Concept Engineering Mixed-Technology Systems

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2024-12-19

Table of contents

List of Figures

List of Tables

Unsyllabus

Name	Description
Course	M 1.9 Concept Engineering Mixed-Technology Systems (CEMS)
Term	Winter 2024/25
Instructor	Prof. Dr.-Ing. M. Meiners, Dipl.-Ing. (FH) T. Ziemann

Part I.

Lecture

1. Introduction and Survey

1.1. Course Objectives

- Interfacing Microsystems
  - Mixed-technology systems (System-on-Chip, SoC)
  - System analysis
  - System specification
- Design Methodology
  - Seamlessly modeling and design over all physical domains
- PCB (System) and IC Design
  - Architecture
  - Partitioning
  - Layout

1.2. Scientific Computing

- Python (Anaconda)
- Matlab (Campus Lizenz)
- Command-line tools

1.3. EDA Tools

- PCB / System Design
  - LTspice
  - KiCad EDA
  - Altium Designer
  - SiemensEDA PCB tools
  - cadence System Design & Analysis
- IC / Silicon Design

  - IIC-OSIC-TOOLS (open-source)
  - SiemensEDA IC tools
  - cadence IC Design & Verification
  - synopsys silicon design (IC)

1.4. OS-Tools

- Microsoft-Terminal
- Microsoft-PowerShell
- MacOS-Terminal
- Linux/MacOS Shell zsh-tools,
- git (Versionskontrolle)

1.5. Code Editors

- Visual Studio Code
- Spyder IDE
- Thonny (Micro-)Python IDE
- Emacs
- Vim

1.6. Data Science

- File system: Files and directories
- Tabular data: Comma/Tab-Separated-Values (CSV/TSV), Spreadsheet (.xlsx, .ods)
- Special formats, e.g. MATLAB mat, HDF5
- Embedded Databases
  - SQL, z.B. SQlite
  - OLAP, z.B. DuckDB

1.7. Publish Computational Content

- Jupyter-Book
- quarto
  - Manuscripts

1.8. Are you writing or TeXing?

- MikTeX (Windows, MacOS, Linux)
- MacTeX (MacOS)
- TeXLive (Linux)

1.9. LaTeX Editors

- IDE's
  - TeXStudio
  - TeXMaker
- Collaborative Frameworks
  - Overleaf, Online LaTeX
  - CoCalc - Online LaTeX

1.10. Bibliography and LaTeX

- Citavi im Detail > Titel exportieren > Export nach BibTeX
- RefWorks - Library Guide Univ. Melbourne
- Benutzerdefinierte BibTex-Keys mit Zotero | nerdpause
- JabRef - Library Guide Univ. Melbourne
- EndNote - Library Guide Univ. Melbourne

1.11. Design Project

Model-Based Systems Engineering of an Inertial Sensor System (MBSE).

- System level, behavioural model
  - Matlab/Simulink,
  - Python
  - HDL (Verilog-ams, VHDL-AMS)
- Circuit level, SPICE with behavioural blocks, e.g. OTA and comparator
- PCB level
  - ESP8266 NodeMCU,
  - TIs ADS1115,
  - ADs ADXL335
- IC level
- **Final Oral Exam/Project Presentation**

1.12. Course Prerequisites

- Fundamentals of linux operating systems
- Fundamentals of microelectronics
  - Device physics and models
  - Transistor level analog circuits, elementary gain stages
- Fundamentals of analog circuit design
  - Operational amplifier
  - Active filter design
  - Noise analysis
  - Switched-capacitor techniques
- Prior exposure to SPICE, Matlab, Python or equivalent.

1.13. Brave New World

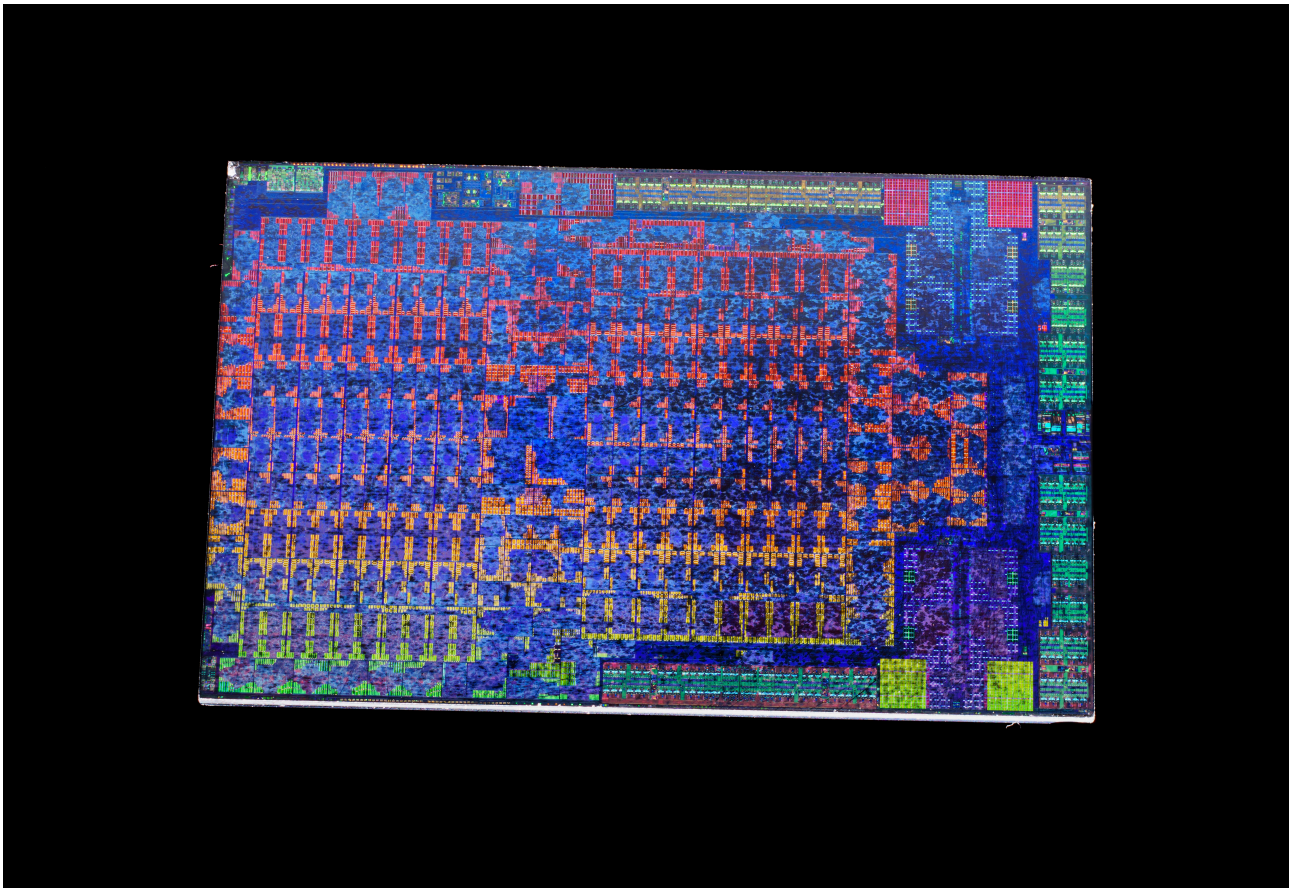


Figure 1.1.: AMD Jaguar APU (CPU/GPU), 16 nm, 325 sqmm, 2016

1.14. From Sand to Silicon (Infineon, Dresden)

https://youtu.be/bor0qLifjz4?list=PLO_wT97BGA6xC6hNy9VGtt1bKwVuQXI5B

1.15. Sand to Silicon (GlobalFoundries, Desden)

https://www.youtube.com/embed/UvluuAIiA50?list=PLO_wT97BGA6xC6hNy9VGtt1bKwVuQXI5B

1.16. FinFET (Intel)

https://www.youtube.com/embed/_VMYPLXnd7E

1.17. TSMC Fab (Next Gen 7/5 nm)

https://www.youtube.com/embed/Hb1WDxSoSec

1.18. Once upon a time ...

Figure 1.2.: 1906 Electron Tube

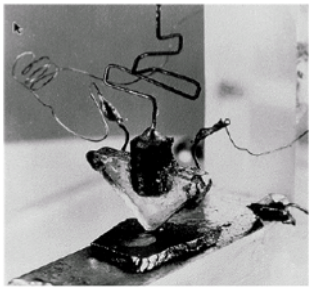


Figure 1.3.: 1947 1st Transistor, Bell Labs

1.19. First IC and today's chips

Figure 1.4.: 1958 Jack Kilby's 1st IC

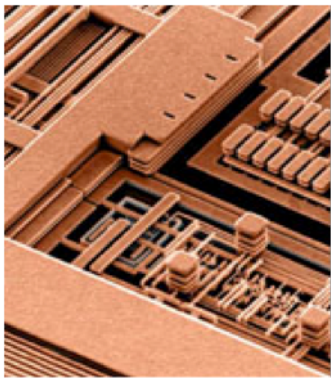


Figure 1.5.: Modern IC

1.20. Packaging Densities

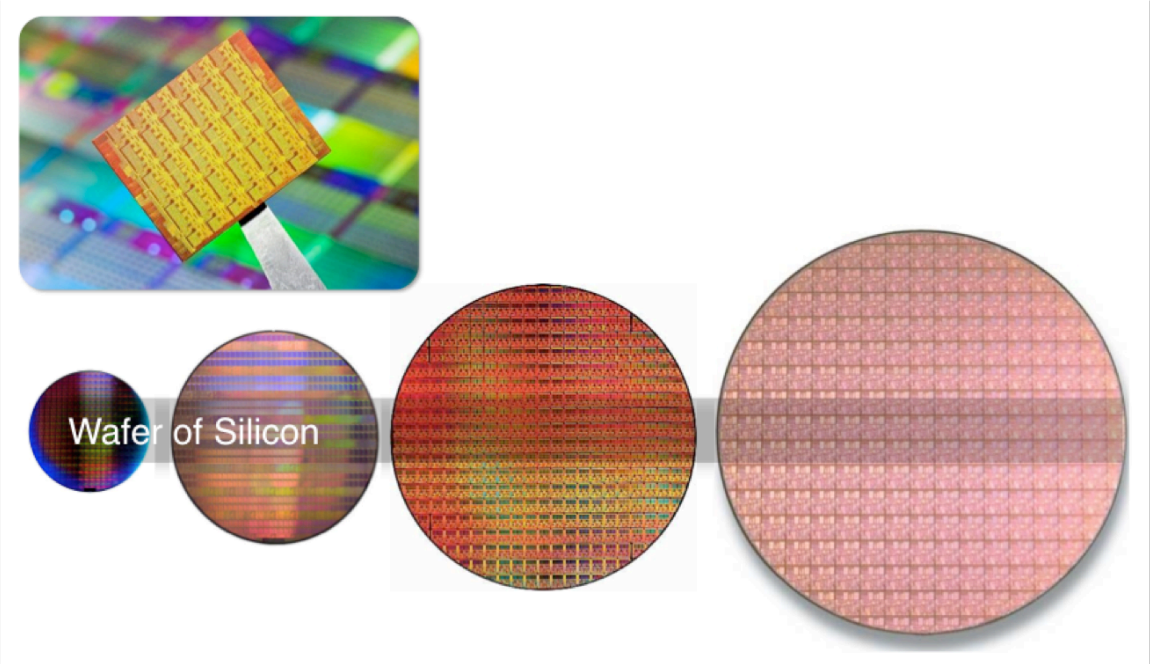
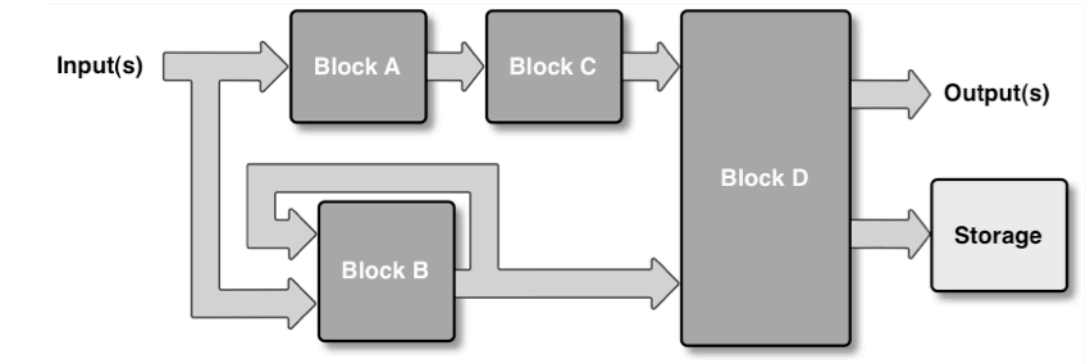


Figure 1.6.: Wafer generations

1.21. Moore's Law

https://www.youtube.com/embed/basGrfRDqts?list=PLO_wT97BGA6xC6hNy9VGtt1bKwVuQXI5B

1.22. System Hierarchy



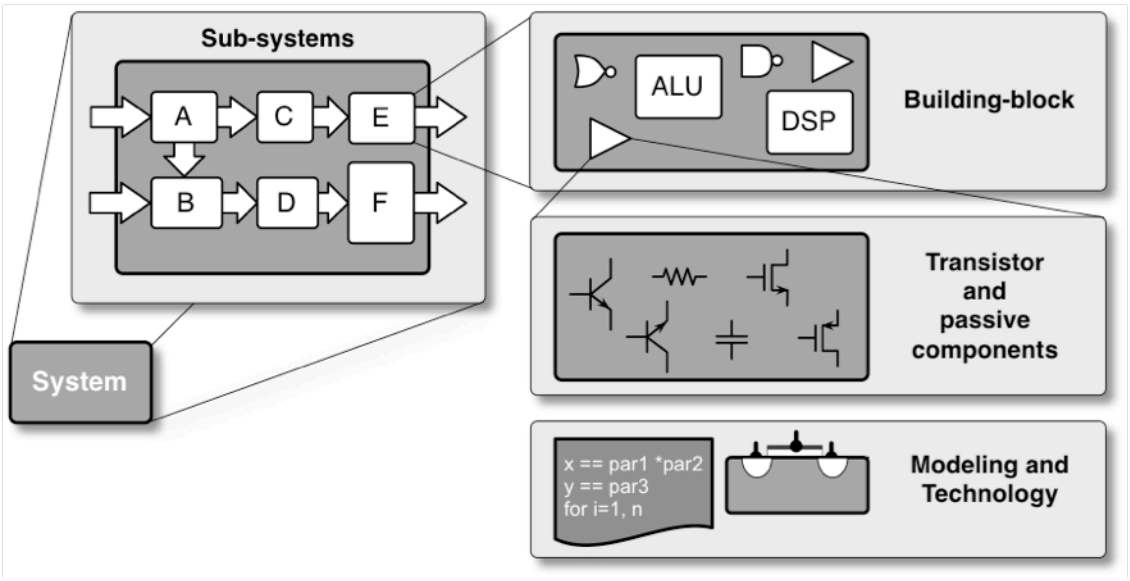


Figure 1.7.: Blocks of an electronic system.

- Use hierarchy to describe complex systems

- Devide and conquer

1.23. System Assembly

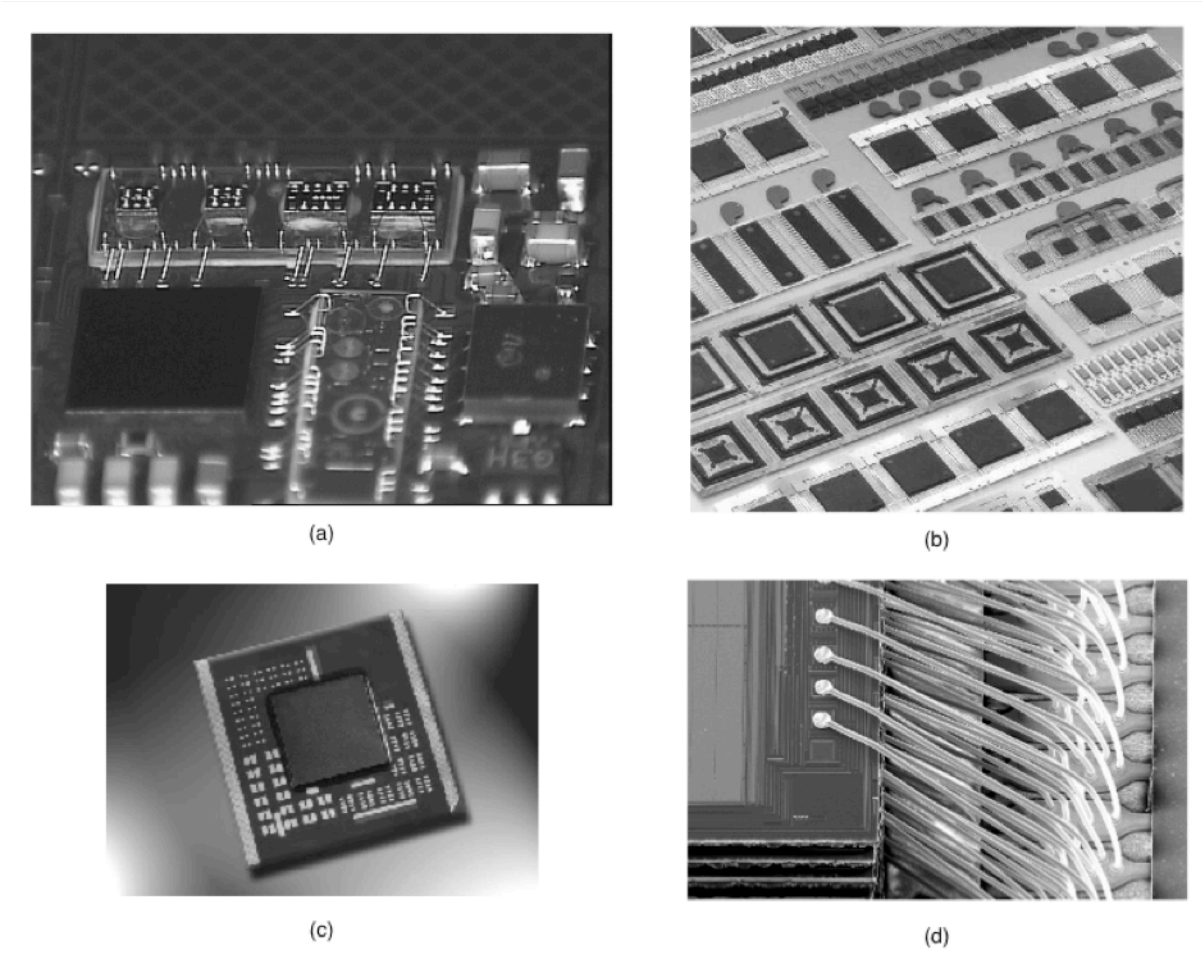


Figure 1.8.: Bottom-up Prozess, Integration.

1.24. Interfacing

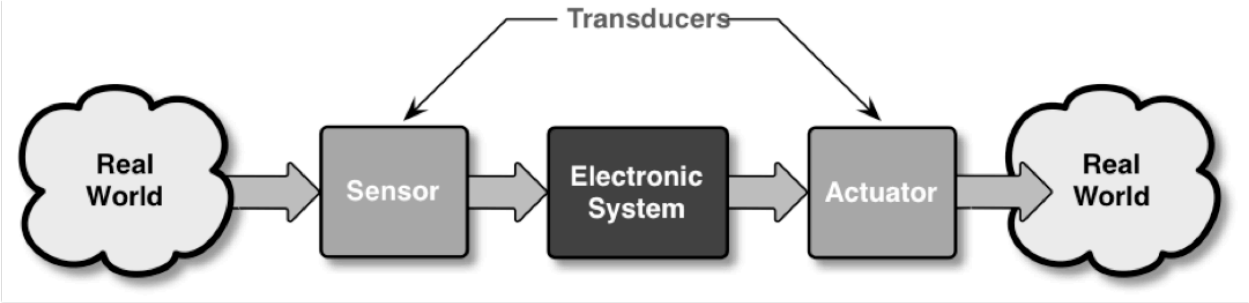


Figure 1.9.: Interfacing.

1.25. Meeting a System (1)

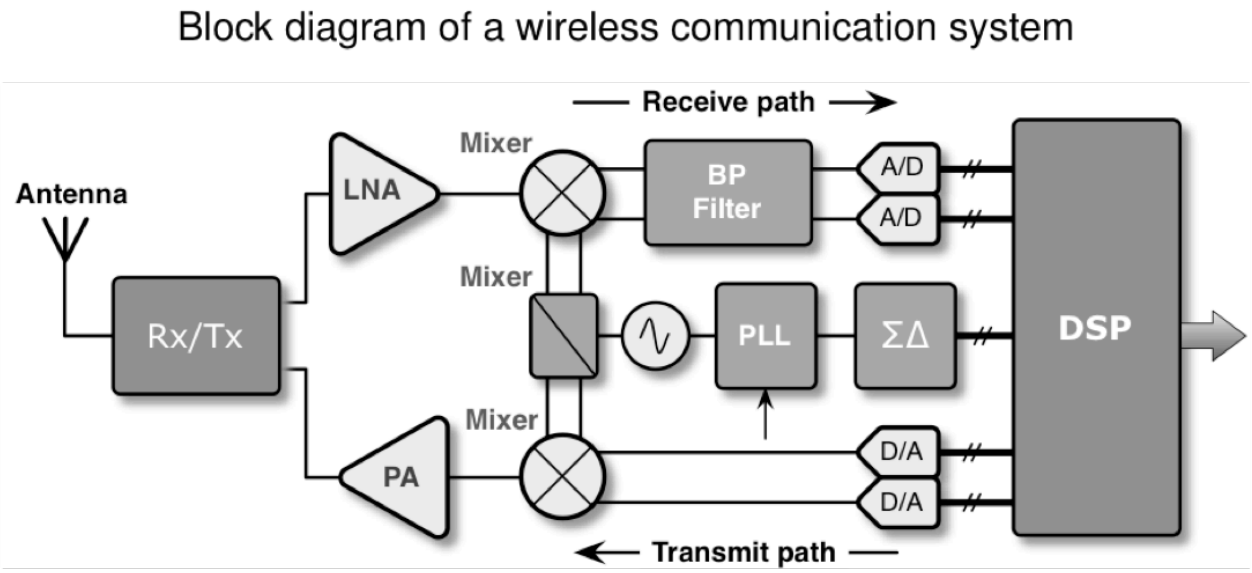
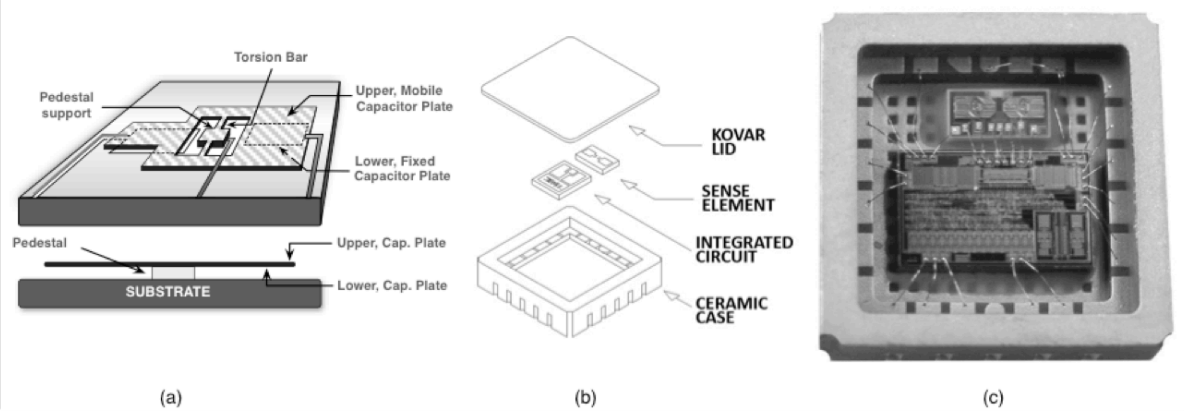


Figure 1.10.: Wireless Communication System.

1.26. System in a Package (SiP)



(a) Micro structure of an accelerometer.

(b) Assembling diagram of the system-on- package.

(c) Microphotograph. (*Courtesy of Silicon Designs, Inc.*).

Figure 1.11.: Accelerometer.

1.27. You will become an expert

Indicators.

- Background Knowledge
  - System Knowledge, Architecture, Processing, Implementation
- Subconscious Knowledge
  - Memorized experiences of success stories and dead ends
- Special Knowledge
  - Dicipline related knowledge, e.g. physics, hardware, software
- Teamwork
  - Communication abilities, reporting and presentation
- Creativity
- Tool-Knowlege

1.28. Views on Hardware

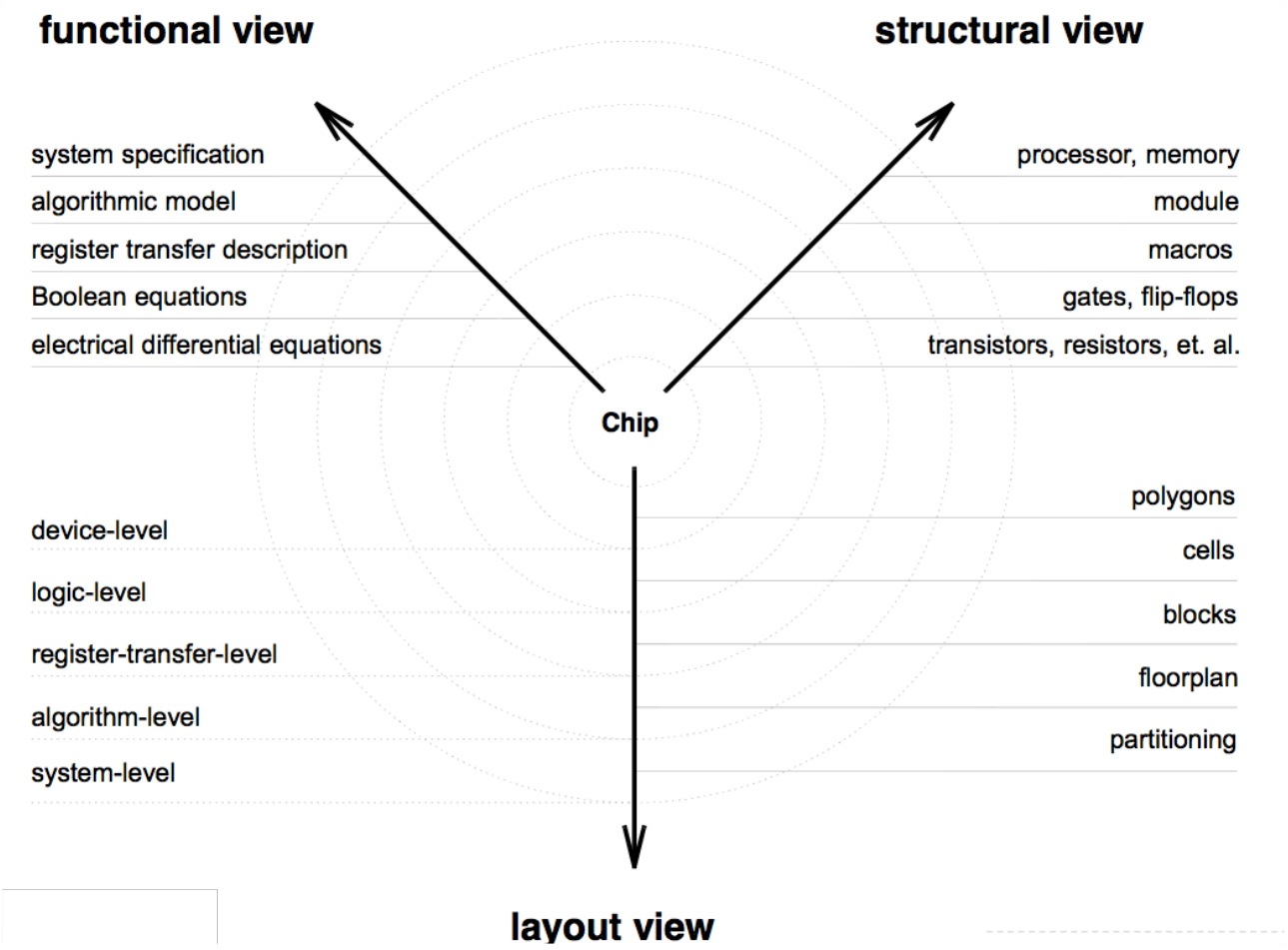


Figure 1.12.: (c) M. Ortmanns, Univ. Ulm.

1.29. Sustainable Electronics ...

https://www.youtube.com/embed/7S5IuaKiZIY

1.30. Why it is worth ...

https://www.youtube.com/embed/SwPGxwBZw6I

1.31. Let's go to the beach ...

https://www.youtube.com/embed/ekkJlQf-K4I

Part II.

Lab

2. MBSE and Design of an Inertial Sensor System

2.1. Design Project

- System level, behavioural model
  - Matlab/Simulink,
  - Python
  - HDL (Verilog-ams, VHDL-AMS)
- Circuit level, SPICE with behavioural blocks, e.g. OTA and comparator
- PCB level
  - ESP8266 NodeMCU,
  - TIs ADS1115,
  - ADs ADXL335
- IC level

2.2. Design Project Flow

- Literature research in journals, professional (serious) internet forums (e.g. application notes of semiconductor companies) and library
- Set-up bibliography, e.g. JabRef, Citavi
- Concept of your system
  - Partitioning
  - Functions
  - Work packages
- Design, implementation and validation
  - Mathmatical description, e.g. Matlab/Simulink model
  - SPICE modeling and simulation, LTspice circuit
  - Data analysis and validation, Serial monitor