Integrated circuit A and B

Microelectronics Research Lab. (MeRL)

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0.1 Course information

LSIs designed in MeRL
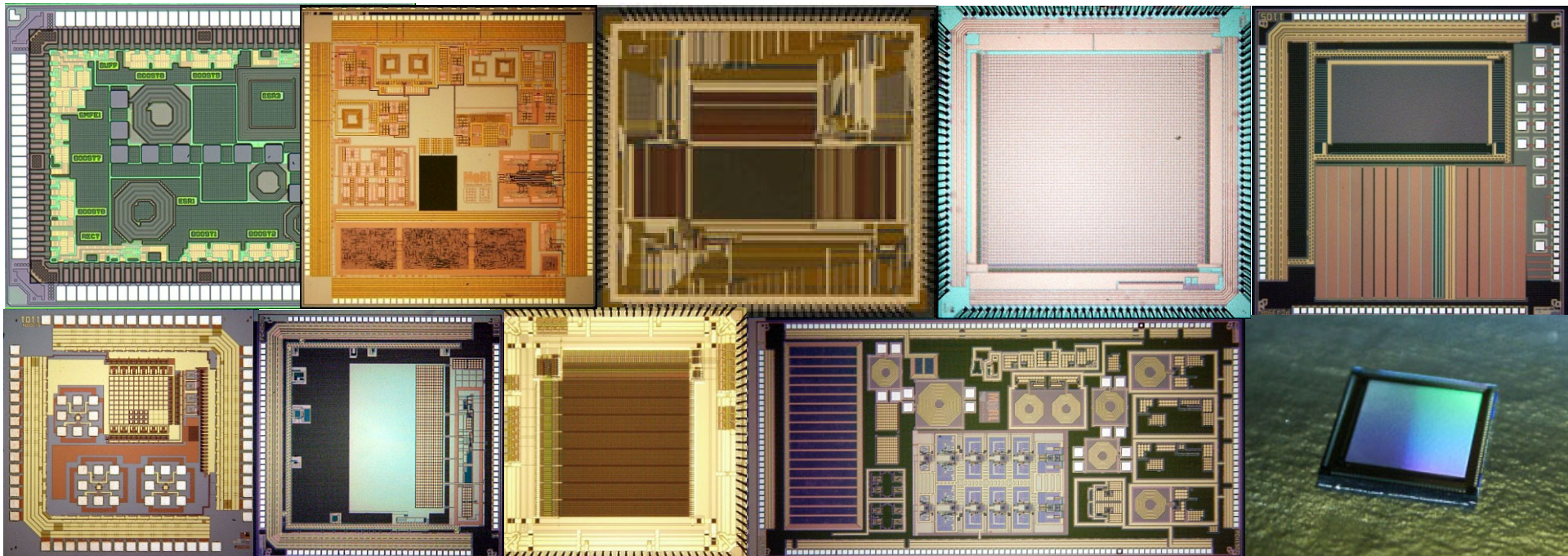

Energy harvester

UHF transceiver

Resistive memory

Particle sensor

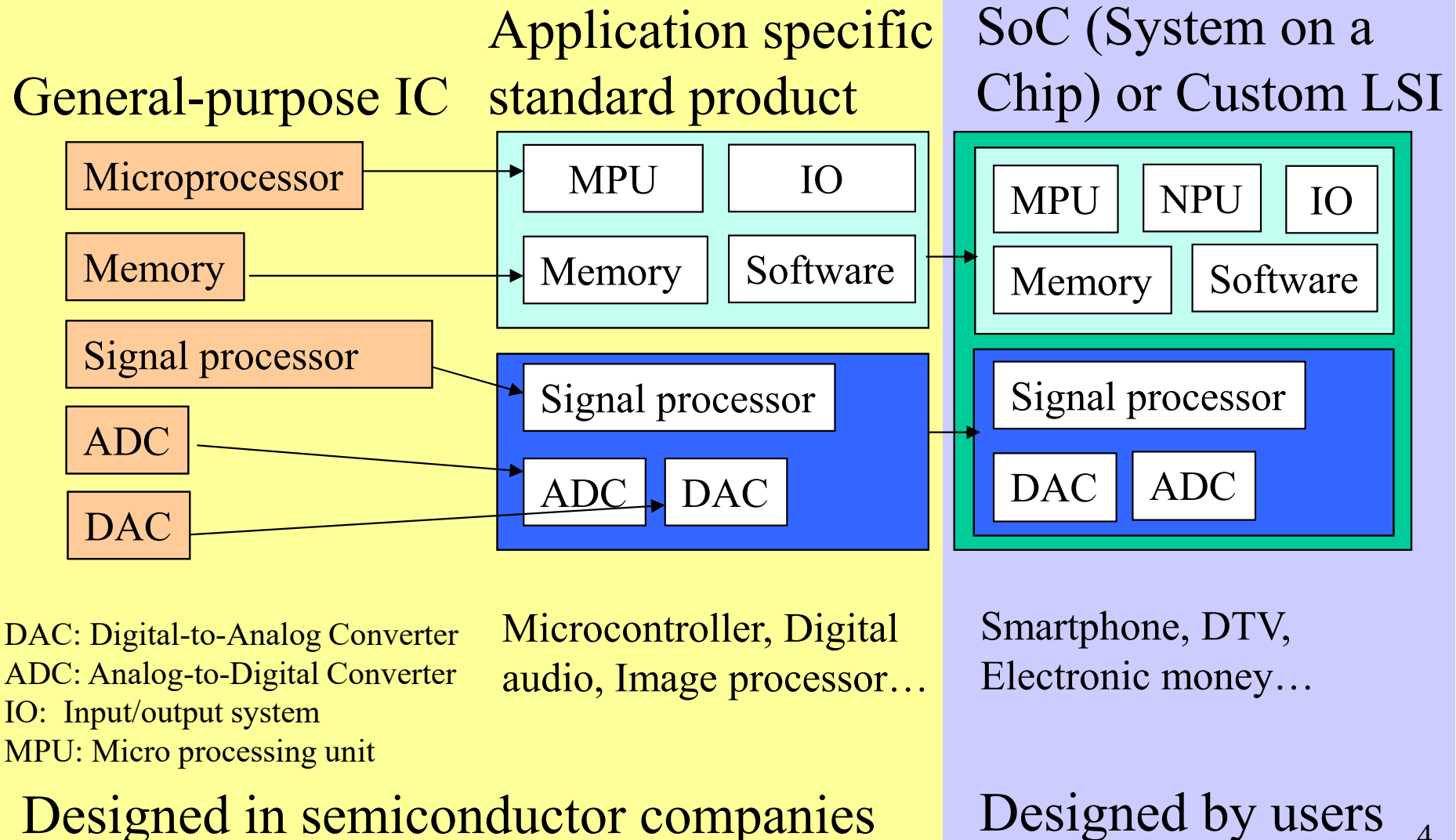Color sensor

Tactile sensor

Phase change memory
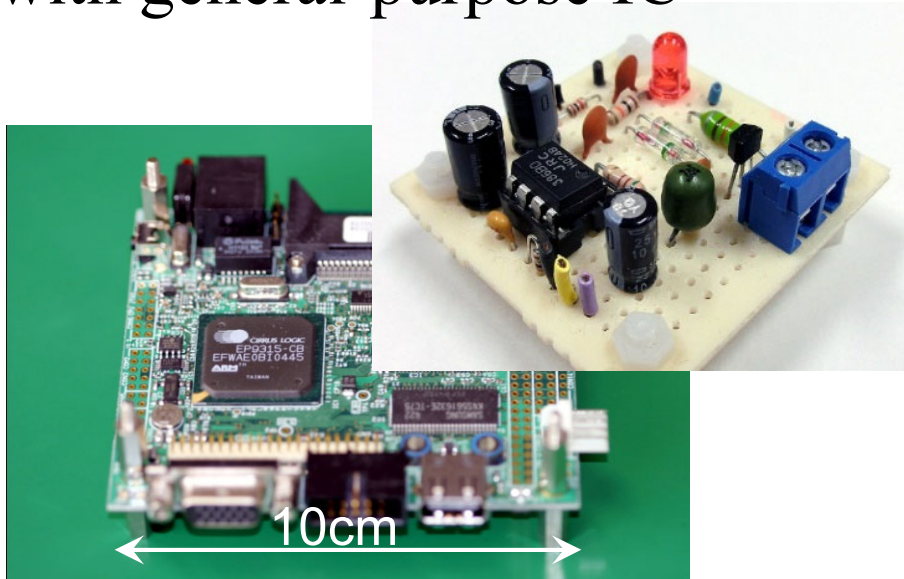
Micro-display

Sensor RF-ID

Dual band transceiver

LSI (Large Scale Integration): The terms of LSI and VLSI are synonyms terms of IC.   3

Integration of functions

General-purpose IC

| Microprocessor |
| Memory |
| Signal processor |
| ADC |
| DAC |

Application specific standard product

| MPU | IO |
| Memory | Software |

| Signal processor | |
| ADC | DAC |

SoC (System on a Chip) or Custom LSI

| MPU | NPU | IO |
| Memory | Software | |

| Signal processor | |
| DAC | ADC |

DAC: Digital-to-Analog Converter
ADC: Analog-to-Digital Converter
IO: Input/output system
MPU: Micro processing unit

Microcontroller, Digital audio, Image processor…

Smartphone, DTV, Electronic money…

Designed in semiconductor companies

Designed by users

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Advantages of custom LSI

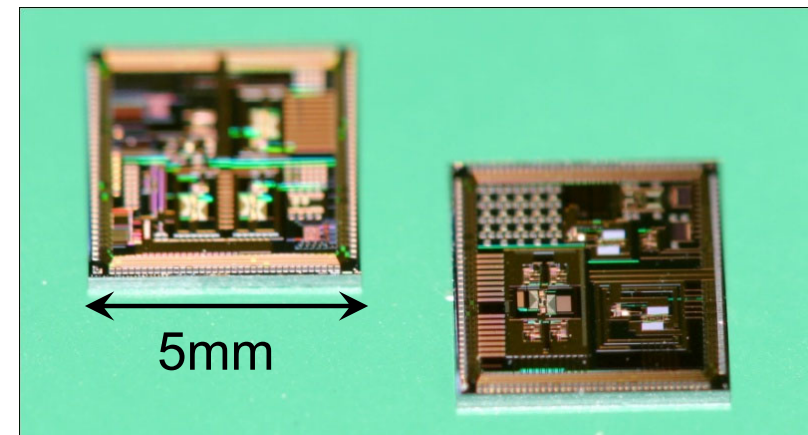PCB (Printed Circuit Board)
with general-purpose IC

Custom LSI

10cm

5mm

Speed < 50MHz
Number of wires < 1000
Low flexibility of design
Short TAT*
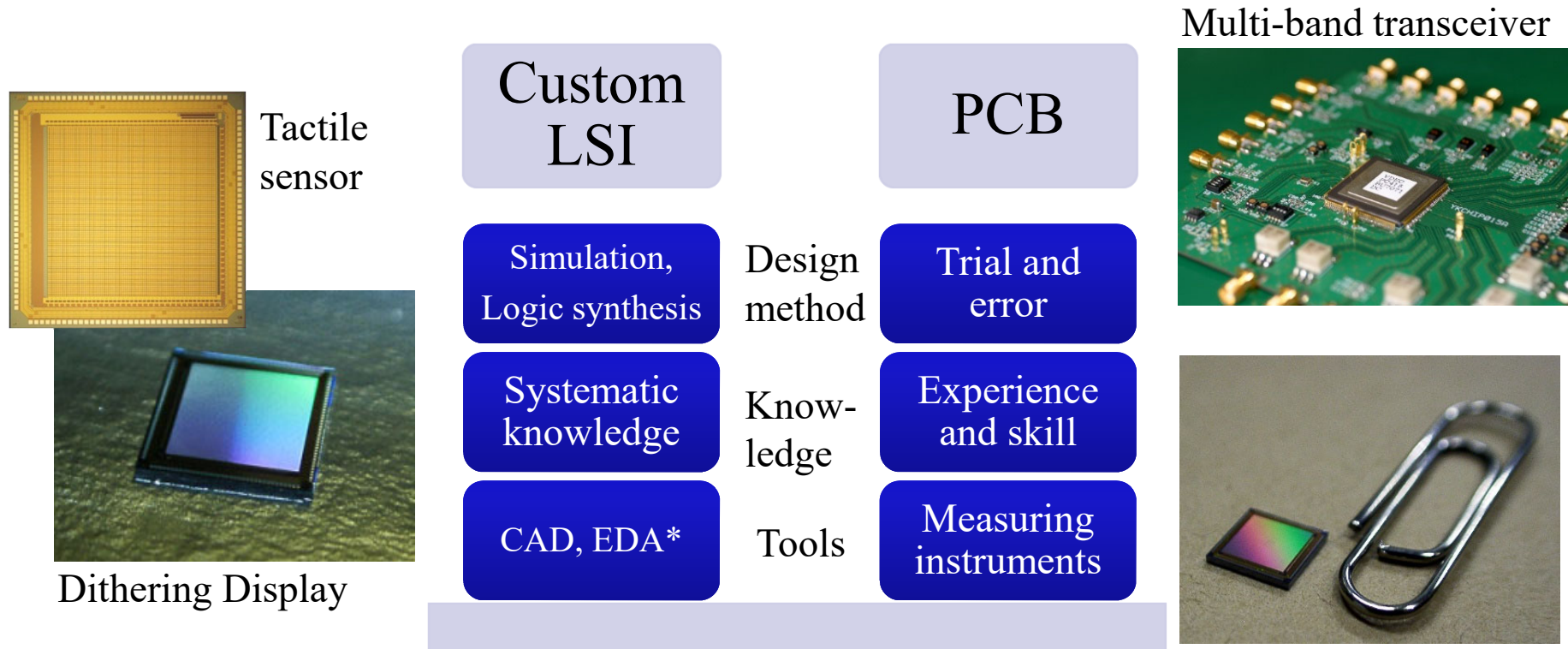
Speed > 100GHz
Number of wires ~ Unlimited
High flexibility of design
Long TAT*

* TAT (Tern around Time) = Work period

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Comparison of design process

Tactile sensor

Dithering Display

Multi-band transceiver

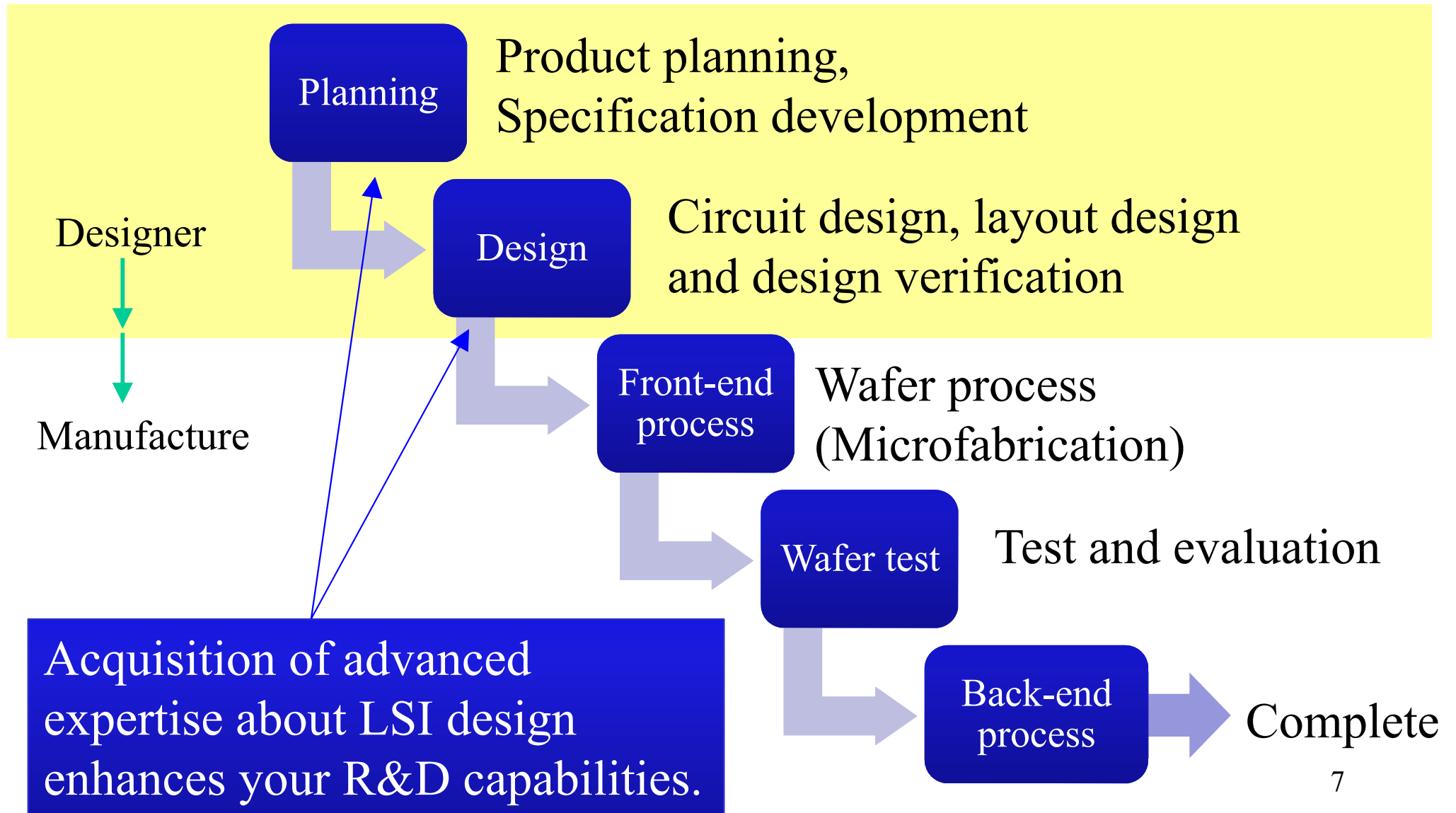| Custom LSI		PCB
Simulation, Logic synthesis	Design method	Trial and error
Systematic knowledge	Know-ledge	Experience and skill
CAD, EDA*	Tools	Measuring instruments

You can use the knowledge that you learn in college.
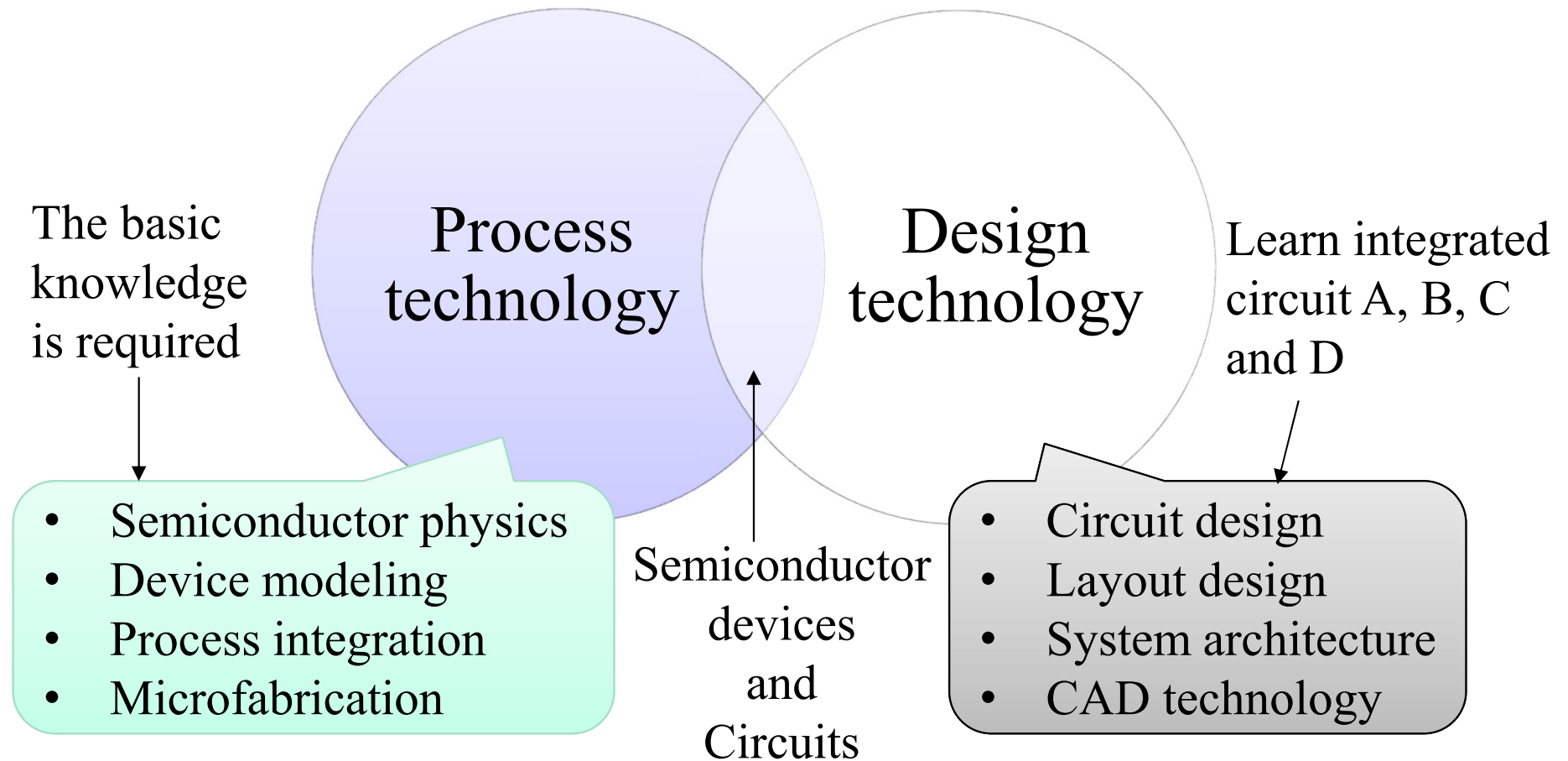
Accumulated know-how is required.

* CAD: Computer Aided Design, EDA: Electronic Design Automation

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Modern LSI development process

Planning — Product planning, Specification development

Designer
↓
Manufacture

Design — Circuit design, layout design and design verification

Front-end process — Wafer process (Microfabrication)

Wafer test — Test and evaluation

Back-end process → Complete

Acquisition of advanced expertise about LSI design enhances your R&D capabilities.

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Academic framework of Microelectronics

Process technology

Design technology

The basic knowledge is required

- Semiconductor physics
- Device modeling
- Process integration
- Microfabrication

Semiconductor devices and Circuits

Learn integrated circuit A, B, C and D

- Circuit design
- Layout design
- System architecture
- CAD technology

Curriculum of LSI design course

4th grade, Spring

VLSI Design & Practice A

- HDL*
- Design of microprocessor

3rd grade, Autumn

Integrated circuit C and D

- Hardware algorithm
- Technology Trends

3rd grade, Spring

Integrated circuit A and B

- Process technology
- Circuit design
- Layout design
- Scaling rule

* Hardware description language
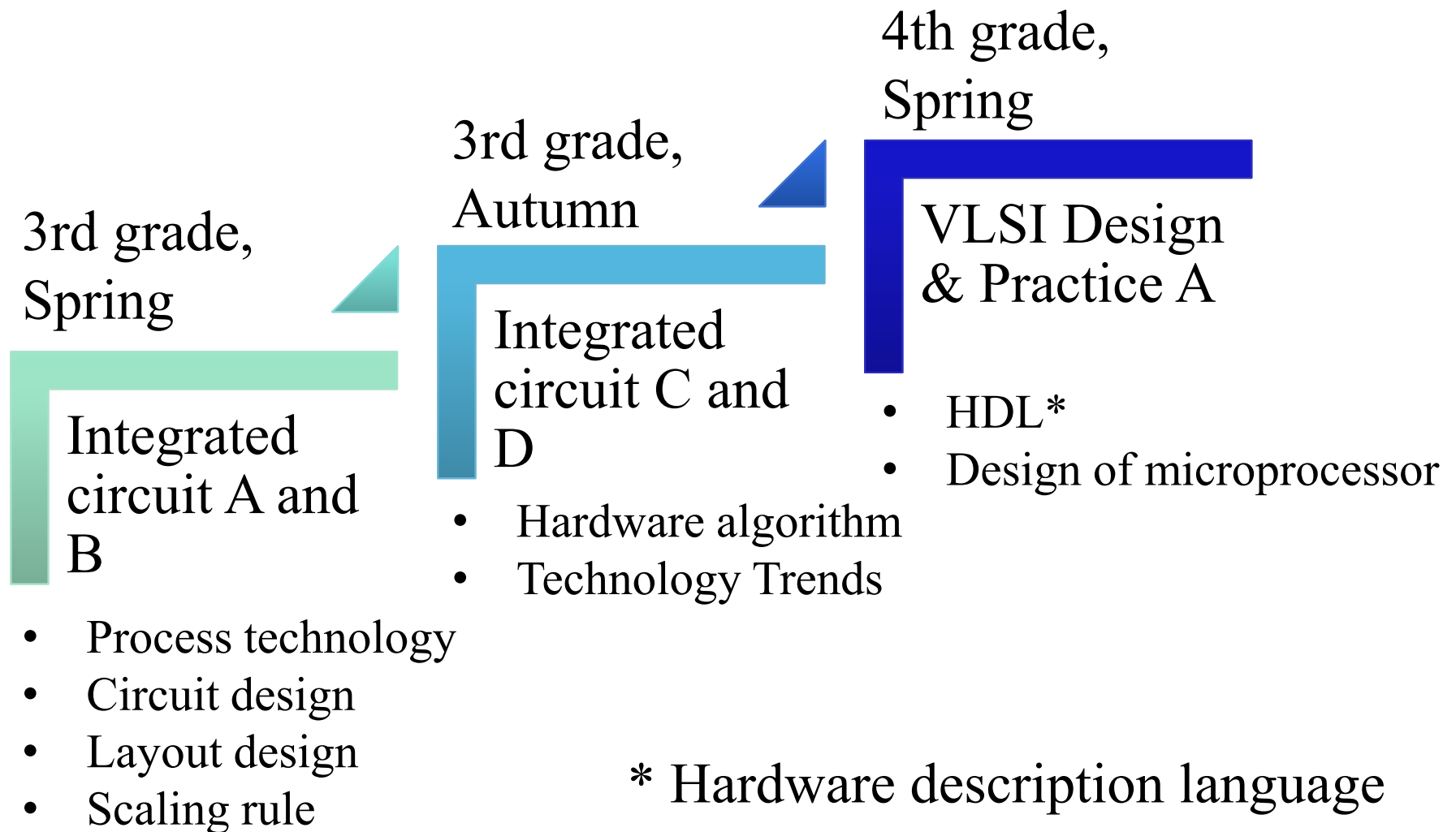
Vicissitude of LSI designers

1970s

Expert of circuits

Circuit design engineers of a semiconductor industry

General-purpose LSI

1990s

System architect

Hardware designers of embedded systems in semiconductor industry

System LSI (SoC)

2010s

LSI user

System designers who can design LSI (outside of semiconductor industry)

Custom LSI

A broader range of knowledge is required with the generation.

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Hierarchical design of LSI

Abstraction level	Design target	Description method
System level (H/W and S/W)	**System architecture** **Software/Hardware partitioning** **Communication protocol** **Embedded software**	**High-level programming language** **SystemC** **SystemVerilog**
Sub-system level (CPU, Memory, Arithmetic unit , and so on)	**Hardware algorithm** **Software interface** **Communication interface**	**Flowchart** **State Transition Diagram** **Behavior level HDL** **Logic circuit, Schematic circuit**
Gate level	**Logic function**	**Logic circuit, Truth table** **State Transition Diagram** **Structure level HDL**
Transistor level	**Logic gate, RF circuit, Clock circuit**	**Schematic circuit** **SPICE netlist**
Physical level (Layout)	**Cell library, Circuit block**	**Layout diagram (GDS-II)**

Course objectives

- ## Contents
  - Design of CMOS (*) logic and transistor circuit
    - You might think you did not have to learn the design of the transistor circuits, because you could use the logic synthesis to design the logic circuits. However, you must learn the principle of the transistor circuits to understand how to use the electronic design automation tools.

      * CMOS: Complementary Metal-Oxide-Semiconductor
  - Estimation of the performance of CMOS logic, such as an operating speed, a power consumption.

- ## Students will be able to
  - design the CMOS combinational logic and the CMOS sequential logic
  - understand the design flow and required CAD software
  - understand the method of the layout design
  - estimate the performance of the CMOS logic
  - understand the scaling rule and the scaling effect

References

- Book
  - ウエスト＆ハリス著「CMOS VLSI回路設計（基礎編）」(丸善出版) ISBN978-4-621-08721-3

- Course materials
  - Download from
    http://jaco.ec.t.kanazawa-u.ac.jp/edu/

- Recommended reading
  - よくわかる!半導体 2012年版 (ICガイドブック) 社団法人電子情報技術産業協会編（古本を探す必要あり）
  - 西久保靖彦著, 図解入門よくわかる最新半導体の基本と仕組み[第2版]（秀和システム）

Course policy

1. Download the lecture slide on the web site shown in the previous page.

2. The course is provided by face-to-face classes.

3. If you have a question in the preparation and the review, send it by email or post the question to the timeline of WebClass (Click the icon of a pen.)

4. Submit the assignment by the deadline.

   – Academic misconduct and scholastic dishonesty such as a plagiarizing or cheating on examinations can be assigned a penalty based on the university regulations.

Grading

- ## Grading policies
    - Final exam (60%) , Assignments (40%)
    - Attendance at special lecture is mandatory.
    - In the final exam, you may refer to any book, notebook, and handouts.
    - The scores of your report taken will become invalidated, if you are late to submit the report.
        - However, even if the submission is delayed, it will be treated as a legitimate submission, when you can prove that you are not responsible. For example, an illness, an official event.

- ## Make-up exam
    - The make-up exam will be carried out, if you cannot take the final exam due to unavoidable circumstances.

- ## Study for an examination
    - Your note and annotation in every class will be helpful in your review and studying for the exam. The course materials is incomplete for the self-learning.

Q & A

- During class
  - Feel free anytime in the class.
- Office hours
  - 5th period on Wednesday
  - Request for an appointment.
- Timeline on WebClass
  - For questions about the lecture.
- Email
  - For questions about your grading, attendance.
  - kitagawa@merl.jp