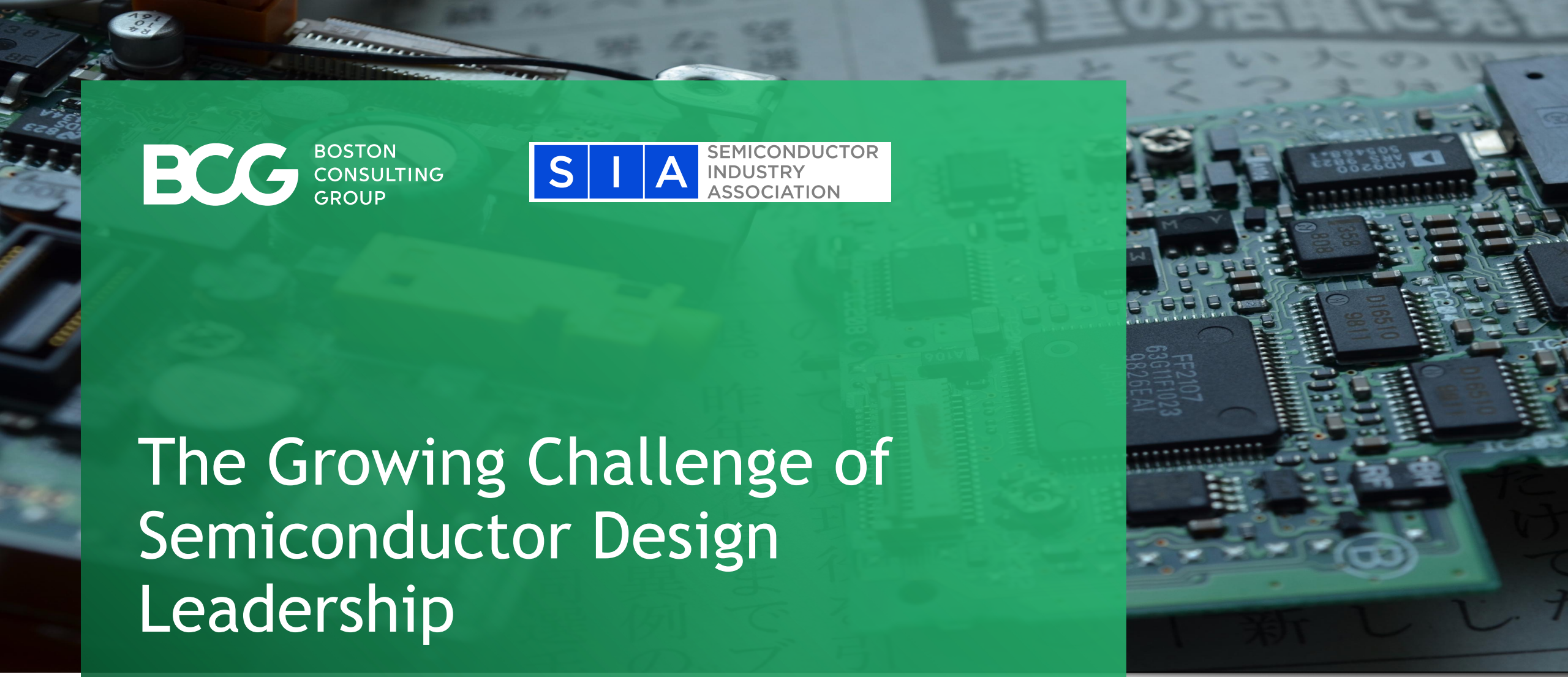


BOSTON CONSULTING GROUP

SEMICONDUCTOR INDUSTRY ASSOCIATION

The Growing Challenge of Semiconductor Design Leadership

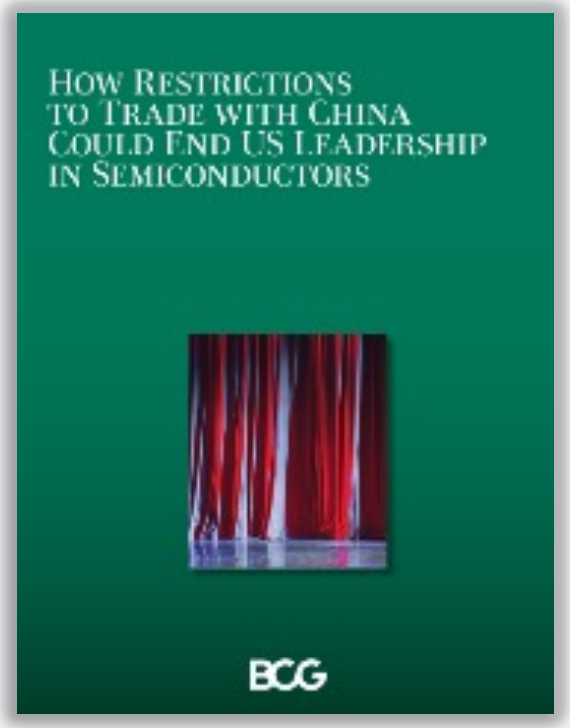
Briefing deck

DECEMBER 2022

Fourth BCG x SIA report focuses on design and design leadership

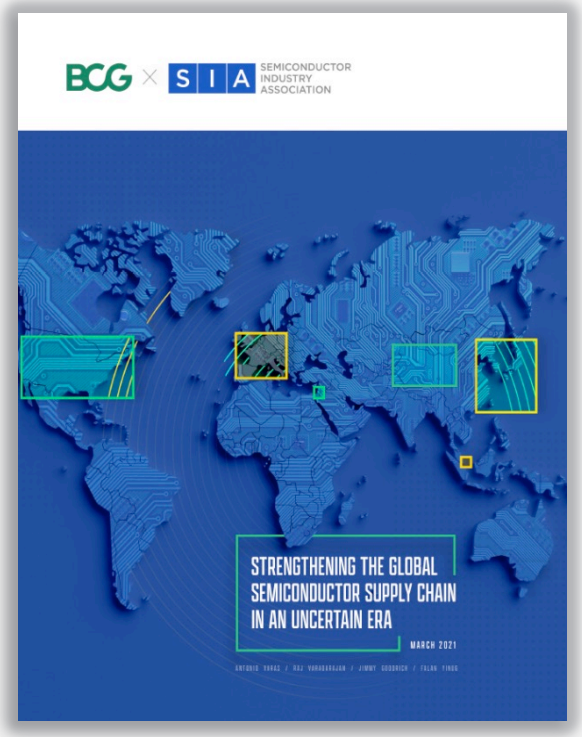
BOSTON CONSULTING GROUP + SEMICONDUCTOR INDUSTRY ASSOCIATION

4 THOUGHT LEADERSHIP REPORTS ON CRITICAL POLICY-RELATED ISSUES FOR THE SEMICONDUCTOR INDUSTRY

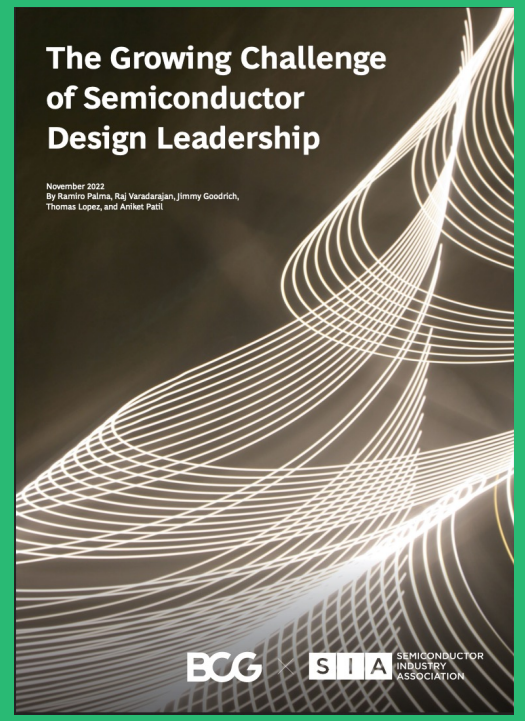


March 2020

September 2020



March 2021



December 2022

Objectives of this report

1. Provide an overview of semiconductor design and the benefits of leadership
2. Discuss the key risks and challenges to maintaining design leadership
3. Outline broad / high-level policy directions to address them

Semiconductor design consists of four major stages

1

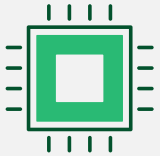
Product definition and specification

Product management, system architecture, and customer define initial product requirements

2

Architecture/ system design

System architects define block-level architecture for the design and may leverage previous IP



3

Integrated circuit design

Multidisciplinary effort

- Logic: Initial analog and digital design
- Circuit: Digital synthesis and design for test
- Layout: Routing and mask generation

Verification

Verification engineers verify design functionality and timing through simulation

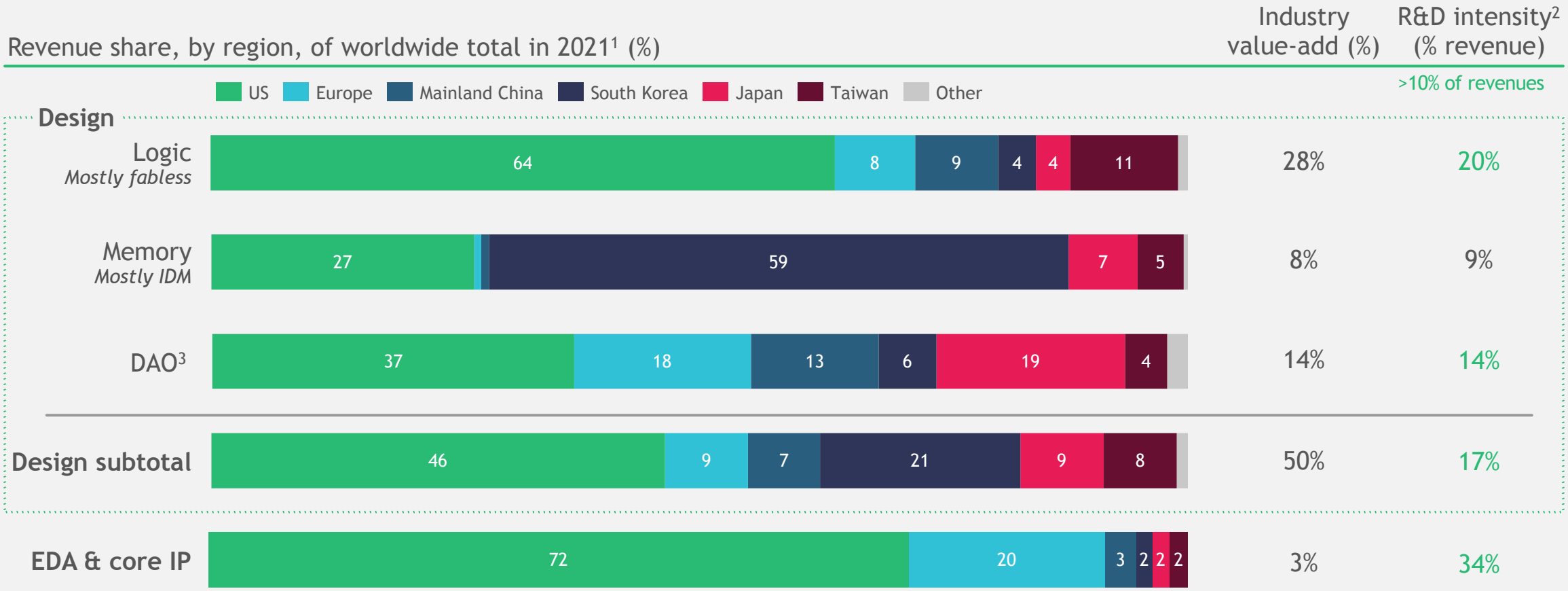
4

Post-silicon validation

Validation engineers validate physical device functionality across extreme working conditions

Source: White House 100 Day Supply Chain Review Report, BCG analysis.

The US is the longstanding global leader in semiconductor design which is both highly value-adding and R&D intense



Source: Capital IQ, SIA Factbook 2022, BCG analysis
Note: DAO = discrete, analog, and other; EDA = electronic design automation; IP = intellectual property. Because of rounding, not all bar segment totals add up to 100%.
[1] The regional breakdown is based on company revenues and headquarters location. Design revenues are based on fabless companies and estimated share of IDM revenues attributable to design. [2] R&D Intensity, measured as R&D divided by revenue [3] Discrete, analog, optoelectronics, sensors, and others.

Leadership in design confers multiple advantages

Virtuous Cycle of Innovation

Leadership attracts global talent and contributes to a cycle of innovation and reinvestment

Ability to Shape Standards

First movers have advantage in setting and leveraging benefits of global technical standards

Stronger Security

National security benefits from improved defense systems at a lower risk of tampering and disruption

High-Quality Employment

Average annual income of workers employed in semiconductor design was $170,000 compared to the US median of $56,000

Benefits for OEMs

Close collaboration between OEMs and local design teams creates competitive advantage

Design leadership however is volatile, with new industry leaders emerging each decade

= New entrant in top 10

TOP 10 SEMICONDUCTOR COMPANIES BY REVENUE

	1990	2000	2010	2020	2030
1	NEC	Intel	Intel	Intel	*Leadership to be determined*
2	Toshiba	Toshiba	Samsung	Samsung	
3	Hitachi	NEC	Toshiba	SK Hynix	
4	Intel	☆ Samsung	Texas Instruments	Micron	
5	Motorola	Texas Instruments	Renesas[1]	Qualcomm	
6	Fujitsu	Motorola	☆ SK Hynix	☆ Broadcom	
7	Mitsubishi	☆ STMicroelectronics	STMicroelectronics	☆ NVIDIA	
8	Texas Instruments	Hitachi	☆ Micron	Texas Instruments	
9	Philips	☆ Infineon	☆ Qualcomm	☆ Apple	
10	Matsushita	Philips	Elpida[2]	Infineon	

Dropped out of top 10:

- Fujitsu
- Mitsubishi
- Matsushita

- Motorola
- Hitachi
- Infineon
- Philips

- Renesas
- STMicro
- Elpida

US
South Korea
Japan
Taiwan
Europe

Source: IC Insights, BCG analysis.
Note: Ranking based on global semiconductor sales excluding pure-play foundries. This exhibit is meant to illustrate the volatility of design market leadership and does not imply that only the top 10 companies by revenue are important to semiconductor design.
[1] Post NEC/Renesas merger. [2] Combination of NEC, Hitachi, and Mitsubishi DRAM business.

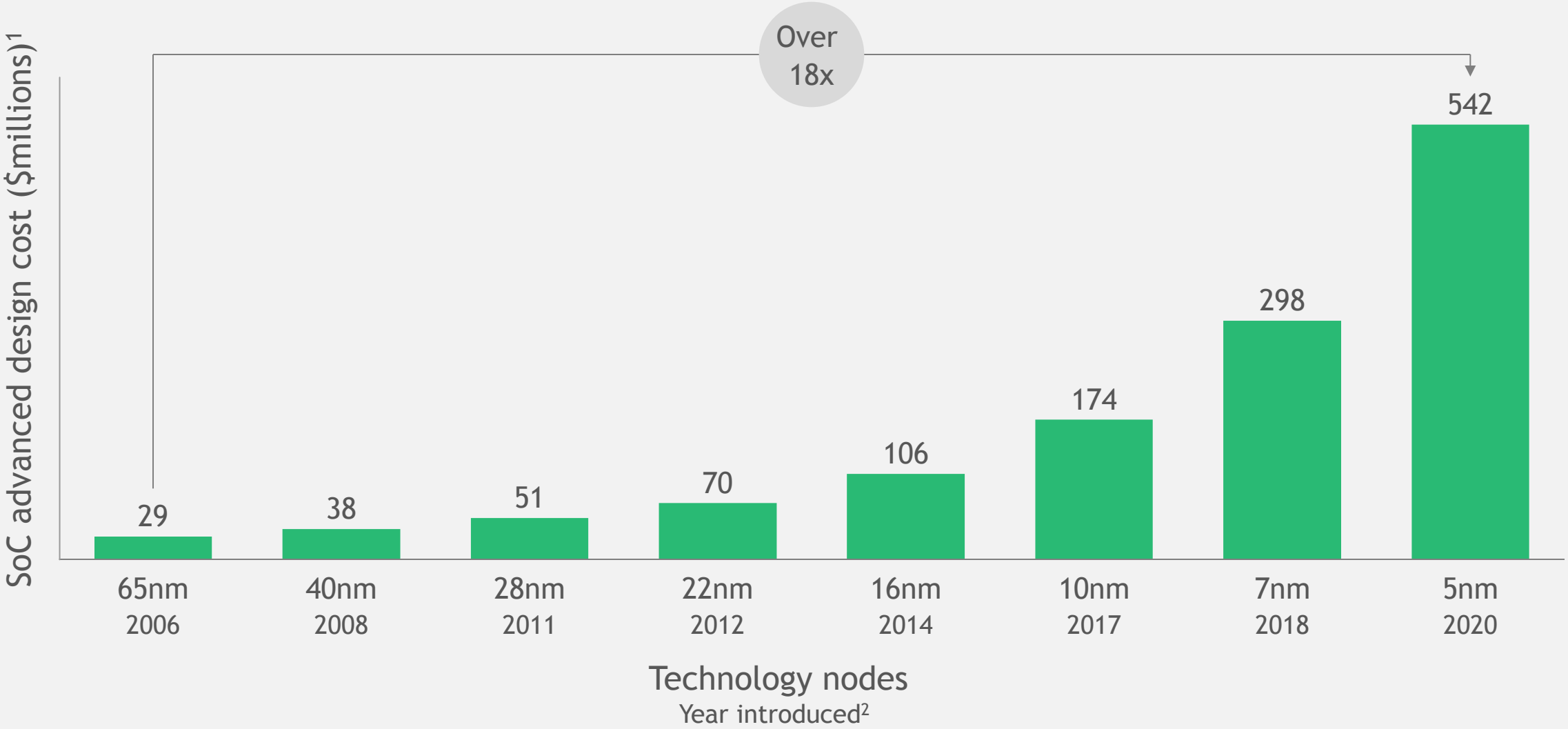
Ongoing US leadership faces three key challenges

I Design costs are rising exponentially for fundamental / technical reasons

II The US design workforce is expected to be significantly undersupplied by 2030

III Ongoing market access, needed to ensure scale and fund R&D, is no longer a given

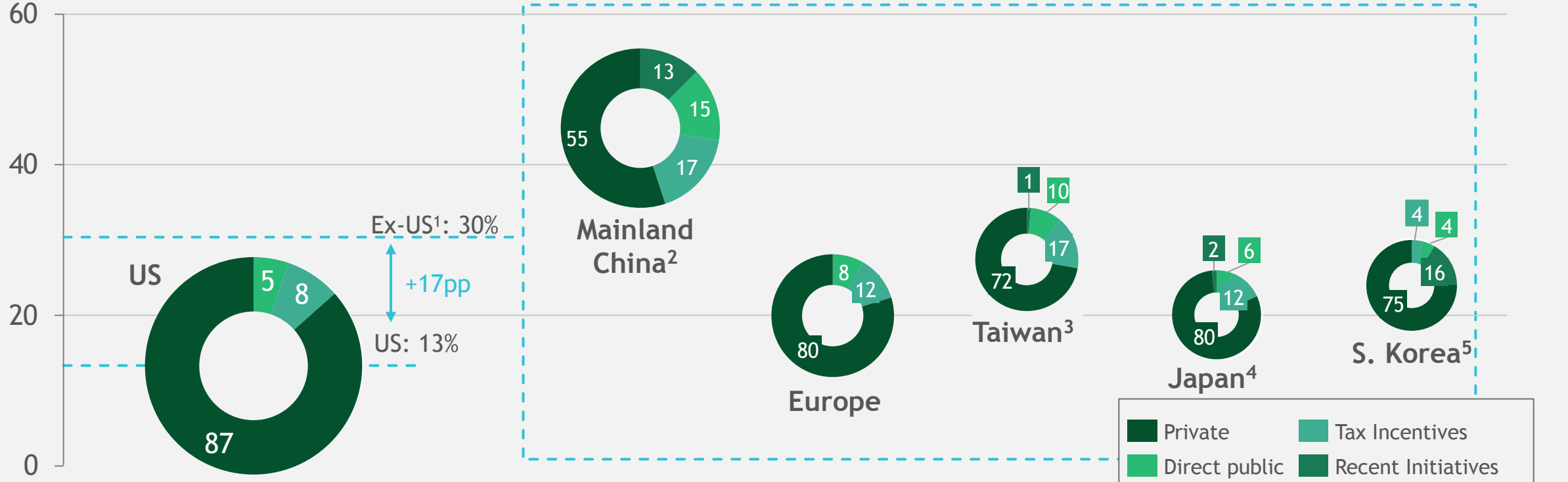
Design costs are rising with each new technology node



Sources: IBS, AnySilicon, TSMC, BCG analysis.
[1] System-on-a-chip (SoC) advanced design costs include intellectual property qualification, architecture, verification, physical, software, prototype, and validation activities. [2] Year in which a technology node began volume production.

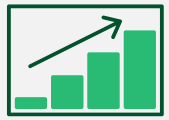
Share of semiconductor-specific design R&D funded by the private sector is greater in the US than other OECD peers

ESTIMATED SHARE OF SEMICONDUCTOR-SPECIFIC DESIGN R&D FUNDED BY PUBLIC INVESTMENT (%)
(INCLUDES ESTIMATES FROM RECENTLY ANNOUNCED INITIATIVES)



Sources: OECD national accounts data and ITIF, Government websites, SIA, BCG analysis.
[1] Includes mainland China, Europe, Taiwan, Japan, and South Korea. [2] Includes elimination of 25% corporate income tax for semiconductor design. [3] Includes $300 million over 7 years for foreign companies to establish R&D centers. [4] Includes recent initiatives such as the Post 5G fund and Green Innovation Fund. [5] Includes recent initiatives such as K-semiconductor belt strategy and AI R&D programs.

The US design workforce is estimated to face a 35% gap between supply and demand by 2030 creating a shortfall of 23,000 workers



89,000
Demand for US-based design workers in 2030

Demand for workers is expected to rise by ~50% …

66,000
Supply of US-based design workers in 2030

… While supply will grow by less than 1% annually …

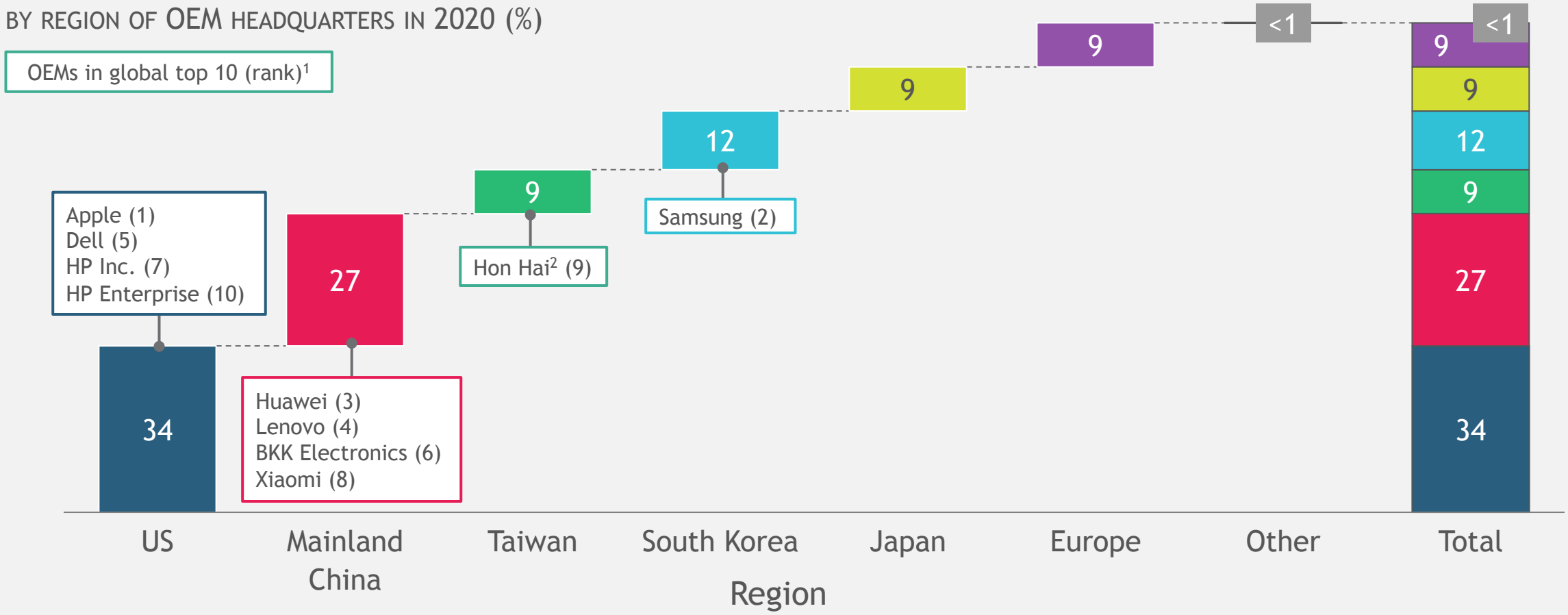
23,000
Shortage of design workers in 2030, growing by 3,000 per year

… Meaning that demand for design workers will **exceed supply** by nearly 35% in 2030

Source: BCG analysis.
Note: Numbers are rounded for clarity and display purposes. For additional information, see "Semiconductor Design Workforce and Market Share Model"

US OEMs have greatest demand for semiconductors, but 2/3 of global demand is outside US making open global markets critical

GLOBAL SEMICONDUCTOR DEMAND
BY REGION OF OEM HEADQUARTERS IN 2020 (%)

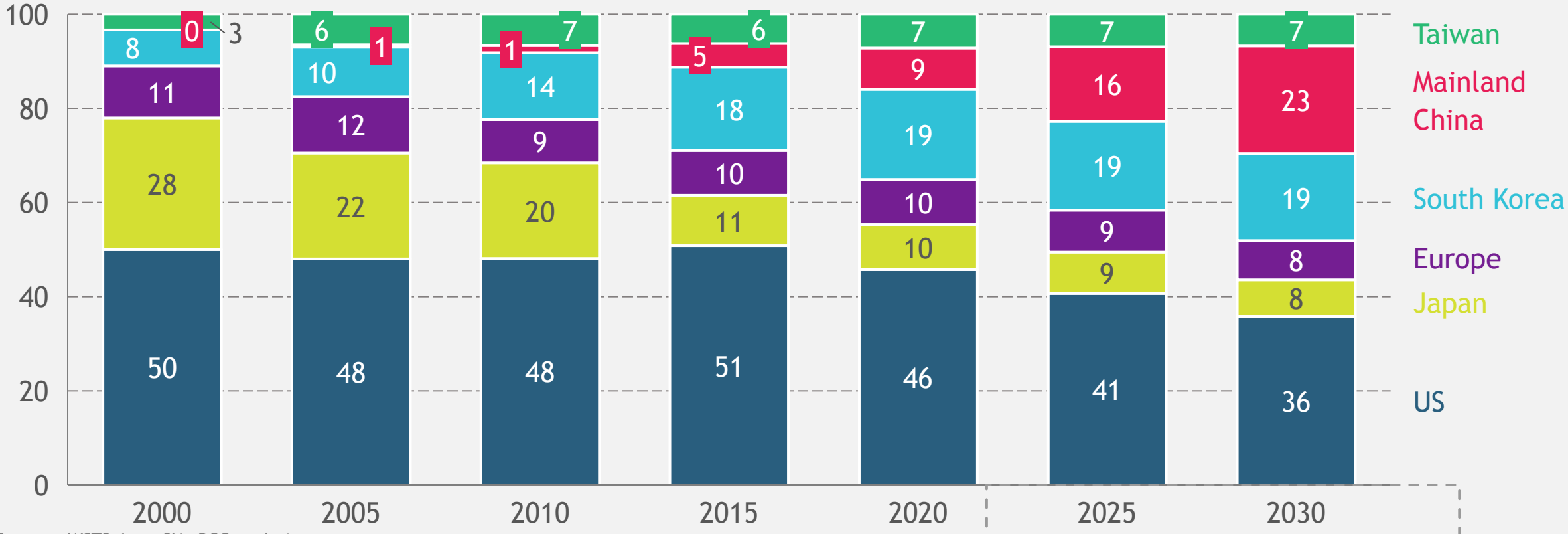


Source: Charts/graphics created by BCG based on Gartner research. Source: Gartner®, "Tool: Semiconductor Spending by Customer, 2020," Masatsune Yamaji, 16 April, 2021. Gartner is a registered trademark and service mark of Gartner, Inc. and/or its affiliates in the US and Internationally and is used herein with permission. All rights reserved.

[1] Rank of OEMs in the global top 10 is based on global revenues in 2020 for all semiconductor devices. [2] Hon Hai Precision Industries, also known as Foxconn, is both an OEM and a contract manufacturer.

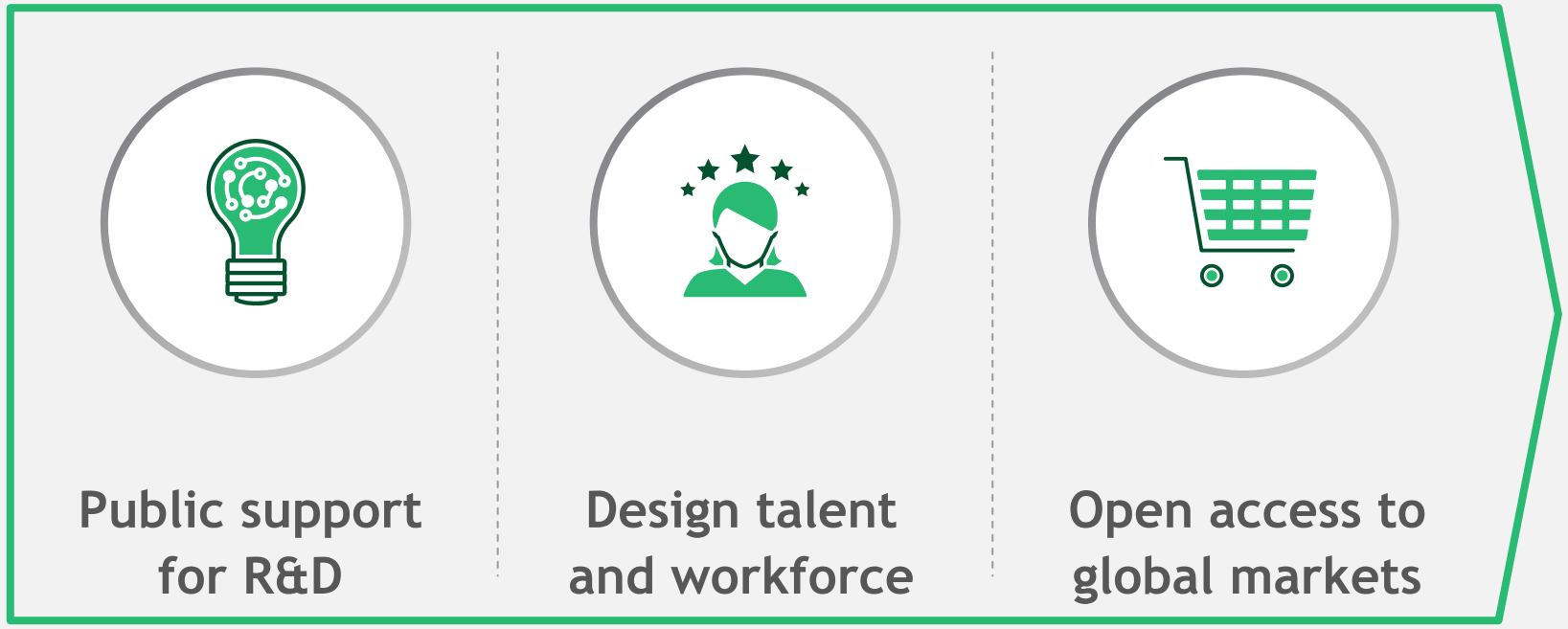
In absence of action, market share of US companies (a proxy for design leadership) is projected to drop to 36% by 2030

MARKET SHARE BY REGION OF COMPANY HEADQUARTERS (%)



Sources: WSTS data, SIA, BCG analysis.
Note: Market share is based on revenues and the region in which headquarters is located for the company responsible for final sale of finished semiconductors; includes fabless, fab-lite, and IDM revenues; foundry and outsourced semiconductor assembly and test (OSAT) revenues are excluded to avoid double-counting. Because of rounding, not all bar segment totals add up to 100%.

Supporting US design leadership with policies targeting major challenges would also create significant economic benefits



10 pp
Higher US market share in semiconductors

$450 billion
In incremental sales over 10 years

153,000
New direct and indirect jobs in 2030

Source: BCG analysis
Note: Market share and jobs impact is sized as of 2030; sales impact is sized cumulatively over 10 years. pp = percentage points.

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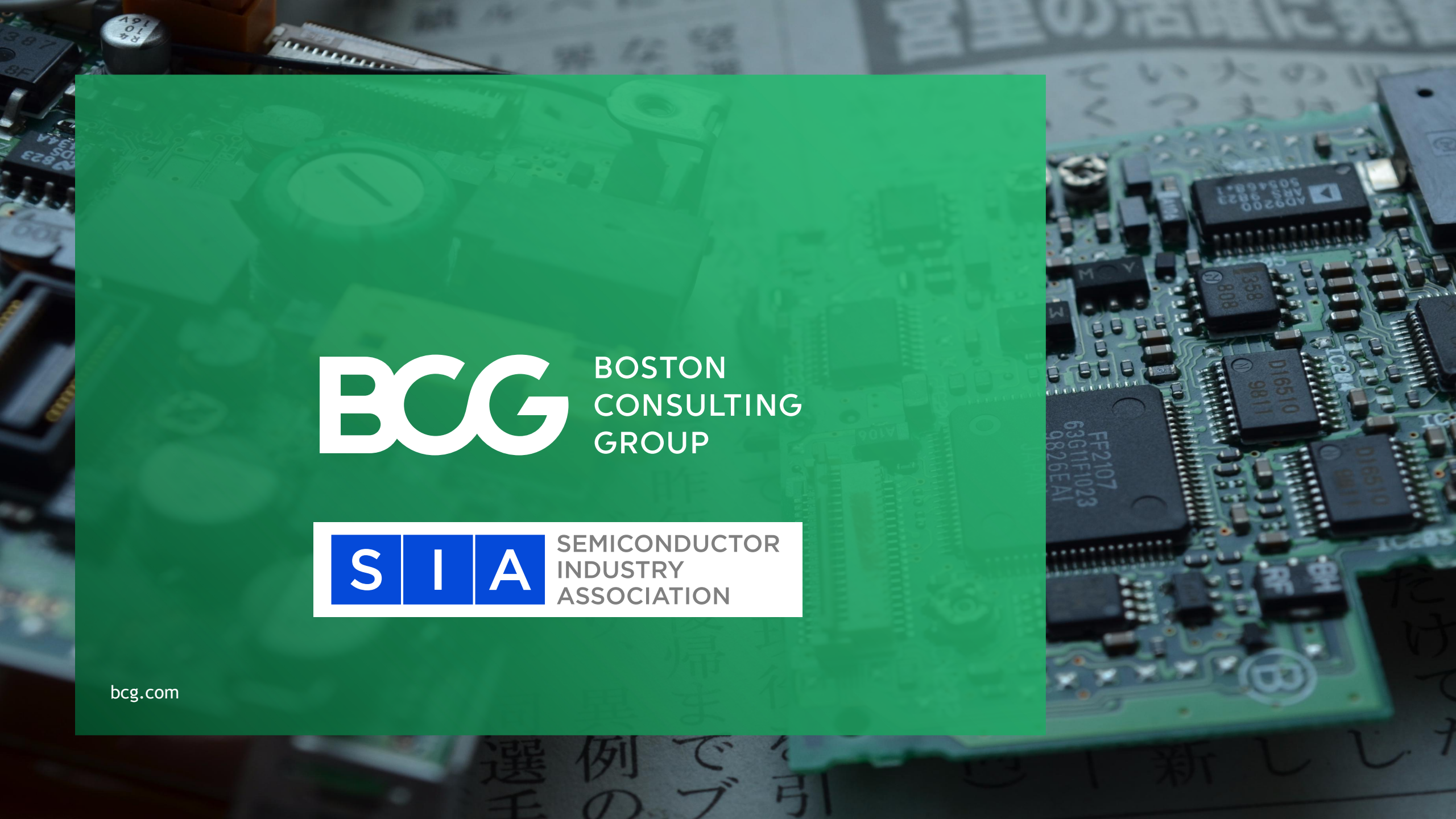

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