Electronics Foresight

Innovation & Imagination

AgenceProton

deftech.ch

Foreword

I have to admit right away that I am not at all a connoisseur of electronics and even less of electronic circuits.

What stimulated this project was a discussion with the two authors about the omnipresence of electronic circuits in today's products. Indeed, if a normal car would have an average of 1500 different ASICS (Application-Specific Integrated Circuit), this figure could go up to 5'000 and more for high-end versions. Quality and functions of today products are therefore directly dependent of these components. What about the future ones?

The manufacturing of these elements is of course expensive and the normal business plan for one chip would normally spread over several years. Understanding what is produced today should therefore allow us to imagine possible products that will for sure integrate those components.

As the world moves digital and software is still eating it, companies such as Apple and Tesla are revolutionizing the industry by applying what Alan Kay once said, "People who are really serious about software should make their own hardware."

This is the environment we are therefore in, not considering on top of that the geopolitical dynamics and ecological implications along the supply and value chains.

The scene is set, the actors will enter the stage, and all the ingredients are present for you to enjoy some scientific vulgarization paving the way for different foresight activities from the world of microelectronics!

Enjoy the ride,

Dr. Quentin Ladetto
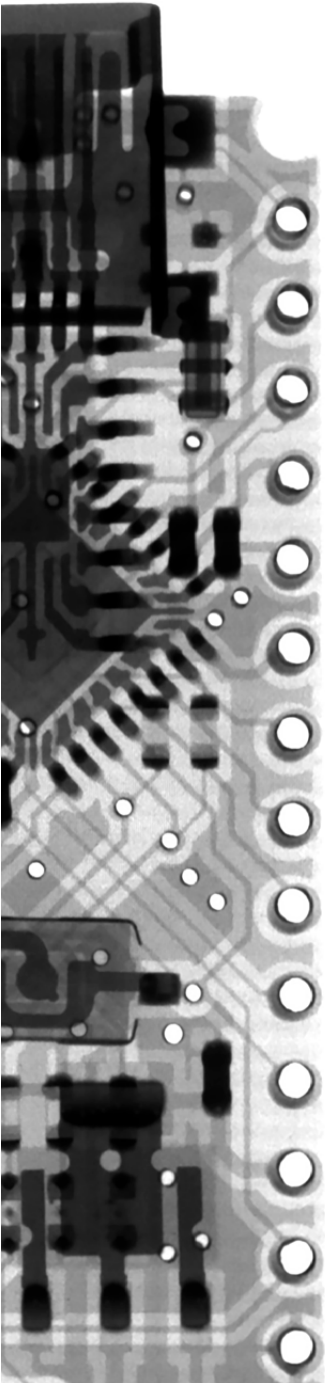**Head of Technology Foresight**

Microelectronics blooms on the wide bandgap substrates...

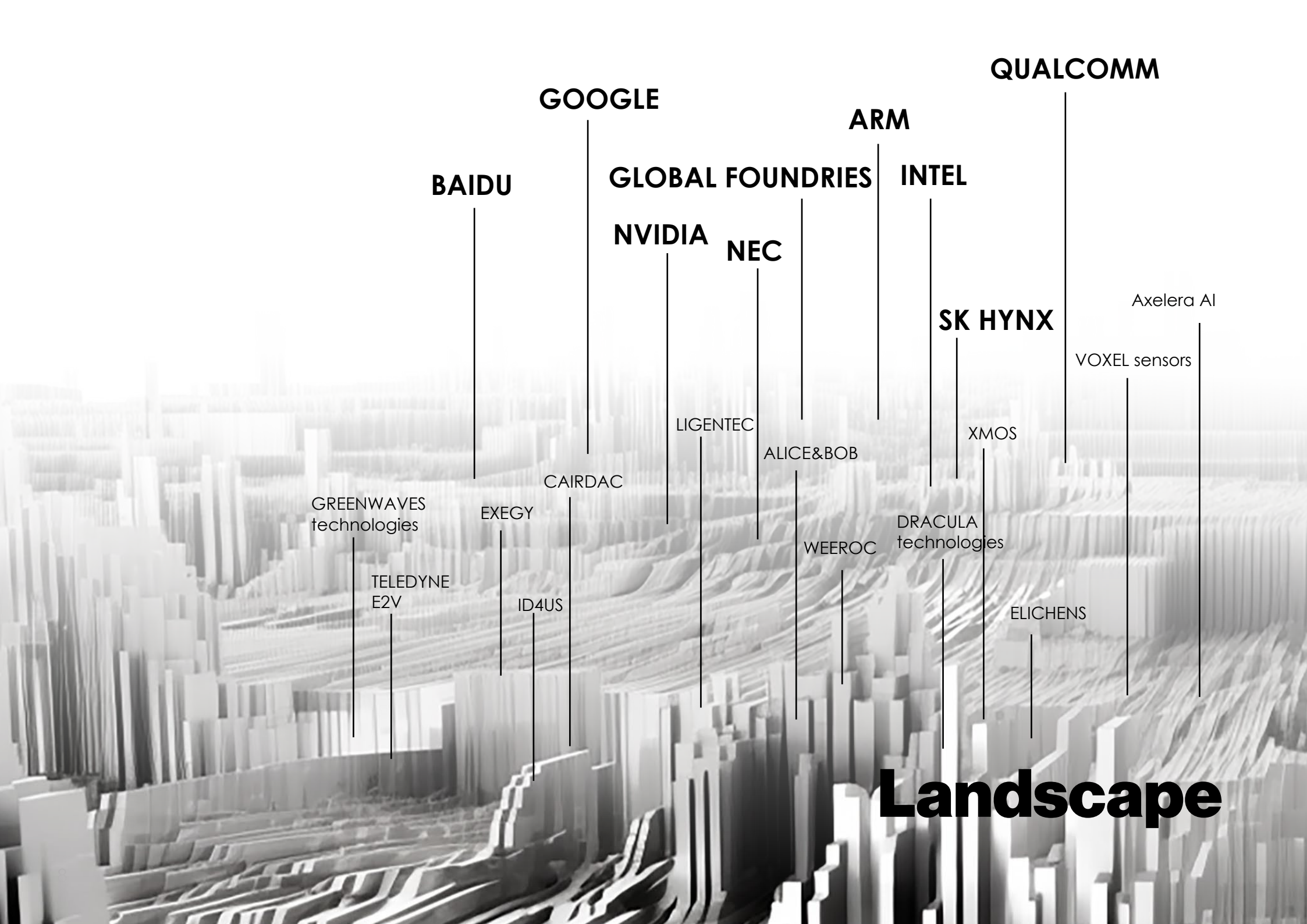Every chip we release,
we create the future

Overview

With this document, we want to share a hardware-based way of thinking about the future. More precisely, we want to take you down into the bowels of electronics, where the intelligence of products resides: **at chip level.**

The purpose is not to give you a complete overview of all that semiconductors can enable but to give you a taste of the power of this creative, component-based, forward-looking approach. With "Electronics Foresight" our aim is to help to go beyond current technology roadmaps and to unleash your imagination in order to think out of the box.

We are addressing researchers, technicians, engineers, semiconductor industry executives, and anyone interested in foresight and passionate about the future of technology.

QUALCOMM

GOOGLE

ARM

BAIDU

GLOBAL FOUNDRIES

INTEL

NVIDIA

NEC

SK HYNX

Axelera AI

VOXEL sensors

LIGENTEC

XMOS

ALICE&BOB

CAIRDAC

GREENWAVES
technologies

EXEGY

WEEROC

DRACULA
technologies

TELEDYNE
E2V

ID4US

ELICHENS

Landscape

ASML

APPLE

TSMC

SAMSUNG

AMD

RENESAS

XFAB

IMEC

DIAMFAB

EYYES

E-PEAS

Stealth Startup

RASPBERRY pi

ARYBALLE

NimbleAI

SCINTIL photonics

COLOGNE chip

SCANTINEL photonics

SIPEARL

IC'ALPS

MENTA

WISE integration

QUANTIC sensors

NEOVISION & DOLPHIN DESIGN
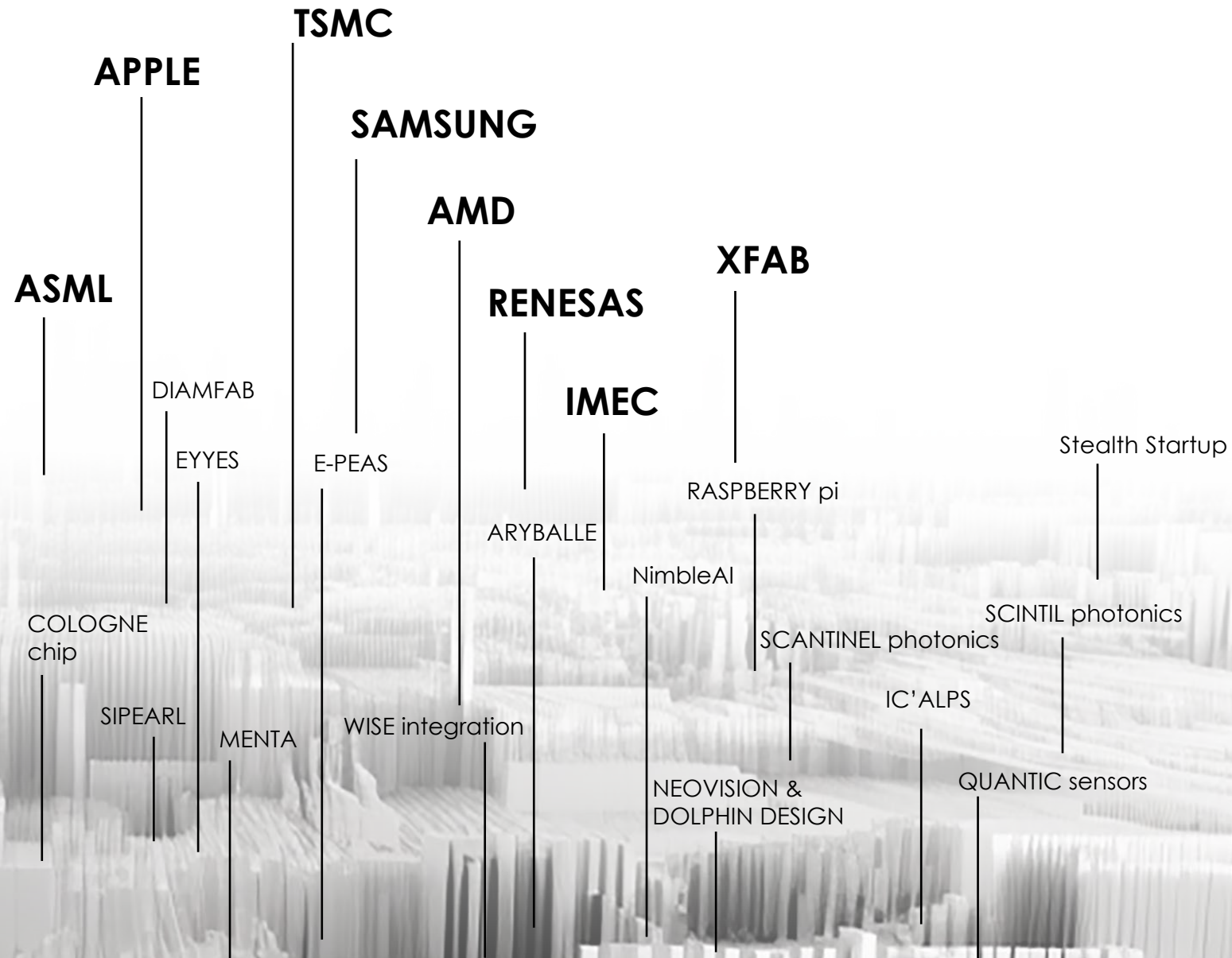
of microelectronics

Reader's warning

This strategic foresight document is the result of a research project carried out by AgenceProton for the **technology foresight program of armasuisse Science and Technology**.

The goal of the project called "Tailor-made technological overview of the products of the future" is to anticipate...

... the new technological products that could be produced in the future, based on the overview of the microprocessors produced today.

This project is a research focused on freshly released techno-centric components level, **principally ASICs**.

The sources and the informations contained in this document are collected from **open sources,** all the material collected is official, principally from websites of companies/organizations.

A piece of Silicon

Table of contents

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Research context

In order to present this original foresight method, you will find hereafter a three-part document: a few semiconductor industry drivers as a framework to think about **[Drivers part]**, some remarkable projects to inspire **[Inspiring Projects part]**, and examples of combining's ideas to show how leveraging of insights **[Playing with ideas part]**.

This method aims to strengthen strategic forecasting skills, create scenarios and innovative organizational practices. We hope it will inspire you, and take you from ideas to an exciting and insightful new device.
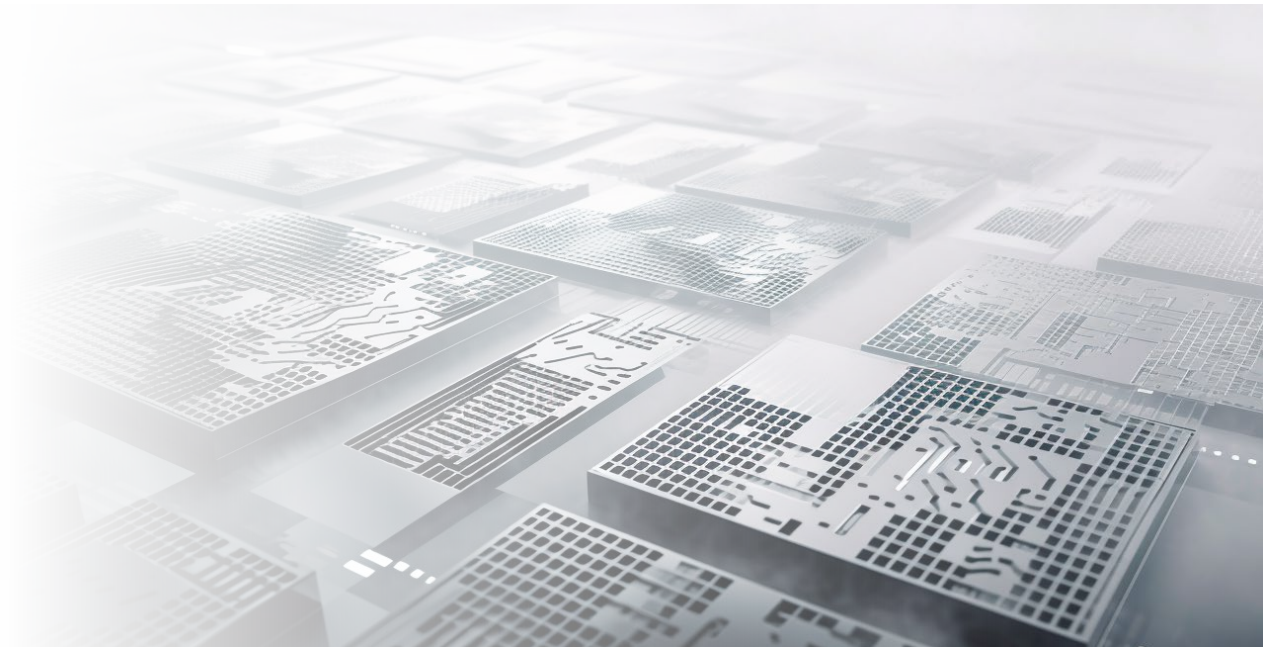
The ASIC movement

ASICs are "powerful building blocks" for electronic devices, and again today they are considered as a mere commodity. They offer a little programmability but provide maximum performance at a given power and cost budget.

They are embedded in large numbers of leading-edge systems and products, that we can use to work in remote, communicate underwater, monitor the climate, our house, our body, improve our senses (listen, smell, see better, …), pay, treat illness, and more.

Among the many, we can quote as examples: an autonomous car (Crash bags, motor control, air sensing, audio amplifiers,…), a cell phone, a fast charger, a smartwatch, a game console, a satellite terminal (Transceiver and beamformer part), a network switch and router, a digital camera, a virtual reality headset, a drone, a computer system, a smart card for contactless payment, a bitcoin mining device, optronics binoculars, a wind turbine (Near ball bearings), a sex toy, a wireless smart thermostat, an order terminal for fast food, a robot companion with AI, a burglar alarm system, a fitness tracker, a photovoltaic system pilot, a deep brain neurostimulator, AI-Augmented earbuds, a safety-critical industrial controller, a pacemaker, a cochlear implant, a pulse oximeter, an insulin pump, and much more.

According to KVB Research, the Global ASIC Chip Market size is expected to reach $24.7 billion by 2025, rising at a market growth of 8.2% CAGR during the forecast period. It is booming.

The semiconductor market is **ever-changing.** Key players and game changers are reshaping the industry and the world, pushing the boundaries of physics and **overcoming breakthroughs** to design and manufacture innovative chips at smaller geometries, with stacking functions (Chiplet approaches, …), using new semiconductor materials (Silicon Carbide SiC, Silicon germanium, Gallium nitride GaN) and trying to reduce the carbon footprint of the entire industry.

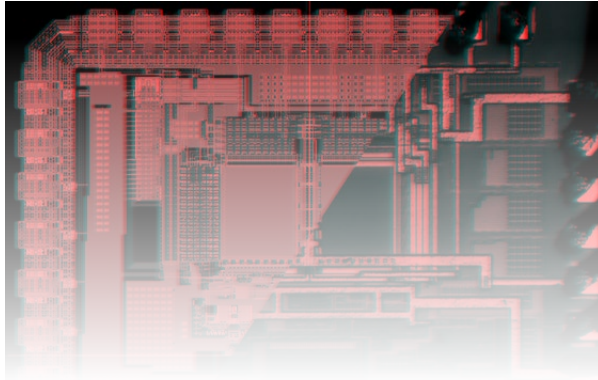The ASIC movement is at the forefront of technological development.

semi sector is driven by...
markets
tech
science
geopolitics
... and visionary people !

1

Drivers

Giving a framework
based on technological
roadmaps

9 Drivers

Patterns of microelectronics *

Fig. 1: The era of geometrical or Dennard[9] scaling of silicon technology ended around the turn of the century (green lines, "happy scaling").

From: 2D materials for future heterogeneous electronics
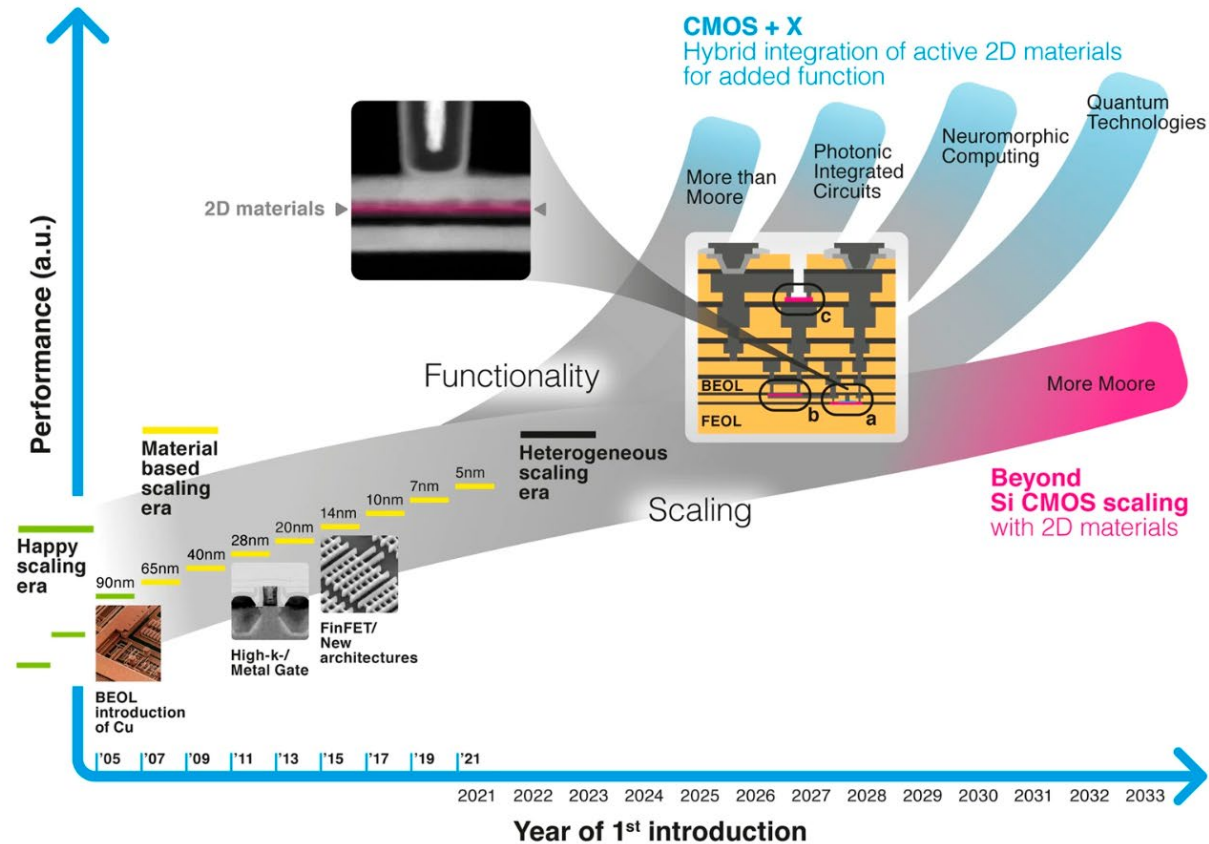
Lemme, M.C., Akinwande, D., Huyghebaert, C. et al. 2D materials for future heterogeneous electronics. Nat Commun 13, 1392 (2022). https://doi.org/10.1038/s41467-022-29001-4- https://rdcu.be/c7FvN

*a hand

The locomotive is ... automotive

"Historically, the semiconductor industry has been driven by four successive engines. First there was the military, then mainframes, then PCs and most recently smartphones. The automobile is the next "Big thing". It should take over from smartphones, whose role as a locomotive is over.

But there are other drivers that could pull the market as well, such as data centers serving the internet and cloud, or the move to an inter-connected, intelligent world."

Dan Hutcheson 02/23/2023.
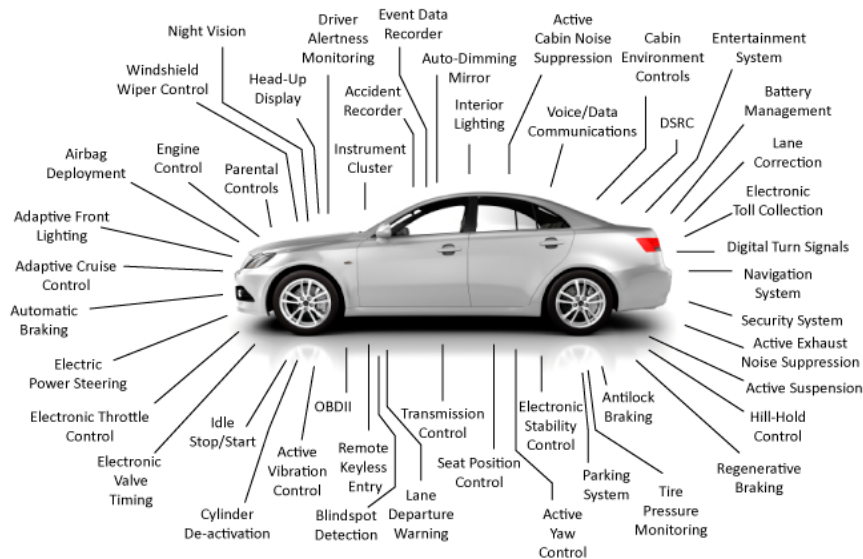
1000-1500 chips for average car, up to 5000 to premium luxury segment.
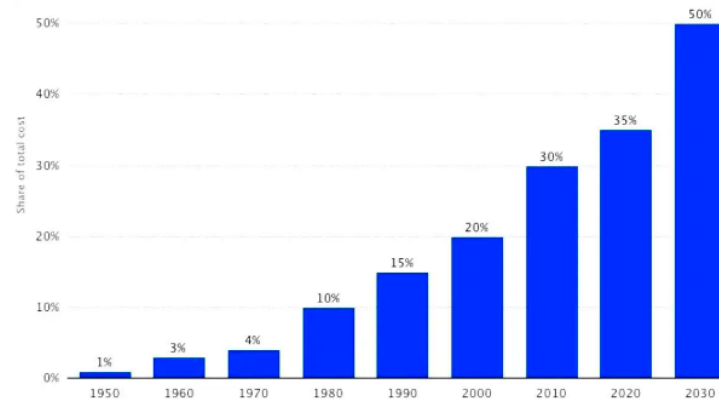Image courtesy of chipsetc.com.

Figure 1 Automotive electronics cost as a share of total car cost from 1950 to 2030.
(Source: Statistica)

Stacking functions

"Multi-die systems - integration of heterogeneous dies, or chiplets - are an answer to the rising systemic and scaling complexitites ..."
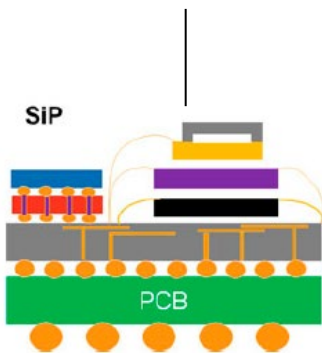
Manuel Mota, Sr Staff product manager, Synopsys Solutions Group
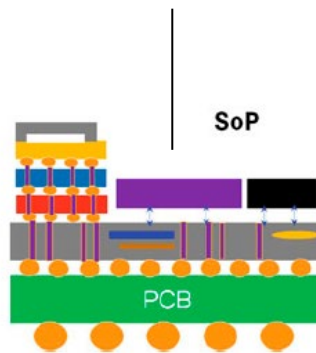
System-on-board (SoB)

Raspberry Pi 4 Model B - Michael H. "Laserlicht" CC BY-SA 4.0

Advanced packaging :
System in package (SiP)

Advanced packaging :
System on package (SoP)

More-than-Moore Devices and Integration for Semiconductors
Francesca Iacopi - Francis Balestra - Springer 2023
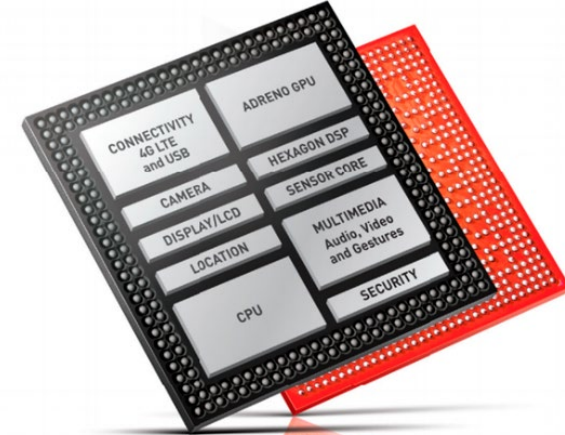
System-on-chip (SoC)

Image courtesy of Qualcomm.

IP vs. open source

"It is hard to predict the future but one can undoubtedly say, the future is RISC machines be it in the form of ARM in every mobile phone or RISC-V in every other device.

For the short term future, ARM has big corporate backers like Qualcomm for Android / Windows camp and Apple with their iPhone and Macs.

RISC-V is generating interest for every other company that needs low-cost custom solutions like Internet of Things manufacturers, cloud computing operators or even universities doing their research works.

It is no wonder that companies like Google, and other Chinese companies are interested in RISC-V designs."

TECH JOURNEYMAN Posted by erwinkarim on 3:02 PM, July 14, 2021
Last updated on 3:56 PM, February 25, 2022

Additive instructions model

Open source & composable

Everybody needs everybody

"The global market for semi-conductors as we know it today was shaped over a 30 to 40-year period.

Every country or continent is vital in specific areas: **Taiwan** and **Korea** handle advanced technological generations (nodes), the rare earth industry in **China**, **Japan** for wafers and process gas, the US deals with complex integrated circuit tools and designs, controlling social networks and the web, and advanced lithography and advanced substrates such as SOI wafers in **Europe**…

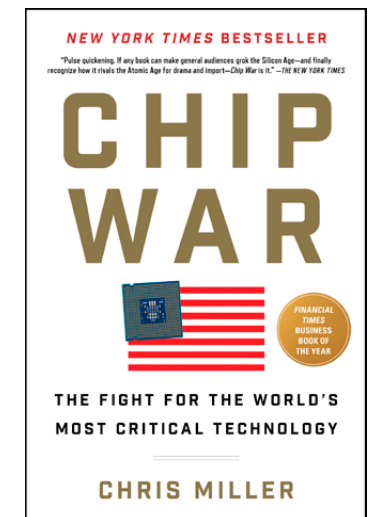Value chains are therefore highly inter-related: everyone needs everyone else; there is no such thing as a component or an electronic device made from A to Z in a single country.

For example, designing and manufacturing a smartphone involves several laps around the world".

Sébastien Dauvé - A Close Look at Major Microelectronics Challenges - (leti-cea.com)

vs Supremacy

"semi conductors are the oil of the 21st century"
Chris Miller

NEW YORK TIMES BESTSELLER

"Pulse quickening. If any book can make general audiences grok the Silicon Age—and finally recognize how it rivals the Atomic Age for drama and import—*Chip War* is it." —*THE NEW YORK TIMES*

CHIP WAR

FINANCIAL TIMES BUSINESS BOOK OF THE YEAR

THE FIGHT FOR THE WORLD'S MOST CRITICAL TECHNOLOGY

CHRIS MILLER

Process dramatically shrinks

Node shrinking is getting even more extreme with TSMC's 1-nm process node, developed in collaboration with the Massachusetts Institute of Technology and the National University of Taiwan.
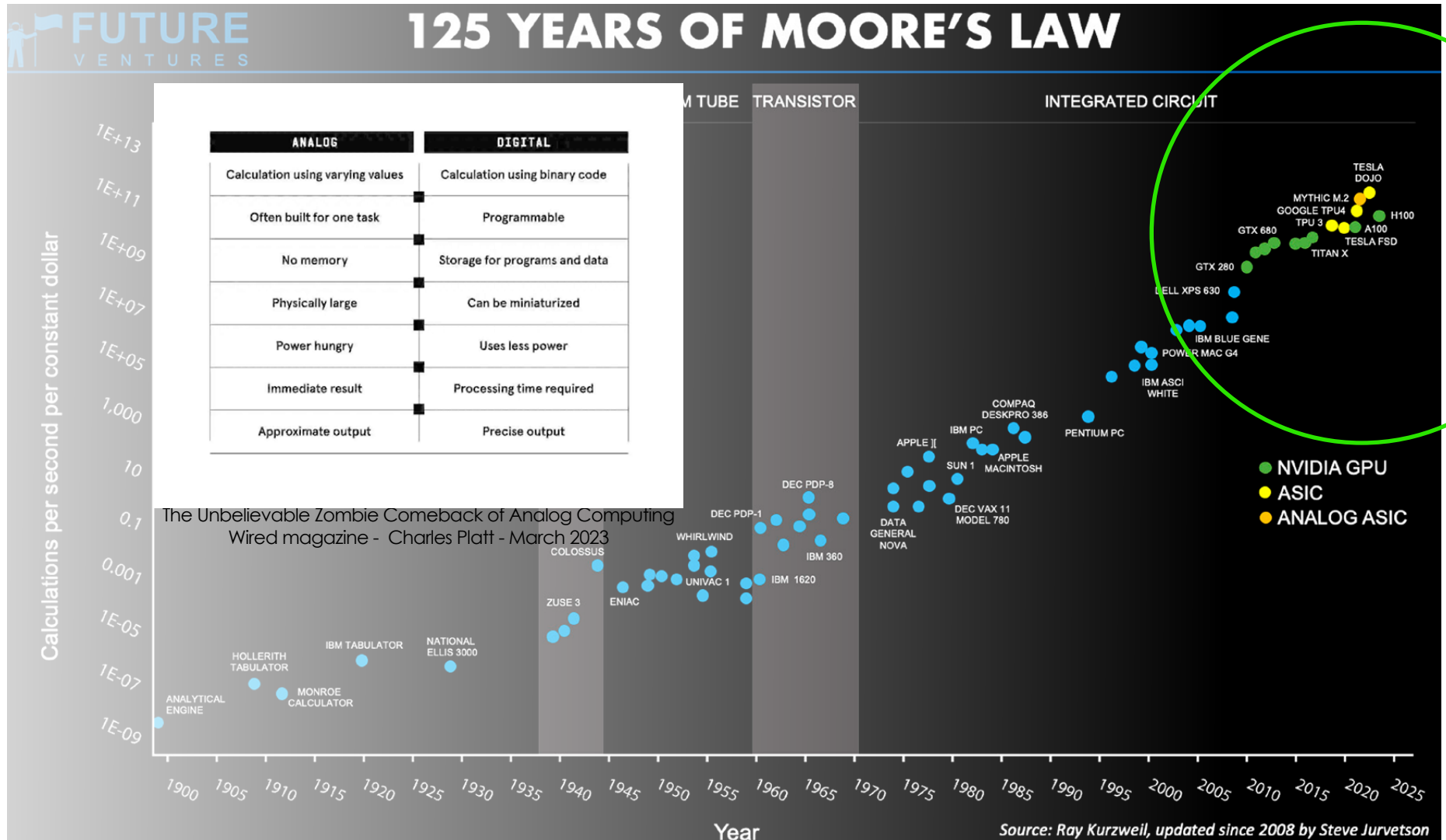
But can we go beyond 1 nm?

Convinced that "Moore's Law will not stop,"

Anne-Françoise Pelé
EDITOR-IN-CHIEF, EE TIMES EUROPE

IMEC is working on a sub-1-nm process, and its latest transistor roadmap extends to 2036. With industry partners ASML, TSMC, Intel, Samsung, and many others, IMEC is preparing to move beyond nanometer geometries to the angstrom era.

the Ångström era

Analog strikes back

125 YEARS OF MOORE'S LAW

ANALOG	DIGITAL
Calculation using varying values	Calculation using binary code
Often built for one task	Programmable
No memory	Storage for programs and data
Physically large	Can be miniaturized
Power hungry	Uses less power
Immediate result	Processing time required
Approximate output	Precise output

The Unbelievable Zombie Comeback of Analog Computing
Wired magazine - Charles Platt - March 2023

Source: Ray Kurzweil, updated since 2008 by Steve Jurvetson

22

Photonics shines

"Overall, the ability to stack semiconductor layers with added functionality using optical connections presents the engineering world with all kinds of possibilities.

If these components are combined with optical PCBs, then we could see a dramatic shift from electrical connections to optical in the near future".

Robin Mitchell - electropages - 24-06-2022
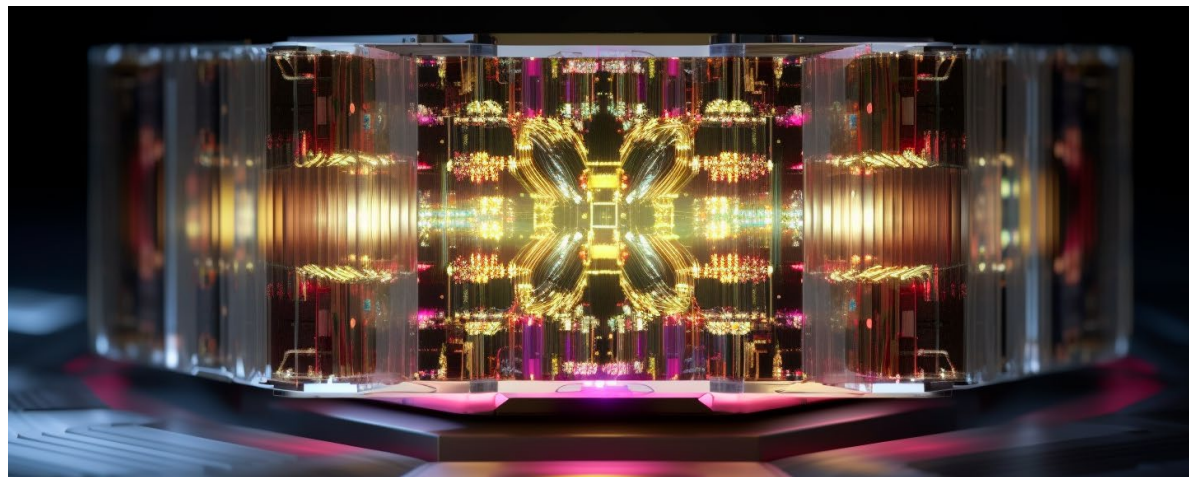
AI is the glue

Sensor fusion
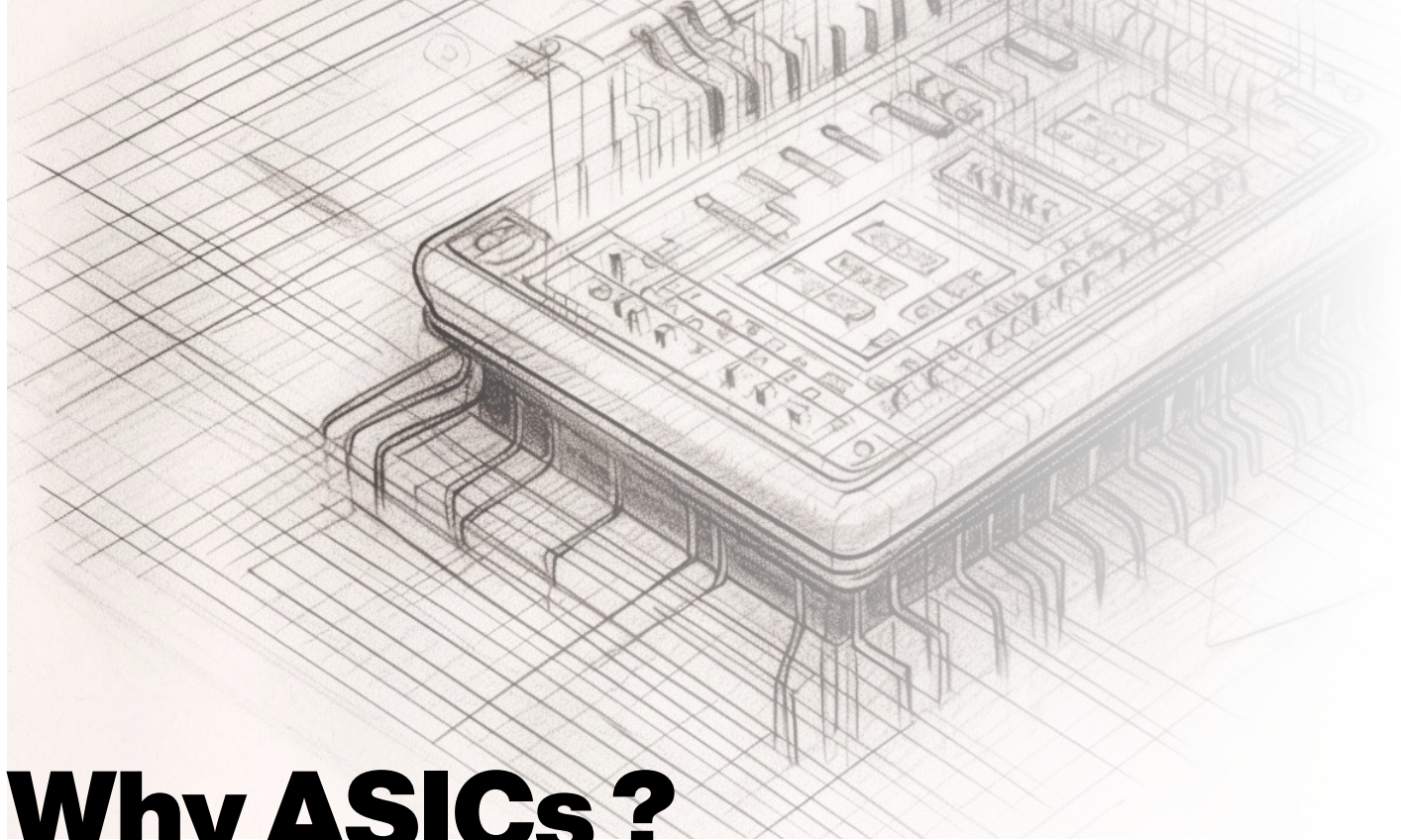
Edge

Sensors

AI

Computing

Cloud

LLM

Why ASICs ?

An ASIC / Application-Specific Integrated Circuit
is an integrated circuit **designed specifically** for one customer to
provide a **specific function required for the customer's application.**

You will find in this document mostly ASICs as inspiring sources, and some other concepts.
This approach from this specific hardware gives us an **original angle of view** because ASICs have strong entry barriers.

They are deeply specific and each is a **revealer of the future path of microelectronics** (Tools, CAPEX, process, talents).

Why ASICs ?

ASICs (Application-Specific Integrated Circuits) are essential in our modern world for several reasons:

Performance: ASICs are designed to perform specific tasks with optimized hardware and algorithms, resulting in superior performance compared to general-purpose processors or software-based solutions. They can execute complex computations and algorithms much faster, enabling high-speed data processing, real-time operations, and improved overall system performance.

Power Efficiency: ASICs are designed to be highly power-efficient, focusing on executing specific tasks with minimal power consumption. By eliminating unnecessary components and optimizing the circuitry for a specific application, ASICs can deliver significant energy savings, making them ideal for battery-powered devices or energy-conscious systems.

Cost Optimization: For applications that require high volumes of specialized computations, ASICs can be cost-effective. While the upfront development costs of designing and manufacturing an ASIC can be significant, the cost per unit decreases with mass production. ASICs can provide a more affordable solution compared to using general-purpose processors or FPGAs (Field-Programmable Gate Arrays) in large-scale deployments.

Customization and Integration: ASICs can be tailored precisely to the requirements of a particular application. By integrating specific functions, algorithms, and interfaces into a single chip, ASICs can achieve high levels of integration, reducing the overall system complexity, size, and cost. This customization allows for optimal performance and compatibility with other system components.

Security: ASICs can enhance security in various applications. By implementing encryption, decryption, secure key storage, or authentication mechanisms directly into the hardware, ASICs can provide robust security features that are harder to compromise compared to software-based solutions. This is especially crucial in industries such as finance, telecommunications, and IoT (Internet of Things).

Specialized Applications: ASICs are designed for specific applications or industries, where general-purpose processors may not be efficient or capable enough to meet the demanding requirements. Examples include cryptocurrency mining, artificial intelligence (AI) acceleration, networking equipment, automotive systems, aerospace technology, medical devices, and more.

Overall, ASICs offer unmatched performance, power efficiency, cost optimization, customization, and security for specialized tasks. They play a vital role in enabling technological advancements and driving innovation across various industries, ensuring that specific applications can operate efficiently, reliably, and at scale in our modern world.

Here are some examples of products in the defence and security domain that feature ASICs (Application-Specific Integrated Circuits):

01. Fire Control Systems: Fire control systems used in military vehicles, aircraft, and naval vessels often incorporate ASICs for tasks such as target tracking, trajectory prediction, and weapon guidance.

02. Radar Systems: ASICs play a crucial role in radar systems, enabling functions such as signal processing, beamforming, target detection, and tracking. These systems are vital for surveillance, threat detection, and situational awareness in defence and security applications.

03. Cryptographic Systems: ASICs are used in cryptographic systems to provide secure encryption and decryption capabilities. These ASICs accelerate cryptographic algorithms, ensuring data security in communication systems, secure communications, and encryption/decryption devices used in defence and security.

04. Satellite Communication Systems: ASICs are employed in satellite communication systems to handle various tasks such as modulation, demodulation, signal processing, and error correction. These systems are critical for secure and reliable communication between defence and security assets.

05. UAV (Unmanned Aerial Vehicle) Systems: ASICs are utilized in UAV systems for flight control, image processing, sensor data fusion, and navigation tasks. These ASICs enable real-time decision-making and autonomous operations in UAVs used for surveillance, reconnaissance, and defence applications.

06. Electronic Warfare Systems: ASICs are integrated into electronic warfare systems for functions such as signal processing, signal analysis, jamming, and countermeasures against hostile electronic threats. These systems enhance the defence and security capabilities against electronic warfare attacks.

07. Secure Access Control Systems: ASICs are employed in secure access control systems used in defence and security installations. These ASICs provide authentication, encryption, and secure communication protocols, ensuring controlled and authorized access to sensitive areas.

08. Battlefield Communication Systems: ASICs are utilized in battlefield communication systems, providing secure and reliable communication channels between military personnel, vehicles, and command centres. These ASICs offer encryption, compression, and signal processing capabilities for efficient and secure communication in hostile environments.

09. Missile Systems: ASICs are a critical component in missile systems, performing tasks such as guidance, navigation, control, and target acquisition. These ASICs enable precise and efficient missile operations in defence and security applications.

10. Secure Identification and Authentication Systems: ASICs are used in secure identification and authentication systems such as biometric recognition devices, smart cards, and access control terminals. These ASICs ensure reliable and secure identification of personnel in defence and security settings.

These examples highlight the use of ASICs in various defence and security products, where their specialized functionality, performance, and security features are essential for critical operations and ensuring national security.

2 Inspiring projects

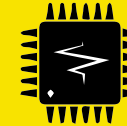**Moving from tech-to-imagination**
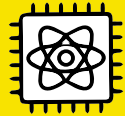
Technologies on stage

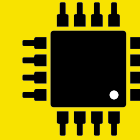Microled display

Biometric sensor
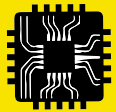
GaN power integrated circuit

Quantum computing

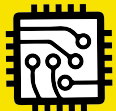Diamond substrate

Read-out chip

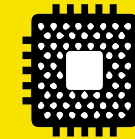Silicon photonics, PICs

High performance computing

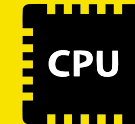X-ray technology

AI neural network

Laser technology

FPGA

Neuro electronic device

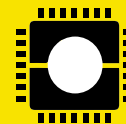DAC signal processing

Low-cost computer

Smart sensor

Terahertz nano-chips

Pacemaker technology
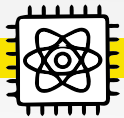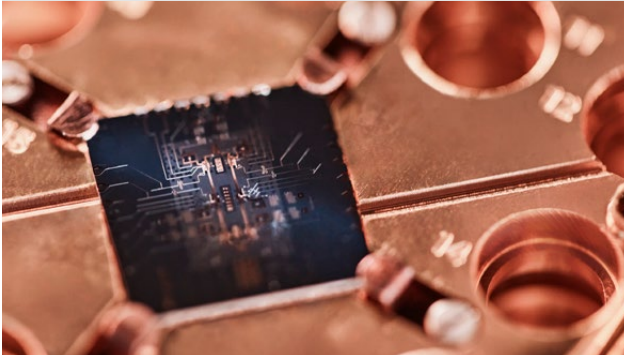
Energy harvesting

Quantic sensors

Brain computer interface

ALICE&BOB

Error-free qubits for quantum computers

A self-correcting quantum bit enable fault-tolerant quantum computing and can run any quantum algorithm.

Quantum computing

MARKETS

Finance
Chemistry
Cryptography
Supply chain
Industrial

CONCEPT/ PRODUCT

Fault tolerant cat qubit

Decoherence leads to errors during computation. More precisely, it randomly switches the phase of quantum superpositions inducing errors called phase-flips. Quantum bits also suffer from a "classical" error, the bit-flip that randomly swap 0s and 1s.

Surprisingly, the bit-flip rate in quantum systems is many orders of magnitude higher than in classical ones. There is no fundamental reason for such a discrepancy : the only error intrinsically tied to quantum systems is the phase-flip.

Alice & Bob have designed a pioneering quantum bit, the cat qubit, that is presumably as insensitive to bit-flips as a classical bit while remaining both coherent and controllable. This way only phase-flips require to be actively corrected. It drastically simplifies the design of the ideal quantum computer.
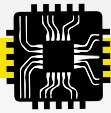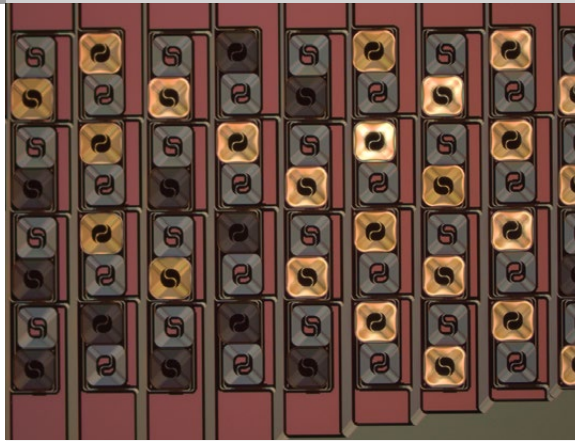
What if...

We could take strategic decisions in a probabilistic universe?

ARYBALLE

A unique odor signature like a fingerprint for odors

Silicon photonics, PICs

MARKETS

Food & Beverage
Consumer packaged
Automotive

CONCEPT/ PRODUCT

Smart sensor
Artificial nose

Digital olfaction combines biochemical sensors, optics and machine learning in a single solution for collecting, representing and analyzing odors.

As objects release odor molecules in response to energy variation or biological processes, these odor molecules are captured by Aryballe's proprietary biosensors grafted to our silicon photonics-based Core Sensor.

Once the odor signatures are detected, software then interprets those signatures based on a database of previously collected and analyzed odors to provide organizations with actionable insights based on odor data.
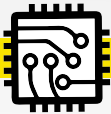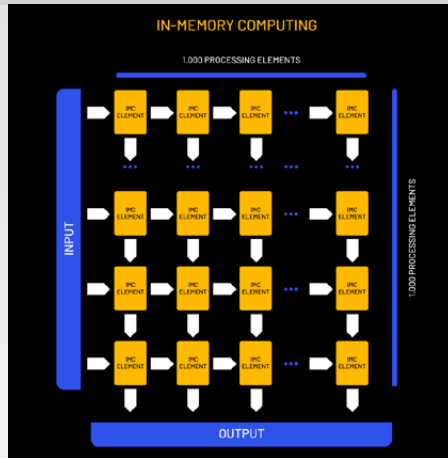
What if...

We could build a radar for odors?

Axelera AI

A hardware and software platform for AI development

A game-changing Edge AI accelerator powered by its disruptive in-memory computing and Risk-V controlled dataflow technology.

AI neural network

MARKETS

Automation
Industry
Security

CONCEPT/ PRODUCT

Ai hardware acceleration
Digital In-Memory Computing

In-memory computing is a radically different approach to data processing, in which crossbar arrays of memory devices can be used to store a matrix and perform matrix-vector multiplications "in-place" without intermediate movement of data.

The proprietary Digital In-Memory Computing (D-IMC) technology is key to delivering high energy efficiency and outstanding perfomance. Based on SRAM (Static Random-Access Memory) combined with digital computations, each memory cell effectively becomes a compute element.

This radically increases the number of operations per computer cycle (one multiplication and one accumulation per cycle per memory cell) without suffering from issues such as noise or lower accuracy.

What if...

Our scouting devices could rely on person/vehicle recognition?

CAIRDAC

A self sustainable leadless pacing system using inertial energy harvester

With its self-sufficient energy design and thanks to a piezoelectric extender, ALPS™ converts the heart's kinetic energy into electrical energy; with every heartbeat the device is accumulating the electrical energy necessary to pace the heart in return; thus, creating a perpetual cycle.

Pacemaker technology

MARKETS

Medical

CONCEPT/ PRODUCT

Implantable devices

ALPS™ is a unique, autonomous and endoscopically implanted leadless pacemaker incorporating a self-sustaining power patented technology harvesting the heart's kinetic energy.

A self-sustainable pacemaker enabled by the use of a proprietary piezoelectric energy harvester associated with its miniaturized ASIC "high-efficient power management circuit".

What if...

## We could monitor the heartbeat for better survivability?

COLOGNE chip

Lowering entry barrier for FPGA technology

GateMate^{TM} FPGA Overview

Designed and manufactured in Germany (Global Foundries 28nm process), significantly reduced total cost of ownership, open-source design flow and expert support give an opportunity for academia and companies to start implementation of new ideas in GateMate FPGA.
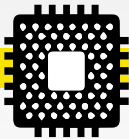
FPGA

MARKETS

Telecommunications
Automotive
Industrial

CONCEPT/ PRODUCT

The GateMate^{TM} FPGA

The GateMate FPGA family leverages the full breadth of Cologne Chip innovation and EU based manufacturing. High logic capacity with multi-die capability and low power footprint combined with lowest cost in industry make GateMate well suited for high volume applications. The strengths of GateMate FPGA devices are reinforced by incorporating open-source design tools, which connect to vast resource of innovation potential and enables easy start with GateMate FPGAs.

The architecture of the GateMate FPGA is based on a novel programmable element (Cologne Programmable Element).

The CPE architecture allows an efficient building of arbitrarily sized logic, such as multipliers for digital signal processing applications.
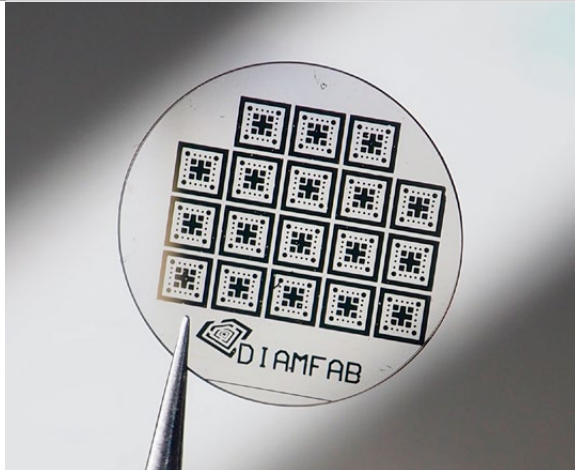
What if...

We could build a FPGA device ecosystem for everyone?

DIAMFAB

Diamond, the ultimate semiconductor for power electronics

Diamond has 5000 times higher current density and 30 times higher voltage compared to silicon and can operate in harsh environments (high temperature and radiation).

Diamond substrate

MARKETS

Automotive
Energy
Space
Defense
Aeronautics

CONCEPT/ PRODUCT

Ultra-wide bandgap semiconductor components

Diamfab's approach to growing synthetic diamond material ranging from a few nanometers in thickness to tens of micrometers is thought to be unique in the industry.

Diamfab diamond wafers can be used for insulator, semiconductor, metallic, and superconductive conduction applications. In automotive applications, Diamfab wafers could allow the fabrication of 80 percent lighter and more compact power converters, according to the company. In power grid applications, Diamfab wafers could also more easily handle higher voltage and reduce energy losses by a factor of 10 compared to silicon.
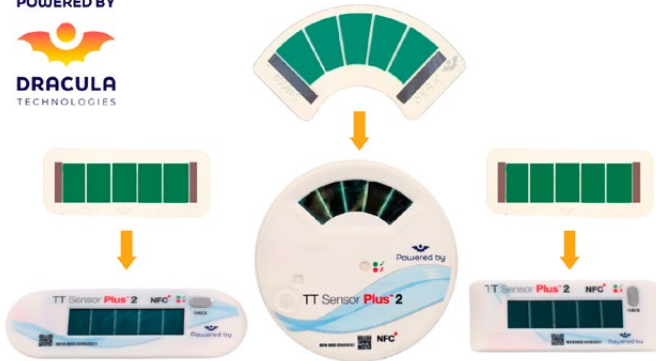
What if...

We could make affordable electronic components for any environment?

DRACULA
Technologies

A printed technology which generates energy from ambient light

POWERED BY

DRACULA
TECHNOLOGIES

**Use the energy around you to power IoT devices.
The industrial process of digital printing makes it possible
to create any imaginable shape.**

Energy harvesting

A technology that converts ambient light, natural or artificial, into electricity. LAYER® is optimized to obtain best performances from 5 to 1000 lux. (corresponding to emergency exit dim light to supermarket high light).

Inkjet Printed Organic Photovoltaic Product.
With more than 10 years of experience, from the laboratory to the industrial stage, we are the first in the world to print with photovoltaic ink.

MARKETS

Automation
Agriculture
Medical
Security
Industry
Consumer

CONCEPT/ PRODUCT

Customized photovoltaic cells

What if...

We could use garments for collecting ambient light energy?

E-PEAS

Maintenance-free solution by increasing battery lifetime

Harvest more

AEM
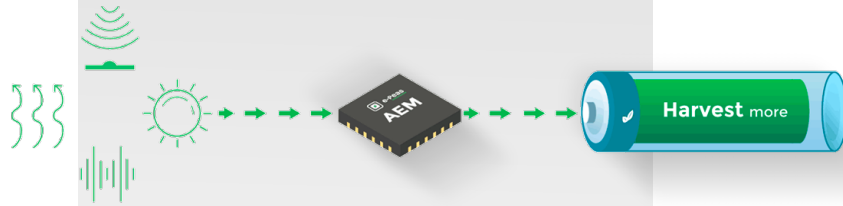
A performing ambient energy harvesting, processing and sensing solutions that make the batteries of your wireless devices live forever.

⚡ Energy harvesting

MARKETS

Automation
Agriculture
Wearable
Security
Medical
Industry

CONCEPT/ PRODUCT

Asset tracker
Solar watch
Migrating birds tracking

E-PEAS provides industry leading energy harvesting and processing solutions – AEMs & Microcontrollers – to give infinite battery life to your wireless device by increasing the amount of harvested energy and by drastically reducing the energy consumption of all power consuming blocks of the system.
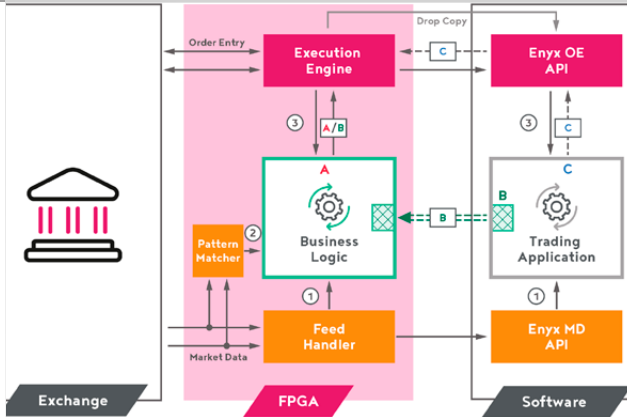
What if...

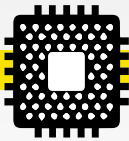## Devices could run without harmful disposable batteries?

EXEGY

Exegy is the only global FPGA technology company that handles the whole trading chain in Hardware, from market data acquisition to order entry.

FPGA

MARKETS

Finance

Telecommunications

High-performance computing industries

NxAccess is a trading engine with an FPGA algo sandbox allowing users to preload orders in hardware, receive market data then trigger & update those orders before sending to the trading venue – with the speed and performance of hardware assisted by the flexibility of software.

With constant, deterministic, and jitter-free performance, nxAccess offers the power of FPGA technology with the integration simplicity of a software solution.
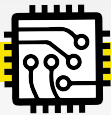
CONCEPT/ PRODUCT

FPGA based trading engine
FPGA based market-data processing

Ultra-low latency cores

What if...

Our systems could use low-latency to react faster than humans?

Deep Learning acceleration on chip thanks to original architecture
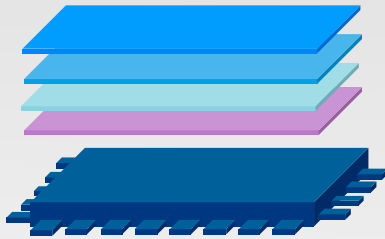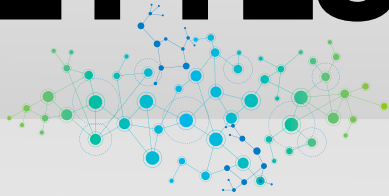
LPU
Layer processing unit

AI neural network

MARKETS

Automotive
Security
Manufacturing

CONCEPT/ PRODUCT

Neuromorphic circuits
and computing

New AI chip architecture, the LPU "Layer Processing Unit", is different from CPU, GPU or TPU, this neural network architecture represents a paradigm shift in the hardware and software structure of neural networks.

The LPU can compute the tensors of all neurons in a layer of a neural network simultaneously in a single computation cycle, including addition of the results and consideration of the activation function of the neurons.

It processes the incoming data in parallel and performs activation and pooling in the same operation step. It is thus a highly efficient chip or processor technology for embedded AI applications.

What if...

UAV navigation systems were based on context recognition instead of inertial?

Dual-channel NDIR Technology

IR µSource — Active signal / reference signal

▌ 1 gas-sensitive detector and filter
▌ 1 detector and reference filter
● gas molecule

Silicon photonics, PICs

MARKETS

Industrial safety
Agriculture
Smart Home
Smart Cities

CONCEPT/ PRODUCT

Ultra low power consumption

Non-dispersive infrared sensor technology (NDIR)

High spatial and temporal resolution air quality information thanks to:
An easily deployable Air quality System (AQS) Network with compact, low power and cost-effective best-in class sensors.

A high-resolution dispersion model with the contribution of reliable real-time data from the AQS network.

Data analysis to provide relevant information on Air Quality to favor the decision making for individuals, communities and government agencies in an eco-aware environment.

An API that offers geolocated information about major pollutants such as NO2, O3, PM1,PM2.5 and PM10 anywhere in the world.

What if...

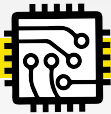## We could build real-time pollutants maps everywhere on earth?

GREENWAVES technologies

Machine learning and digital signal processing on energy constrained devices

Gap9 processor

AI + DSP

GAP9 is a unique, ultra-low power easy-to-program processor that is able to combine classic and ultra-low latency, sample by sample Digital Signal Processing (DSP) and Neural Network (NN) workloads to power the next generation of hearables, wearables and IoT devices.

MARKETS

Hearables, TWS
Smart IoT sensors
AI wearables,
Smart buildings,
Smart home and more

CONCEPT/ PRODUCT

Ultra low power
Risc-V processor
Edge AI + DSP

GAP9 processor revolutionizes hearable products with features like ultra-low latency adaptive noise cancellation, neural network-based noise reduction and dynamic spatial audio.

The GAP9 hearable platform is exceptionally power efficient for voice and music processing, giving headroom in energy and processing power that can be used to develop innovative new features in audio products while preserving space, cost and energy.

GAP9 also allows for multi sensor analysis (vision and sound) and is a perfect solution for battery-powered smart security systems and smart building sensors.

What if...

we could add new audio features without sacrificing battery life?

inspired by ...

ID4US

Biometric fingerprint sensors based on 4D ultrasound identification.

Biometric sensor

MARKETS

Security
Consumer electronics

CONCEPT/ PRODUCT

Ultrasonic 4D
technology

"4D Ultra Sound Identification sensor brings robust information to the system, enabling it to detect along the time the blood flow for calm subjects. Providing more secure biometric solutions. It integrates specific sensors, integrated circuits (ASIC) and software"

ID4US developments are based on the unique technological expertise of the Doliam group for ultrasound sensors.
(with its companies MODULEUS and IC'ALPS).
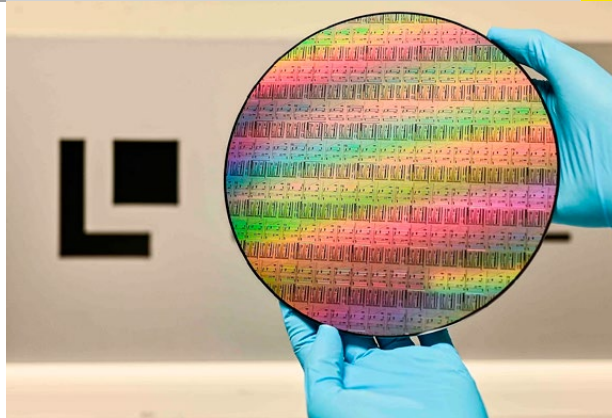
What if...
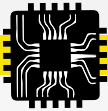
We could share our emotional state by a simple touch?

LIGENTEC

Photonic integrated circuits (PIC)

Customer specific, low loss Photonic Integrated Circuits (PICs) based on silicon nitride waveguides.

Silicon photonics, PICs

MARKETS

Telecom
Datacom
Quantum Computing
Metrology
Biosensing
LiDAR

CONCEPT/ PRODUCT

Development Support
Manufacturing of PICs

LIGENTEC offers for silicon-nitride based Photonic Integrated Circuits from concept to high volumes in applications such as communication, autonomous driving, quantum computing, metrology, biomedical and more.

LIGENTEC, originated from the Federal Institute of Technology in Lausanne (EPFL), has it's main office in Lausanne and a subsidary in France near Paris where it has it's technology installed in an automotive qualified 200mm CMOS volume fab.

What if...
The electronic IC revolution repeats, and a shoebox sized optical instrument would shrink to the size of a fingernail?

43

NEOVISION
& dolphin design

Power efficient Neural Processing IP Platform specialized in sound and vision

For CES 2023, **Dolphin Design & Neovision teamed up to build CamCube**, a device-like demonstrator enabling AI-based vision applications at sub-mW level.
Credits: Dolphin Design

The camera device leverages Dolphin Design's silicon IP design platforms, the company's ultra-low power Edge AI accelerator IP, and runs Neovision's high-performance and compact machine learning models.
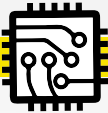
AI neural network

MARKETS

Environment
Digital
Industrial
Healthcare

CONCEPT/ PRODUCT

AI training

The solution to deal with data deluge, while preventing the increase of power consumed by data centers, is known as Edge AI. This solution consists in transferring most of the processing intelligence from the cloud to the sensor.
It translates into an unprecedented need to increase performances of «smart devices» by a factor of 1,000 at constant energy consumption.
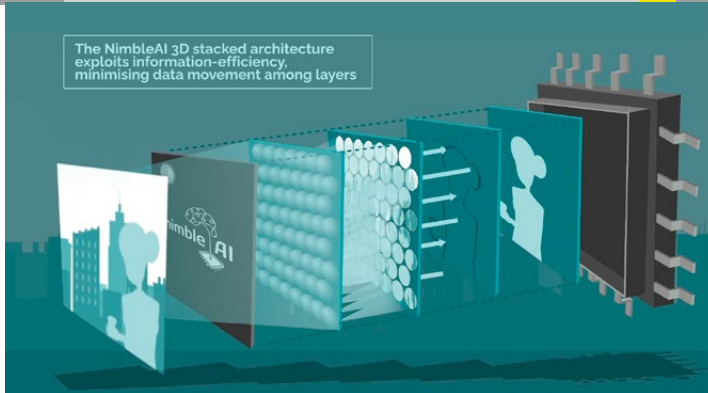
What if...

Everybody could make image recognition?

NimbleAI
project

Sandbox for testing new concepts, new computer vision algorithms, and new runtime optimizations

The NimbleAI 3D stacked architecture exploits information-efficiency, minimising data movement among layers

Integral sensing-processing neuromorphic architecture that efficiently and accurately runs computer vision algorithms in 3D integrated silicon.
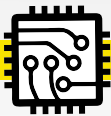
AI neural network

MARKETS

Security
Industrial
Medical

CONCEPT/ PRODUCT

Neuromorphic sensing and processing 3D integrated chip

The project will deliver a prototype FPGA implementation of the 3D silicon stacked sensing and processing architecture, as well as the corresponding programming tools to develop and run computer vision applications on this architecture.

The prototype will serve as a research vehicle for testing new concepts, new computer vision algorithms, and new runtime optimizations.

The results of NimbleAI will lead to practical implementations in the next generations of commercially available neuromorphic chips.

The eFPGA technology developed by Menta is an answer to the problem of obsolescence induced by Artificial Intelligence. Algorithms such as those used by AI evolve 4 times faster than the production rate of a chip. Therefore, the ability to reprogram chips after they have been produced allows them to be constantly adapted to these needs. This is particularly true for the aeronautics, space and automotive sectors but also for the medical imagery.

What if...
this technology could be embedded on insects?

45

QUANTIC sensors

A new sensitivity improving approach
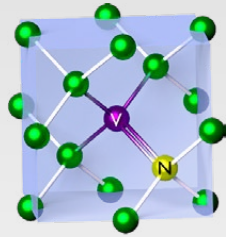
Simplified atomic structure of the nitrogen-vacancy centers (NV) defect (Source : WIKIPEDIA)

Quantic sensors

MARKETS

Finance
Metrology
Cryptography
Navigation
Medical

CONCEPT/ PRODUCT

Ultra-precise optical clocks
3D vision using quantum lidar
Real-time mapping of the
Earth's gravity...

Gravimeters, gyrometers, accelerometers, time or magnetic field sensors, temperature or chemical activity sensors... All technological sectors are concerned, and the applications are countless.

"To be located without GPS, to measure magnetic fields at high pressures, to map gravitational irregularities on the surface of the oceans: so many concrete services rendered by these small objects which upset metrology and its applications".
Le Monde -14 février 2023 - David Larousserie

"Diamonds are robust hosts that can survive in the real world and, inside, carry a piece of the quantum world".
Ron Walsworth

The NV center is a point defect where one carbon atom in the diamond's crystal lattice is replaced by an nitrogen atom (N) and an adjacent lattice site is left empty (vacancy, V). The NV color center emits a red fluorescence signal (600–800 nm) when illuminated with green light (532 nm). The NV spin state exhibits high quantum coherence, can be fully controlled by microwave radiation and measured by visible light, and its resonance frequency is highly sensitive to magnetic field.
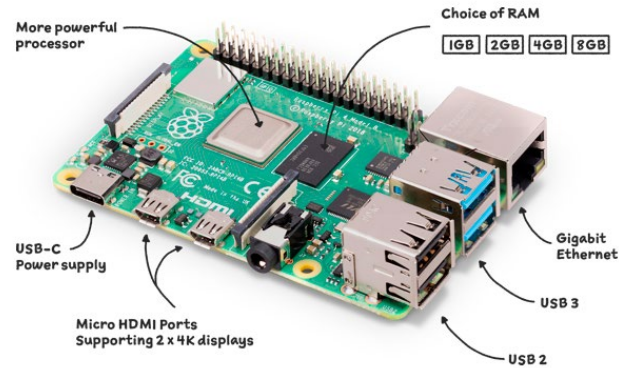
What if...

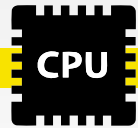**We brought in three orders of magnitude more accurate sensors on an operating theatre?**

RASPBERRY Pi

Affordable way to do something useful or fun

Low-cost, high-performance single-board computers and microcontrollers, witch operates in the open source ecosystem.

CPU **Low-cost computer**

MARKETS

Consumer products
Industrial

CONCEPT/ PRODUCT

Raspberry Pi 4 model B

Democratising technology – providing access to tools – has been our motivation since the Raspberry Pi project began.
By driving down the cost of general-purpose computing to below $5, we've opened up the ability for anybody to use computers in projects that used to require prohibitive amounts of capital.
Today, with barriers to entry being removed, we see Raspberry Pi computers being used everywhere from interactive museum exhibits and schools to national postal sorting offices and government call centres.
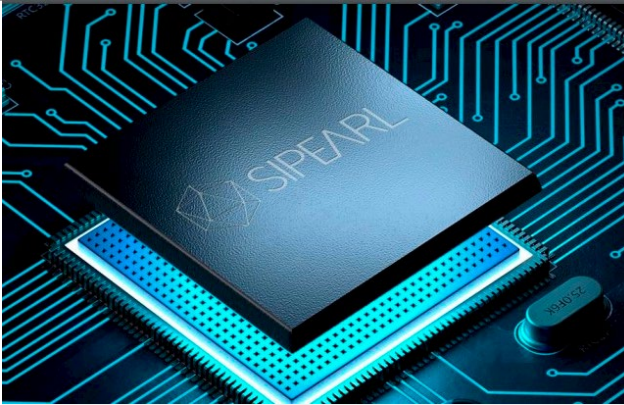
What if...

Low-tech is the *future* of high-tech?

SI PEARL

Microprocessor that will power exascale supercomputers

Development of an high-performance, low-power and backdoor-free security microprocessor (Rhea) that will be at the heart of European supercomputers.

High performance computing

MARKETS

Supercomputing

CONCEPT/ PRODUCT

Rhea processor
Advanced logic and memories

With the Arm® Neoverse V1 platform, Rhea will be the world's first dedicated high-performance computing microprocessor designed to work with any third-party accelerator, such as GPUs artificial intelligence chips or quantum accelerators.

Cooperative agreements with GPU vendors (AMD, Intel, NVIDIA) and artificial intelligence processor vendors (Graphcore) have already been announced.

Optimized for energy efficiency, Rhea will consume half the energy for equivalent computing power.
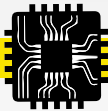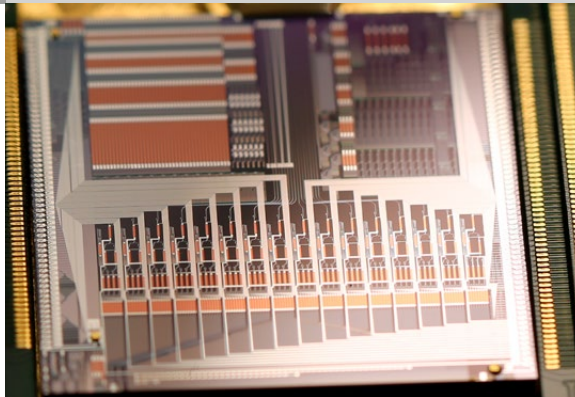
What if...

The US banned their technology exports towards Western Europe?

SCANTINEL
Photonics

New LIDAR technology

A Frequency Modulated Continuous Wave (FMCW) LiDAR is a LiDAR that can also directly measure the speed of an object. These are also named Doppler LiDARs or 4D LiDARs, or chirped LiDARs, because these LiDARs are now using the Doppler Effect calculated using the FMCW chip.

Silicon photonics, PICs

MARKETS

Automotive
Security

CONCEPT/ PRODUCT

Frequency Modulated
Continuous Wave (FMCW) LiDAR

Scantinel has developed a unique solid-state beam steering technology called Optical Enhanced Array (OEA). This is a unique combination of a photonic integrated chip and advanced optical system.

A photonic integrated chip processes light on silicon in a similar way to what electronic chips do with electric signals.

This PIC, designed by Scantinel and manufactured by manufactured in high-volume CMOS fabs, steers multiple FMCW channels in parallel via a solid-state fast scanning axis.

What if...
any vehicle could detect a threat?

SCINTIL
photonics

Silicon photonics, PICs

Next generation optical compute interconnect link
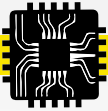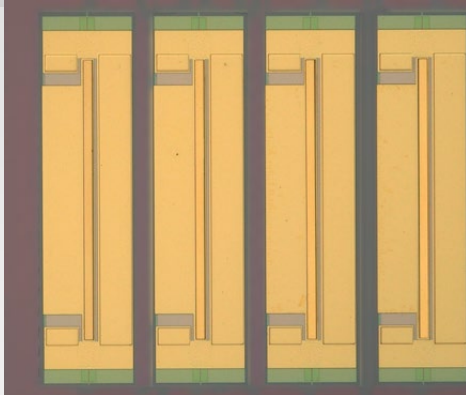
A solution for ultimate optical connectivity in Data Centers, and Cloud HPC thanks to a silicon photonic integrated circuit augmented with integrated lasers and optical amplifiers.

MARKETS

HPC, Cloud computing

CONCEPT/ PRODUCT

Single chip multiwavelength DFB array Laser Source

The DFB comb laser source is designed to fuel optics co-packaged with host **ASICs.** It features:

Multiple optical carriers spaced by 100 GHz or 200 GHz all combined on either one or multiple output ports.

Configurations that can offer transmissions up to 16 optical carriers x 64 Gbps per fiber, which are suitable to support next generation optical compute interconnect links.
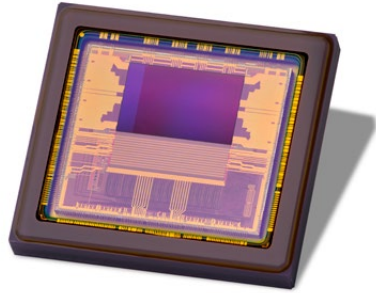
What if...

We could connect all the supercomputers in the world?

High resolution Time-of-Flight Sensor to work in all light conditions without motion artefacts.

Hydra3D+ is a 832 x 600 pixel resolution Time-of-Flight (ToF) CMOS image sensor, designed with Teledyne e2v's proprietary CMOS technology, and is tailored for versatile 3D detection and measurement.

Smart sensor

MARKETS

Defense
Factory Automation
Monitoring
Industrial
Space

CONCEPT/ PRODUCT

CMOS 3D Time-of-Flight Sensor

The sensor includes a brand-new 10μm, three-tap pixel, which provides very fast transfer times, excellent modulation contrast and high sensitivity in the NIR wavelength

This enables the sensor to operate in real-time without motion artefacts for customers seeking reliable 3D detection and the highest levels of 3D performance, including high depth resolution, high speed and flexible operation conditions, all without system interference.

What if...

We could know instantly the distance of a threat?

TELEDYNE e2v

New Digital Analog Converter (DAC) providing significant leap for Radio Frequency (RF) Softwarization

At any band up to Ka, System designers can now migrate more RF hardware to digital code than ever before. Enabling unprecendented levels of dynamic RF system reconfiguration on the fly.

DAC signal processing

MARKETS

Telecom
Space
Military
Security
IoT

CONCEPT/ PRODUCT

Multiband data
conversion technology
up to Ka-band

EV12DD700 dual-channel DACs are capable of operating up into Ka-band frequencies and support beamforming applications

They have a 25GHz output bandwidth with only 3dB attenuation being witnessed, and can go way beyond this with just a little over 3dB attenuation. Built into each DAC is an array of sophisticated signal processing functionality
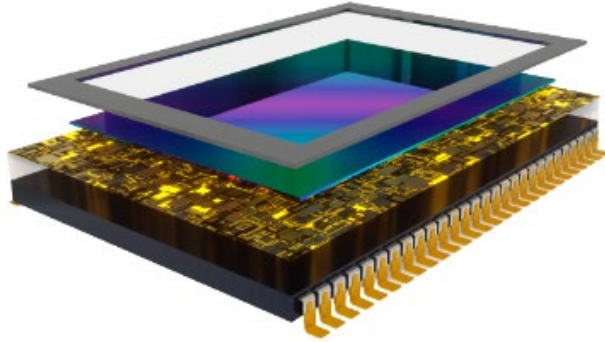
This encompasses a programmable anti-sinc filter and direct digital synthesis (DDS) capabilities, as well as a programmable complex mixer.

What if...

We could digitize the whole electromagnetic spectrum?

VOXEL sensors

3D Perception to Seamlessly Blend the Physical and Digital Worlds

SPAES is a revolutionary sensor architecture designed for laser beam scanning based 3D perception.
It localizes active laser points or structures in space.
The output is used to generate a 3D point – a voxel – at a rate of 100 MHz.

Smart sensor

Laser technology
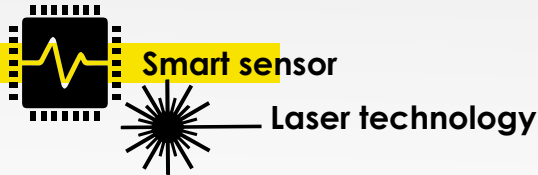
MARKETS

Consumer
Industry
Virtual, Augmented, Mixed reality wearables

CONCEPT/ PRODUCT

Switching Pixels® Active Event Sensor (SPAES)

It produces 3D data with the absolute minimum amount of energy consumed.
The single photon sensitive sensors localize the tip of the laser beam with high temporal resolution (up to 100 MVoxel/s) and generate ultra-low latency depth data at a rate 100x faster than any other technology.

The perception technology is designed to be ambient light robust and immune to concurrent optical sensing systems.

By serializing the depth acquisition by means of scanning triangulation, the system has low computational complexity since no stereo-matching of complex images is needed. The produced data is extremely versatile in its use: a serialized, low latency, continuous, scalable and flexible data stream provides a natural trade-off between data density and data aggregation window.

What if...

Any given context could be captured in 3D at lightspeed?

WISE integration

Innovative electronics solutions for power management
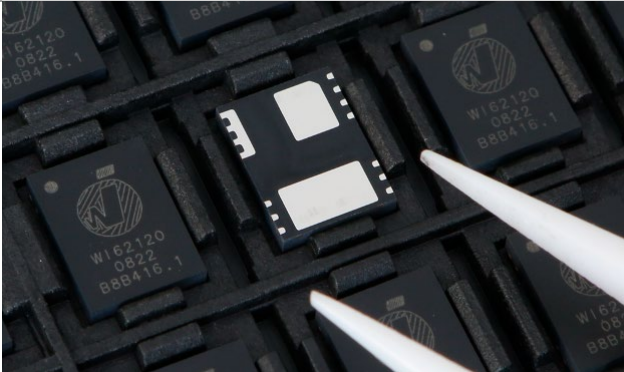
Combining the unique properties of GaN, like high voltage breakdown and operation at the high current and switching frequency, with the high performance of digital control, Wise Integration has developed a technology offering ultra-miniaturized power supplies.

GaN power integrated circuit

MARKETS

Consumer electronics

E-mobility

Industry

Data center

CONCEPT/ PRODUCT

WiseGan®, WiseWare®

Customized chip and digital controller for a miniaturization of the Power Supply

Wise-integration is a fabless company providing power GaN integrated circuit with digital control to reach ultimate customers power supplies performances with a simple design : smaller size, better efficiency and more reliability at lower cost.

They have developed a range of power management products based on their patented GaN integrated circuits technology and digital controller, which enables greater energy efficiency and miniaturization of power supply units.

What if...

we recharge our equipements and vehicles ... quickly and reliably?

WEEROC

On-the-shelf programmable analogue and mixed front-end ASICs for photodetector and particle detector read-out.

A young, innovative CNRS start-up that develops and markets microelectronic circuits for industry and research in the fields of medical imaging, scientific instrumentation and space.
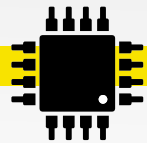
Read-out chip

MARKETS

Medical imaging
Scientific instrumentation
Security
Consumer electronics
Space
Nuclear protection

CONCEPT/ PRODUCT

Photodetector read-out ASIC
SiPM-based LIDAR read-out chip

As part of the development of new LiDAR-related technologies, Weeroc has developed a SiPM reading ASIC adapted to LiDAR applications (LIROC). Systems are currently being developed to meet the needs of various customers (Automotive LiDAR, Atmospheric LiDAR, Space LiDAR).

LIROC ASIC is designed in TSMC 130nm CM013G. This technology has been qualified by CERN for its excellent radiation hardness over total irradiation dose. LIROC is a 64-channel front-end ASIC designed to read out Silicon Photo-Multipliers (SiPM) for LIDAR application.
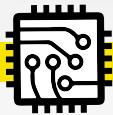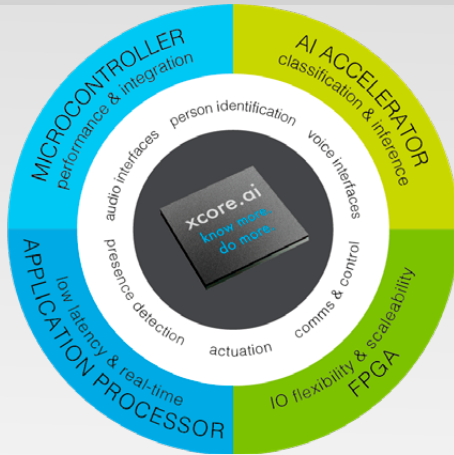
What if...

We could use photodetectors for collecting perfect ramdom numbers?

Machine learning and digital signal processing on unique multicore architecture

Solutions for a wide range of applications, including industrial, automotive, consumer electronics, and enterprise communications.

Multicore platform for the intelligent IoT

MARKETS

Smart IoT sensors
Public monitoring
Asset tracking
Smart farming

CONCEPT/ PRODUCT

XCORE®.AI

Efficient data capture and processing with deep neural networks; inferencing and characterisation of 8bit, 16bit, 32bit and binarized network models are supported. Programmable in C with standard tools, and frameworks.

Fast and predictable, xcore.ai delivers high performance computing at the edge. DSP, AI, control and communication can be processed concurrently with execution determinism measured in single cycles.

Incredible processing power for the cost. With flexible forms of computing and connectivity in a single device, eBOM is kept low, enabling manufacturers to design intelligent products that make life simpler, safer and more satisfying for all.
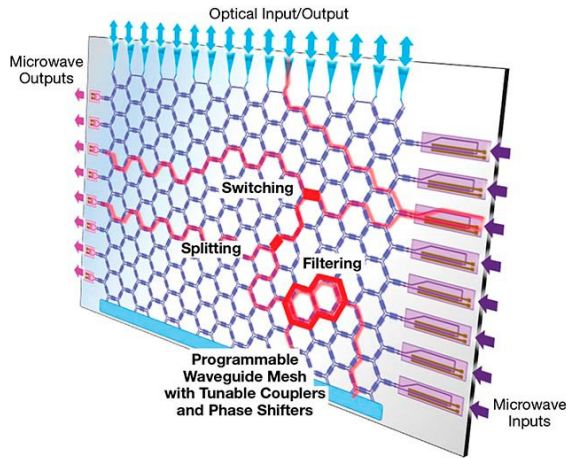
What if...

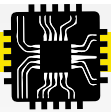## We could instantly analyse and source detonations?

Liquid crystal technology and MEMS are enabling reprogrammable PICs

Optical Input/Output
Microwave Outputs
Switching
Splitting
Filtering
Programmable Waveguide Mesh with Tunable Couplers and Phase Shifters
Microwave Inputs

Silicon photonics, PICs

MARKETS

Telecom
Quantum Computing
Metrology

CONCEPT/ PRODUCT

Development Support
Manufacturing of PICs

Developing low-power building blocks for large-scale and reconfigurable photonic integrated circuits (PICs)

"Multipurpose programmable electronics, such as field-programmable gate arrays (FPGAs), have been a crucial enabler for innovation in consumer electronics. Photonics needs chips with a similar use model: Buy a general-purpose, off-the-shelf chip and then configure it to perform the optical functions needed. A programmable photonic chip such as this could bring down the prototyping timeline for a new photonic product from many years to a few months or even weeks. This will lead to an enormous boost in the use of photonic chips and the diversity of their applications."
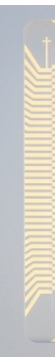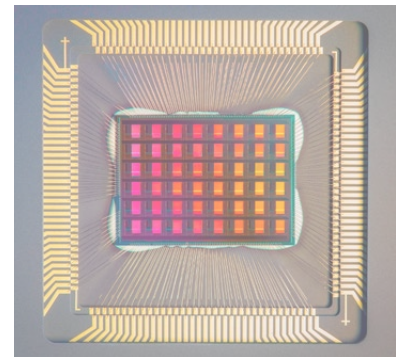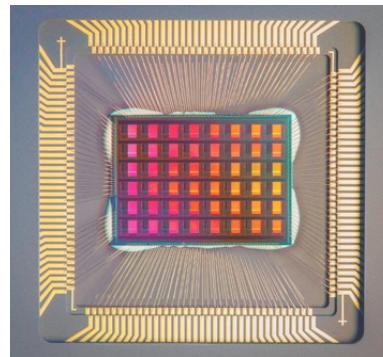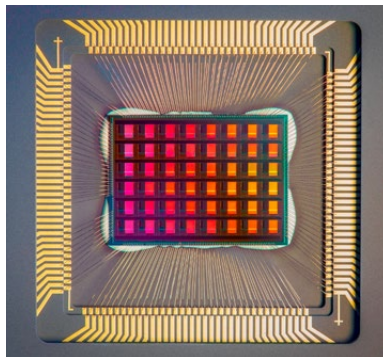
"The capability to use the same chip to prototype different functions is a potential a game changer for the field of PICs because it enables the same sort of rapid development models that proved so successful in the development of electronics".

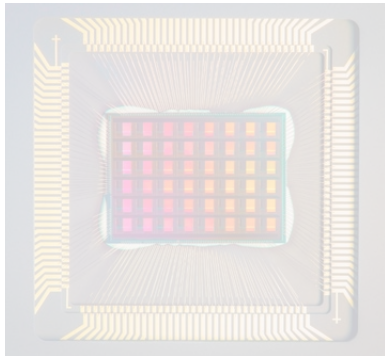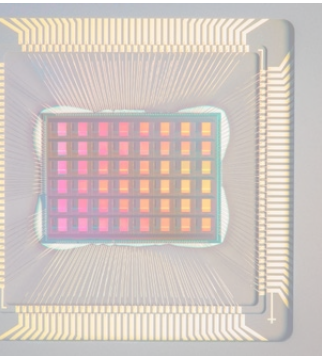Wim Bogaerts - Photonics spectra - Apr 2023

What if...

Photonics integrated circuits could be on everybody laptop?

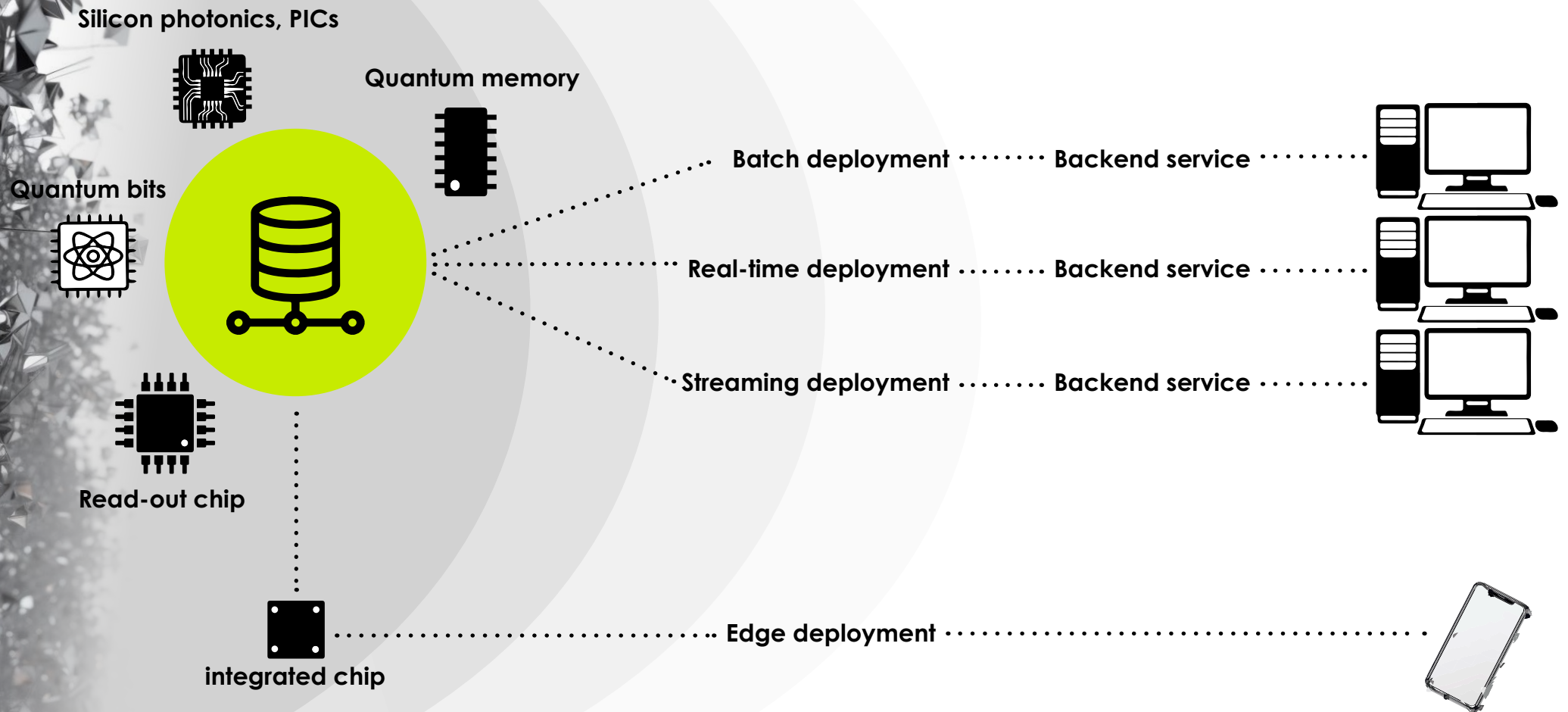# 3 Playing with ideas
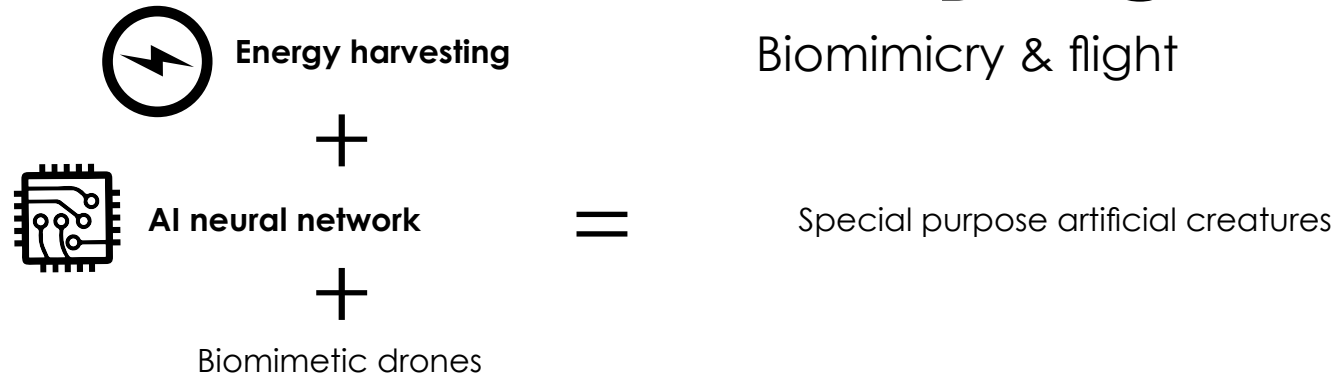
Combining inspiration & contexts

Playing with ideas

# Playing with ideas

From quantic computation
as a service to edge Q

Silicon photonics, PICs

Quantum memory

Quantum bits

Batch deployment ········· Backend service ·········

Real-time deployment ········ Backend service ·········

Streaming deployment ········ Backend service ·········

Read-out chip

integrated chip

Edge deployment ················

Biomimicry & flight

Energy harvesting

+

AI neural network

+

Biomimetic drones

=

Special purpose artificial creatures

Tanaka, S.; Asignacion, A.; Nakata, T.; Suzuki, S.; Liu, H. Review of Biomimetic Approaches for Drones. Drones 2022, 6, 320.
https://doi.org/10.3390/drones6110320
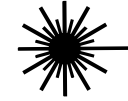
Playing with ideas

CubeSat swarm for synthetic
aperture radar (SAR) applications
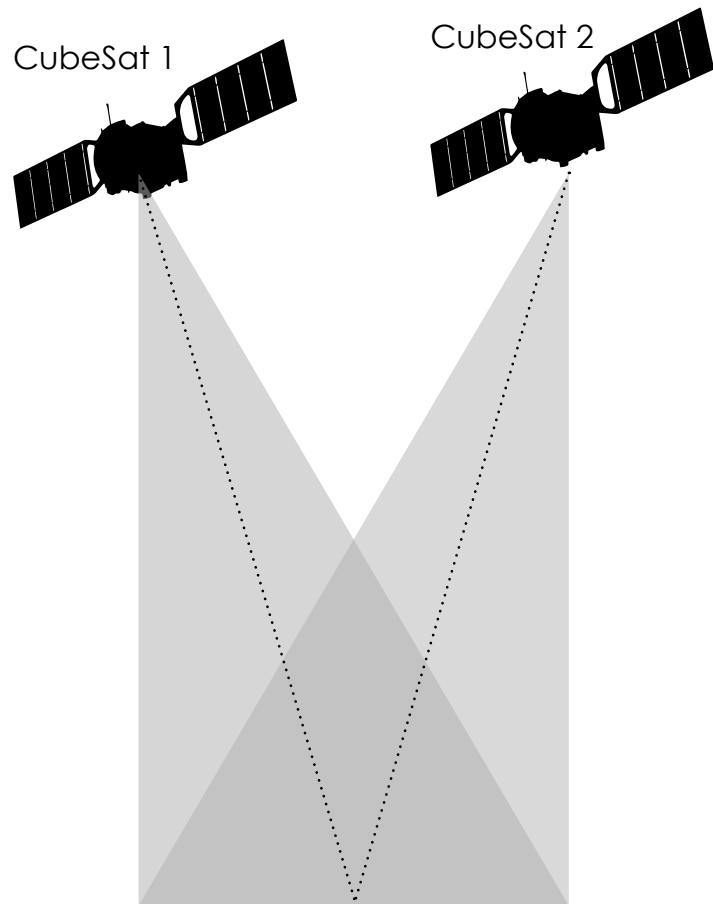
CubeSat 1

CubeSat 2

Cooperative Multiple Output Mutiple
Input (MIMO) Swarms of SAR CubeSats
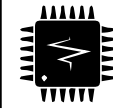
Smart sensor

Laser technology

DAC signal processing

Diamond substrate
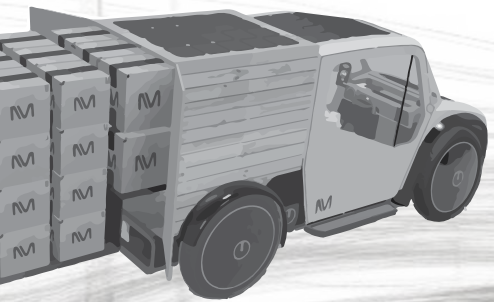
How the world of hardware

GaN power integrated circuit
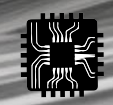
Smart sensor

Energy harvesting

GaN power integrated circuit

High performance computing

Silicon photonics, PICs
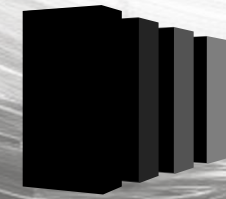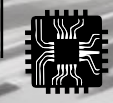
Smart sensor

Microled display

Neuro electronic device

Smart sensor

High performance computing

Silicon photonics, PICs

Quantum computing

GaN power integrated circuit

Energy harvesting

Smart sensor

inspires the world of foresight
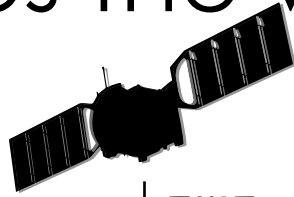
Quantic sensors

DAC signal processing

Diamond substrate

Smart sensor

GaN power integrated circuit

AI neural network

AI neural network
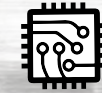
Smart sensor
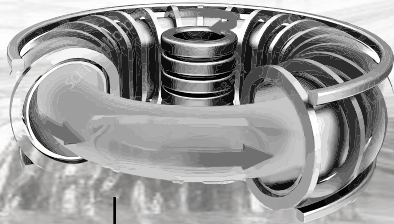
Energy harvesting

X-ray technology

Laser technology

High performance computing

Diamond substrate

Smart sensor

Microled display

AI neural network

Smart sensor

A three-track method

1 **Drivers** ....

Giving a framework based on technological roadmaps

2 **Inspiring projects** ....

Moving from tech-to-imagination

3 **Playing with ideas** ....

Combining inspiration & contexts

A three-track method

9 **Drivers**

Inspiring projects

In a box of possibilities

Combining with n context Events
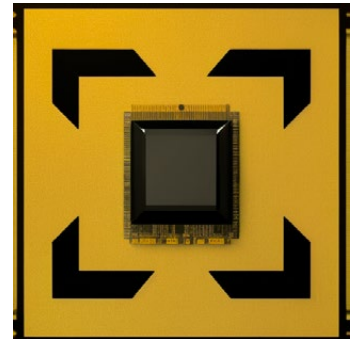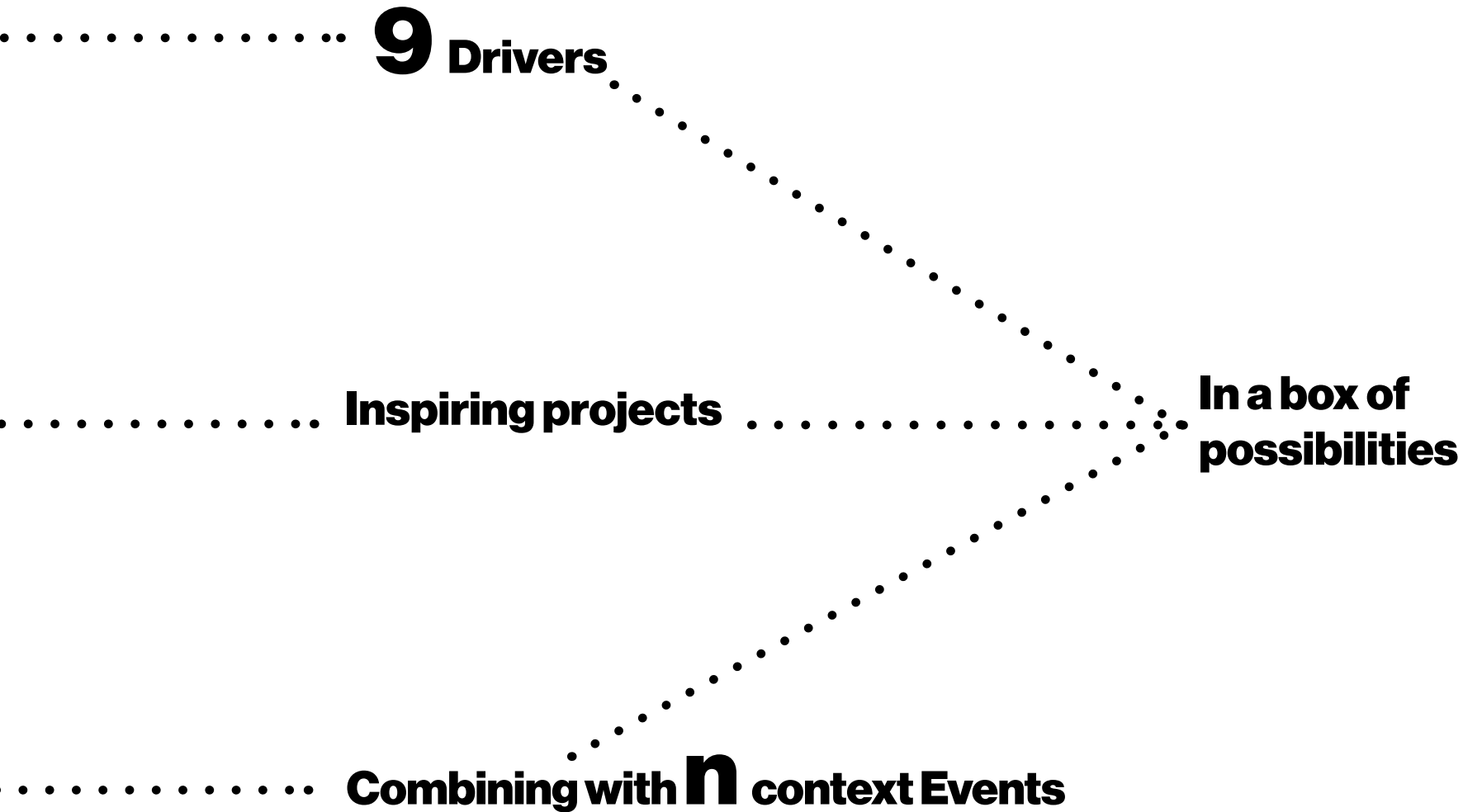
Bibiography / sources

Inspiring projects:

ALICE & BOB (France)
https://alice-bob.com/

ARYBALLE (France)
https://aryballe.com/

Axelera AI (Netherlands, Switzerland)
https://www.axelera.ai/

CAIRDAC (France)
https://www.cairdac.com/

COLOGNE CHIP (Germany)
https://www.colognechip.com/

DIAMFAB (France)
https://diamfab.com/

DRACULA Technologies (France)
https://dracula-technologies.com/

Groupe DOLIAM (France)
https://doliam.fr/

DOLPHIN DESIGN (France)
www.dolphin-design.fr

E-PEAS (Belgium)
https://e-peas.com/

EXEGY (France)
https://www.exegy.com/

EYYES (Germany)
https://www.eyyes.com/en/

ELICHENS (France)
https://www.elichens.com/

GREENWAVES TECHNOLOGIES (France)
https://greenwaves-technologies.com/

IC'ALPS (France)
www.icalps.com

ID4US (France)
https://www.id4us.fr/ (under construction)

LIGENTEC (Switzerland)
https://www.ligentec.com/

MENTA (France)
https://www.menta-efpga.com/

NEOVISION (France)
https://neovision.fr/

NIMBLE AI project (Europe)
https://www.nimbleai.eu/technology/

RASPBERRY PI (United Kingdom)
https://www.raspberrypi.com/

SIPEARL (France, Germany, Spain)
https://sipearl.com/

SCANTINEL Photonics (Germany)
https://scantinel.com/

SCINTIL Photonics (France)
https://www.scintil-photonics.com/

TELEDYNE-E2V (France, United Kingdom)
https://www.teledyne-e2v.com/en/home/

VOXEL SENSORS (Belgium)
https://voxelsensors.com/

WISE-INTEGRATION (France)
http://wise-integration.com/

WEEROC (France)
https://www.weeroc.com/

XMOS (United Kingdom)
https://www.xmos.ai/

Others:

MIDIPILE MOBILITY (France)
https://midipile.eu/

THE FLETCHER SCHOOL AT TUFTS UNIVERSITY (United States)
https://fletcher.tufts.edu/

SIMON & SCHUSTER (United States)
https://www.simonandschuster.com/

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L'industrie des semi-conducteurs et son futur, les séances thématiques de l'académie des technologies – May 11, 2022

WORKSHOP Sustainable Electronics and International Cooperation On Semiconductors Grenoble – ICOS (International Cooperation On Semiconductors) - April 26-28, 2023

DEFTECH 2022 https://deftech.ch/

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Glossary

2.5D integration
An advanced integrated circuit packaging technology that bonds dies and/or chiplets onto an interposer for enclosure within a single package.

3D integration
An advanced semiconductor technology that incorporates multiple layers of circuitry into a single chip, integrated both vertically and horizontally.

3D-IC (also 3DIC or 3D IC)
Three-dimensional integrated circuit; an integrated circuit built with 3D integration.

ASIC
Application-Specific Integrated Circuits (ASICs), are custom manufactured for specific design tasks.

ASML
Is a large Dutch company and one of the world's leading manufacturers of photolithography machines for the semiconductor industry.

Chip
An integrated circuit; may refer to either a bare die or a packaged device.

Chiplet
A small die designed to be integrated with other components within a single package.

Die
An unpackaged integrated circuit; a rectangular piece cut (diced) from a processed wafer.

Fab
A semiconductor fabrication plant.

FPGA
Field Programmable Gate Arrays (FPGAs) are semiconductor devices that are based around a matrix of configurable logic blocks (CLBs) connected via programmable interconnects. FPGAs can be reprogrammed to desired application or functionality requirements after manufacturing.

GaN
Gallium Nitride (GaN) is a very hard, mechanically stable wide bandgap semiconductor. With higher breakdown strength, faster switching speed, higher thermal conductivity and lower on-resistance, power devices based on GaN significantly outperform silicon-based devices.

Integrated Circuit (IC)
Aminiature electronic circuit formed by microfabrication on semiconducting material, performing the same function as a larger circuit made from discrete components.

Microelectronics
The study and manufacture (or microfabrication) of very small electronic designs and components.

Photonic integrated circuit (PIC)
A photonic integrated circuit (PIC) is a chip that contains photonic components, which are components that work with light (photons).

Semiconductor
A material with an electrical conductivity value falling between that of a conductor and an insulator; its resistivity falls as its temperature rises.

SiC
SiC is a semiconductor compound made up of silicon (Si) and carbon (C). It belongs to the wide bandgap family of materials and has a very strong physical bond, which gives the material high mechanical, chemical, and thermal stability.

Silicon
The semiconductor material used most frequently as a substrate in electronics.

Silicon on insulator (SoI)
A layered silicon–insulator–silicon substrate.

Substrate
The semiconductor material underlying the circuitry of an IC, usually silicon.

System on chip (SoC)
A single IC that integrates all or most components of a computer or other electronic system.

Technology node
An industry standard semiconductor manufacturing process generation defined by the minimum size of the transistor gate length.

TSMC
The world's largest dedicated independent pure-player semiconductor foundry. TSMC recorded a market share of 58.5 percent in the global semiconductor foundry market in Q4 2022.

Acknowledgements

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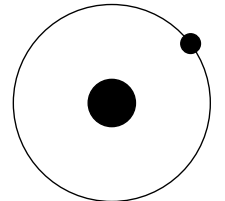The ProtonBot
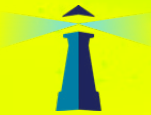**www.agenceproton.com**
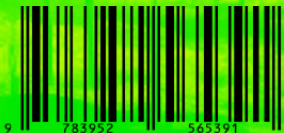**AgenceProton@protonmail.com**

deftech.ch

Every chip we release, we create the future.

With this document, we want to share a hardware-based way of thinking about the future. More precisely, we want to take you down into the bowels of electronics, where the intelligence of products resides: at chip level.

AgenceProton
Imaginaire et interactions fortes