BOM Catalyzing Change

Rijksdienst voor Ondernemend Nederland

Buck Consultants International

Towards a Semiconductor Industry Value Proposition

Opportunities for Dutch companies in Singapore

Report – for external use

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Profile BCI Global

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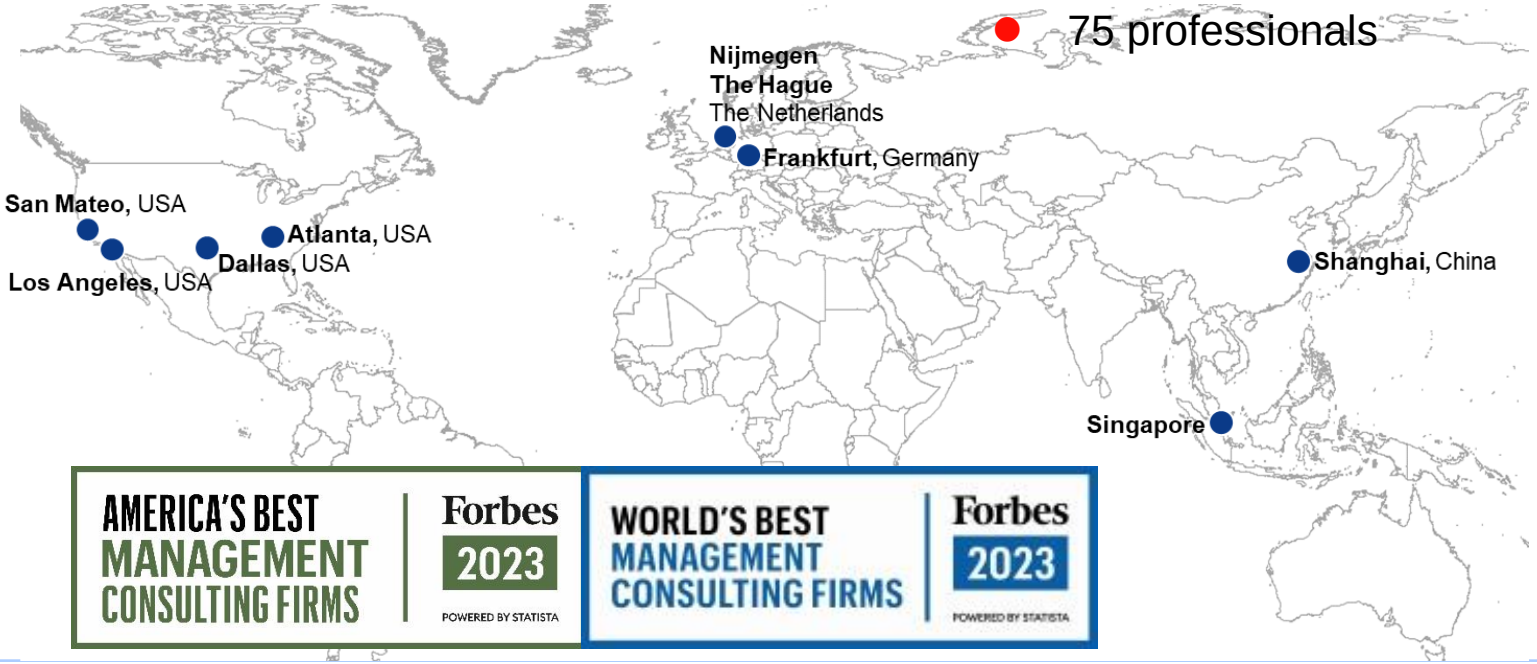
Corporate clients

- **Location advice**
- **Manufacturing footprint strategy**
- **Supply chain optimization**
- Business strategy development
- Real estate strategy and projects

Profile

- Established in Nijmegen, the Netherlands in 1985
- Offices in
  - Europe: The Netherlands, Frankfurt
  - Asia: Singapore, Shanghai
  - US: Atlanta, San Mateo, Los Angeles, Dallas
- Performed studies in more than 50 countries worldwide
- 75 professionals



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Client Base (Examples)

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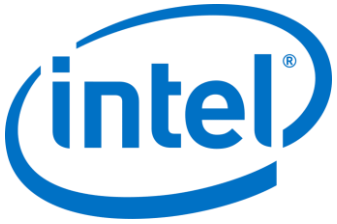

Agenda

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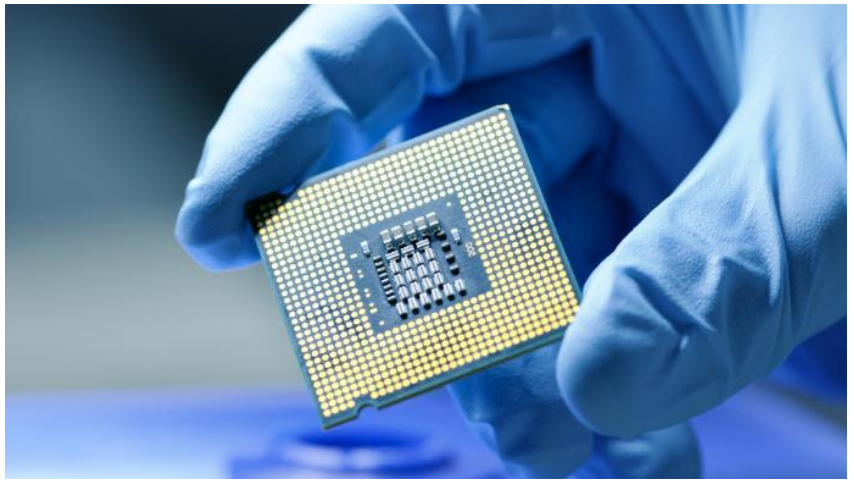

1 The Southeast Asia Regional Perspective

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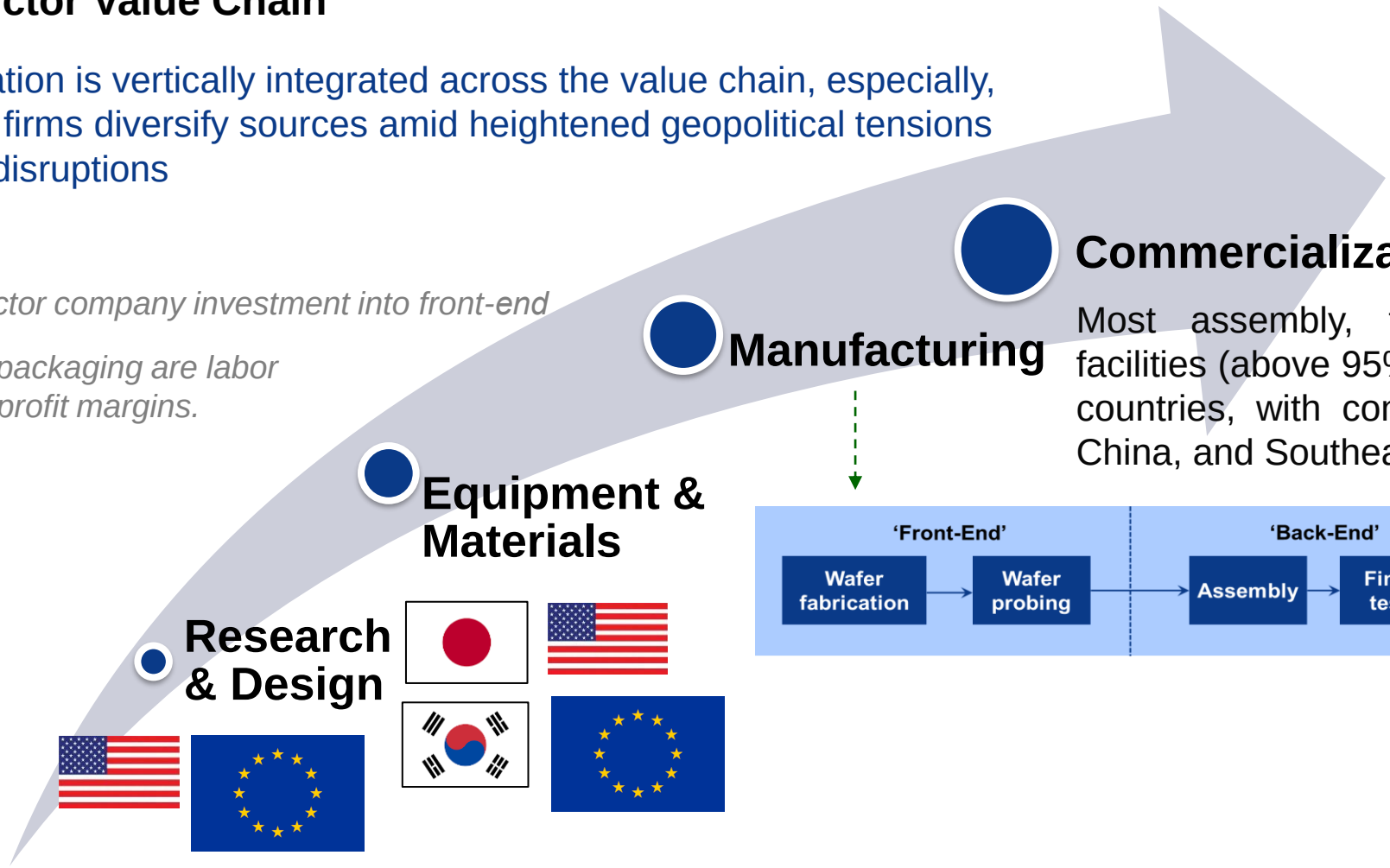
The Semiconductor Value Chain

No company or nation is vertically integrated across the value chain, especially, as semiconductor firms diversify sources amid heightened geopolitical tensions and supply chain disruptions

~70% of semiconductor company investment into front-end

Assembly, test, and packaging are labor intensive with lower profit margins.



The Southeast Asia Regional Perspective

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Value Chain	Singapore	Malaysia	Vietnam	Philippines	Thailand	Indonesia
R&D/ IC Design						
Equipment/ Material						
Front-end manufacturing						
Back-end manufacturing						

Only Singapore and Malaysia have the complete Semiconductor value chain, while the back-end manufacturing is strong in many Southeast Asian countries

Challenges

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- **Going up the value chain,** Malaysia and Vietnam face strong competition from Singapore and the big 4 in Asia “China, Japan, South Korea & Taiwan”
  - **Relatively lower R&D budget and spending** than Singapore and other developed countries
  - **Low labor cost causes human capital flight:** Malaysian scientists and technicians would often go to Australia, Singapore, or the United States to work due to higher wages

- **Going down the value chain**, Malaysia and Singapore face strong competition from other Southeast Asian countries
  - **Lower labor cost in other Southeast Asian countries**: the average salaries in Vietnam and Philippines are only one-third of Malaysia’s, while Singapore is more than 150% than the rest of Southeast Asia
  - **Bigger working population in other Southeast Asian countries**: the labor force of Malaysia is only about 40% of that of Thailand and 30% of Vietnam


Singapore leads Southeast Asia in the high-end of the value chain, while Vietnam is a rising star

Singapore

3 of the world's largest wafer foundries are present in Singapore

- **Global foundries** has five wafer foundries in Singapore
- **United Microelectronics Corporation and World Advanced Packaging Electronics** each have one 8-inch factory in Singapore
- **TSMC** has a wafer foundry in Singapore, which primarily focuses on 0.25-micron and 0.18-micron processes

Singapore's skilled workforce, political stability, business-friendly environment, and mature Semiconductor industry attracts Semiconductor companies from the higher-end of the value chain

Vietnam

- **Samsung** began making semiconductor parts in Vietnam, one of only four countries — alongside South Korea, China and the United States — that produce semiconductors for the world's largest memory chipmaker
- **Hanmi Semiconductor** opened a global branch office in the northern province
- **Amkor Technology** has so far invested $1.6 billion in Bac Ninh and will be among its biggest covering around 23 hectares in the Yen Phong II-C Industrial Park

Vietnam's abundant low-wage workforce and its proximity to the Chinese market are attracting global businesses (now both the lower and the higher end of the value chain, with the investment from Samsung)

Source: Disk Manufacturer, EastAsiaForum, and BCI Global

Comparison of Singapore, Malaysia and Vietnam

Semiconductor Key Location Criteria

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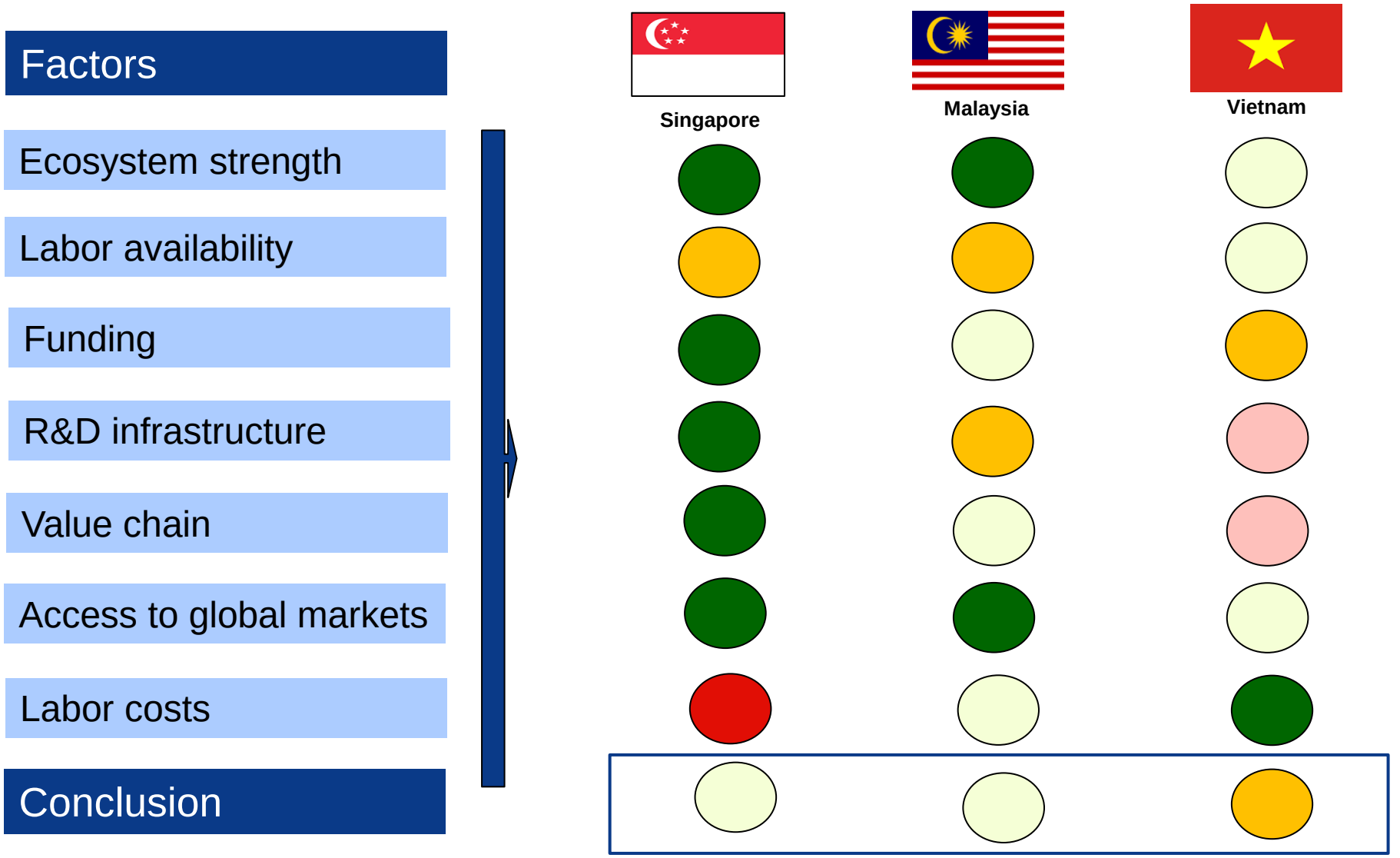

2 The State of the Singapore Semiconductor Industry

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Consistent presence on a global scale

Singapore has a consistent presence in semiconductor industry, coupled with its ecosystem and supportive government policies, it has positioned itself as a prime location for semiconductor manufacturing. Singapore's semiconductor output currently makes up 11% of the global semiconductor market and about one-fifth of global semiconductor equipment is manufactured here

Supported by the government

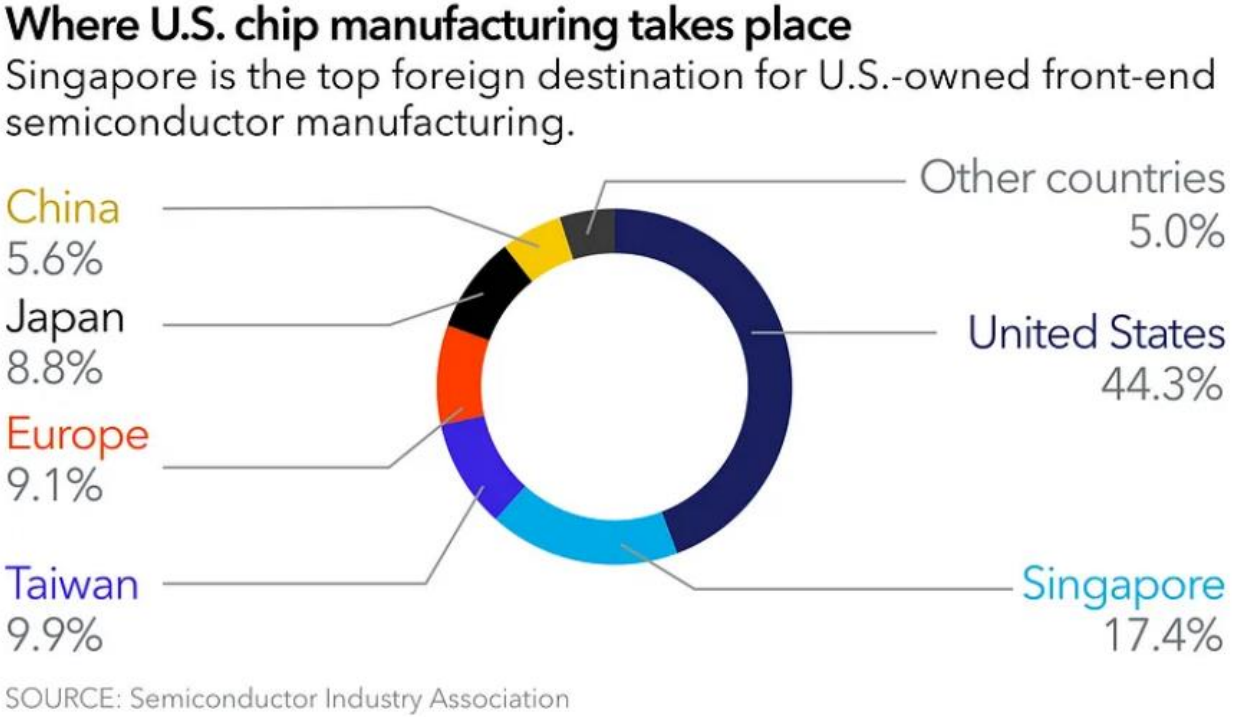
The semiconductor sector contributes about 7% of Singapore's GDP and the government investing $18 Billion between 2021 and 2025 to support research & development and innovation within the semiconductor industry

Recent Key Developments in the Singapore Semiconductor Industry

Singapore manufactures 5% of all the world's chips. Among U.S. chip manufacturers, Singapore is the most popular foreign place of chip making, with a 17.4% share of U.S. front-end capacity

In mid September 2023 the world's third-largest contract chip manufacturer GlobalFoundries has announced the official opening of its $4 Billion expansion fabrication plant in Singapore. The 23,000 sqm facility will create 1,000 high value jobs, 95% of which will include equipment technicians, process technicians and engineers.

One of the world's biggest producers of silicon wafers German Siltronic and another wafer producer named Soitec are planning to scale up operations in Singapore.



Source: FDI intelligence

Recent notable FDI's in Singapore in semiconductor industry

Global Foundries
- Opening its new fabric
- $4 Billion Investment
- Creating 1,000 new jobs

Infineon
- $27 Million investment over 3 years to make Singapore its global artificial intelligence innovation hub
- 250 new jobs created

Micron
- Planning to hire 1,500 people in Singapore for its expansion
- Globally investing $150 billion

Siltronic
- Announced 2 billion euro investment until the end of 2024 for a 300mm wafer manufacturing facility
- Creating 600 jobs

Soitec
- Investing EUR400 M on an extension to double the size of its Pasir Ris factory,
- Plans to double its headcount to more than 600

United Microelectronics Corporation
- Investing $5 Billion on a new factory to produce 22 and 28 nanometre chips, capitalising on demand for 5G and auto electronics.
- Expected to have monthly capacity of 30,000 wafers

➢ Singapore has seen increasing investments from India, China, and Southeast Asia in recent years and the U.S. remains its largest investor

Focus on Singapore's Semiconductor Ecosystem

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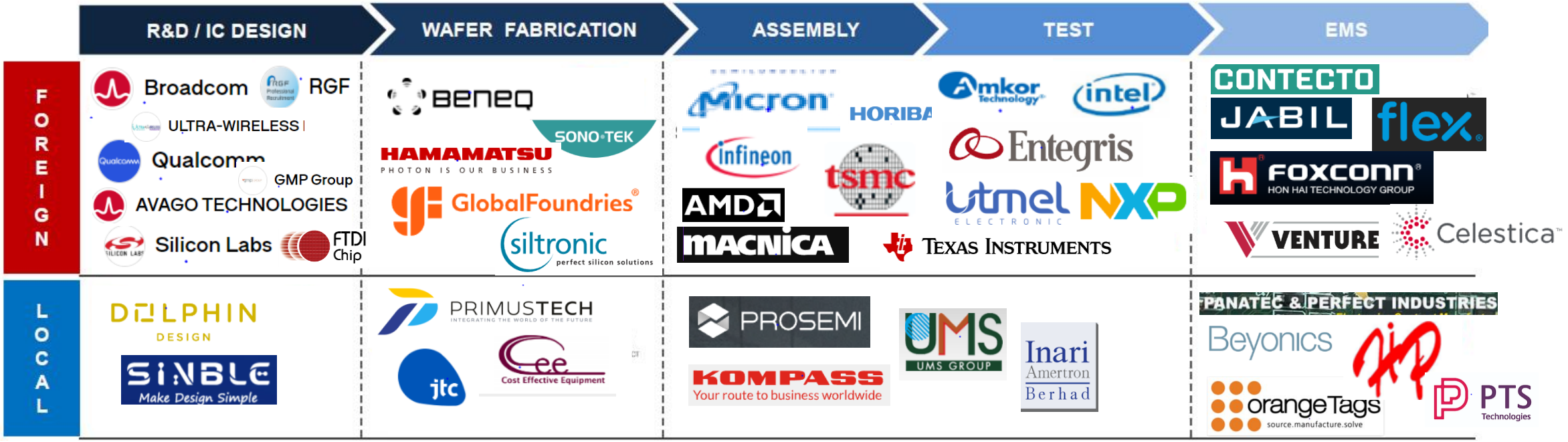
Upcoming **Developing** **Mature**



Singapore has the complete semiconductor value chain from R&D, EMS (Electronic Manufacturing Services) to Assembly and Testing .

Source: MSIA

Focus on Singapore's Nurturing Ecosystem

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A comprehensive overview of the nurturing ecosystem which empowers semiconductor industry in Singapore. Singapore established itself in wafer fabrication, assembly and testing.

Source: MSIA

Semiconductors Market in Singapore

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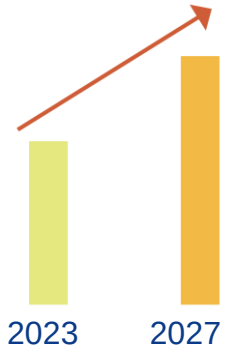
Market growth expected (2023-2027) to **ACCELERATE** at a **CAGR** of

7.91%

Year-over-year growth rate for **2023**

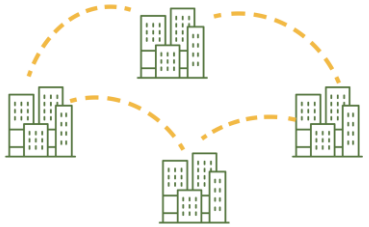
7.5%



Market Value projected to be in 2027 (BN).

$56.91

The Q4 revenue is projected to reach $41.97 BN in 2023



The ecosystem is **vibrant** with **semiconductor giants** operating already in the market

Source: FDI intelligence

Singapore attracts giant investments in semiconductor industry

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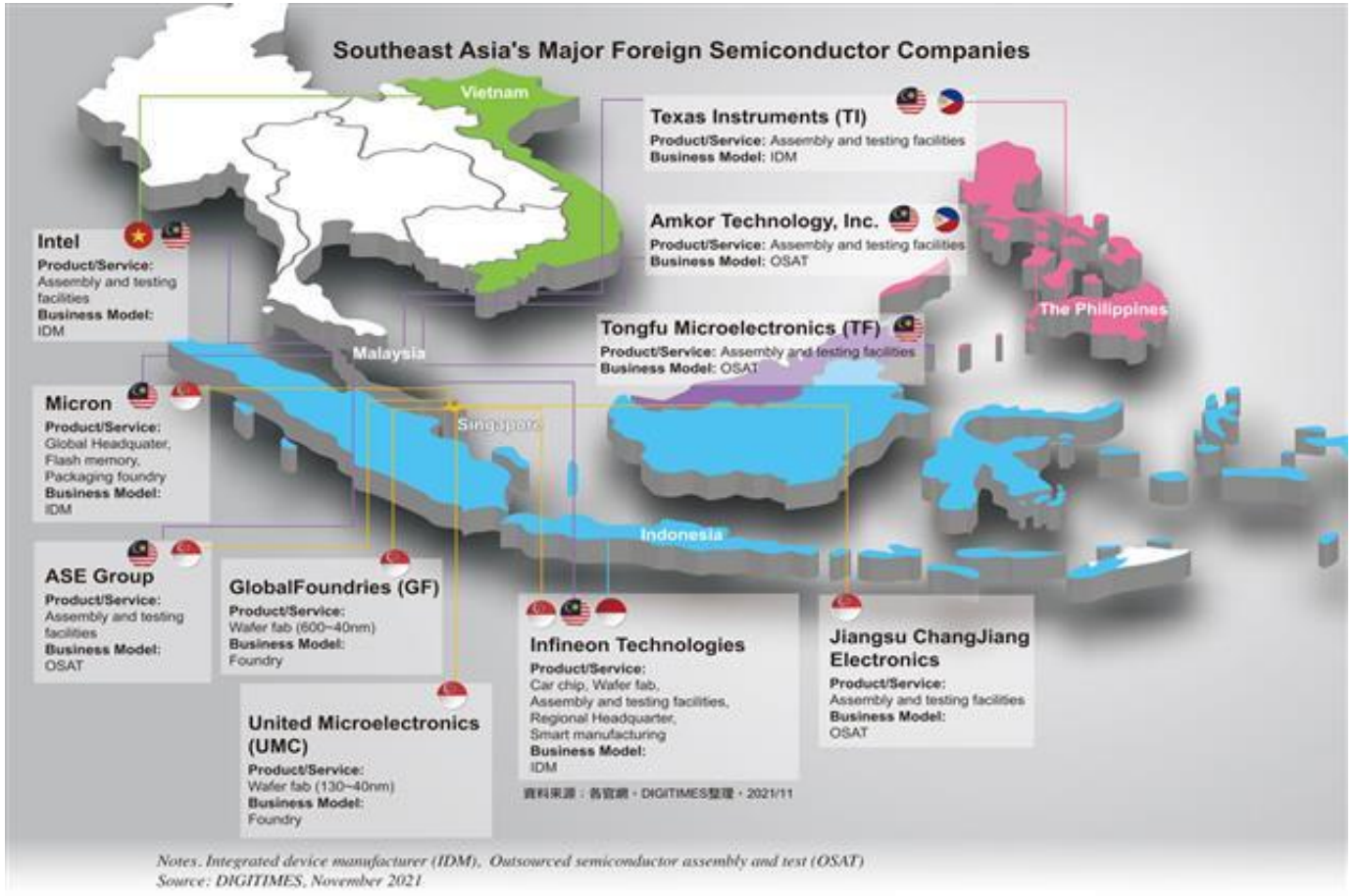
In Southeast Asia, Singapore and Malaysia stand out as hotspot locations for the semiconductor industry

Singapore's progress in the semiconductor industry can be largely attributed to its success in drawing substantial foreign direct investment (FDI).

Singapore attracted $16,4 Billion in fixed asset investments for 2022, according to the country's Economic Development Board. A substantial portion of these commitments was driven by the semiconductor industries.



Source: FDI intelligence

Singapore, a mature hotspot location for Semiconductor FDI (foreign direct investments)

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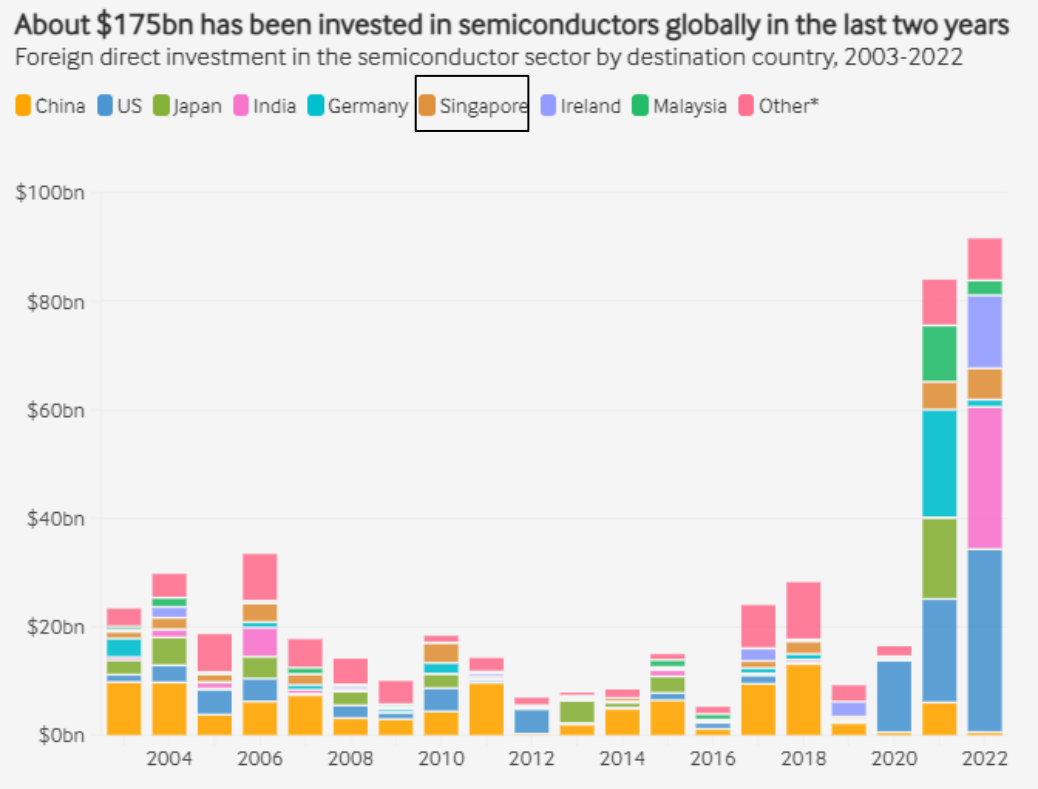
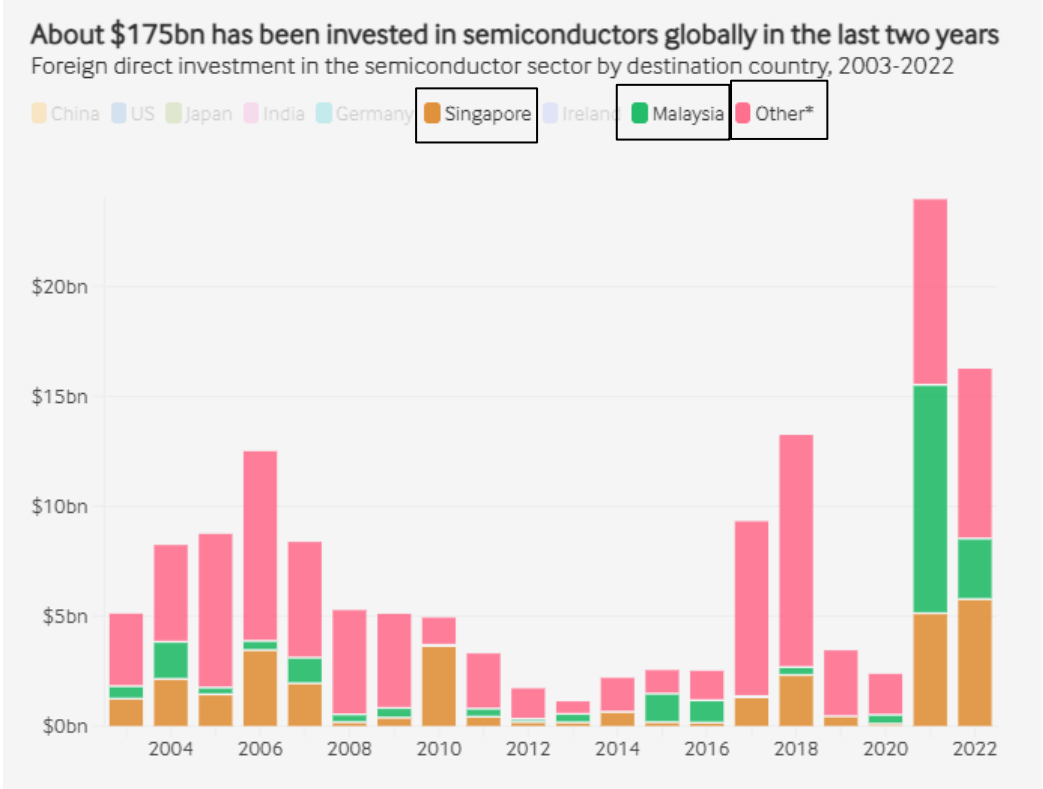
Singapore is the 5th destination with the highest FDI flow in the semiconductor industry globally

In Southeast Asia, Singapore and Malaysia are the hotspot locations for semiconductor foreign direct investments





Source: FDI intelligence

Specifics of example companies active in Singapore

- Micron Technology is a world leader in innovative memory solutions
- Singapore serves as Micron's worldwide operations headquarter and the country's strategic location has enabled the company to effectively serve customers in Asia
- Singapore is also home to Micron's NAND Center of Excellence (COE) for non-volatile memory and the company's largest manufacturing footprint with three 200mm and 300mm memory wafer fabrication facilities, as well as a test and assembly facility
- The COE also comprises an R&D technology center for NAND innovation, and a shared service center providing centralized support for Singapore and Asia Pacific operations

Micron's investments over the years include:

✓ **$4 billion expansion of 3D NAND flash memory fabrication facility**
In September 2016, Micron expanded its facility at North Coast Drive, adding 255,000 square-feet of cleanroom space, and creating an additional 500 high value jobs. The facility produces the latest generation 3D NAND flash memory and is Micron's biggest and most advanced NAND wafer fabrication location.

✓ **Automating front and back-end manufacturing**
Focusing on front and back-end automation in areas that deliver the most business benefit has increased Micron's cost competitiveness across integrated COE facilities.

What makes Singapore an ideal destination for high-tech investors? (1/3)

Singapore's ability to attract high-quality, high-tech foreign direct investment (FDI) projects is a testament to its compelling strategies and business environment

Transparent legal landscape and attractive tax incentives

- ✓ Singapore has an extensive incentive policy, which is pioneering work permit called Tech Pass. This permit is specifically designed to support highly accomplished technology entrepreneurs, experts and business leaders. It does not require the sponsorship of a local employer, granting professionals greater flexibility in their activities
- ✓ Country has an attractive tax regime for high tech investors including corporate tax rates, exemptions, including research and development tax incentives, investment allowances etc. These measures significantly reduce the tax burden for companies operating in high-tech sector

Well-established infrastructure

- ✓ Singapore's dedication to infrastructure investment has propelled it to the forefront of global rankings, securing its position as the world leader in terms of infrastructure quality
- ✓ Singapore has been investing heavily in the development of cutting-edge facilities and technology parks that cater specifically to the needs of high-tech companies

What makes Singapore an ideal destination for high-tech investors? (2/3)

Government's intensive investment in R&D

- ✓ Singapore has committed to allocating over $25billion for R&D for the next five years in a continuing effort to build a more resilient and sustainable economy. This is a 30% increase from the previous allocation
- ✓ To support the R&D efforts, Singapore has also established model factories within its universities and research centers, providing researchers and industry players a testbed for new manufacturing techniques, technologies and business models, to refine their innovations

Singapore's intensive investment in tech-talent

- ✓ Singapore boasts a highly skilled workforce, securing the second rank globally in the 2021 Global Talent Competitiveness Index, published by INSEAD
- ✓ The country continues to prioritize investment in tech skills, with major banks like OCBC, DBS and UOB offering training programs for technology staff

What makes Singapore an ideal destination for high-tech investors? (3/3)

Local Industry Development and Collaboration

- ✓ The Singapore Semiconductor Industry Association (SSIA) plays an essential role in nurturing local SMEs in the sector
- ✓ With around 200 members, 70% of which are home-grown companies, SSIA helps create opportunities for collaboration and learning between local companies and multinational corporations (MNCs)
- ✓ These collaborations contribute to the growth and development of Singapore's semiconductor industry and help local firms build their capabilities and expertise

Intellectual Property Protection

- ✓ Intellectual property protection is crucial for semiconductor companies to safeguard their innovations and maintain their competitive edge
- ✓ Singapore is considered safe from an IP perspective, offering a secure environment for these companies to operate and collaborate

Focus on Singapore's Semiconductor Value Chain

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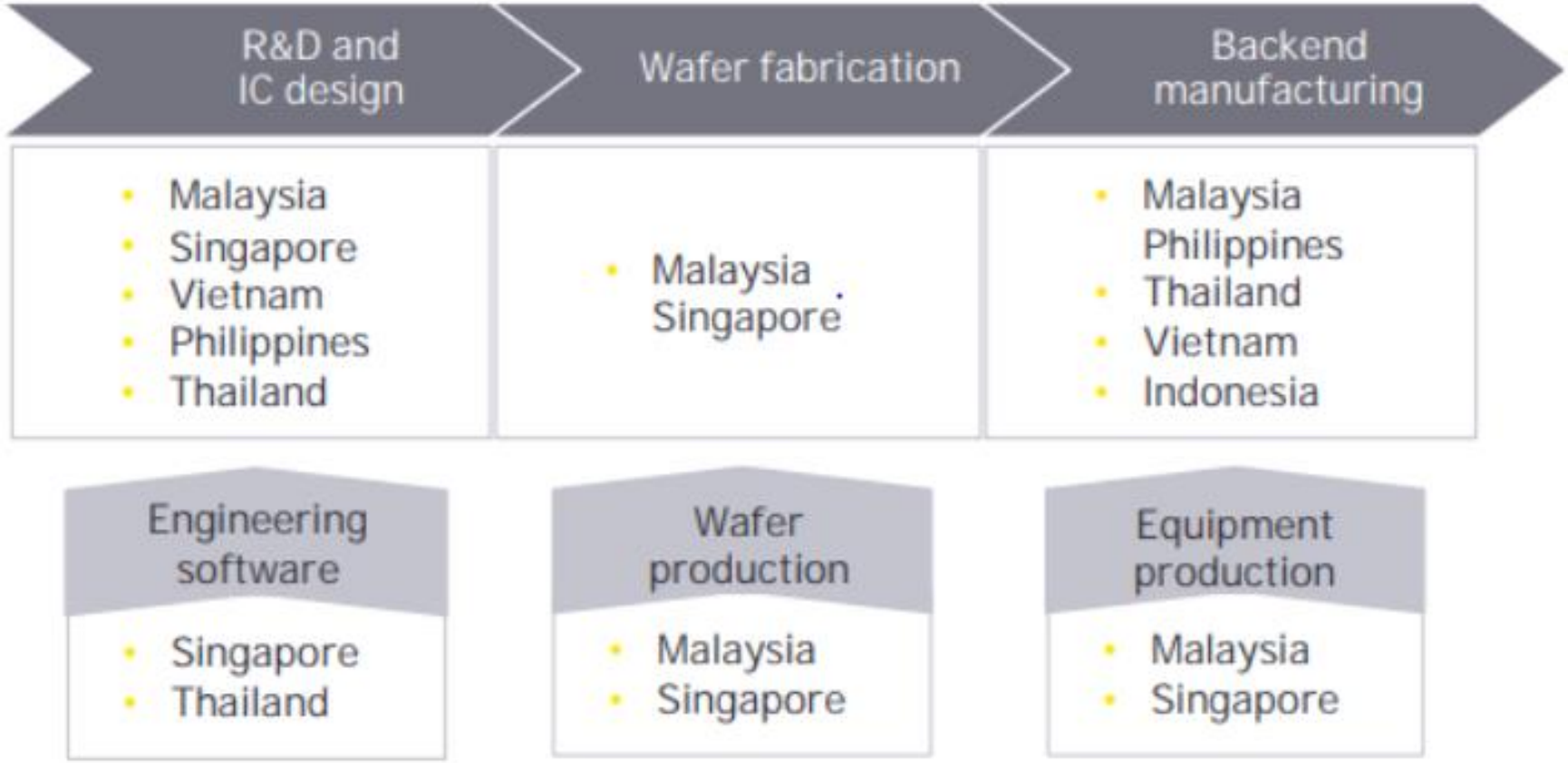
Singapore is involved in all stages of the semiconductor value chain.
The semiconductor industry in Singapore is an essential component of the global supply chain.
Many devices that are used all over the world are developed and manufactured in Singapore.



Source: MSIA

Singapore's share on wafer capacity

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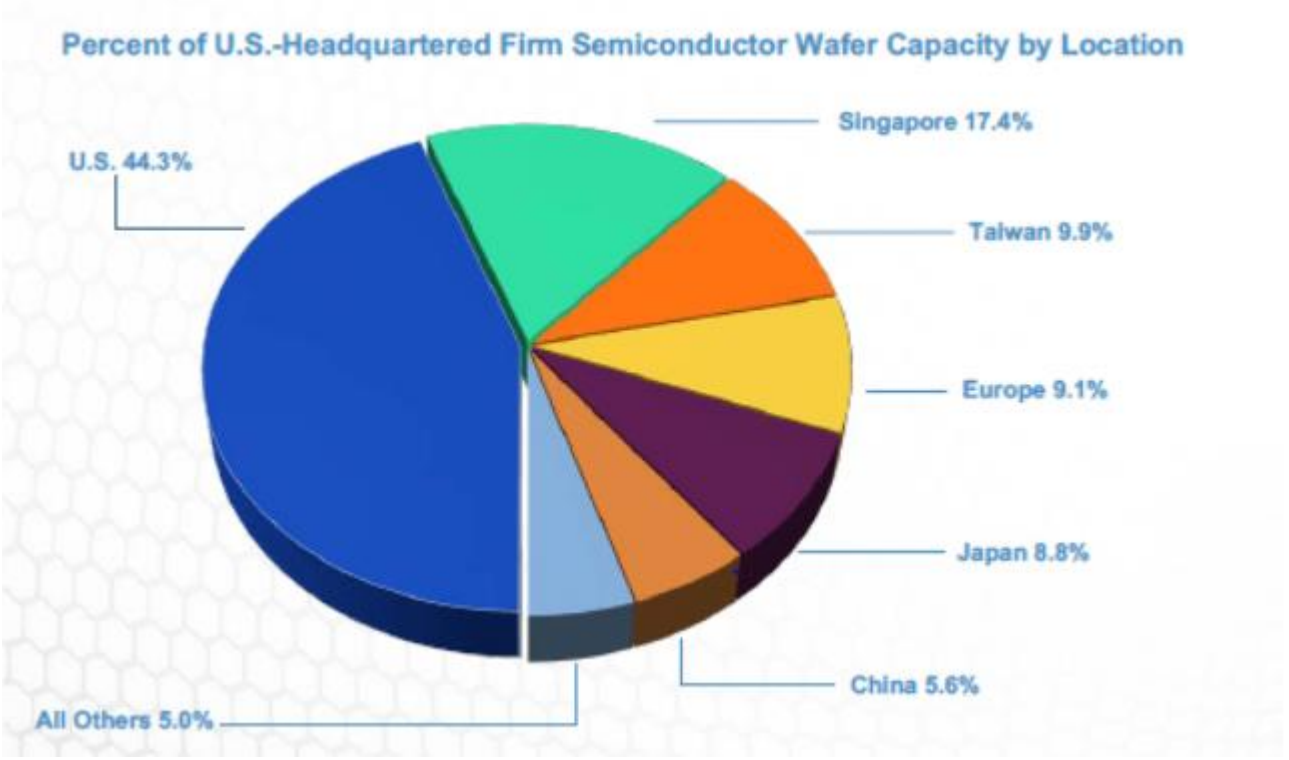
Singapore offers a favorable business environment that includes an end-to-end semiconductor ecosystem. Companies involved in chip manufacturing have taken advantage of a plug-and-play environment in Singapore, gaining access to a strong talent pool and a robust supplier network.
In the equipment manufacturing sector, leading equipment manufacturers entrust Singapore with more than 80% of their global manufacturing, assembly, and/or testing of equipment and tools.

Singapore produces 5% of the world's chips. Singapore is the most popular foreign location for chip manufacturing among US chip manufacturers. They account for 17.4% of US front-end capacity

CHIPS and Science Act: As Singapore accounts for 17.4% of US front-end capacity, Singapore set to benefit from the United States CHIPS and Science Act. Short for Creating Helpful Incentives to Produce Semiconductors and Science Act, the Act commits over $280 billion including $52.7 billion in subsidies to support semiconductor production and research in the US



Source: MSIA

Singapore's Share on Semiconductor Equipment Manufacturing

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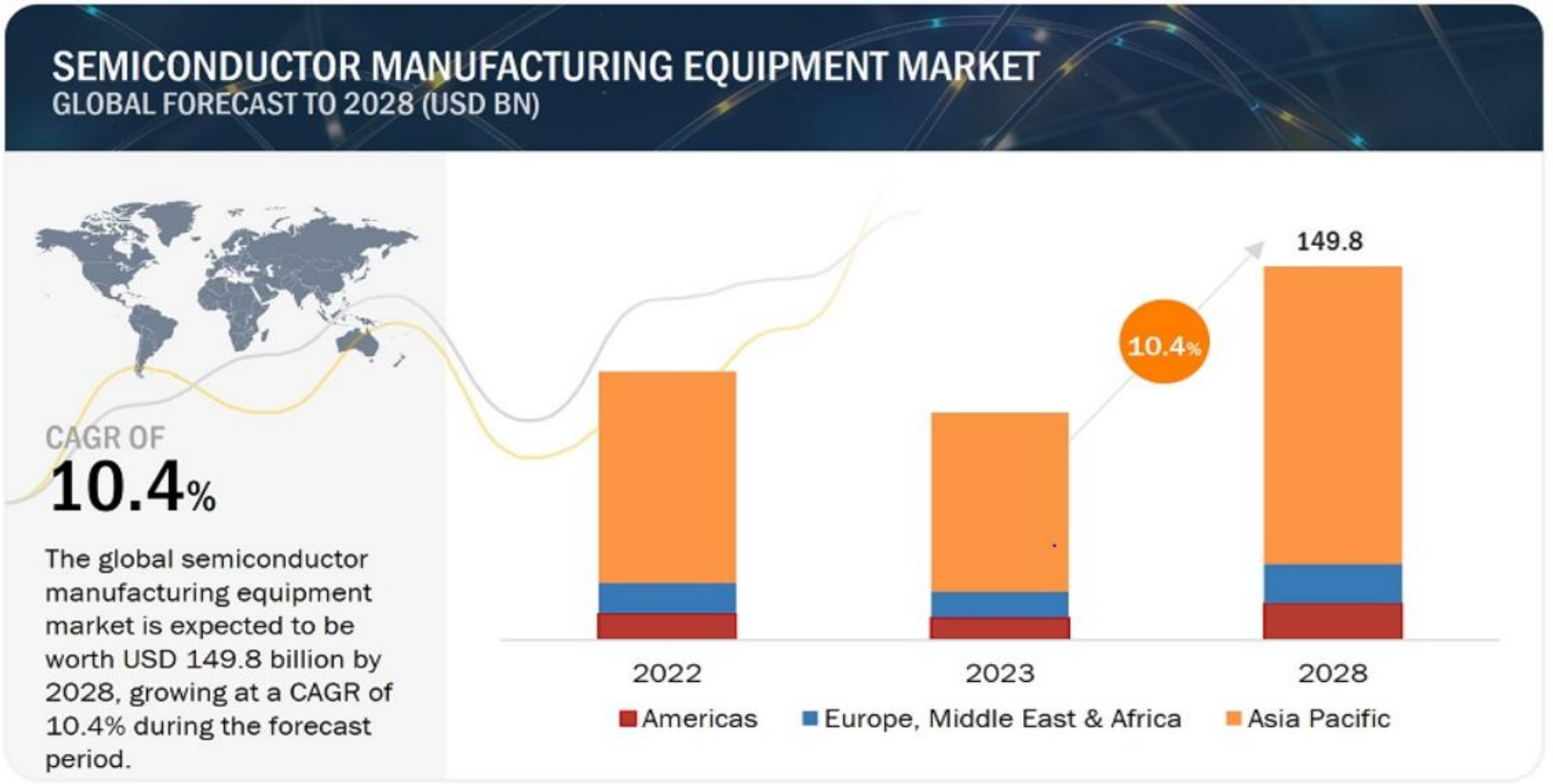
The city-state is even more important in semiconductor manufacturing equipment. For example, Applied Materials, the world's largest chip equipment manufacturer by revenue, manufactures half of its global output in Singapore. Singapore produces nearly 20% of all semiconductor production equipment, thanks to a supplier ecosystem that includes 1,000 precision engineering firms. According to data published by the US government, it is the fourth-largest exporter of such machineries and equipment.

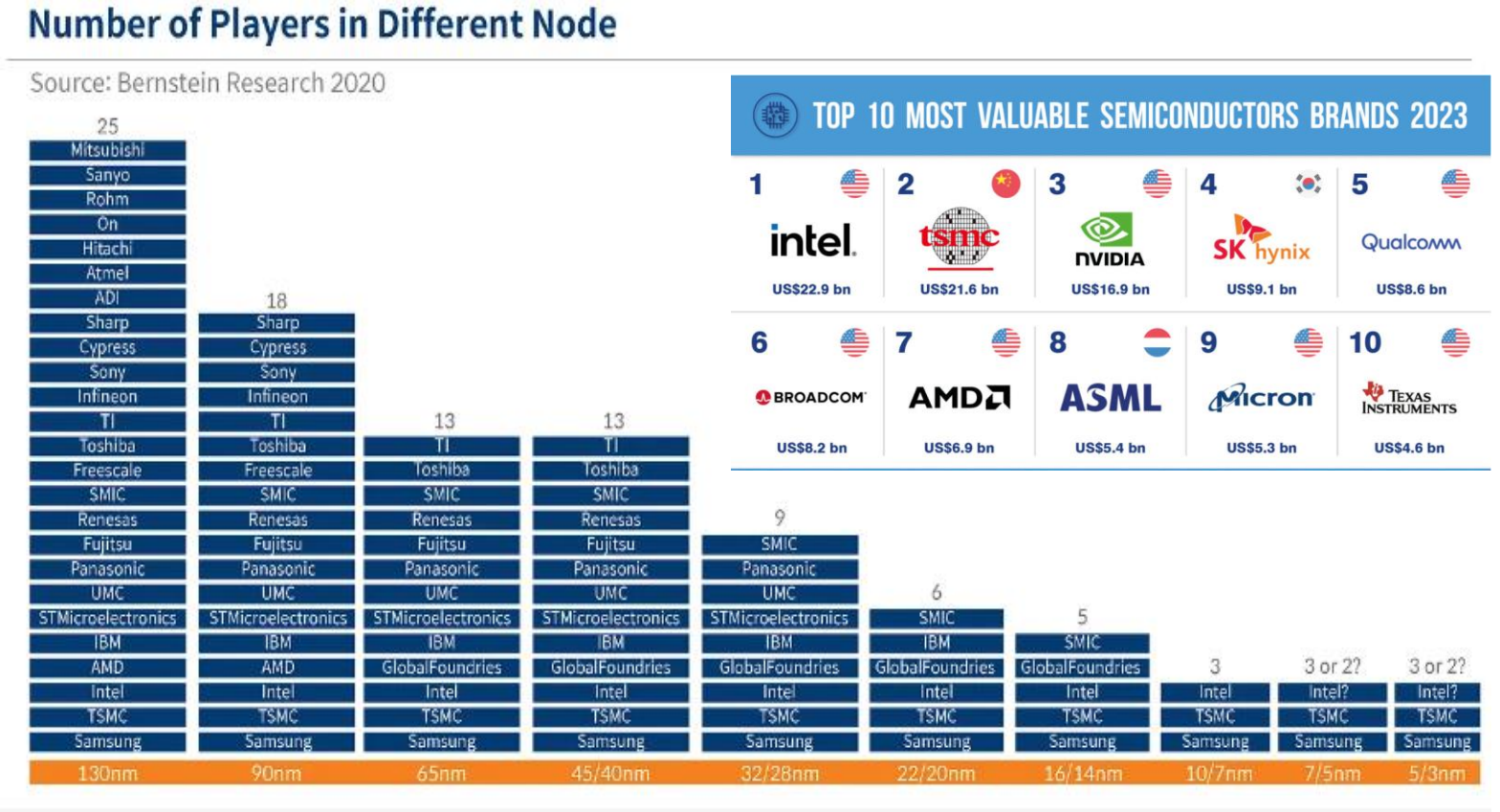


Source: MSIA

Role of GlobalFoundries in Singapore

China and Taiwan take over 50% of the >45 nm fabrication market, therefore GF's Singapore plant is critical for the U.S. competition with China over this vertical, making sure that China will not be able to establish its own chokepoints for U.S. auto production

- ✓ Once CSM based in Singapore was one of the world's most powerful semiconductors in 2004
- ✓ In 2009 it was sold to GlobalFoundries
- ✓ GlobalFoundries made CSM even greater than before
- ✓ In 2020, GF has one third of its employees hired in Singapore providing thousands of high-tech jobs for Singapore's economy
- ✓ In July 2021, GF announced a $4 billion commitment to expands its production in Singapore. This will enable Singapore to become an important node in the semiconductor supply chain



Source: BCI and Orissa International

Several Dutch semiconductor companies and suppliers are operating in Singapore

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NXP's presence in Singapore focuses on design, supply, sales and technical support

Dutch multinational ASM International assembles and tests advanced deposition tools in Singapore. It moved most of its production to Singapore in 2007.Its new manufacturing floor opened in 2020 and a second is planned to be ready at the start of 2023

Besi SG is the center of Excellence for Besi in Asia; sustaining Besi mainstream products. With an 800 sqm testing lab, Besi Singapore is capable to perform customer sample, machine demo, design, testing, development, R&D and packaging services

Design and contract manufacturing partner VDL Enabling Technologies Group, which is part of Dutch carmaker VDL, has a subsidiary in Singapore that works on system integration.

Small Dutch mechatronics companies DEMCON, Sioux Technologies and NTS also maintain Singapore offices

The STEM talent base in Singapore

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Singapore has a highly skilled workforce in technology, suitable to the semiconductor industry. It has research institutes and training establishments, including the Singapore University of Technology and Design, Temasek Polytechnic, Nanyang Technological University of Singapore

International Universities and Institutions

NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

Temasek POLYTECHNIC

SiT

SSIA Singapore Semiconductor Industry Association

SP Singapore Polytechnic

SUTD SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN

Education Programs Specific to this Industry: There are semiconductor specific study tracks such as ''Applied Physics with Concentration in Semiconductor Technology" at Nanyang Technology University and ''Specialist Diploma in Semiconductor Technology Track" at Temasek Polytechnic.

The semiconductor industry employs over 33,000 people in Singapore. With new investments on the horizon, it is expected to create at least another 2,000 jobs in the next three to five years.

To keep up with the semiconductor industry's rapid growth, Singapore needs to expand its pool of skilled workers, so the Singapore Semiconductor Industry Association (SSIA) has been working on raising awareness about the industry and attracting younger talent.

A new Semiconductor Active Youth program was launched. This program meets the SSIA's top priority of building a strong talent pipeline in the electronics sector. Under this program, leaders of major companies such as AMD and GlobalFoundries will hold one-on-one mentoring sessions with chosen youth ambassadors.

The SSIA and Institute of Technical Education (ITE) also signed a memorandum of understanding to enhance collaboration

Source: MIDA & Department of Statistics Malaysia, 2023

Singapore as a top destination for expats

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Singapore is a metropolitan city-state well known for its diversity and almost futuristic architecture. Located in the Malay Peninsula, in Southeast Asia, 29% of Singapore's population are categorized as "non-residents" meaning expats

Top 10 most liveable locations for East Asian expatriates

Location	Country	2022 ranking	2021 ranking
Singapore	Singapore	1	1
Tokyo	Japan	2	3
Wellington	New Zealand	3	2
Osaka	Japan	4	3
Yokohama	Japan	4	8
Adelaide	Australia	4	10
Brisbane	Australia	4	10
Auckland	New Zealand	4	24
Copenhagen	Denmark	9	3
Sydney	Australia	9	10

© Employment Conditions Abroad 2023

Singapore remains the most liveable location in the world for expatriates from East Asia with an improved liveability score in the past year, as revealed by the latest Location Ratings survey published by global mobility expert, ECA International

IMD

The IMD World Competitiveness Yearbook (WCY), first published in 1989, is a comprehensive annual report and worldwide reference point on the competitiveness of countries. It provides benchmarking and trends, as well as statistics and survey data based on extensive research. It analyzes and ranks countries according to how they manage their competencies to achieve long-term value creation.

WORLD COMPETITIVENESS CENTER

2023	Country
01	Denmark
02	Ireland
03	Switzerland
04	Singapore
05	Netherlands
06	Taiwan, China
07	Hong Kong SAR
08	Sweden
09	USA
10	UAE

3 Opportunities for Dutch Companies

A General areas of opportunity

1 Labor-driven

- **Low labor cost in Malaysia and Vietnam:** EU salaries for production workers is more than 150% on average than Malaysia and Vietnam
- **High labor quality in Malaysia and Singapore:**
  - Malaysia has a high percentage of STEM graduates: UNESCO data show that tertiary students in Malaysia tops the world with the most graduates in a STEM field with 43.5%
  - Singapore ranks globally in terms of research and development, integrated circuit design and sub-system equipment production

2 Risk-driven

- **Political neutrality of Malaysia, Vietnam, and Singapore enable companies to diversify supply chain from geopolitical pressures (US-China trade war)**
  - Some Chinese players have been placed on the US trade blacklist “Entity List”, for example SMIC and Huawei, to create “China-free supply chains.” Third countries are pulled into geopolitical competition, Taiwan for instance stopped supplying to Huawei

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3 Ecosystem-driven

- **Malaysia and Singapore have well-established and complete semiconductor ecosystem**
  - Top global semiconductor companies are currently operating in Malaysia and Singapore
  - Only Malaysia and Singapore in Southeast Asia have the complete Semiconductor value chain: from R&D to front-end and back-end manufacturing

4 Market-driven

- **Malaysia, Singapore, and Vietnam have market access to 3 large free trade groups**
  - **The ASEAN** (Association of Southeast Asian Nations), the 3rd largest market in the world with 622 million people (only behind China and India)
  - **The RCEP** (The Regional Comprehensive Economic Partnership), the world's largest free trade agreement, covering 15 countries with 2.2 billion or 30% of the world's population (10 ASEAN member countries + China, South Korea, Japan, Australia, and New Zealand)
  - **The CPTPP** (Comprehensive and Progressive Agreement for Trans-Pacific Partnership) will add new markets of Canada, Mexico, Peru, and Chile with combined market of 217 million

Opportunities for Dutch Companies in Singapore

There are opportunities for Dutch semiconductor / high tech related companies on three levels

A Singapore as supply / partner base

- Dutch companies can partner with relevant companies that are already present in the Singapore semiconductor ecosystem (contract manufacturing, development, etc.)
- Dutch companies can source from specialized suppliers in Singapore

B Singapore as market

- Singapore offers market potential for Dutch companies: selling materials/components/ services to companies that are located in Singapore

C Singapore as potential new location

- Singapore offers a good investment climate for semiconductor related investments, e.g. into new manufacturing sites

Focus on Singapore's Semiconductor Ecosystem

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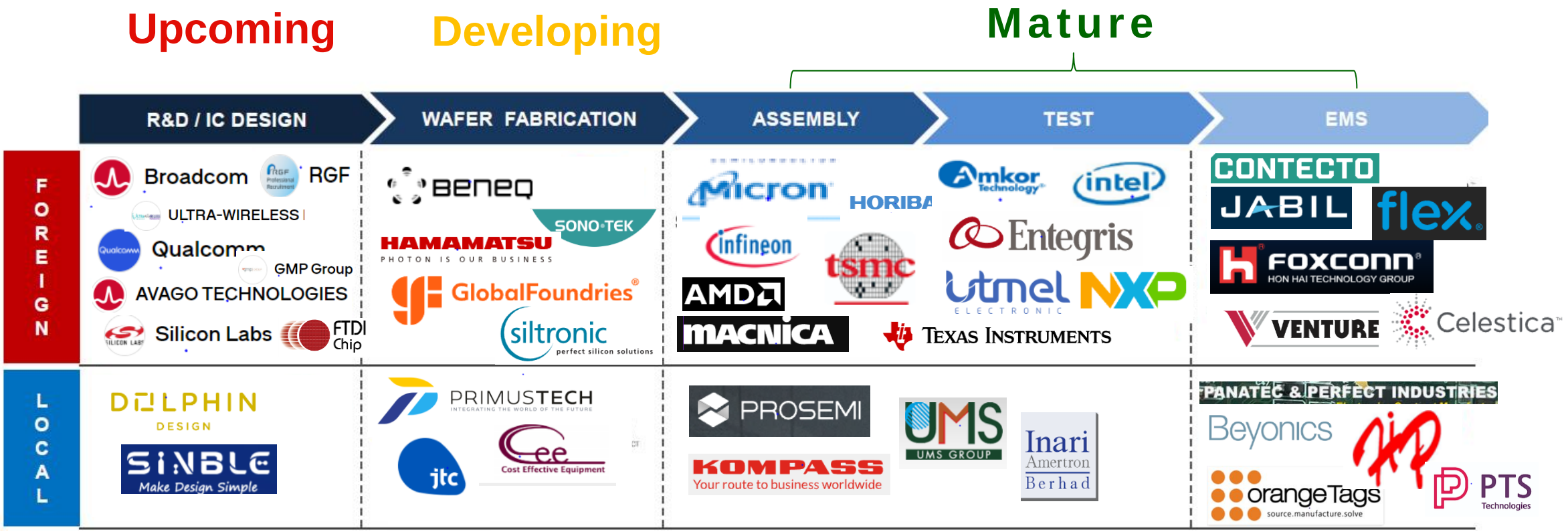

Singapore has the complete semiconductor value chain from R&D, EMS (Electronic Manufacturing Services) to Assembly and Testing .

Source: MSIA

B Singapore as a market

Singapore's semiconductor output currently makes up 11 % of the global semiconductor market and about one-fifth of global semiconductor equipment is manufactured in Singapore

7.91% CAGR growth rate in 2023

High labor availability and quality

13 bilateral and 12 regional Free Trade Agreements

- The semiconductor market in Singapore is expected to have a market value of $56,91 billion in 2027
- The semiconductor industry in Singapore is currently growing with a CAGR of 7.91%
- The country's 15 bilateral and 12 regional FTAs include some of the largest combined trade agreements in the ASEAN-China, ASEAN-India, and ASEAN-Hong Kong trade blocs — providing Singapore-based businesses with access to preferential markets, free or reduced import tariffs, as well as enhanced intellectual property

Industry breakdown

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Production value in 2022

Source: Malaysia Semiconductor Industry Association (MSIA), 2023

- **Singapore's semiconductor output currently makes up 11% of the global semiconductor market and about one-fifth of global semiconductor equipment is manufactured here**

Market opportunities in Singapore

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Opportunities	Challenges
A Diverse Ecosystem consist of global giants that can span the entire value chain of chip making and established infrastructure	Small landscape, higher land cost
Singapore has an attractive incentive scheme and tax regime for manufacturing companies	Singapore faces fierce competition from other regional players such as China, Taiwan, South Korea and Malaysia
Intellectual property protection is crucial for semiconductor companies Singapore is considered as ''safe'' from IP perspective, offering a secure environment	Limited access to green energy (priority for chip suppliers)
The help of Local Industry development and collaboration such as Singapore Semiconductor Industry Association (SSIA).	Higher labor cost than other Southeast Asian countries
Growing workforce and talent development with more than 33,000 people employed in semiconductor industry.	
Government's intense investment in R&D and tech-talent	

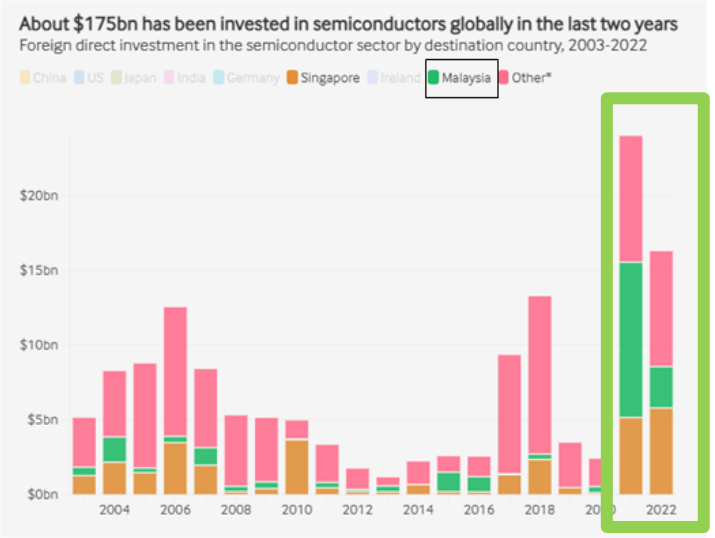
Semiconductor industry

- Singapore has the goal of training high-quality workforce in semiconductor industry, with the goal of training 50,000 workers by 2030
- SSIA helps create opportunities for collaboration on learning between local companies and multinational corporations (MNCs)

C Singapore as a potential new location for Dutch companies

- Scarcity of space / capacity / labor in The Netherlands
- Trend towards decentralizing / de-risking end to end supply chains, risk mitigation
- China +1 strategy
- Decarbonization; e.g. reducing freight distances inbound and outbound
- ….

In Southeast Asia, Singapore and Malaysia are the hotspot locations for semiconductor foreign direct investments



Source: FDI intelligence

Classification of opportunities

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	Type	Opportunity	R&D / Design	Equipment / Material	Front end mfg	Back end mfg	Indication of opportunity scale	Remarks
Short term	A. Supply/Partner base							
	A1	New component suppliers	✓	✓	✓	✓	●	
	A2	New contract manufacturers	✓	✓	✓	✓	●	
	A3	New R&D partners	✓	✓	✓		◔	
	B. Market							
	B1	Sales to local market	✓	✓	✓	✓	●	Opportunities across value chain
Mid-long term	C. FDI							
	C1	New design / R&D centers	✓	✓			◑	
	C2	New mfg plants	✓	✓	✓	✓	◔	

4 Take Aways on Singapore's Case

Buck Consultants International

Developing value chain in the region

- Singapore covers the full value chain from R&D/IC Design, through equipment/material, front & back manufacturing and commercialization

Attractive base

- Vibrant ecosystem, with big semiconductor firms being present in the market
- High government incentives and grants
- High FDI flow
- Highly skilled workforce

Opportunities for Dutch companies

- Achieving risk mitigation
- High quality labor
- Establishing partnerships and collaboration with world semiconductor giants