EE2026 Digital Design

INTRODUCTION

Massimo ALIOTO
Dept of Electrical and Computer Engineering
Email: massimo.alioto@nus.edu.sg

Get to know the latest silicon system breakthroughs from our labs in 1-minute video demos

Explore | Follow | Discover more | What's happening | Stay tuned | Be connected | Communicate

Instructors

- **Massimo ALIOTO (Part 1)**
  - Email: massimo.alioto@nus.edu.sg
  - Office: E4-05-24

- **Dingjuan CHUA (Part 2)**
  - Email: elechuad@nus.edu.sg
  - Office: E1-08-02

- **Tutors and Teaching Assistants**
  - see EE2026 webpage on CANVAS

Course Introduction

Contents

- **Part 1**
  - Number systems
  - Hardware Description Languages: Verilog
  - Boolean Algebra and logic gates
  - Gate-level design and minimization + Verilog
  - Combinational logic circuits and design + Verilog

- **Part 2**
  - Sequential logic circuits + Verilog
  - Combining combinational/sequential building blocks + Verilog
  - Finite State Machines+ Verilog

Course Description

- First course on digital systems
- Introduces fundamental digital logic, digital circuits, and programmable devices
- The course also provides an overview of computer systems
- This course provides students with an understanding of the building blocks of modern digital systems and methods of designing, simulating and realizing such systems
- The emphasis of this module is on understanding the fundamentals of **digital design across different levels of abstraction** using Hardware Description Languages
- Developing valuable design skills for the design of digital systems through FPGAs and state-of-the-art CAD tools, as required by the job market (**exciting projects**)

Course Organization – Part I (refer to CANVAS)

Week	Lab (E4-03-06 Digital Electronics Lab)	Lecture (LT7A / LT6)	Tutorial
WK 1		✓	
WK 2	(B01 Friday Session one week ahead)	✓	Tutorial – 1
WK 3	**Lab 1**	✓	Tutorial – 2
WK 4	**Lab 2**	✓	Tutorial – 3
WK 5		✓	Tutorial – 4
WK 6	**Lab 3**	**Mid-Semester Quiz**	
Recess Week			

Course Organization – Part II (refer to CANVAS)

Week	Lab	Lecture	Tutorial
WK 7	Project 1	✓	Tutorial – 5
WK 8	Project 2	✓	Tutorial – 6
WK 9	Project 3	✓	Tutorial – 7
WK 10			Tutorial – 8
WK 11	**Verilog Evaluation**		
WK 12		**Final Quiz**	
WK 13	**Project Assessment and Demo**		

Course Assessment

Component	Assessment Weight
Quizzes	**Total 40%**
○ Mid-Term Quiz	20%
○ Weekly Canvas Quizzes	5%
○ Final Quiz	15%
Labs	**Total 30%**
○ Lab Assignment 1	3%
○ Lab Assignment 2	5%
○ Lab Assignment 3	10%
○ Verilog Evaluation	12%
Design Project – Team Work	**Total 30%**
○ Project basic features (specified) ○ Enhanced features (open-ended)	30%

No final exam ☺

Further Information on Support and Readings

Course materials

- CANVAS (everything about the course)

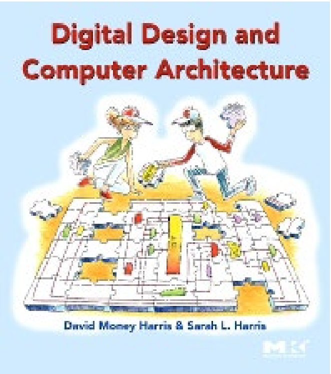
Help and clarifications

- Discussion Forum under CANVAS (preferred)
- Tutors (tutorial questions)
- GAs during lab sessions (labs and projects)
- Face-to-face consultation with lecturer(s)
  - by appointment, to be taken over email or at the end of each lecture
  - date/time of the appointment announced on CANVAS, so that anyone can join

Reference book (download from NUS library)

D. Harris, S. Harris, Digital Design and Computer Architecture

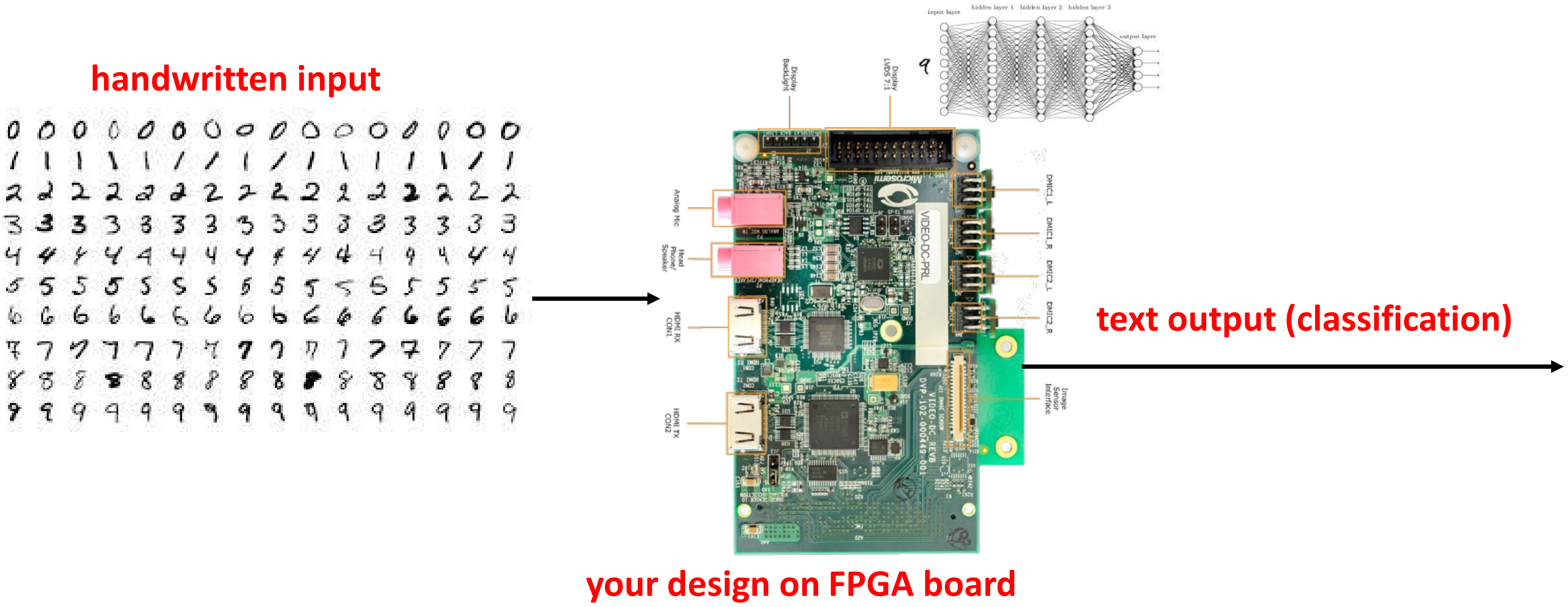
(1st ed.), Morgan Kaufmann, 2007



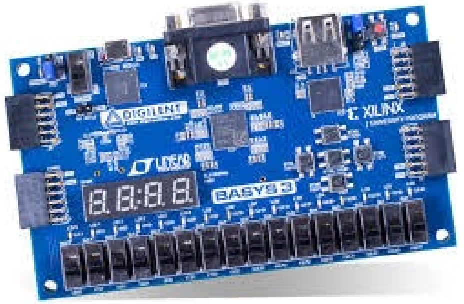
What WE Will Accomplish in EE2026

Think & Do: strong foundations, real-world design

- Highly industry-relevant project
- This year: machine learning and human-machine interfaces (neural network accelerator for digit recognition – MNIST)



What WE Will Accomplish in EE2026



- EE2026 is a hands-on module
  $\rightarrow$ significant lab and project time / components
- Software : Xilinx Vivado 2018.2
- Referring to installation instructions provided on Canvas, please install the software by end of Week 3
- Unfortunately, this software is not supported on Mac operating systems (only Windows / Linux)
- If you have difficulties accessing a windows-based system, PC Cluster access is available. Details on Canvas Pages $\rightarrow$ EE2026 - PC Cluster Access for Mac Users
- Project will be done in groups of 4, students are to be from same lab group.

Some Industry Context

- Design skills in very high demand
  - FPGA designer (startups, SMEs, MNCs) and semiconductor industry

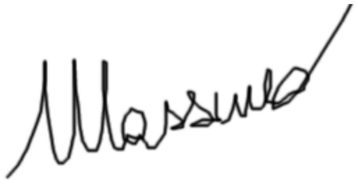
AND SO ON AND SO FORTH…

  - Not capital intensive: create YOUR OWN technology/company

Setting the Tone Right…

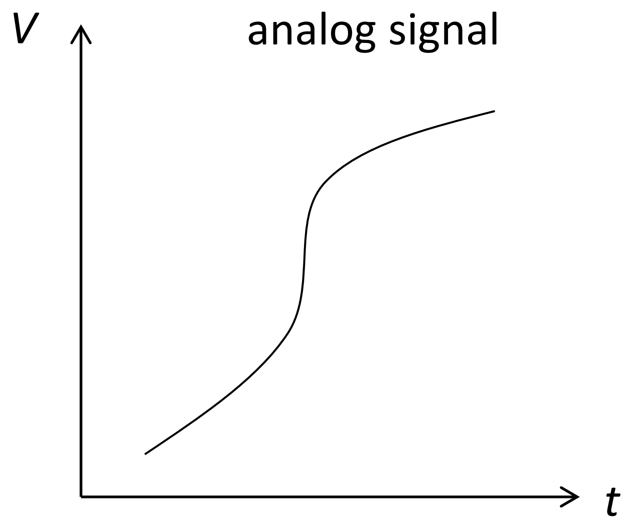
MOTIVATION: WHY ARE WE DOING THIS?

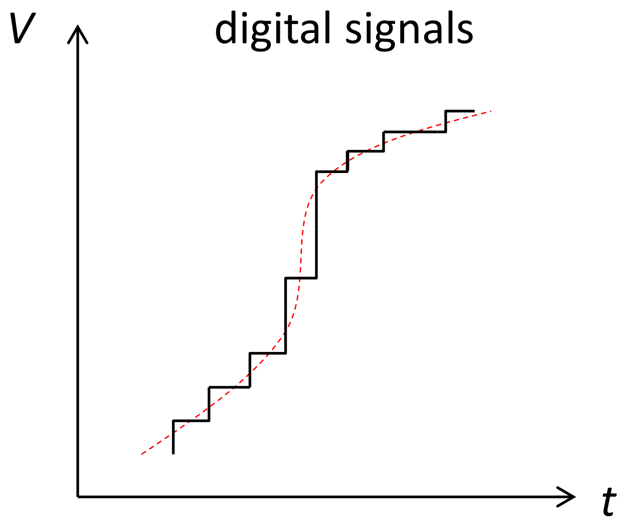
IMPACT: WHAT CAN YOU DO WITH YOUR KNOWLEDGE?



Analog vs. Digital Circuits

- Analog circuits deal with continuous signals
- Digital circuits deal with discrete signals (discrete levels)

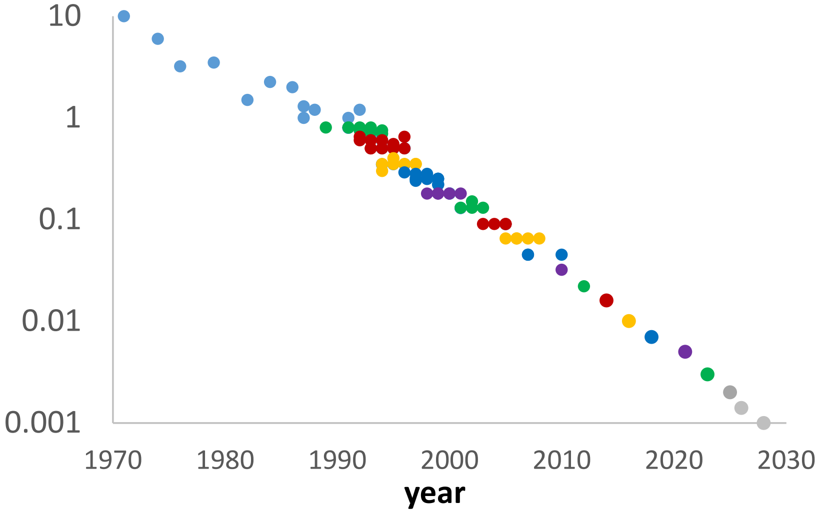




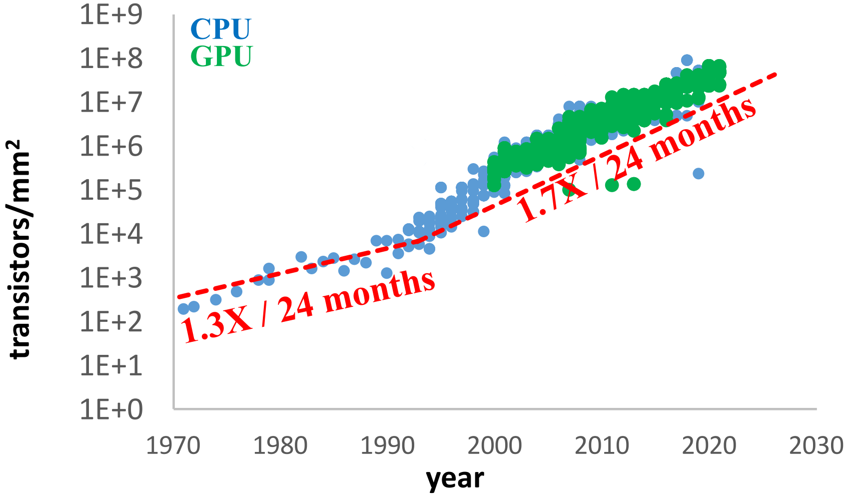
- Advantages of digital signal processing
    - Robustness (reliability), programmability, scalability (integrated circuit technology), cost

Digital Circuits Fueled by Exponential Advances

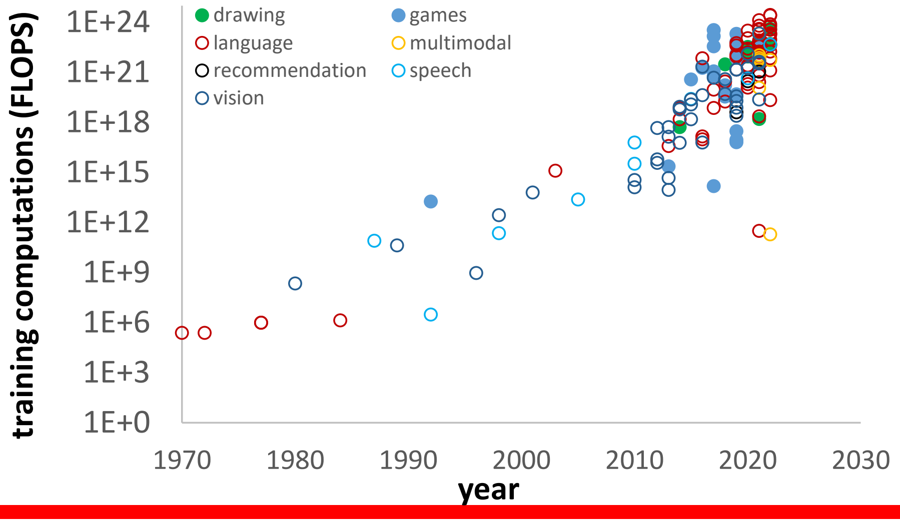
Transistor minimum feature size (µm)



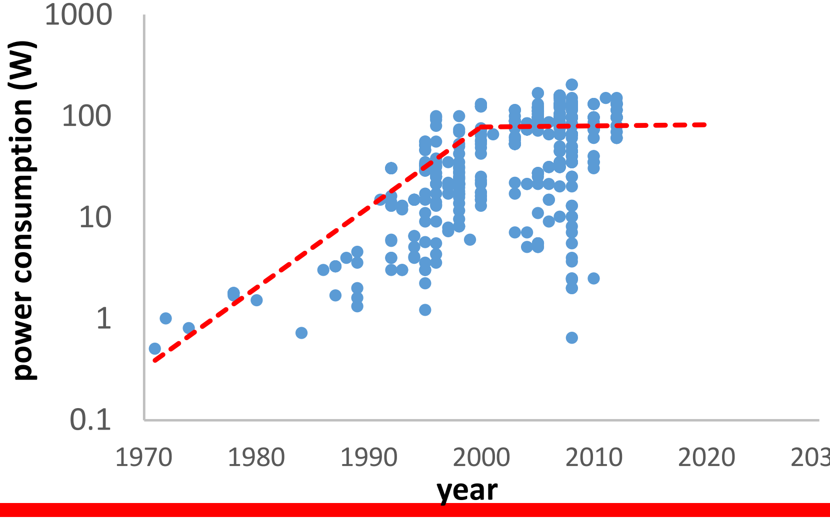
Transistors per unit area (Moore's law)



AI training computational capability



Power consumption as a challenge

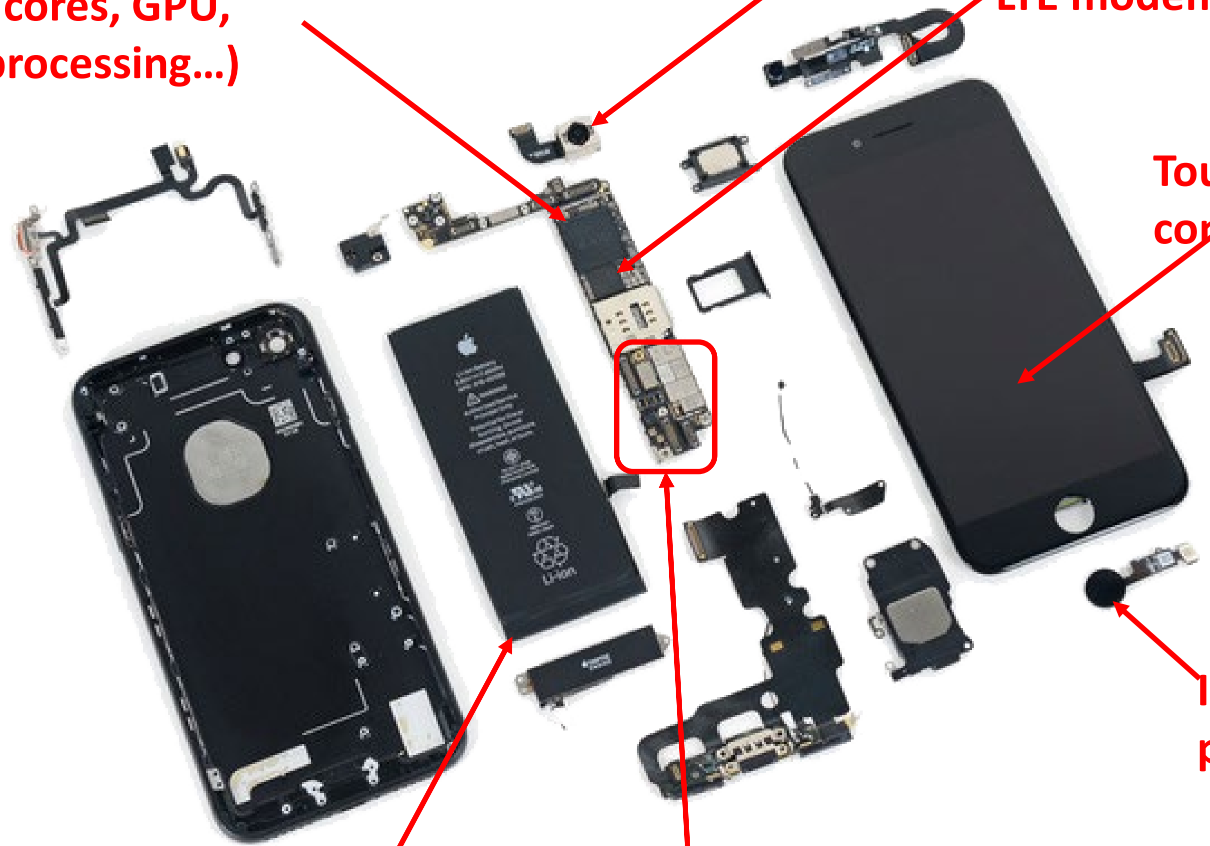


Example in Your Pocket (Today)

Application Processor (AP)
(microprocessor cores, GPU,
memory, video processing…)

Image sensor + pre-processing

LTE modem



Touchscreen
controller

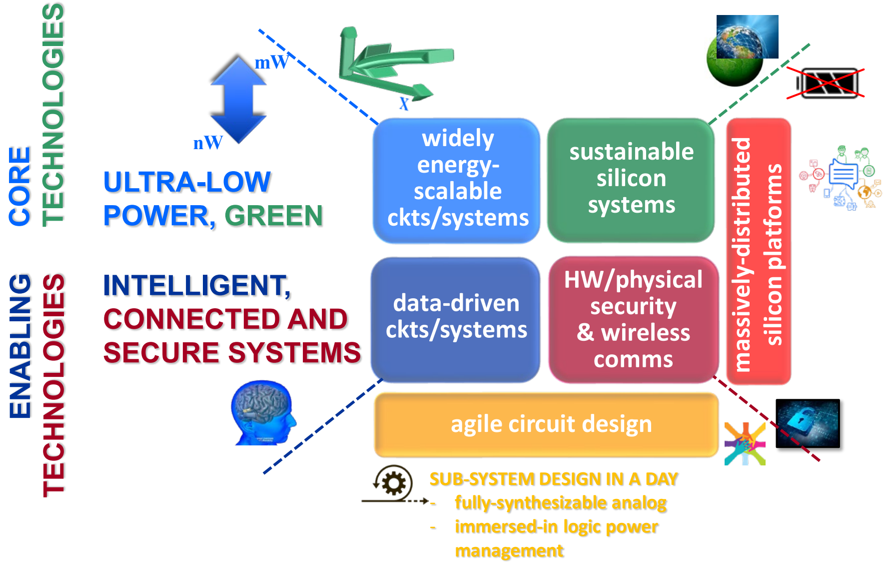
Image sensor +
pre-processing

smart battery
(charge, wearing, genuineness)

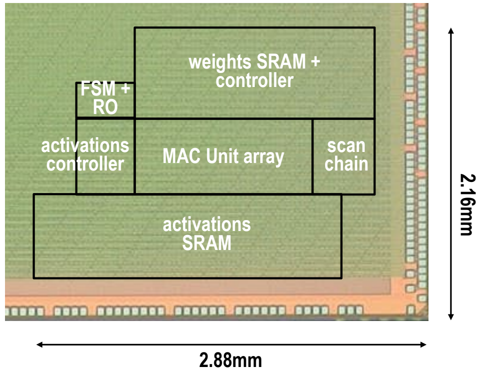
GPS, WiFi, DRAM, Flash, RF transceiver, Power
Management, NFC, audio, display power management,
FPGA, battery charger, compass, other sensors

Example from our Green IC Labs (Future)

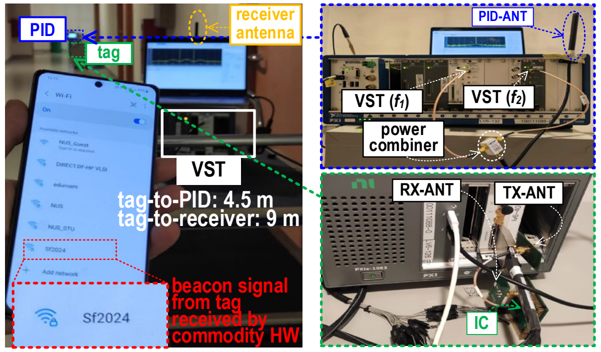
Green IC
changing the world, by design



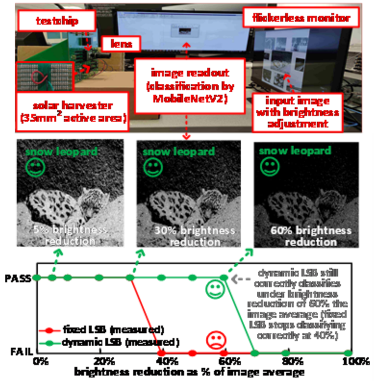
AI accelerator with best energy efficiency in the world (100-400 TOPS/W)



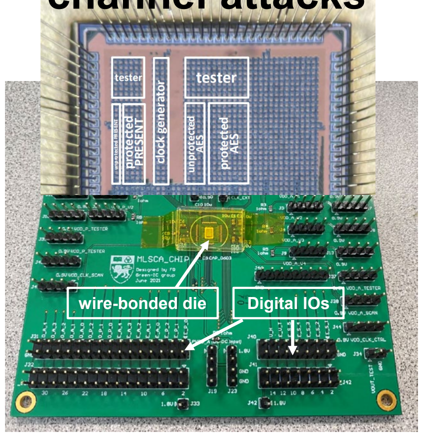
1st sub-μW WiFi radio for ubiquitous connectivity



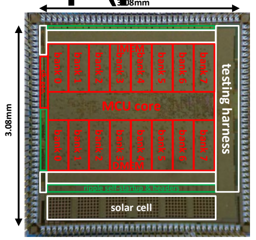
1st battery-less smart image sensor



1st AI protection against side-channel attacks



1st lunar-powered chip (power ~1nW)

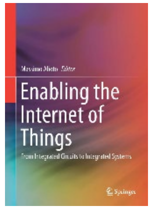


PRESS

PCWorld

PHYS.ORG

HOT CHIPS



1st book on chip design for IoT