From Semiconductor Industry to Biomedical Industry

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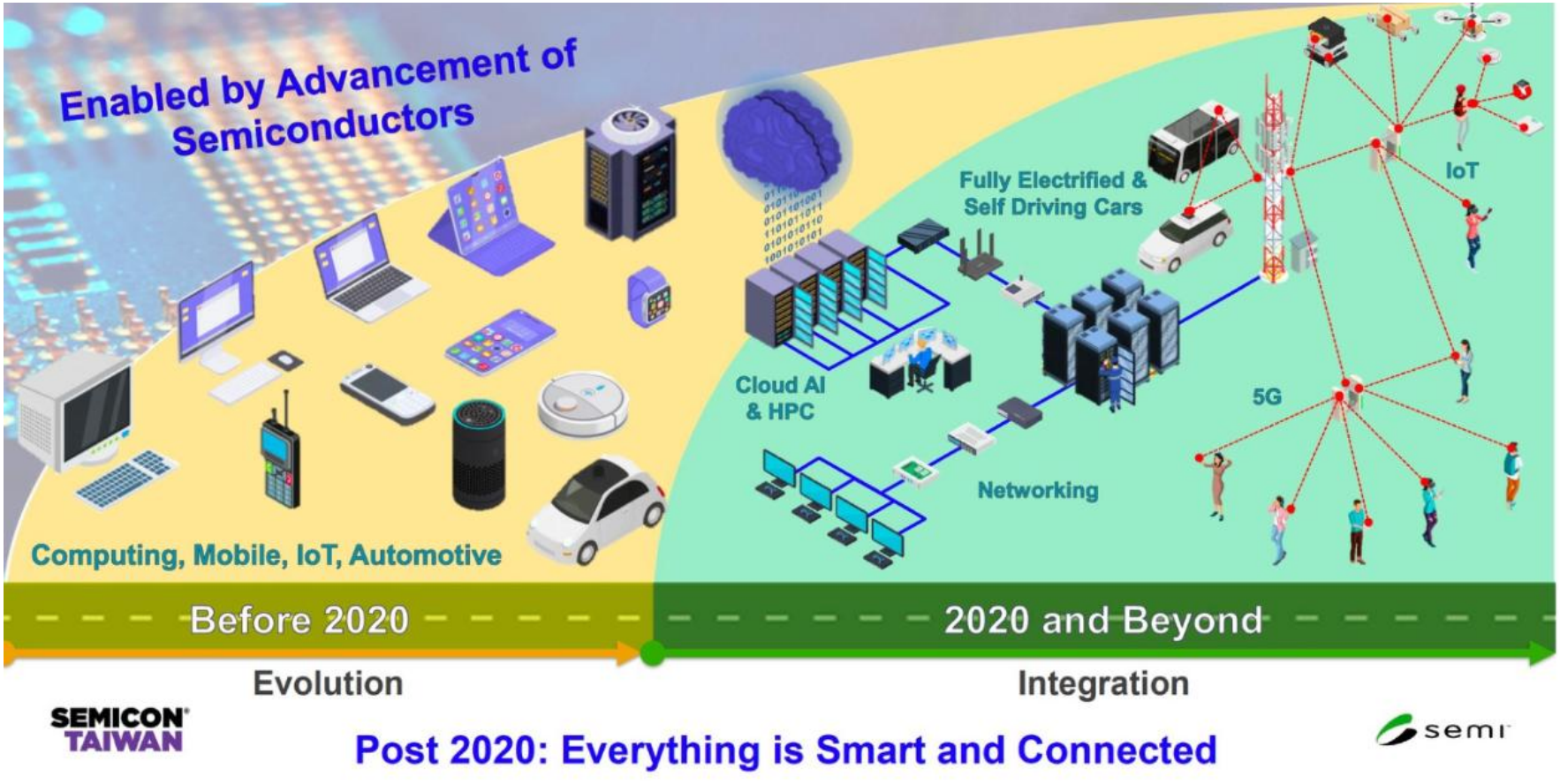
Outline

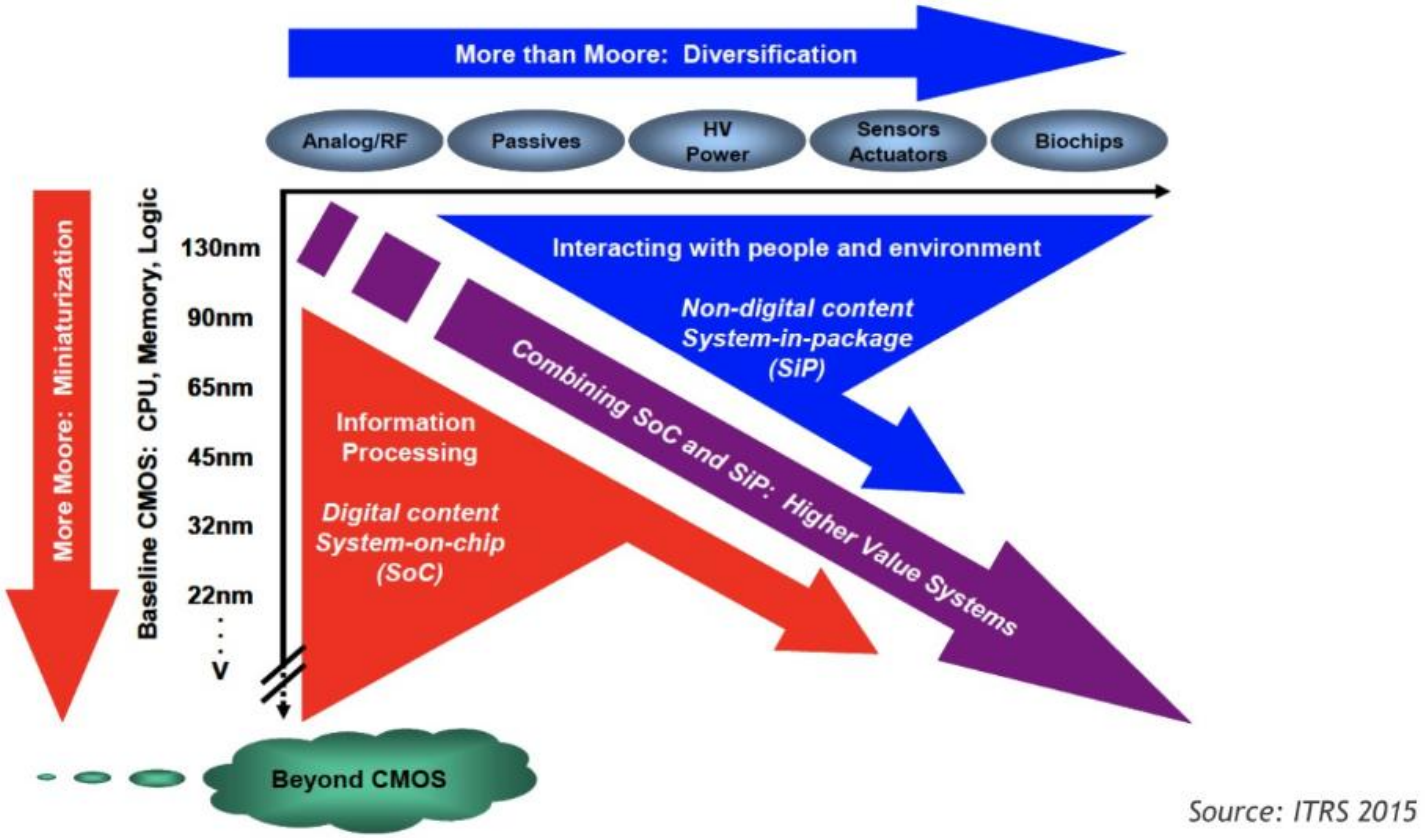
- Semiconductor Industry
  - Application、Technology、Basics
  - Semiconductor Industry Eco-system
  - Taiwan Foundry: When, Where, Who
- Semiconductor Smart R&D
- Lessons to Taiwan Biomedical Industry
- Upgrade the Values of Taiwanese Talents
- Summary & QA

Semiconductor Applications



Source: Semicon Taiwan 2020

Semiconductor Technology Trend

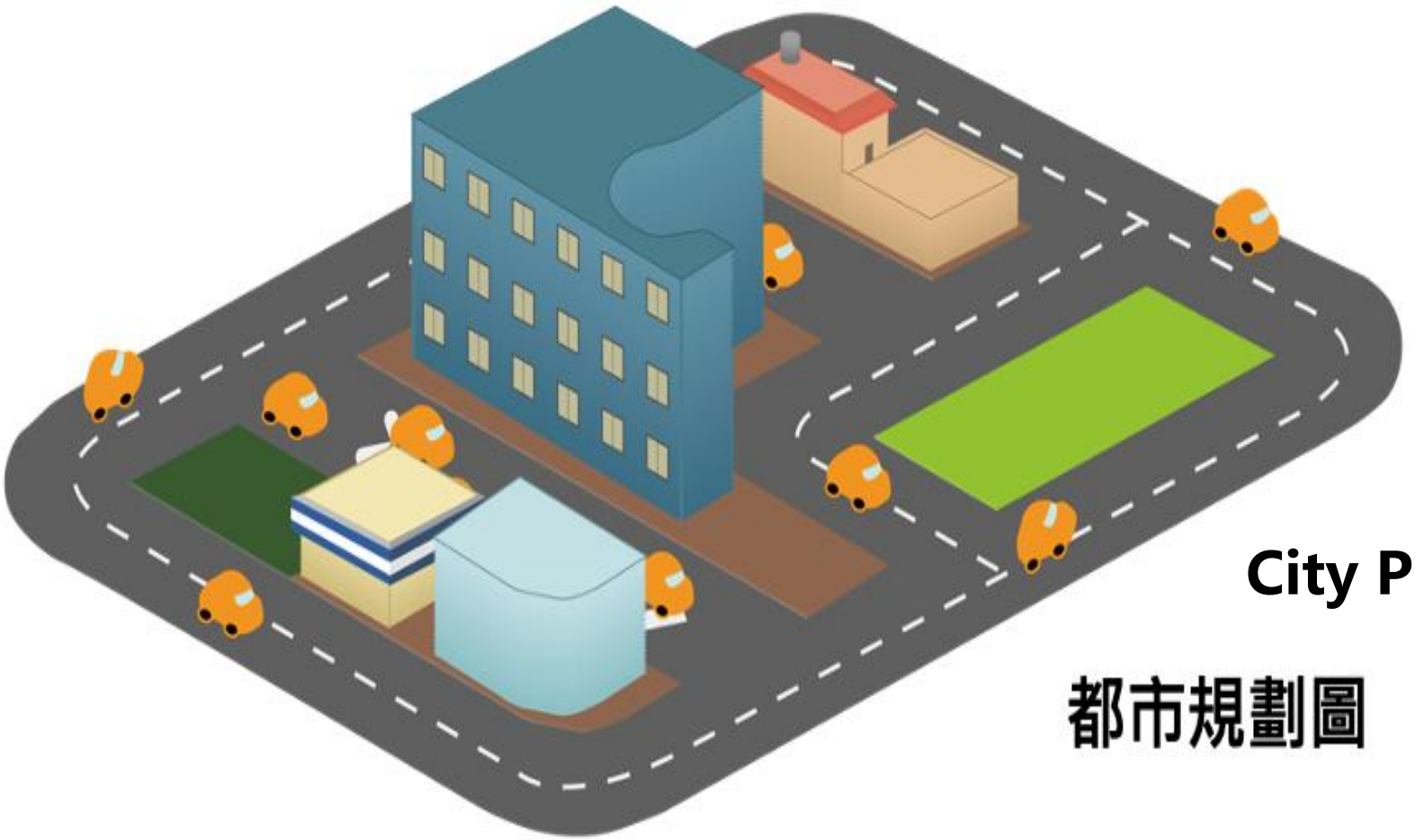


Source: ITRS 2015

The combined need for digital and non-digital functionalities in an integrated system is translated as a dual trend in the International Technology Roadmap for Semiconductors: miniaturization of the digital functions ("More Moore") and functional diversification ("More-than-Moore").

Semiconductor: Basics

- **Semiconductor 半導體** : a kind of material based on its electric conductor characteristics, compared with insulator and conductor.
- **Semiconductor Device 半導體元件** : Basic building element for electrical functions.
  - Active : Transistor (Faucet, Traffic light), Diode (One-way road)
  - Passive: Resistor, Capacitor, Inductor
- **Integrated Circuits (Chip)積體電路(晶片) :** Groups of semiconductor devices, connected to perform complex function
  - Rectangular size in a few centimeters each side, like a small city.
  - Logic (CPU,GPU, APU…), Memory (DRAM, SRAM, Flash, ROM, …), Analog (A2D, D2A, RF, …)

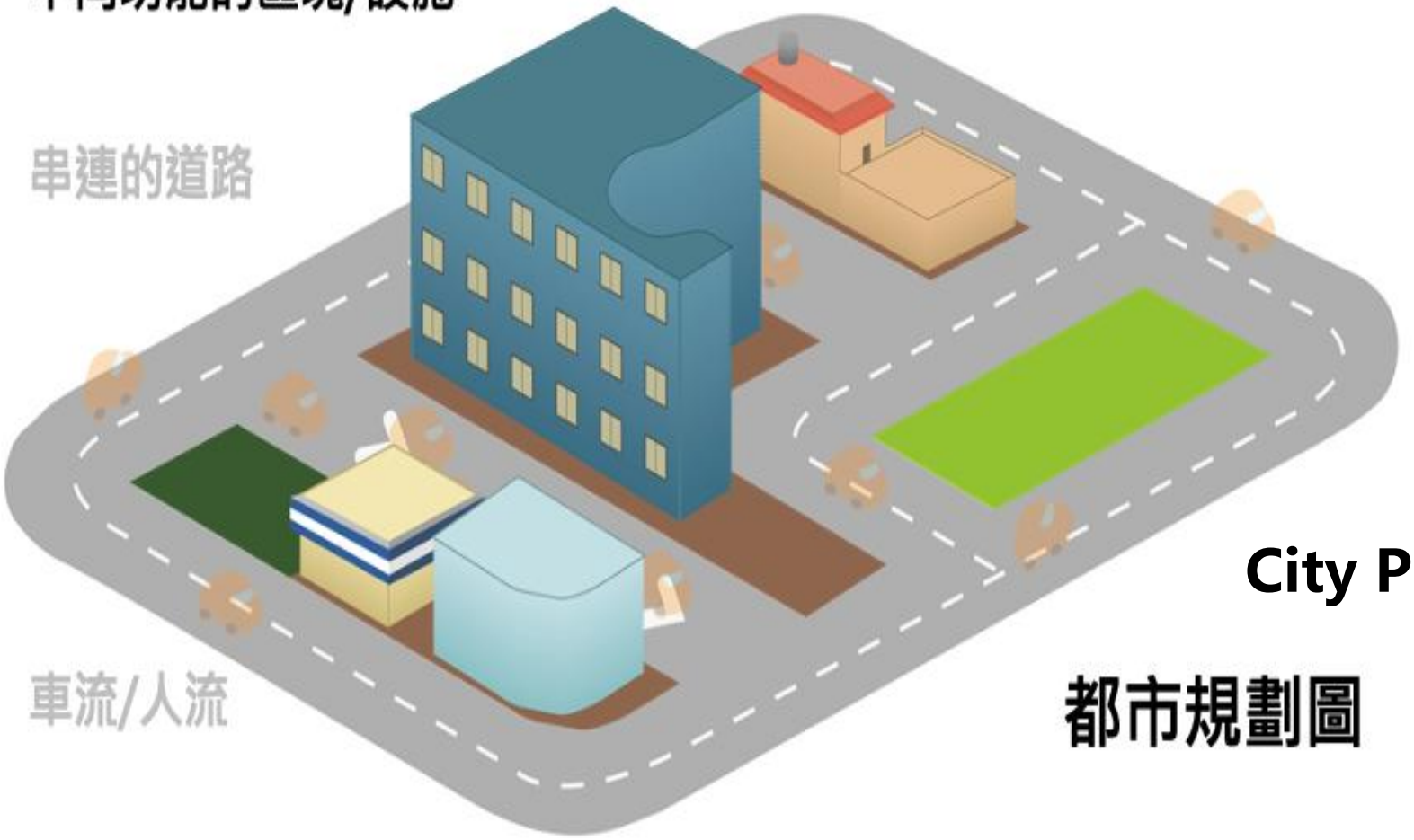


City Plan

都市規劃圖

Block/building for different functions

不同功能的區塊/設施

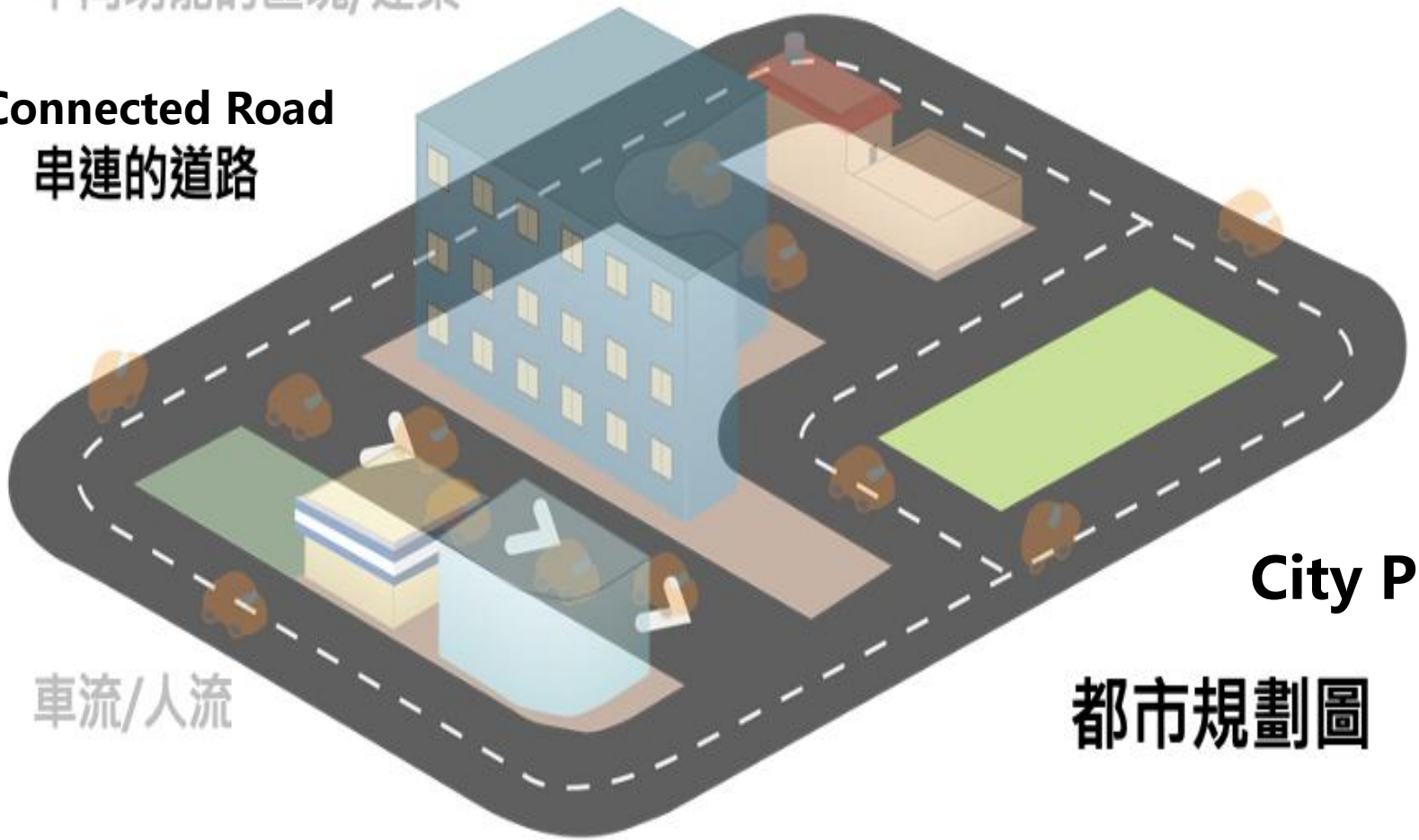


City Plan

都市規劃圖

不同功能的區塊/建築

Connected Road
串連的道路



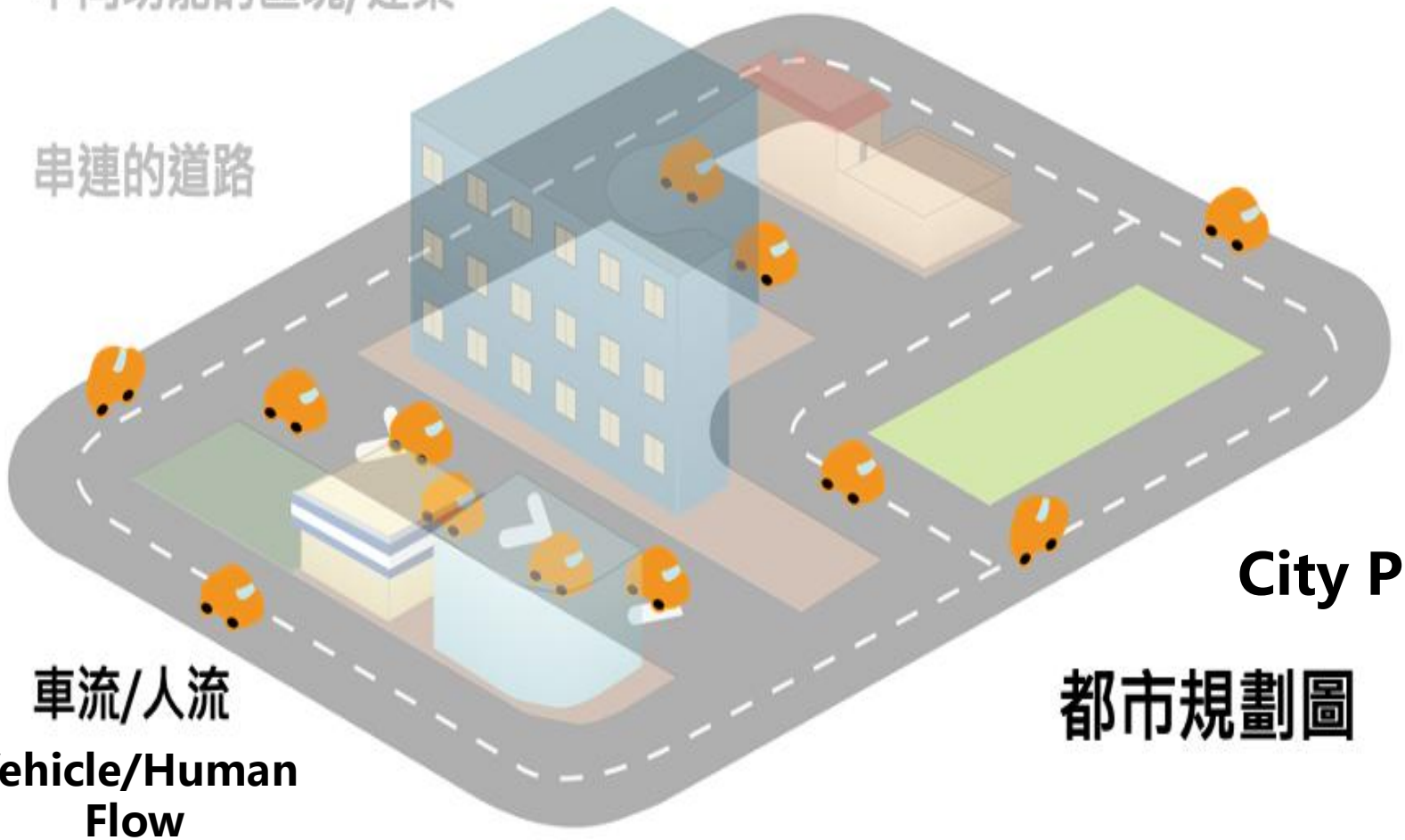
City Plan

都市規劃圖

車流/人流

不同功能的區塊/建築

串連的道路

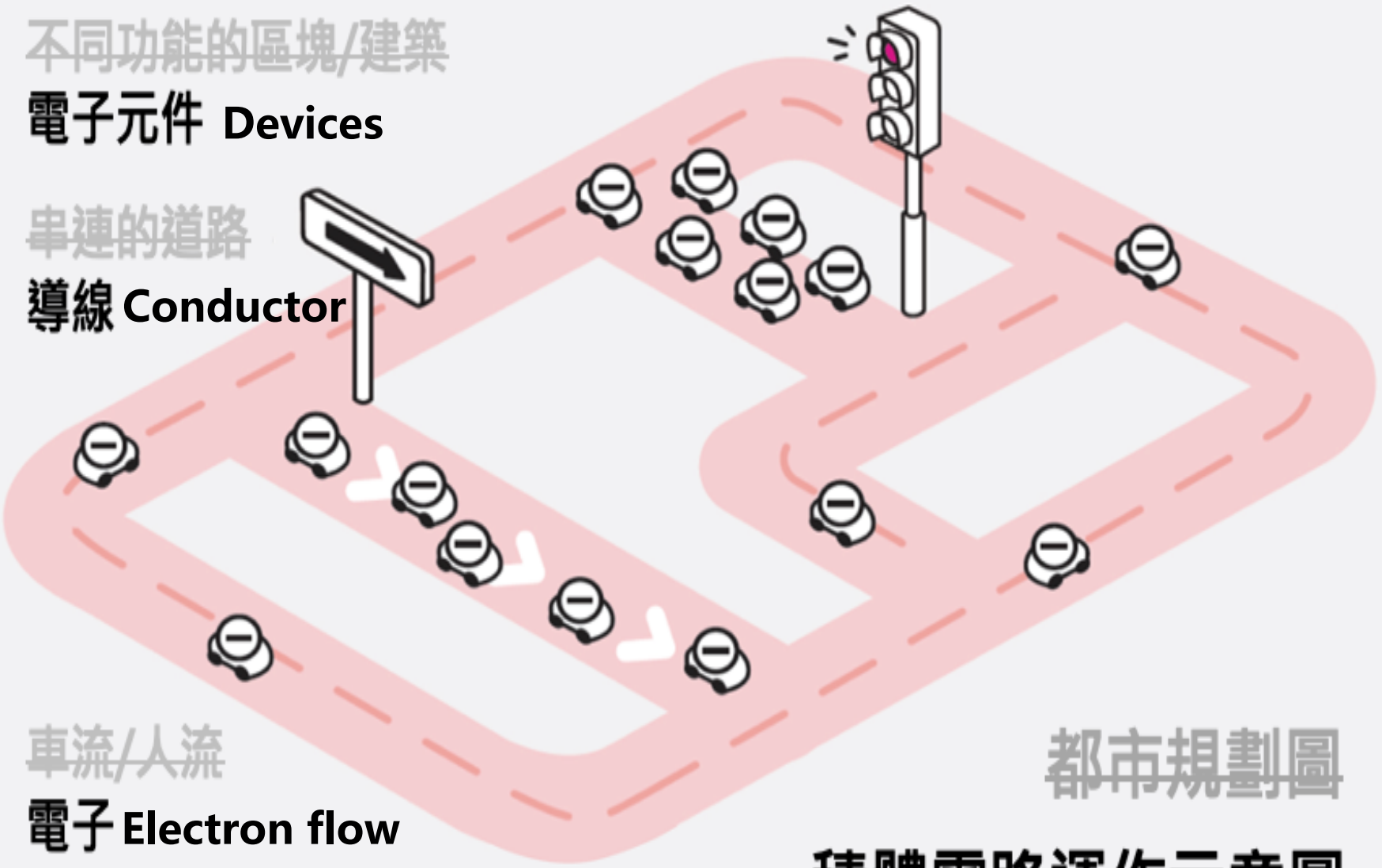


車流/人流

Vehicle/Human Flow

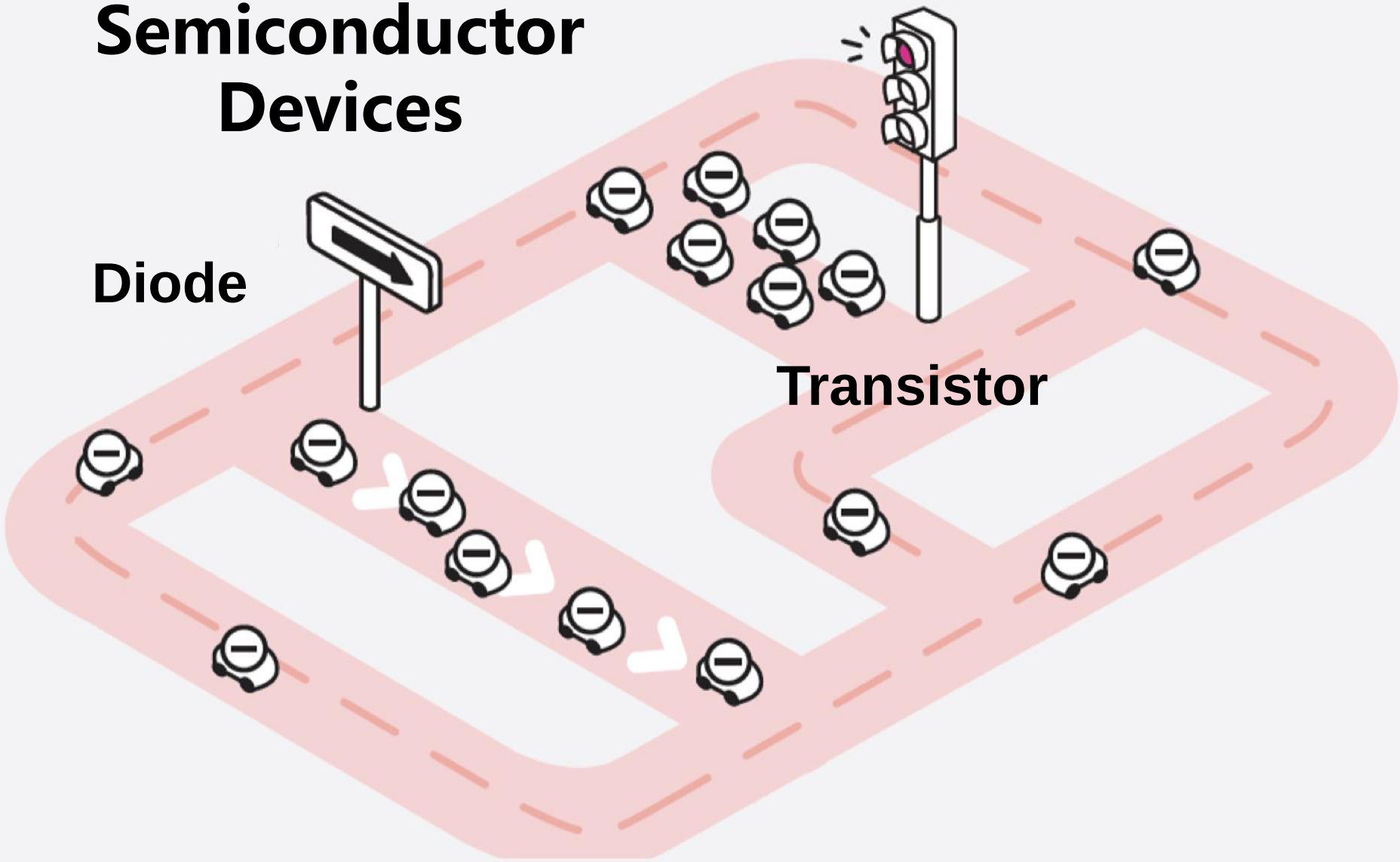
City Plan

都市規劃圖



積體電路運作示意圖
Integrated Circuit

Semiconductor Devices



我們的世界

生活上可知覺的聲音、影像、物體。

Our World

Analog

類比

世界

半導體的世界

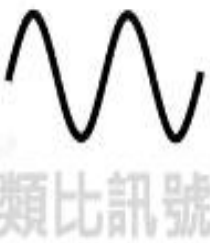
看不見的資訊、訊號之轉換與快速處理。

Semiconductor World

Digital

數位

世界



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數位訊號

接收

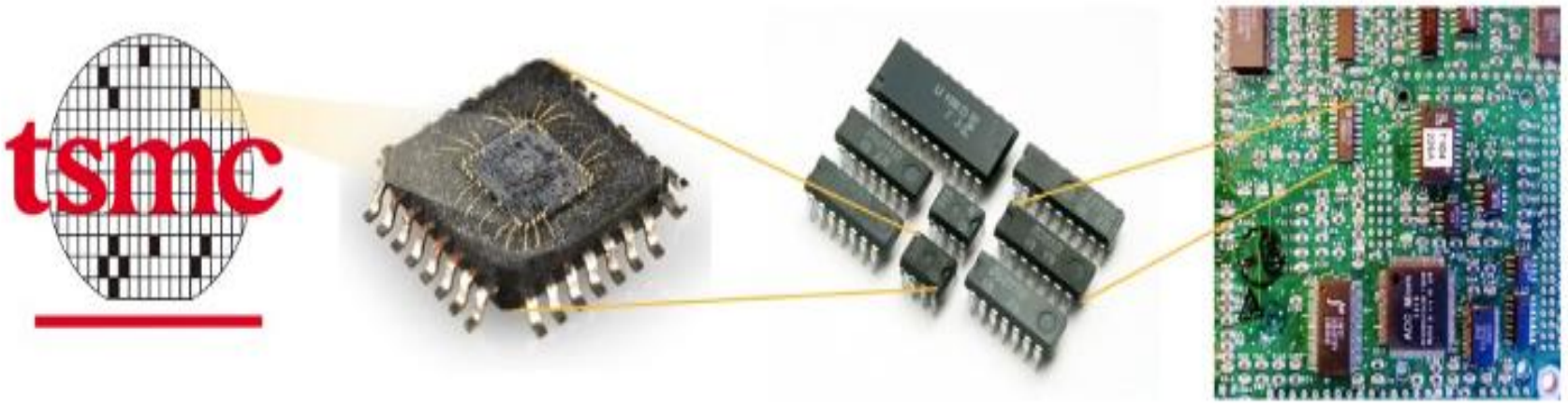
轉換

轉換

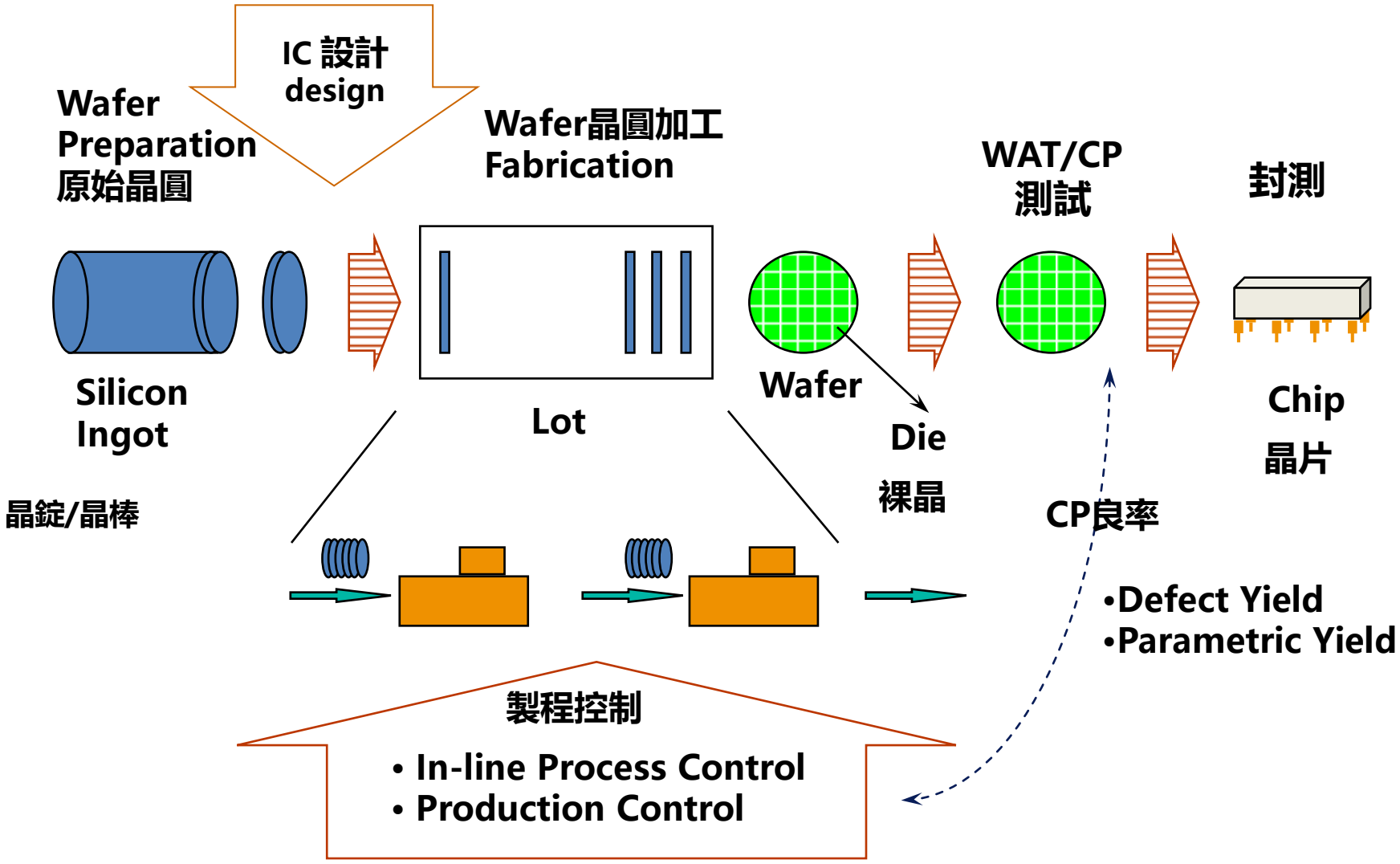
輸出

Circuit Board

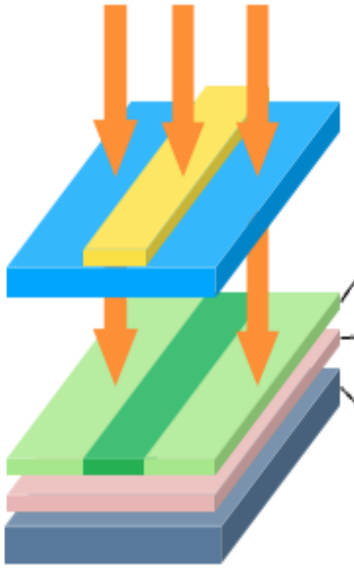
Wafer 晶片 Die 裸晶 IC 電路板



Semiconductor Manufacturing Flow



IC製造



光阻

矽薄膜

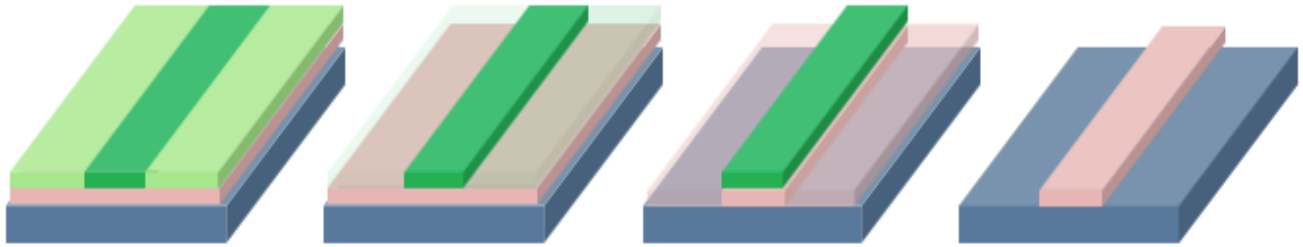
晶圓

4 長膜

5 微影：將光罩的圖案
以光打在光阻上

6

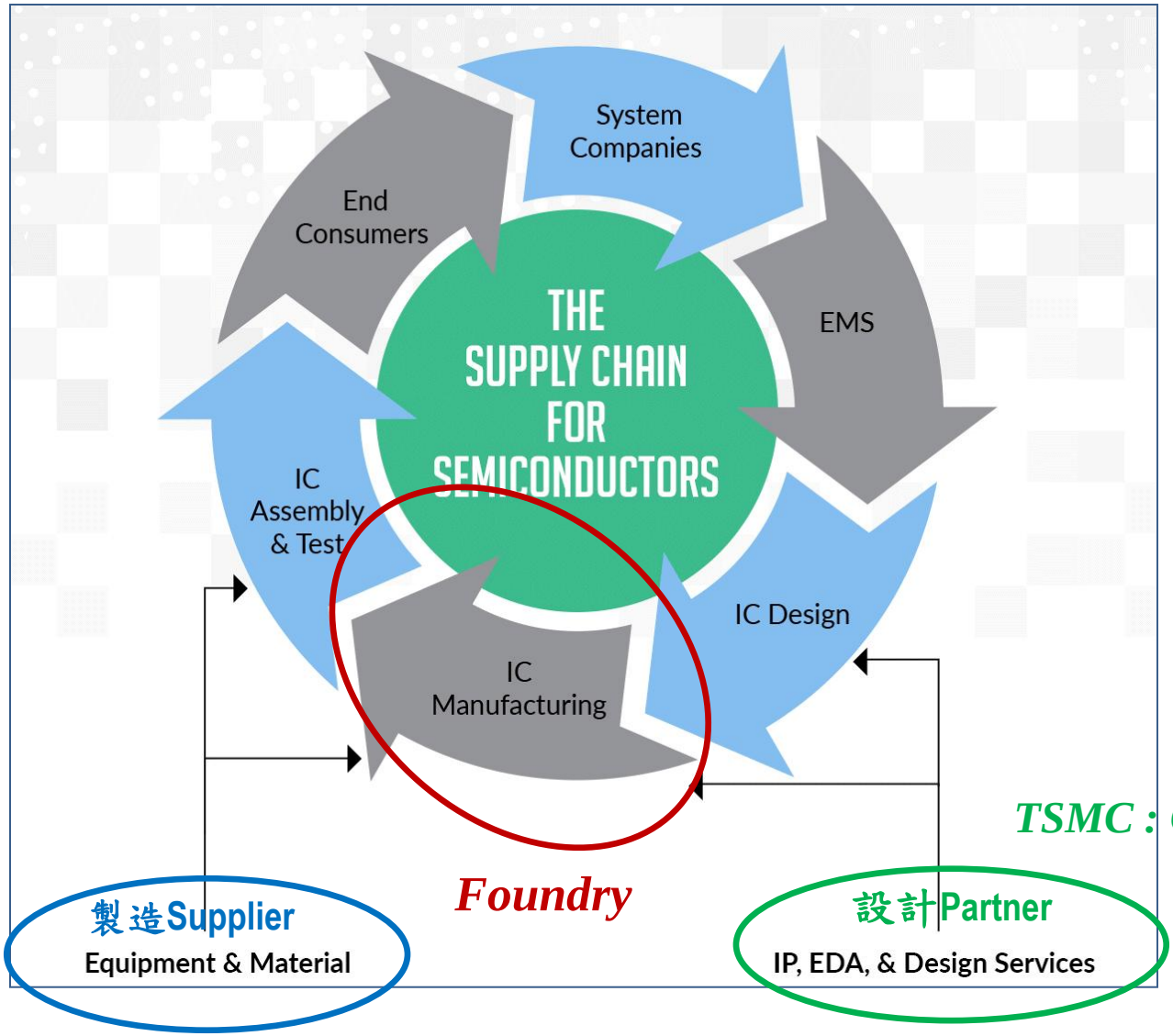
呈影 → 顯影 → 蝕刻 → 剝膜、成形



Semiconductor Industry Innovation

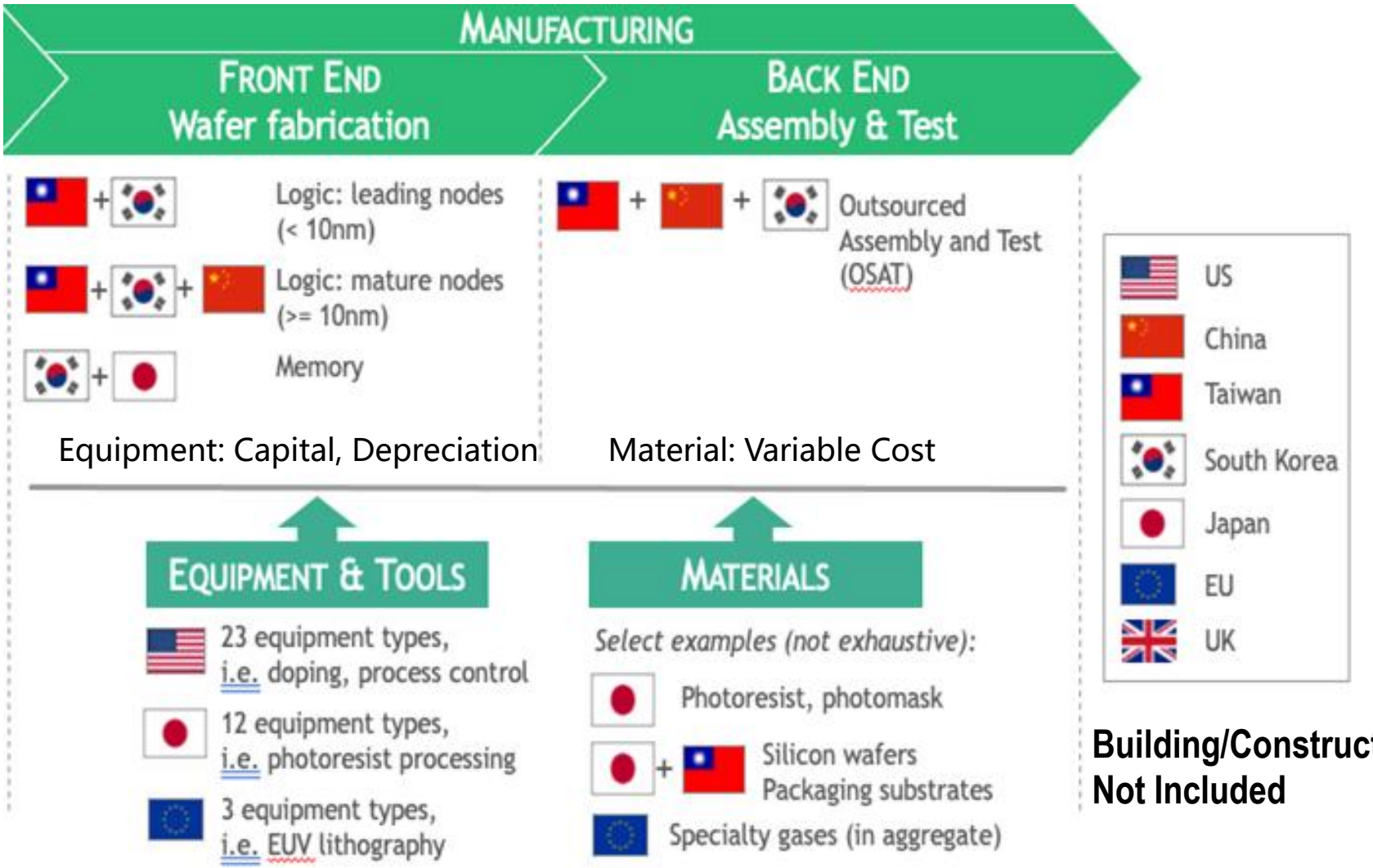
- Basic device innovation: miniaturization of tunable switch device (vacuum tube → transistor)
  - 1956 Nobel Price in Physics: “Invention of the transistor, a small semiconductor device that would change the world” by Bell Labs scientists John Bardeen, Walter Brattain, and William Shockley
- Material & structure evolution
  - IV element: Ge(鍺) → Si (矽), Compound: IV-IV(SiC), III-V(GaP, GaAs,InP...)
  - Al→Cu (130nm), SiO2/Poly-Si→ HigK/Metal Gate(28nm)
  - 2D→3D (FinFET 16nm/GAA 3nm/...)
- Standard & pre-competitive collaboration
  - Moore’s law
  - ITRS(International Technology Roadmap for Semiconductors)
  - JEDEC (Joint Electron Device Engineering Council) Standards
  - SEMI Standards

Semiconductor Supply Chain 半導體供應鏈



https://www.tsmc.com/english/aboutTSMC/dc_infographics_supplychain

Semiconductor Manufacturing Supply Chain



Building/Construction Not Included

https://www.semiconductors.org/strengthening-the-global-semiconductor-supply-chain-in-an-uncertain-era/

IC Design Eco-system Example: TSMC OIP

(TSMC + EDA/IP Partners) Support Customers

https://www.bnext.com.tw/article/62644/tsmc-oip-2021

Taiwan Foundry – When, Where, Who

- When: Timing
  - US manufacturing moved offshore to reduce cost after'90
  - Special stock bonus plan in '90 to maintain low talent cost
  - Foundry/Fabless trend up vs. IDM for logic products after 2006
- Where: Location & Local Eco-system
  - Taiwan government special focus & treatment
  - ITRI founded in1973, spun off UMC 1982, TSMC 1987, VIS 1994
  - **Unique no/low worldwide competition in silicon foundry**
  - **Risk: geo-political effects**
- Who: Talents/Workforce
  - STEM college education: 45%(1997)→32%(2022) of all students, MS/Ph.D. students within STEM: 9%(1997) → 20.8% (2022)
  - Taiwanese international students in US in 1970-90's
    - ✓ trained and developed with major US companies
  - Dominant IC job market in terms of $ compensation

Semiconductor Smart R&D

- Semiconductor Technology RD at the Inflection Point
  - Moore's law roadblock
  - Time-to-Market (TtM) pressures
  - Methodology and infrastructure requirements
- Software and "AI" Enablement
  - Quality time & talents enabled technical depth
  - Domain expert system
- Smart RD under Rigid MFG MES System
  - An interface system btw RD flexibility & MFG rigid MES

Daily Work of an R&D Engineer

- ~40% for handling lot running gates
  - >1000 gates to go through a process route
  - Frequent mid-night calling because the night-shift staffs could not handle the issues
- ~40% for searching and putting data together and did minor analysis
  - Tedious & repetitive tasks
- ~20% for ineffective hurdle meeting
  - Tiredness
  - No time to get the effective information
- Hard manual works lead to stupidity 勤補反拙

Smart RD System

- Simplify & Optimize Work Flow
- Synchronize Data Flow
- Design Principles
  - Hierarchical structures & leverage existing system
  - Unification: Co-design work flow and data flow
  - Modularity: Flexible & modular design under overall framework
  - Centralization: Merge existing systems into one central platform
- Execution
  - By-pass surgery system co-exists with existing system
  - Short-term phase release with cohesive long-term plan

Lessons Learned From Taiwan Semiconductor to Biomedical Industry

- Search for key opportunities of timing, location and talents
- Explore global market with Taiwanese competitive advantages
- Ecosystem: collaborative efforts
- Smart system
- Cross-discipline: science + technology + engineering + AI

Advantages & Disadvantages for Taiwanese Talents

- Advantages
  - Traditional good STEM education
  - Hardware Industry: e.g. semiconductor
  - Hard-working & dedication workers
- Disadvantages
  - Low-value domestic market
  - Too much rely on government (B2G)
  - Innovative characters

Upgrade the Values of Taiwanese Talents

- Top line: uplift the market values
  - Expand to the global market
- Bottom line: enhance the productivity per capital
  - Intelligent work flow and data flow

Prepare for the Unknown Future

- **Be independent 獨立自主, 自信心/企圖心 “I can”, “I will”**
  - Critical thinking, creativity, GRIT
- **Be trustful: trust = (empathy + credibility + reliability) / ego**
  - Communication, collaboration
- **Be productive: work smart, better than work hard**
  - Adopt good tools as a helper, simplify and optimize legacy work flow
- **Beyond test score, “what does it mean to me?” 學與習**
  - Learn-and-practice cycle , problem solving
  - Continuous feedback between inner self and outside world
- **Interdisciplinary talents are required “from I to T” 跨領域**
  - STEAM & social/business skills

Summary

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