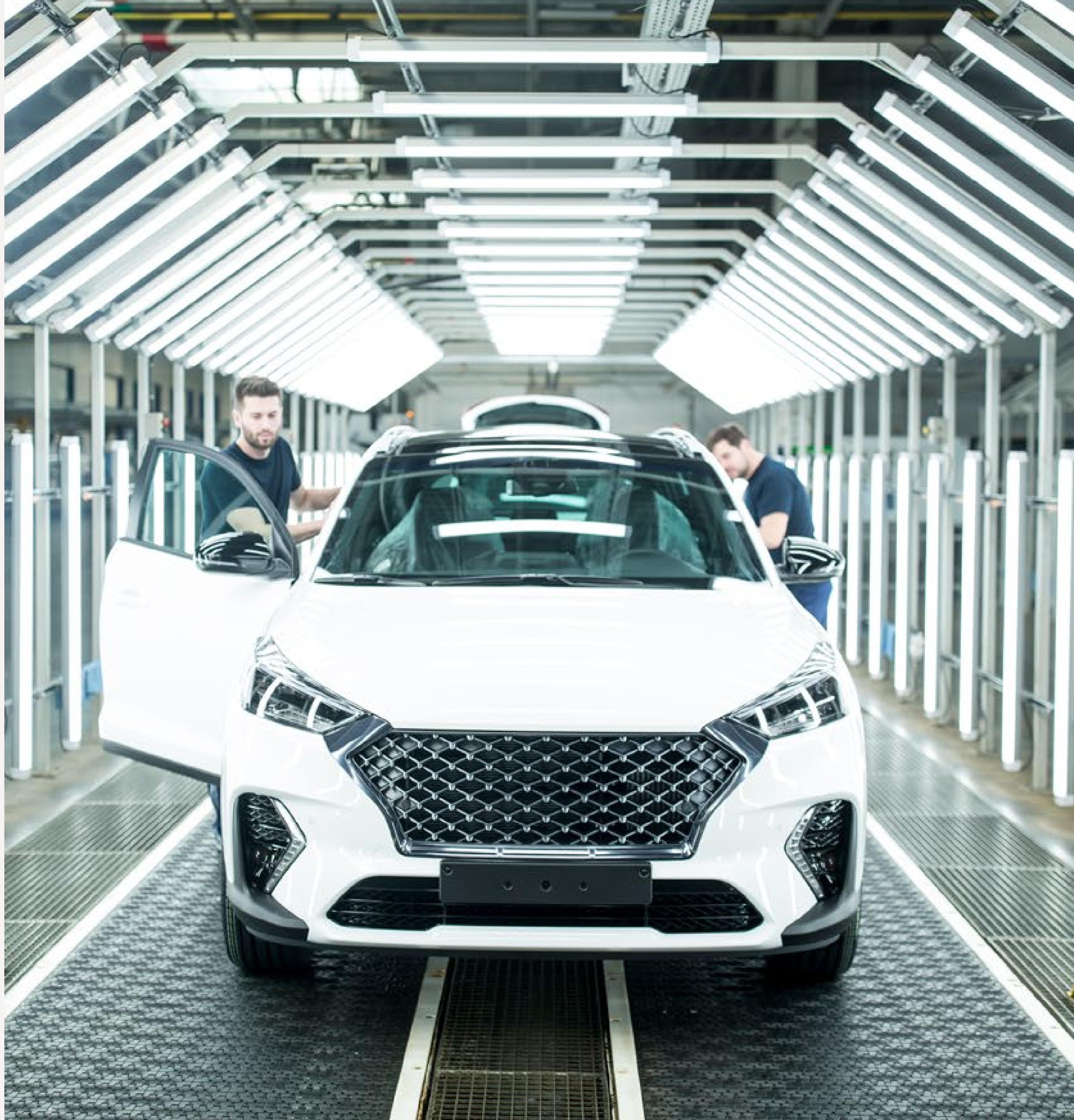
BCG

Automotive Industry Semiconductor Outlook

OCTOBER 2022



Early signs suggest that the semiconductor supply will remain tight in the coming years

The automotive semiconductor market is expected to grow by more than 9% annually through 2030.

- **The adoption of electric vehicles (EVs) and advanced driver-assistance systems (ADAS) will substantially increase the semiconductor content in vehicles, even as production volume remains steady.**
- Battery electric vehicles (BEVs), which are expected to have the highest market share among EVs by 2026, have twice the semiconductor content of internal combustion engine (ICE) vehicles, owing to the need for discrete-power and analog chips.
- ADAS Level 2+ is expected to gain the largest market share among assistance systems. Each additional level of sophistication exponentially increases the need for memory and logic computing.

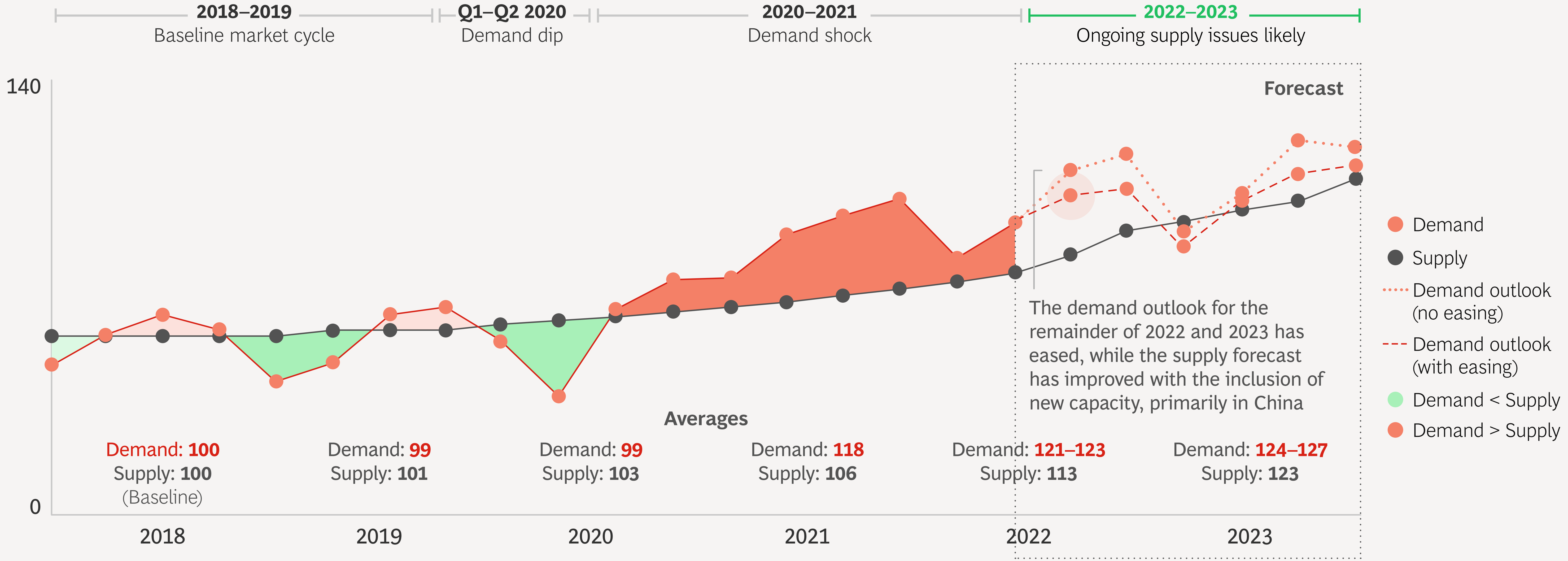
As a result, some semiconductor supply challenges are expected to persist through 2026.

- Shortages of analog chips and MEMS may persist given limited planned-capacity investments.
- Discrete-power chips may experience additional demand pressure with the adoption of 800-volt vehicles; there may be insufficient wide-bandgap manufacturing capacity to meet demand.
- Approximately 50% of future fabrication capacity is planned in mainland China, which will increase risk if the planned capacity does not come online or is inaccessible to Western OEMs and Tier 1 suppliers.
- Automotive demand growth will be highest for logic chips made on 20nm to 45nm nodes in order to meet the increasing computing needs of centralized electrical/electronic architectures; we expect this to ease demand pressure on mature node sizes larger than 55nm.

Source: BCG analysis.
Note: ADC = analog-to-digital converter; E/E = electrical/electronic; IGBT = insulated gate bipolar transistor; MEMS = microelectromechanical systems; MOSFET = metal oxide semiconductor field effect transistor; nm = nanometer; OEM = original equipment manufacturer.

Pandemic-induced manufacturing and logistics challenges are easing, but supply issues will persist

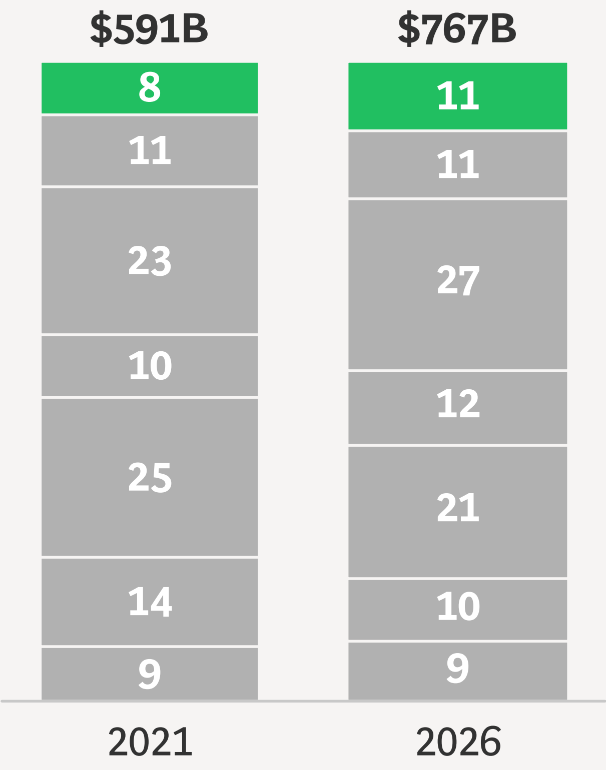
SEMICONDUCTOR DEMAND AND SUPPLY, INDEXED TO THE QUARTERLY AVERAGE OF 2018



Sources: BCG IC Model Forecast; BCG analysis.
Note: Semiconductors are purchased one quarter before the actual end-market sales year. Demand forecasts are determined by expected demand of representative industries. Supply forecasts are determined by foundry capacity. Semiconductor memory devices not included in this analysis.

The auto industry currently occupies a small share of the semiconductor market, but it’s growing rapidly

GLOBAL SEMICONDUCTOR DEMAND BY SEGMENT (%)



		2021	2026
Auto adoption	xEVs	**15%**	**60%**
	ADAS Level 3 or Higher	**1%**	**5%**

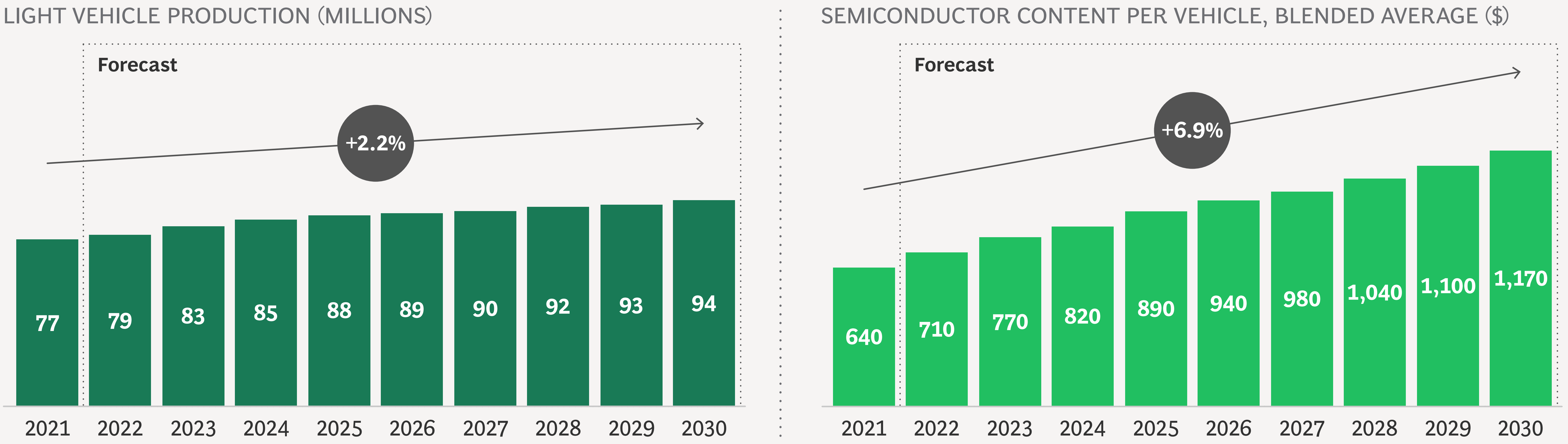
2021–26 CAGR

Total:	**5%**	
Auto	**11%**	Share expected to grow based on strong demand to support EVs and ADAS
Consumer electronics	**4%**	Stable growth, near market average
Data center	**9%**	Adoption of cloud storage and computing will support continued growth
Industrial	**9%**	Strong demand growth expected, to support adoption of connected solutions and smart machines
Smart phones	**2%**	Growth will slow coming out of 5G super cycle
PCs	**–2%**	Pandemic-driven refresh cycle will trend downward before reaching steady state
Others[1]	**7%**	

● Below market average ● Above market average

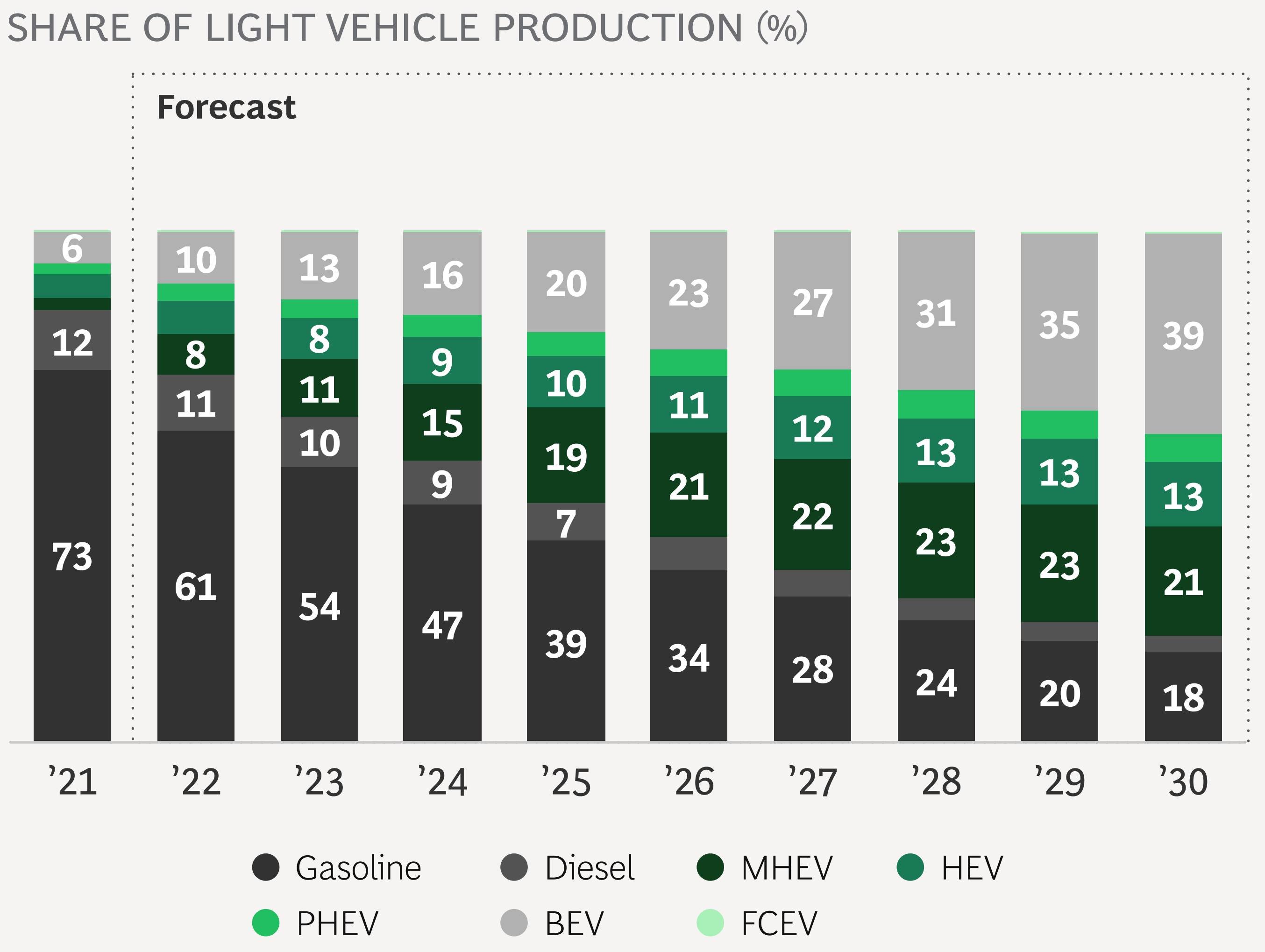
Sources: Gartner; BCG analysis.
[1]Other industries include aerospace and defense and communications infrastructure.

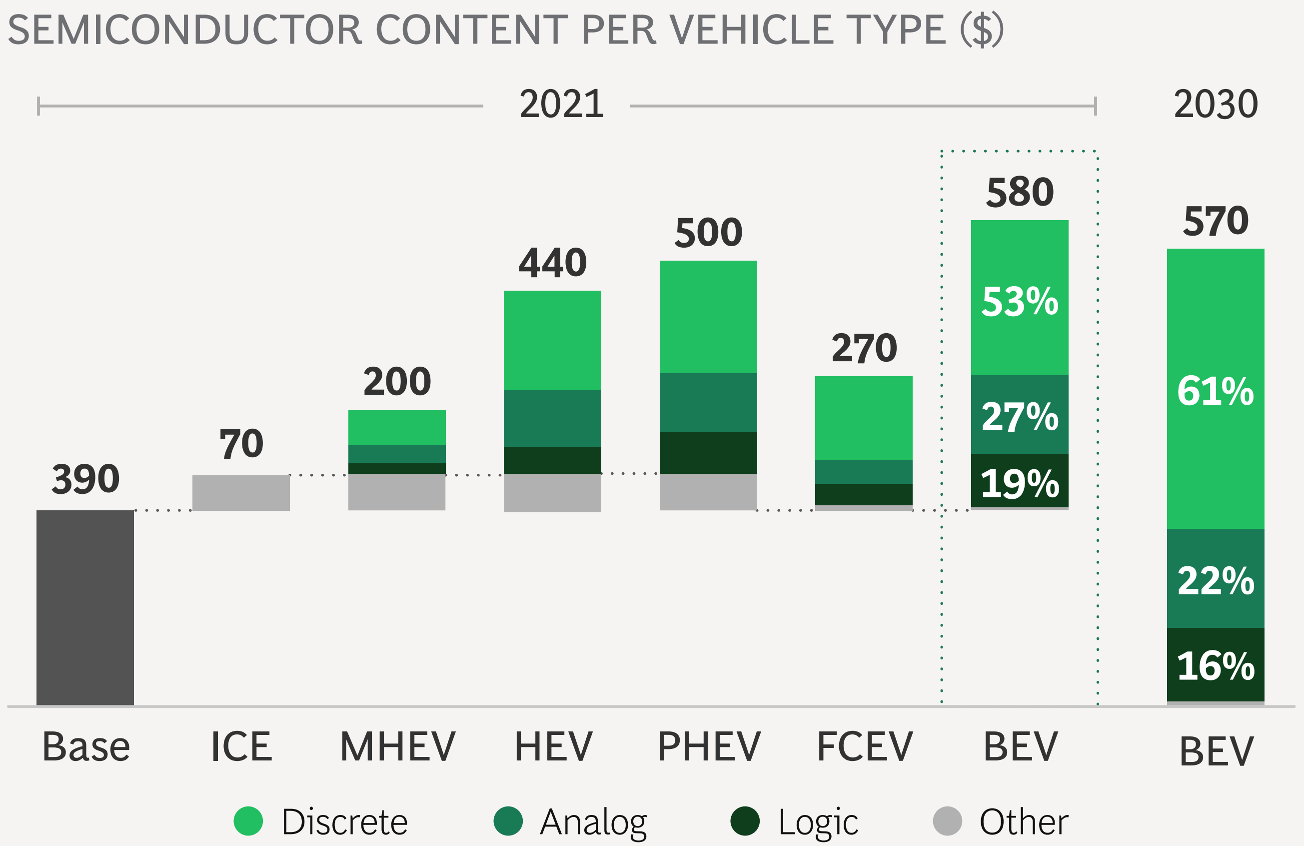
Increasing semiconductor content per vehicle will promote demand, even as total vehicle production remains steady



Sources: Gartner; Strategy Analytics; BCG IC model forecast; BCG analysis.

BEVs are expected to have the largest share of the market and require the most semiconductor content





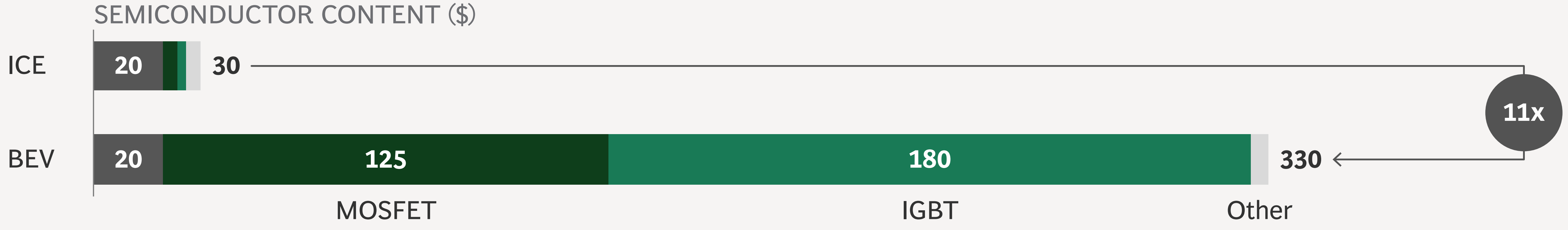
Adoption of premium wide-bandgap chips is expected to increase demand for power-discrete chips

Sources: Gartner; Strategy Analytics; BCG semiconductor supply-demand forecast; BCG powertrain model; BCG analysis.
Note: BEV = battery electric vehicles; FCEV = fuel-cell electric vehicles; HEV = hybrid electric vehicles; MHEV = mild hybrid electric vehicles; PHEV = plug-in hybrid electric vehicles.

On average, BEV powertrains require more discrete-power chips and analog content than internal combustion engines

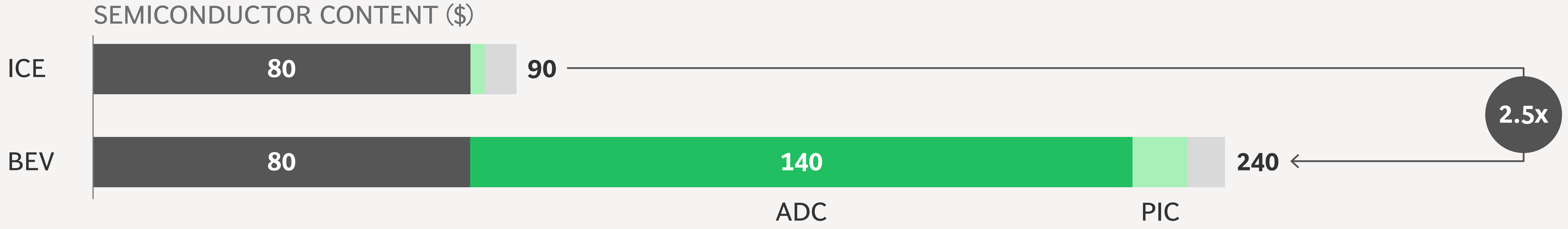
Discrete

Inverter, DC/DC, and OBC require substantially higher content of discrete chips in BEV power electronics



Analog

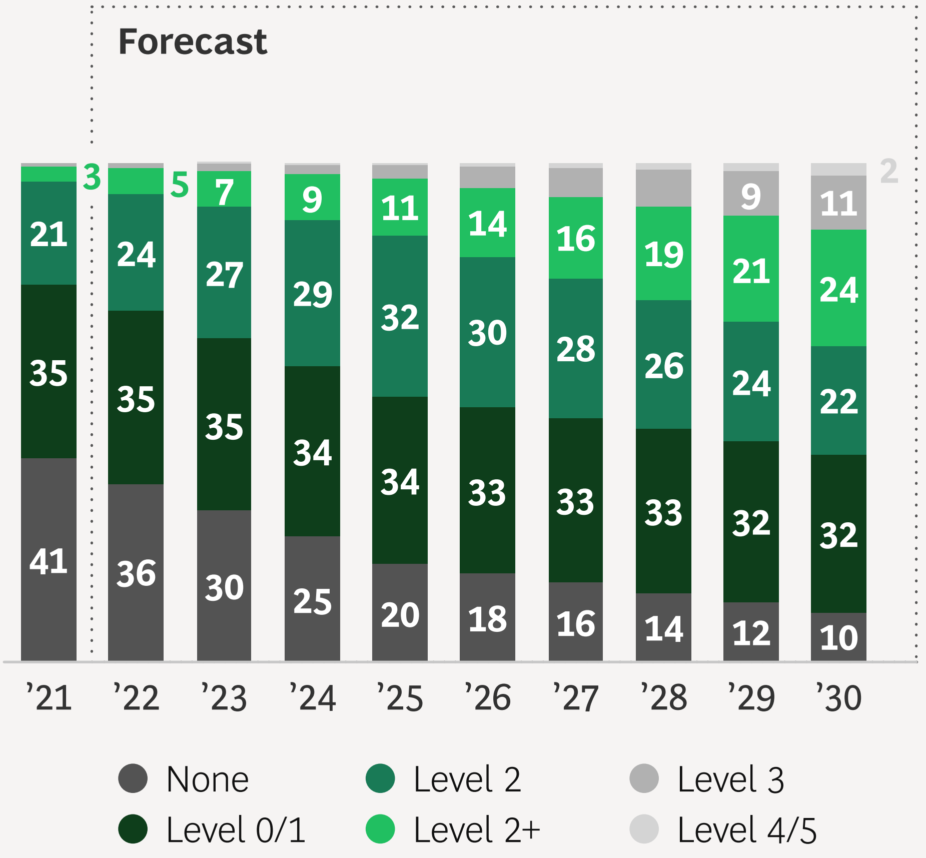
Analog-to-digital signal converters translate critical sensory outputs in BEVs, driving analog demand



Sources: Gartner; Strategy Analytics; Morgan Stanley; Wells Fargo; expert interviews; BCG analysis.
Note: ADC = analog-to-digital converter; BMC = battery management controller; DC/DC = direct current to direct current; IGBT = insulated gate bipolar transistor; MOSFET = metal oxide semiconductor field effect transistor; OBC = onboard charger; PIC = power integrated circuit.

ADAS Level 2+ will see the highest penetration growth through 2030, increasing demand for logic and memory

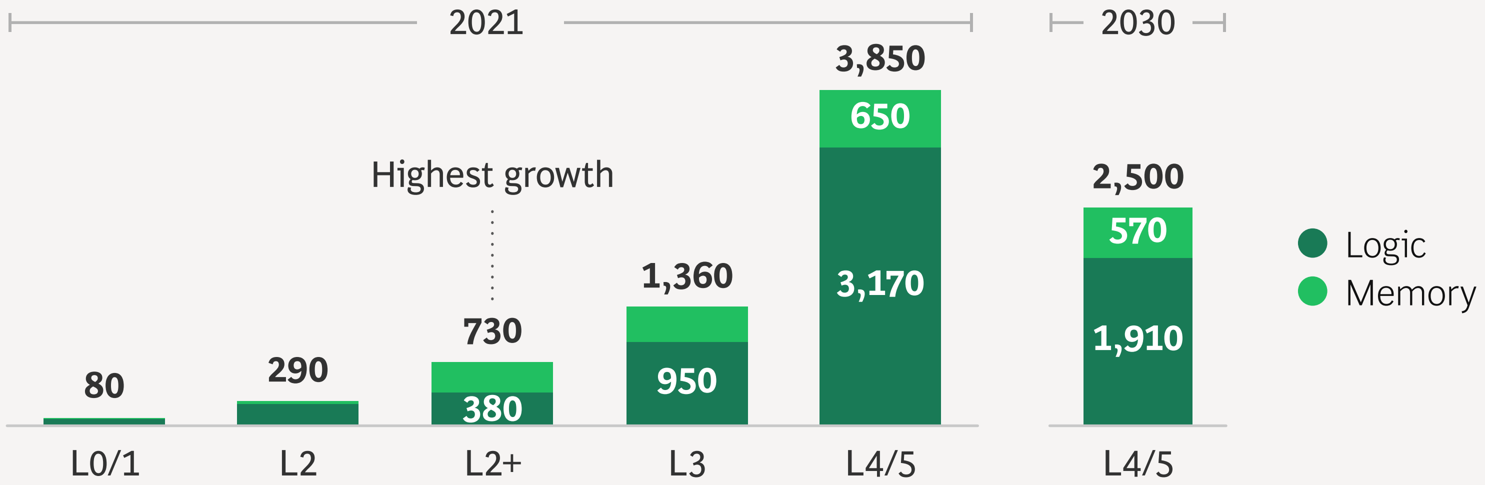
ADAS SHARE OF LIGHT VEHICLE PRODUCTION (%)



Share change

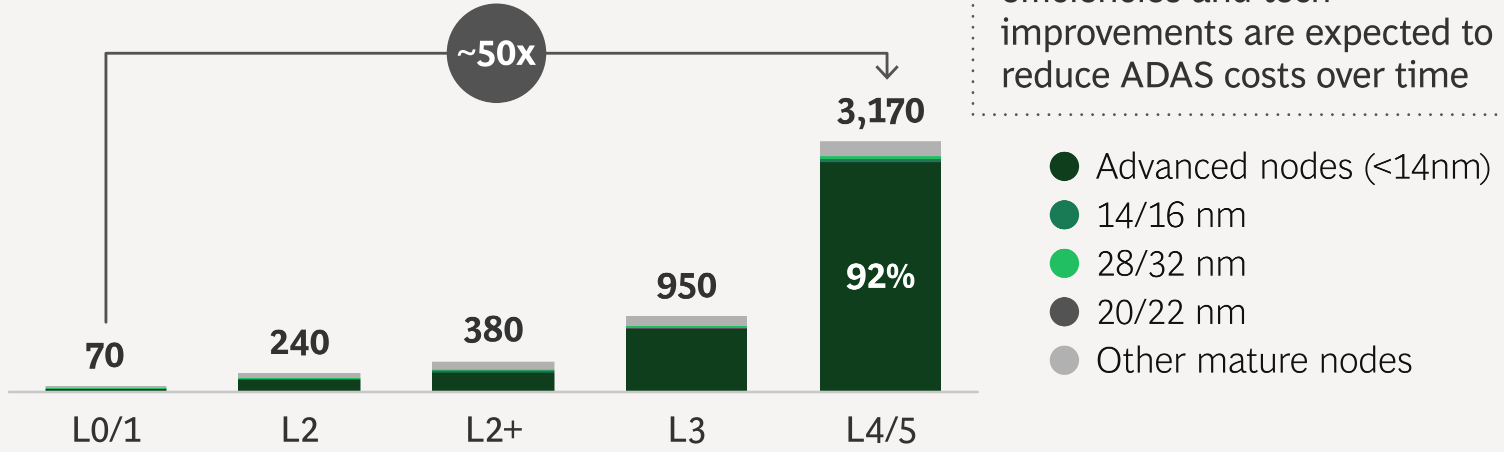
None	–31%
L 0/1	–3%
L 2	+1%
L 2+	+21%
L 3	+11%
L 4/5	+2%

ADAS SEMICONDUCTOR CONTENT ($)



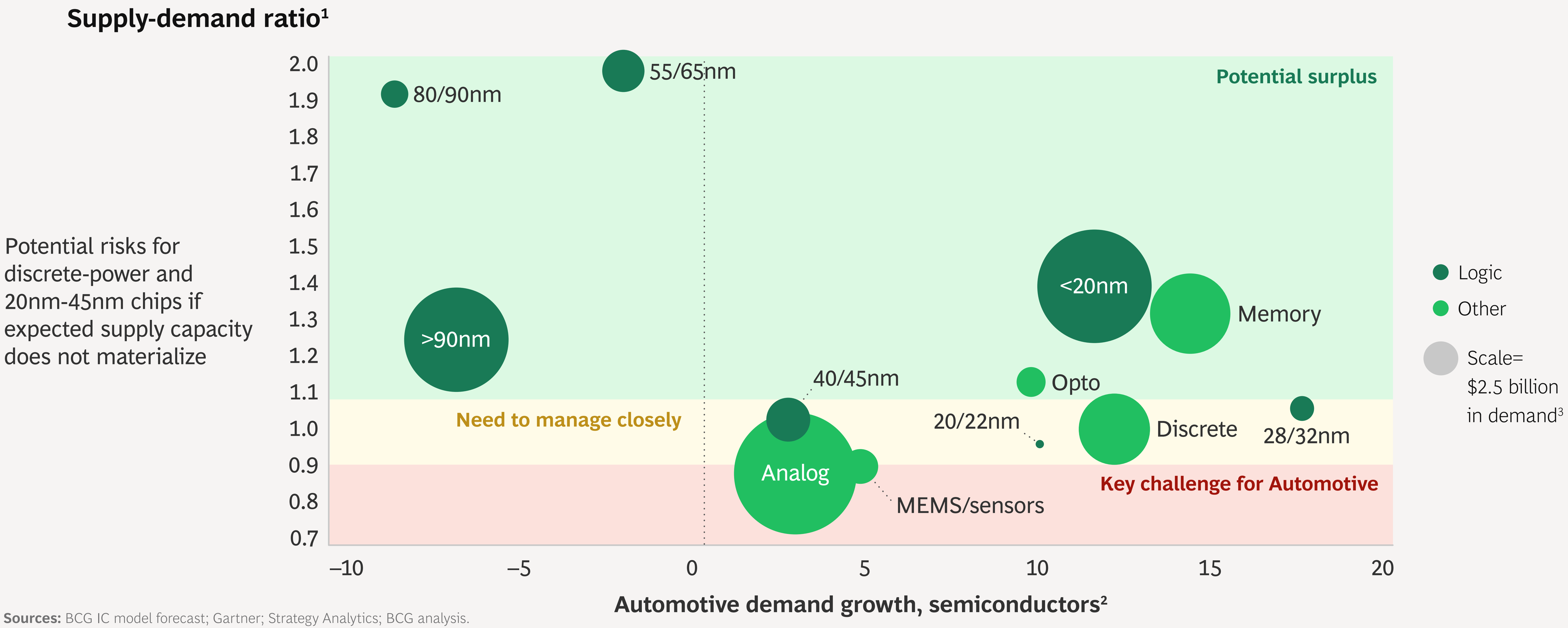
Hardware and software efficiencies and tech improvements are expected to reduce ADAS costs over time

ADAS LOGIC CHIP CONTENT, 2021 ($)



Sources: Gartner; Strategy Analytics; BCG analysis.

Analog and MEMS will be the key semiconductor challenges through 2026

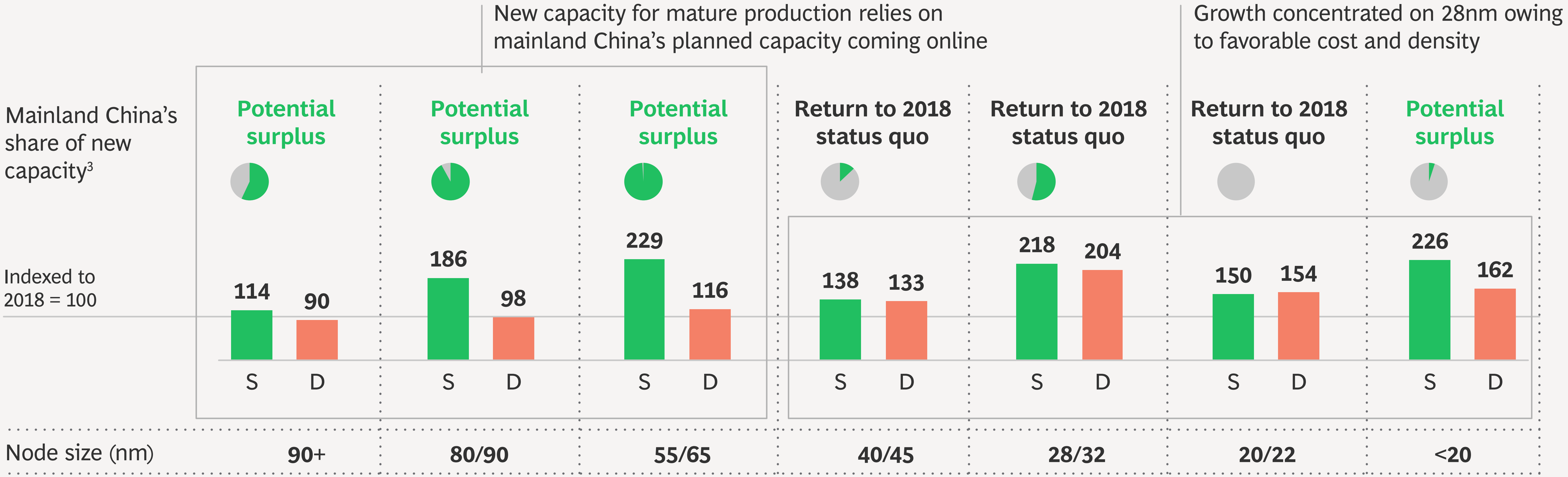


Sources: BCG IC model forecast; Gartner; Strategy Analytics; BCG analysis.
MEMS = microelectromechanical systems; Opto = optoelectronic.
[1]Expected 2026 supply divided by demand, indexed to 2018. Inflation adjusted.
[2]CAGR 2018 – 2026, inflation adjusted.
[3]2021 automotive demand.

Automotives’ transition to more advanced logic nodes should ease demand pressure on mature sizes larger than 55 nanometers

Global semiconductor supply[1] vs. demand[2] forecasts, 2018–26

INDEXED TO 2018

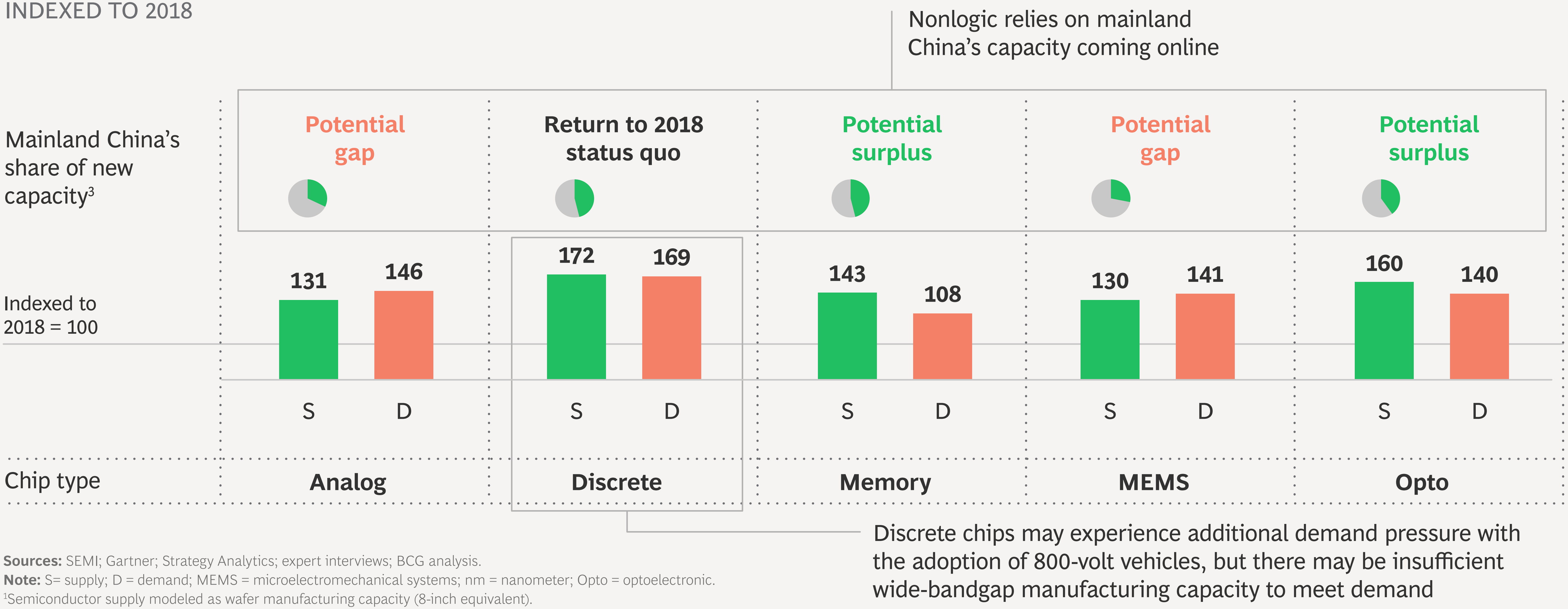


Sources: SEMI; Gartner; Strategy Analytics; expert interviews; BCG analysis.
Note: S = supply; D = demand.
[1]Semiconductor supply modeled as wafer manufacturing capacity (8-inch equivalent).
[2]Industry demand modeled in inflation-adjusted US dollars.
[3]New capacity from 2018-2026.

For nonlogic chips, automotive growth will place stress on analog and MEMS

Global semiconductor supply[1] vs demand[2] forecasts, 2018–26

INDEXED TO 2018



Sources: SEMI; Gartner; Strategy Analytics; expert interviews; BCG analysis.

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[1]Semiconductor supply modeled as wafer manufacturing capacity (8-inch equivalent).

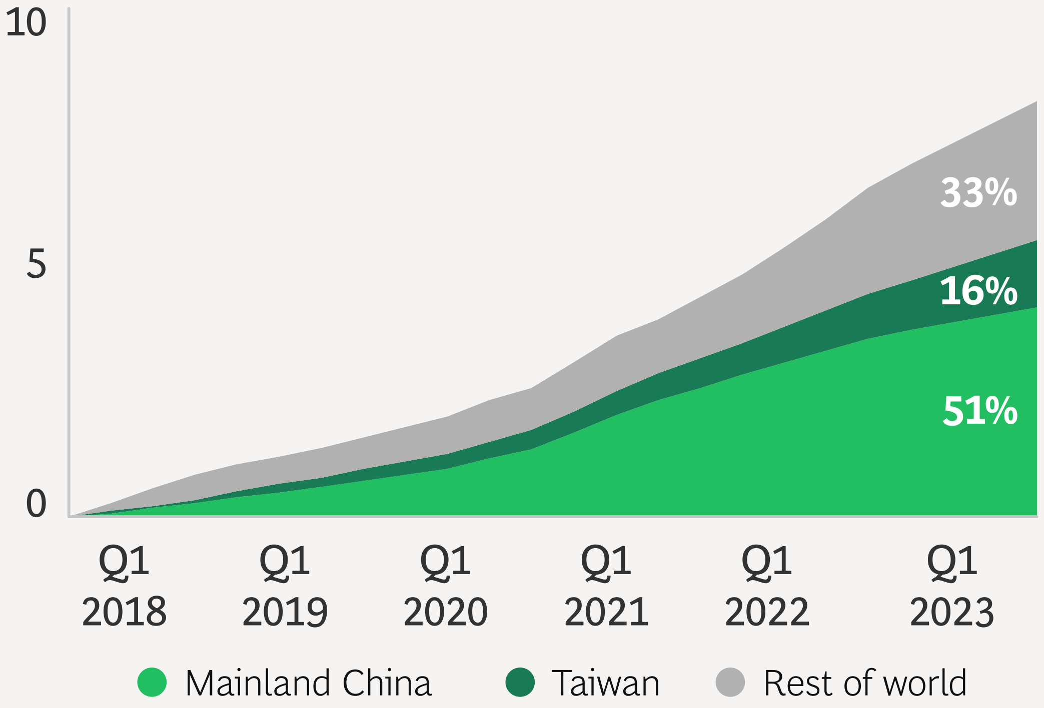
[2]Industry demand modeled in inflation-adjusted US dollars.

[3]New capacity from 2018-2026.

Uncertain access to mainland China's fabrication capacity may increase risk in the automotive supply chain

Approximately 50% of semiconductor capacity growth comes from mainland China

SEMICONDUCTOR CAPACITY, 2018–2023, (MILLIONS OF 8-INCH EQUIVALENTS)



Geopolitical risks that could create challenges for supply strategies

01
Planned capacity in mainland China does not come online
The US government is pushing ASML to stop sales of DUV lithography tools to mainland China (in addition to the existing EUV ban), inhibiting China's ability to produce older nodes

02
Western OEMs and Tier 1 suppliers cannot access Chinese capacity
Recent and increasing trade tensions and tariffs create supply chain risk, potentially placing Western buyers at risk relative to local competitors

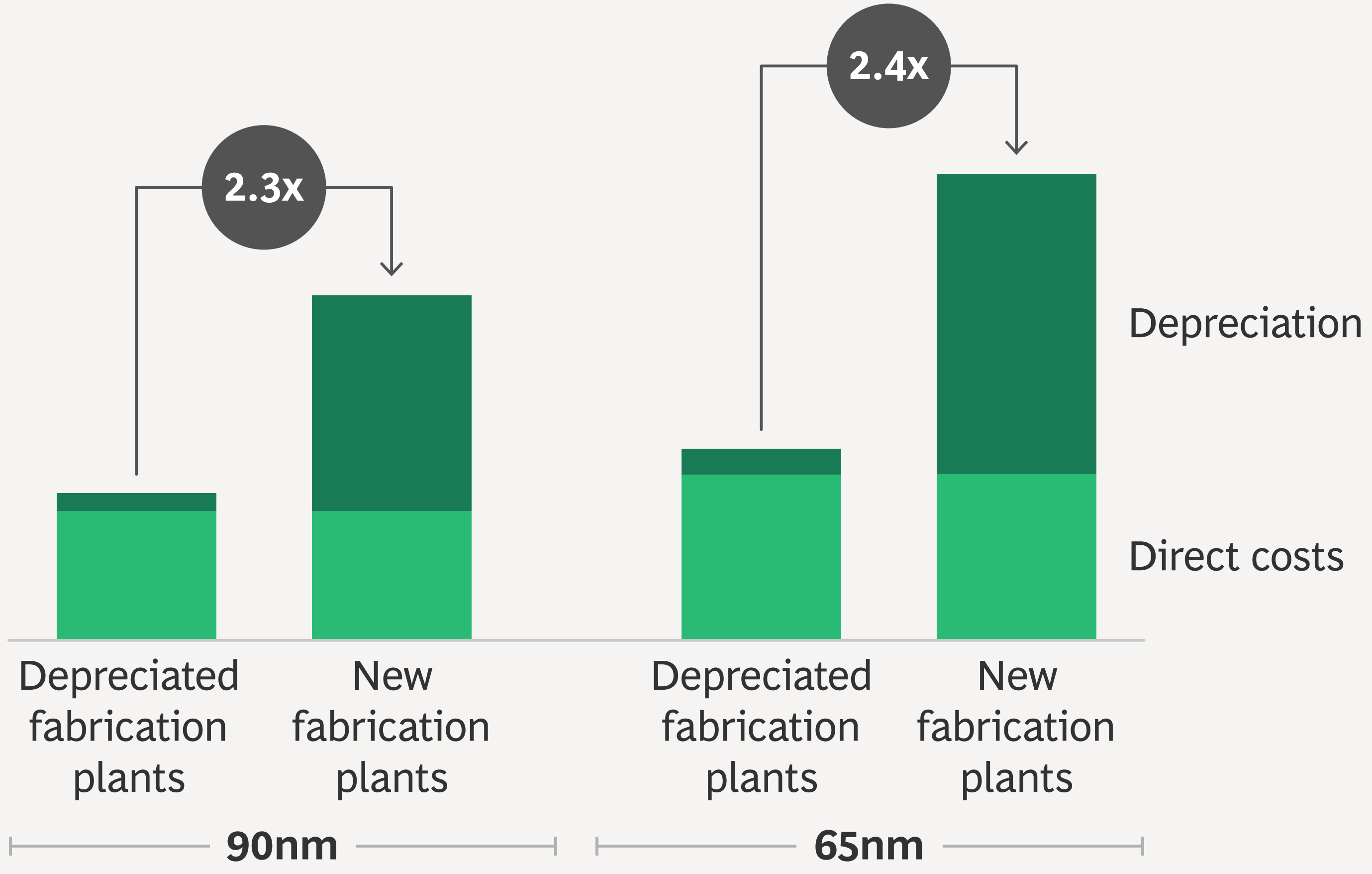
Increased demand may strain fabrication capacity outside of China as Western OEMs and Tier 1 suppliers try to mitigate potential geopolitical risks

Sources: SEMI; Bloomberg; expert interviews; BCG analysis.
Note: DUV = deep ultraviolet; EUV = extreme ultraviolet; OEM = original equipment manufacturer.

Outside of mainland China, underinvestment in mature capacity persists owing to a cost penalty for new fabricators and older chips

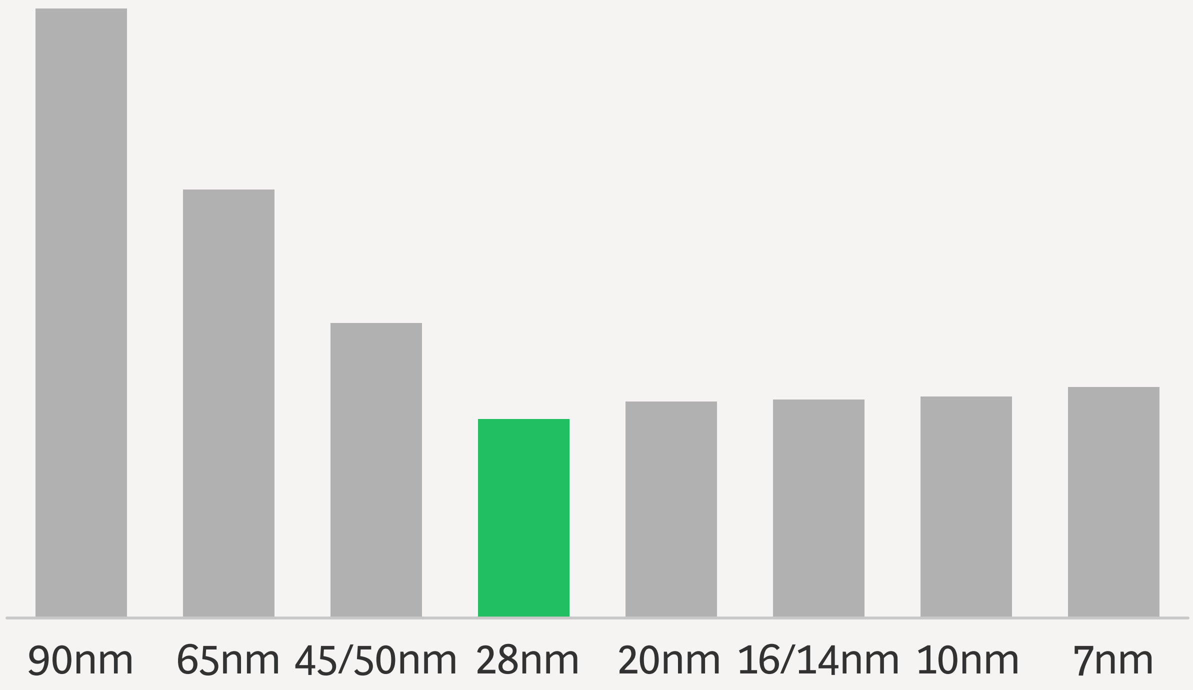
New fabrication plants see significantly higher wafer costs owing to high impact of depreciation

WAFER PRODUCTION COSTS ($)



28nm is the current sweet spot for cost per density, significantly better than older nodes

INDEXED COST PER 100 MILLION GATES



Sources: IBS; BCG analysis.
Note: Deprecation expense is calculated based on a five-year period.

Automotive OEMs are implementing new semiconductor engagement models

Engagement models

Direct agreements

BMW × Inova Semiconductors / Global Foundries

Direct supply agreements with microchip developer Inova Semiconductors and Global Foundries for smart LED technology

GM × Wolfspeed

Strategic supplier agreement with Wolfspeed for SiC power devices

Renault × ST Microelectronics

Strategic partnership with STMicroelectronics to ensure supply of power electronics for xEVs.

Focus locally

Toyota × Denso

Denso (part of Toyota Group) invested of $350 million in JASM, TSMC's majority-owned manufacturing subsidiary in Japan

Ford × Global Foundries

Collaboration to boost manufacturing and R&D in the US

GM × 7 suppliers

Collaboration with seven suppliers to redesign and standardize new families of MCUs in North America

Planning ahead

BMW/ Mercedes × Qualcomm/ NVIDIA

Cooperation with Qualcomm and Nvidia, respectively, to codevelop autonomous driving software solutions coupled with SoCs

VW × ST Microelectronics / TSMC

Codevelopment of CARIAD semiconductors with STMicroelectronics and TSMC

Stellantis × Foxconn

Cooperation with Foxconn to develop standardized chip families

Own it yourself

Tesla × TSMC/Samsung Foundry

Development of proprietary Full Self-Driving chipset and intensive cooperation with TSMC and Samsung foundry

Hyundai × Hyundai Mobis

Development of in-house semiconductors, especially MCUs and power ICs by Hyundai Mobis

BYD × BYD Semicon.

Vertical integration in high-power semiconductors with in-house fabrication project

But a targeted approach is needed to secure supply for chip types and processes at the highest risk of persistent shortages

Sources: Press releases; public information (such as interviews) from OEMs, integrated device manufacturers, and foundries; BCG analysis.
Note: IC = integrated circuit; LED = light emitting diode; MCU = microcontrollers; SiC = silicon carbide; SoC = system on a chip.

Key actions to take now to ensure success going forward

Stay focused on building resilient supply chains

- Continue to use crisis-response centers to create transparency and promote cross-functional collaboration
- Invest in collaborative three-way relationships with Tier 1 suppliers and IDMs to secure access to current-generation semiconductors
- Optimize your inventory plan and properly account for potential geopolitical risks

Align semiconductor strategy with product strategy

- Evaluate platform-architecture designs and procurement with a focus on reducing semiconductor supply risks
- Cooperate to forge consortium, share chip design efforts, drive standards across Tier 1 suppliers and IDMs, and enable semiconductor capacity sharing
- Codevelop differentiating ICs with IDMs and foundries for the next generation of MCU and MPUs

Shape your future

- Establish your place in the value chain—from software to semiconductors—and plan build, buy, or partner strategies
- Develop clear, robust fact bases and analyses to help inform policymakers of the full impact of their decisions

Source: BCG analysis.
Note: IC = integrated circuits; IDM = integrated device manufacturer; MCU = microcontrollers; MPU = microprocessors.

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