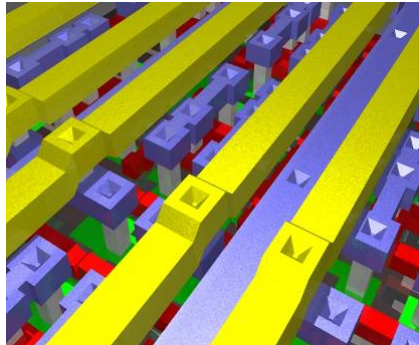


# Micro-Electronic Circuits and Systems

## Design, Modeling, Methodology and Automation



Nick van der Meijs  
Rene van Leuken  
Edoardo Charbon

EEMCS/CAS  
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[ens.ewi.tudelft.nl/~nick/](http://ens.ewi.tudelft.nl/~nick/)



## From Walkman to iPod

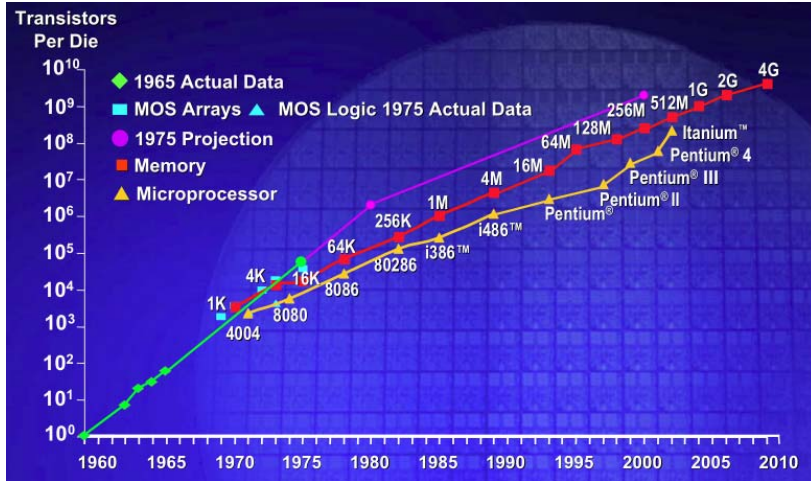


1979

[<http://pocketcalculatorshow.com/walkman/sony/>]



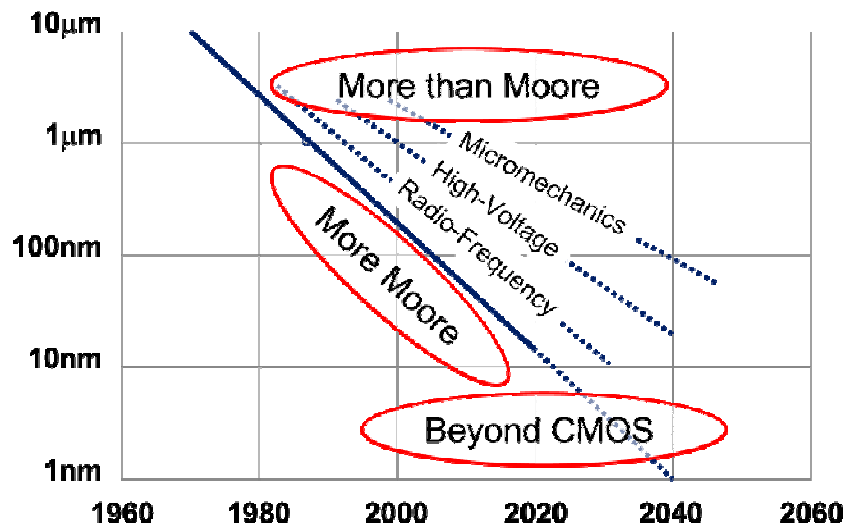
# Moore's Law



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# Technology Roadmap (eniac)



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## Circuits and Systems Topics Sampler

### Digital and Quantum Integrated Circuits

- **Quantum Architectures**  
Bridging IC technology and physics
- **Digital VLSI and Electronics for Nanometer Technologies**  
When the Boolean abstraction breaks down
- **VLSI SoC design and automation**  
System integration of IP and communication, low power

**(MSc Thesis Project, Extra Project, Essay Topics)**

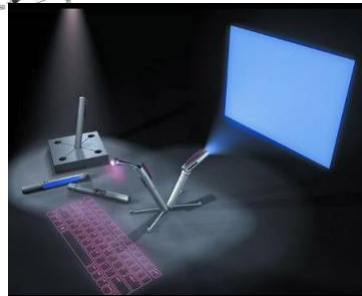
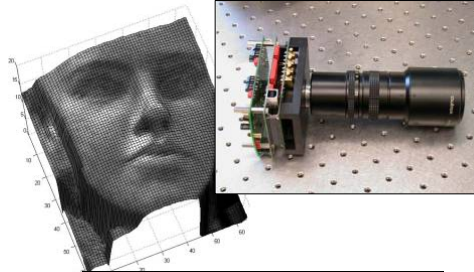
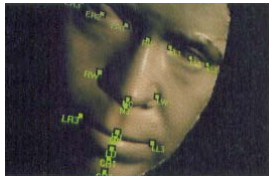
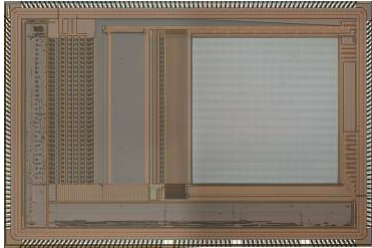
## Quantum Architectures



- **Edoardo Charbon**
- **Bridging physics and IC technology**
- **'Exotic' semiconductor behavior for fascinating applications beyond digital VLSI**
- **Single-photon imaging, dna detection, implantable sensors, etc.**

## Quantum Architectures

- Single-photon imaging
- 3D imaging
- Ultra-high speed cameras

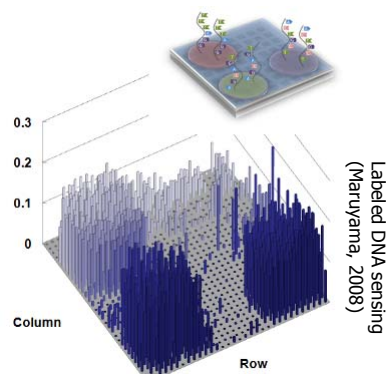
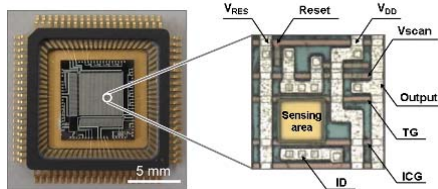


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## Quantum Architectures

- 2D fluorescence lifetime imaging microscopy (FLIM)
- Label-free CMOS DNA sensors  
Single-photon imaging

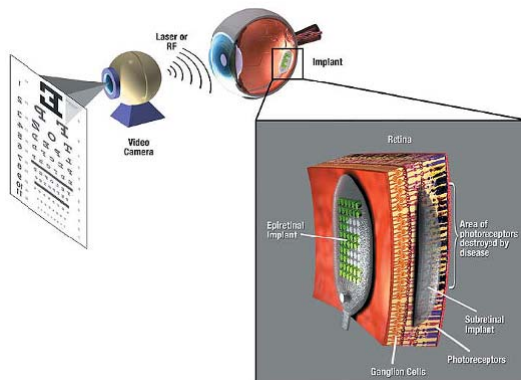


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## Quantum Architectures

- Biomedical science, e.g. single-molecule spectroscopy
- Neurophysiology, e.g. real time neuro-functional activity
- Medicine, e.g. implantable sensors



**Macular Degeneration**  
**AMD, Coats, Diabetes**  
 - central loss of vision

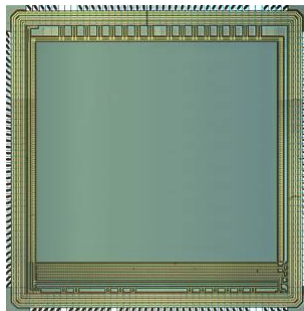
**Retinitis Pigmentosa (RP)** - peripheral vision loss

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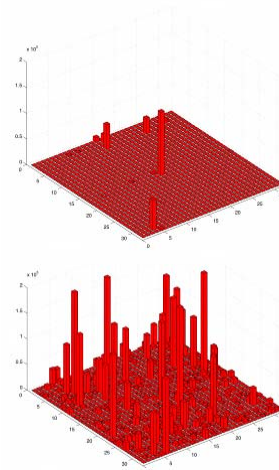
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## Quantum Architectures

- Radiation-tolerant CMOS sensors
- Space-based optical navigation



RADHARD: radiation-tolerant single-photon CMOS imager for Earth sensing

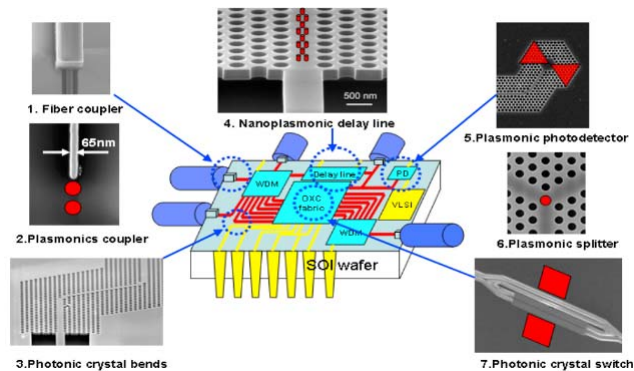


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## Quantum Architectures

- Integration of plasmonic elements onto silicon
- Plasmonic ICs



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## MSc Projects

- Histogramming processor and firmware for SPAD array
- Single-photon imagers in 90nm CMOS
- Single-carrier electronics in CMOS
- ICs with picosecond resolution
- Back-side illumination of SPAD imaging sensor
- Label-free CMOS DNA sensing
- ...

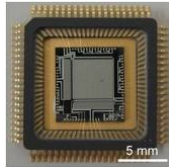


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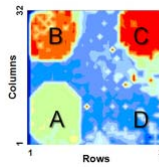
12

## CMOS Image Sensor Demos

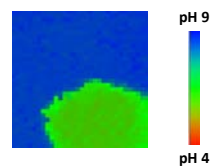
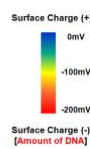
### Demonstration of the Bio-image sensor (Bio Lab. HB16.130)



32 x 32 surface potential detector



DNA detection

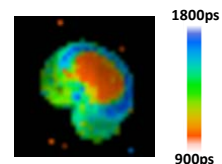


pH detection (today's demo)

### Introduction of the FLIM device (Optical Lab. HB16.120)



32 x 32 time-resolved optical detector



FLIM image form pollen grain

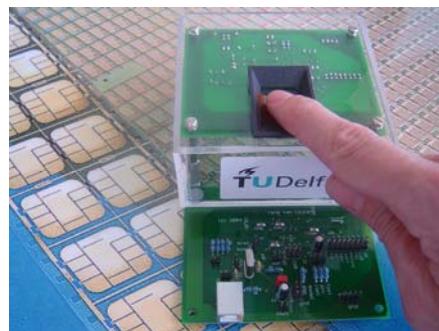
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## VLSI SoC design and automation

- Rene van Leuken
- High-level SoC design and design methodology  
Custom architectures, VHDL blocks

VLSI / ASIC design  
Low power design  
SystemC, SystemC-AMS, VHDL  
FPGA realizations  
Systems-on-a-chip  
Appl. to smartcards, mobile chipsets,  
sensor networks



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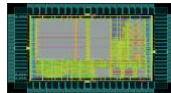
## Research Area's

1. Algorithms to Architectures (SystemC / VHDL)
2. Architectures to RTL implementation ( VHDL / FPGA)
3. RTL implementation to ASIC ( VLSI physical design)
4. Software / DA tools

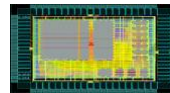
## VLSI Design: 90nm Communication Processor



Die photograph

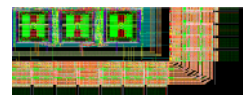
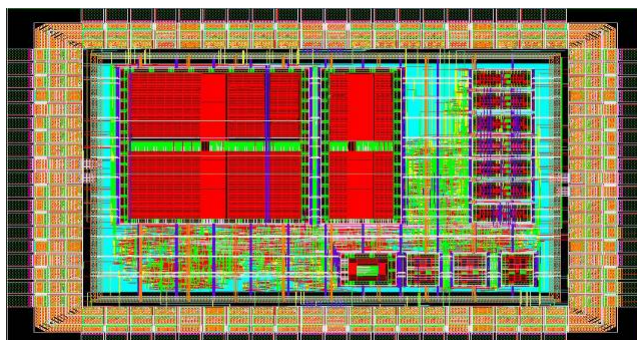


Threshold =  
90mV



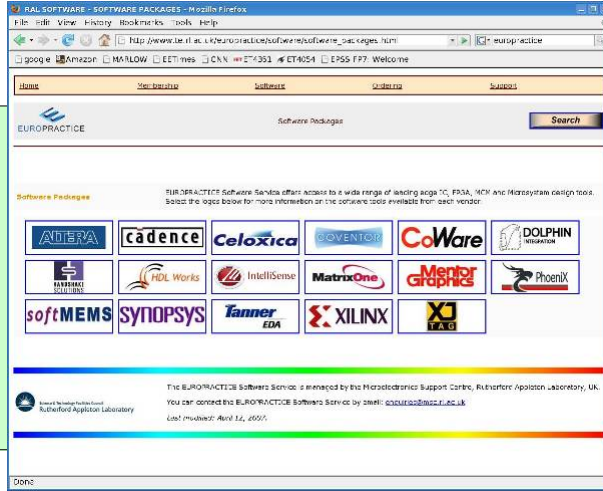
Threshold =  
10mV

Statistics	
Die size	2x2 mm
Bonding pad pitch	10 $\mu$ m
Speed	250 MHz
Power	160 mW
Core Voltage	1 V
I/O Voltage	2.5 V
Process	UMC L90 SP Low-k
Tool Chain	Modelsim



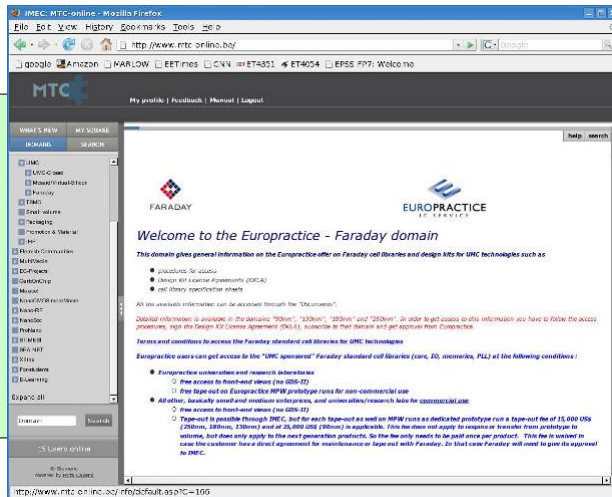
# Electronic Design Tools

- Synplify
- Modeltech
- Synopsys
- Cadence
- MAGMA
- ...



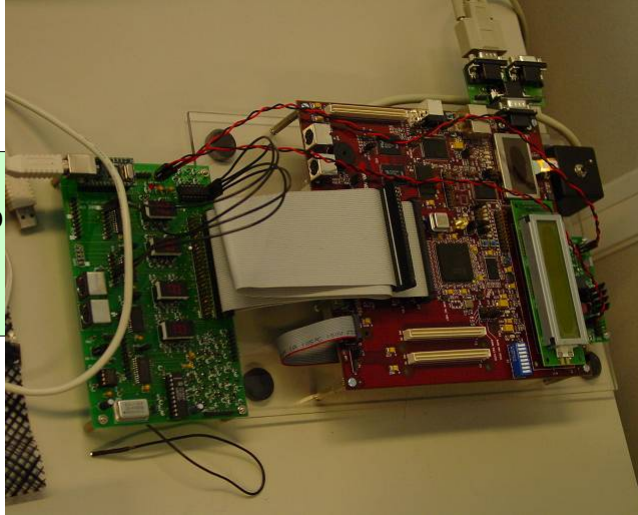
# VLSI Chip processing

- UMC
- TSMC
- IBM
- ST
- DIMES



## FPGA Boards

- Spartan 3
- Virtex 2 Pro
- Virtex 5



## CAS ESD and DA Activities

### *Current activities*

- **Low power** SOC design and methods
- **IP** building blocks (VHDL, C code)
- Reliable on-chip **communication**
  
- VHDL (SystemC & SystemC-AMS) design language
- FPGA Xilinx prototype boards
- Simulation models (SystemC, C)
- **ASIC design**

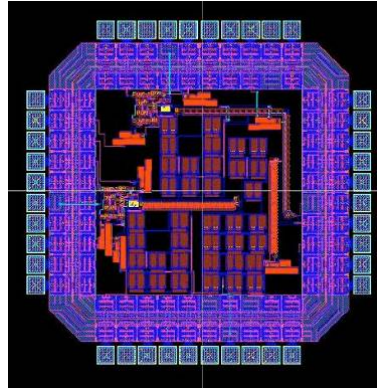
## MSc Projects

### Past:

- Fingerprint engine
- LT codes for error correction of NoC
- VHDL to SystemC translator
- DMA controller for Automotive (NXP)
- Micro Blaze 32 bit processor
- ASIC design: 8 bit processor
- ASIC design: R-Vex 32 bit VLWI processor
- Video Motion detection SoC

### Current:

- SystemC AMS synthesis tool
- Async, dataflow synthesis tool
- Async SoC design/ASIC
- MicroBlaze VLSI realization
- Video motion detection ASIC realization
- SystemC SoC models
- ...



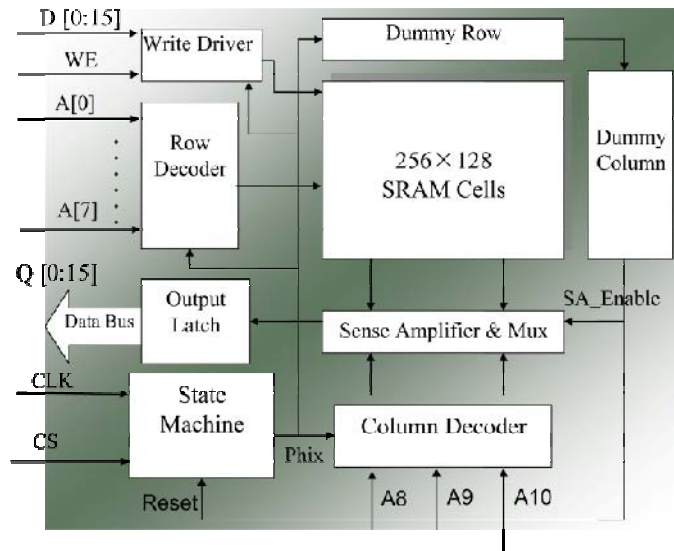
Also: FPGA prototyping

## Digital VLSI and Electronics for Nanometer Technologies



- Nick van der Meijs
- When digital becomes analog
  - VLSI Design
  - Modeling, Methodology and Automation

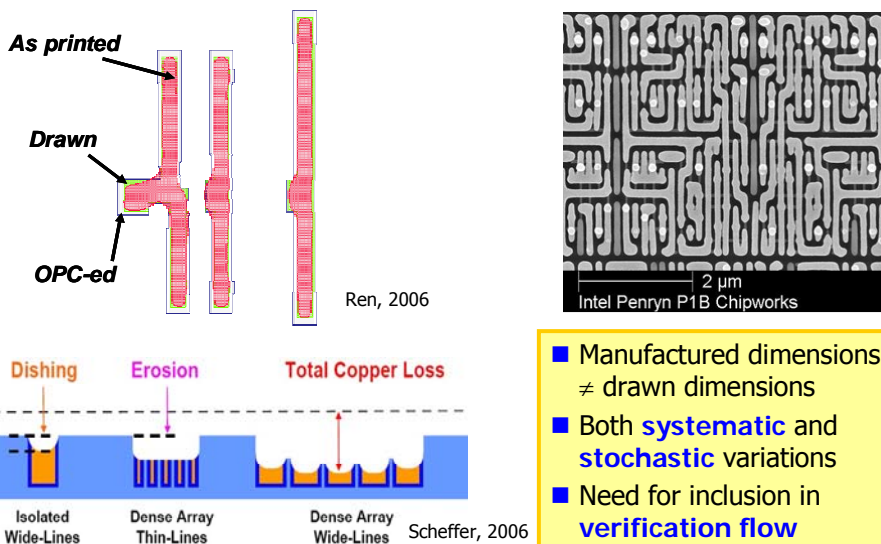
## Example: Embedded SRAM Design



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## Dealing with Manufacturing Variability

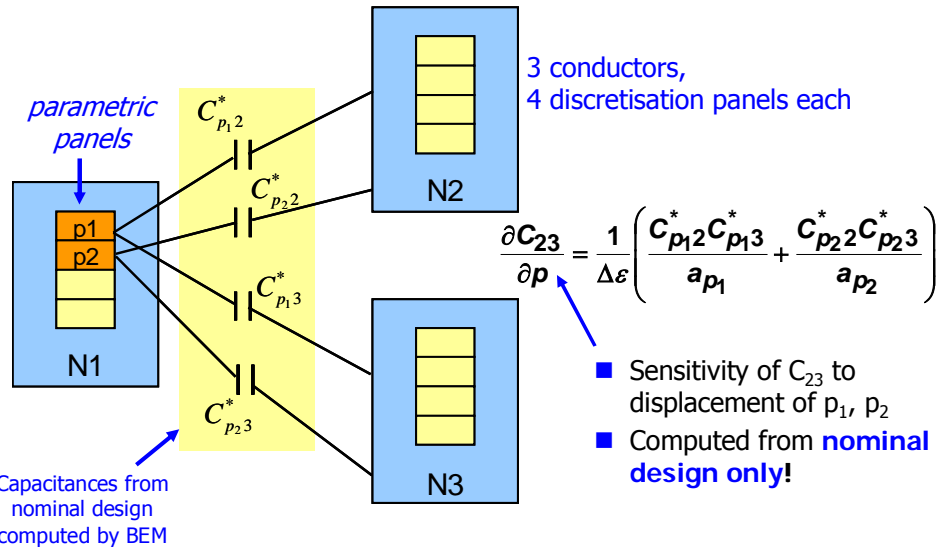


- Manufactured dimensions  $\neq$  drawn dimensions
- Both **systematic** and **stochastic** variations
- Need for inclusion in **verification flow**

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## Sensitivity of Parasitic C wrt Geometry



## MSc Projects

### Past:

- FFT Processor for Wireless UWB Design in 90nm CMOS (presented this week at SOCC conference)
- Low-voltage Embedded SRAM design (@NXP)
- Effects of Manufacturing Variations on Integrated Passive Components
- Wake-up receiver for Ultra-Low Power sensor network (@ Holst Centre)
- Digital Linearization of Class E power amplifier for Satellite Transmitter
- SRAM Power Reduction - an Ultra-Low-Power SRAM Architecture in 45nm Technology (@ NXP)
- 45nm Extraction and Verification Flow with SPACE

### Current:

- Electrically-based standard cell modeling
- Robust clock network synthesis
- Digital processing for 'Dirty RF'
- Modeling for manufacturing variability
- ...

## CAS Lab. Tour

### **Group A : ???**

20 people  
HB17. ???

### **Group B : Demo and introduction of the Image sensors**

20 people    Bio-image sensor (Demonstration)    --- 10 people  
                  FLIM Device (Introduction)            --- 10 people

HB16.120, 130