Transformation on a (shoestring) budget

TheEdge SME Forum 2019

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Agenda

1. SILTERRA
2. Transformation
3. Technologies
4. Working with us

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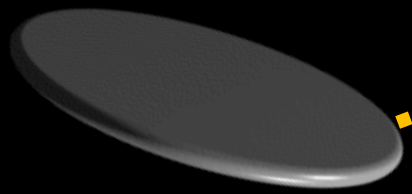
SILTERRA

FROM WAFER TO CHIPS

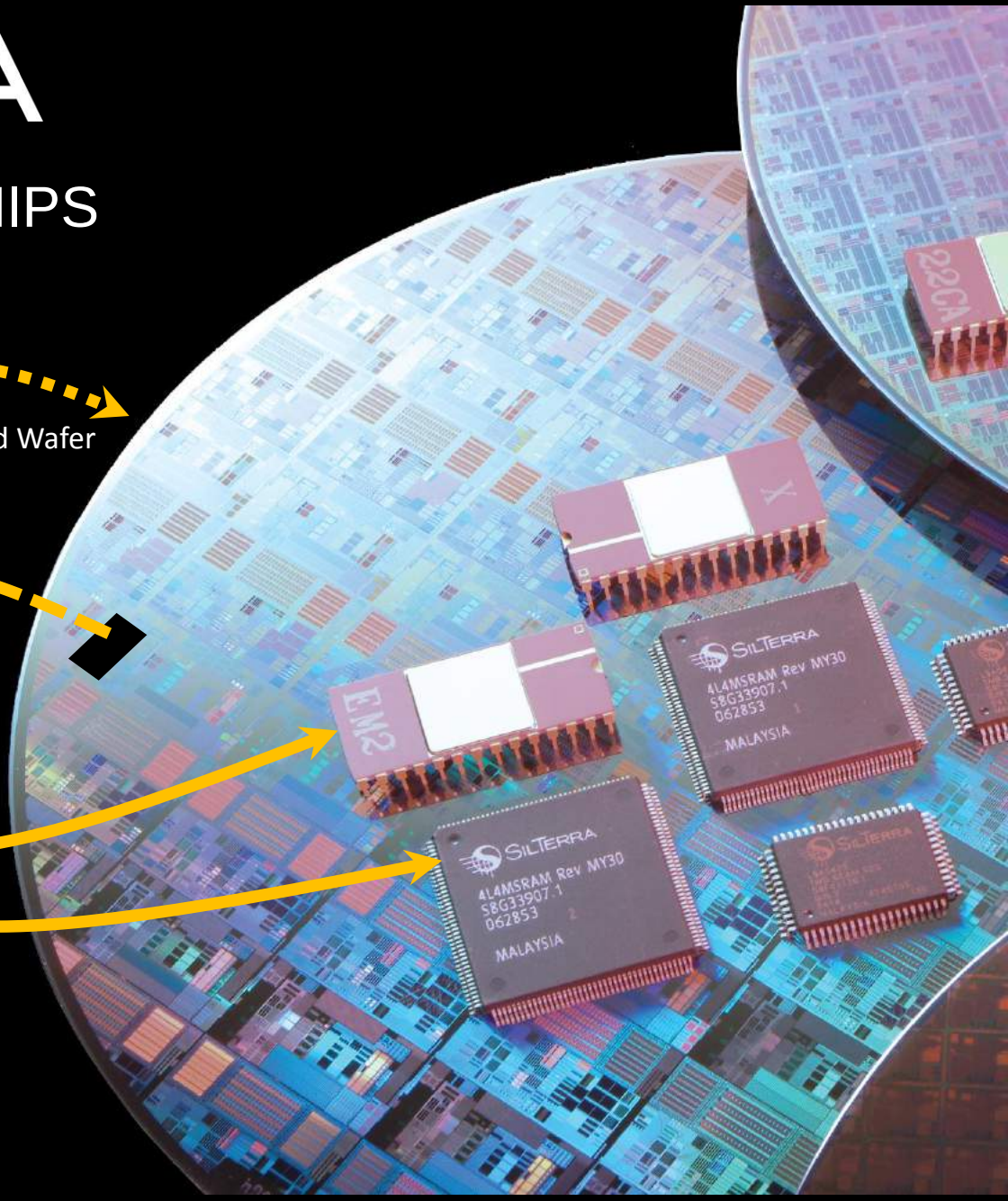


Raw Wafer

Processed Wafer

A single DIE

Packaged into CHIPS



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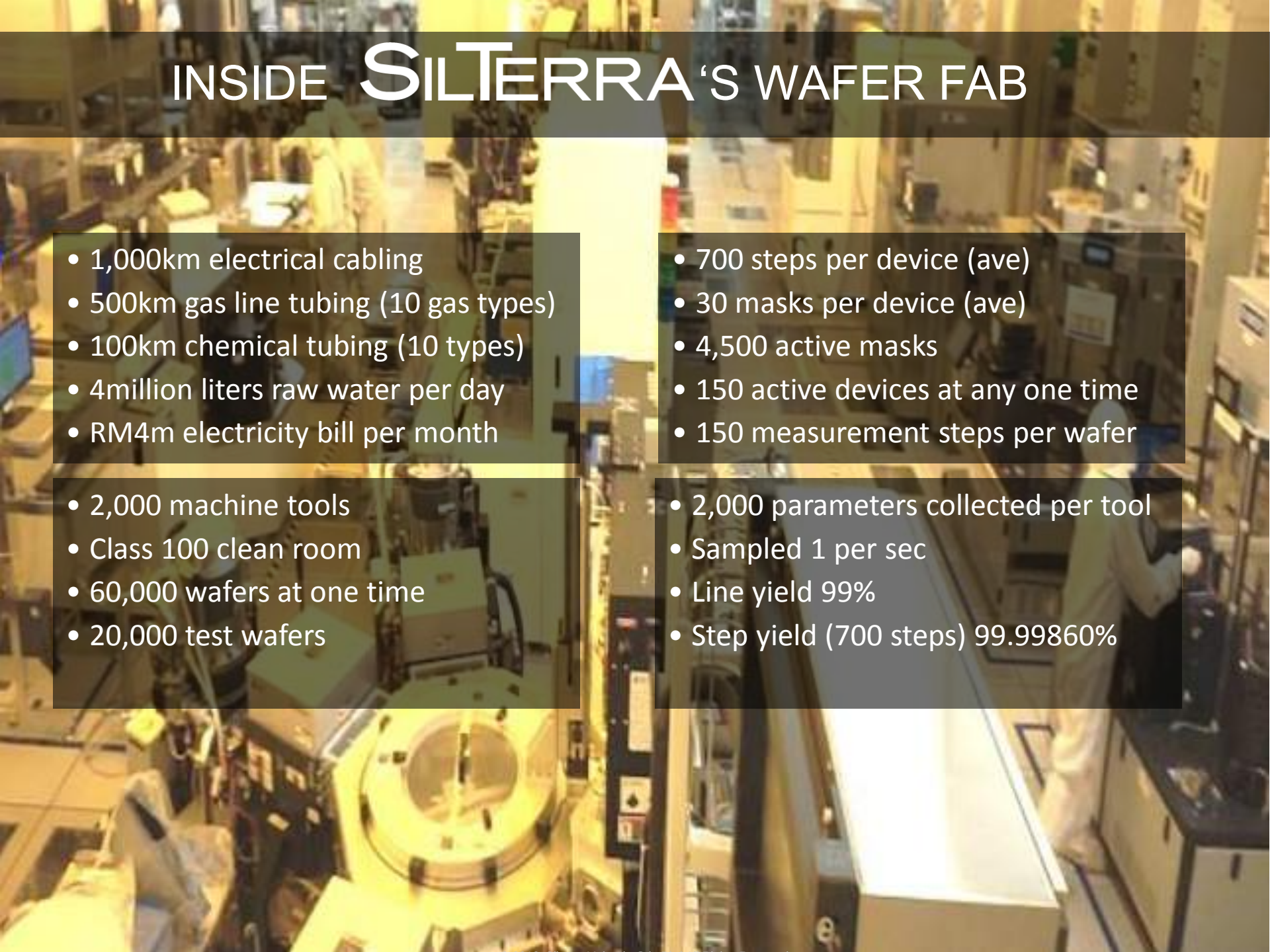
INSIDE SILTERRA'S WAFER FAB



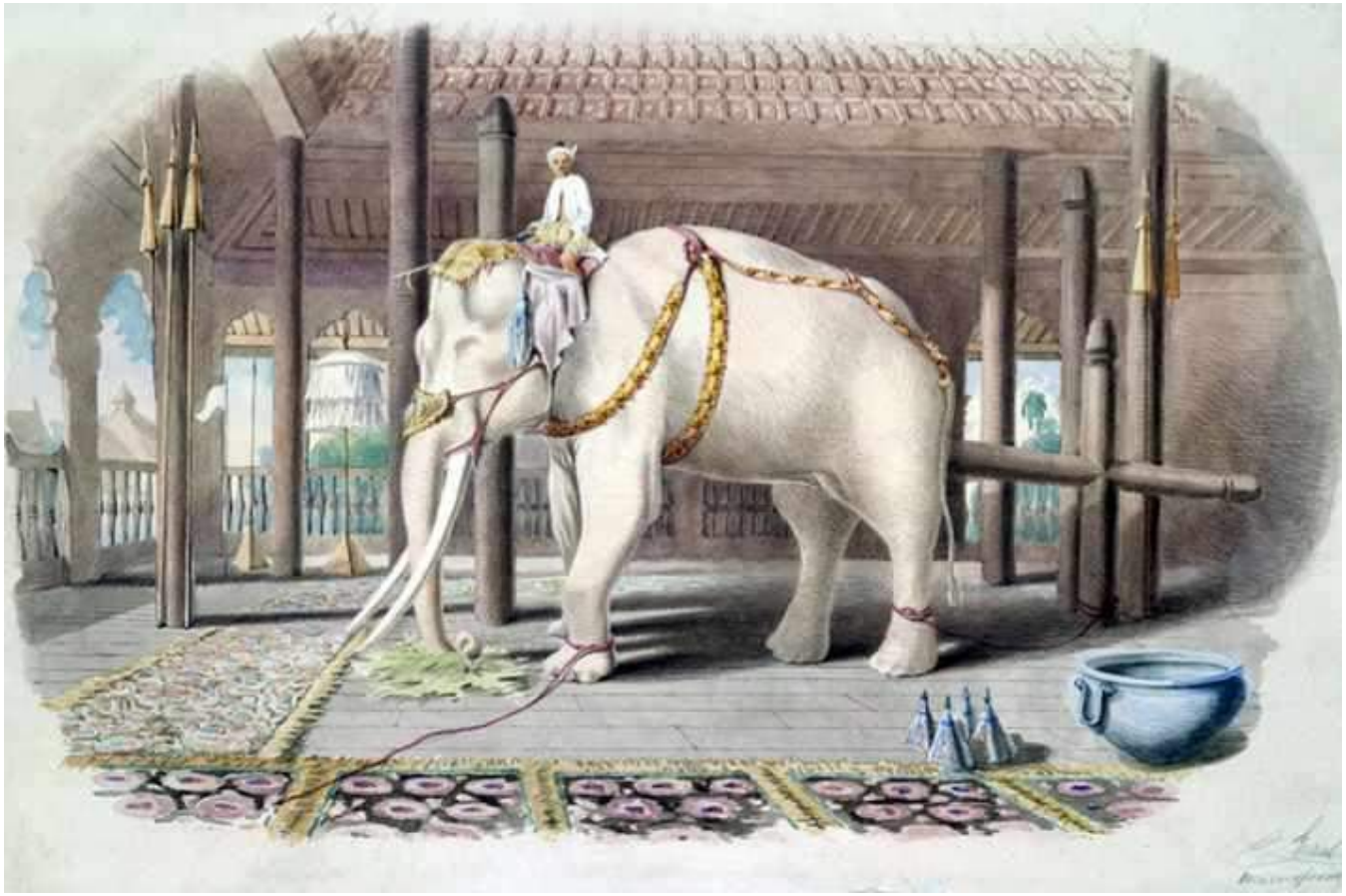
- 1,000km electrical cabling
- 500km gas line tubing (10 gas types)
- 100km chemical tubing (10 types)
- 4million liters raw water per day
- RM4m electricity bill per month

- 700 steps per device (ave)
- 30 masks per device (ave)
- 4,500 active masks
- 150 active devices at any one time
- 150 measurement steps per wafer

- 2,000 machine tools
- Class 100 clean room
- 60,000 wafers at one time
- 20,000 test wafers

- 2,000 parameters collected per tool
- Sampled 1 per sec
- Line yield 99%
- Step yield (700 steps) 99.99860%

SilTerra – what actually comes to mind….?



White elephant – a possession that is useless or troublesome, especially one that is expensive to maintain or difficult to dispose of

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A different view – the “Industry of the Future”

Tun Dr Mahathir in Beijing, 19 August 2018:

1. SilTerra is a good project

2. SilTerra has done quite well

3. It is a very expensive business but it is **worthwhile spending money on SilTerra** and having the capacity to produce these microchips because it is the **industry of the future**; it will control everything (e.g. the drones he saw from DJIA earlier that morning)

5. We have an (semiconductor) industry, it is still going but **unfortunately the previous government was not interested in it**

6. Now **we are very interested**, unfortunately we don’t have money

→ **Last major capex investment was in 2007**

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But we are still alive and kicking…

16TH

IN GARTNER'S GLOBAL PURE PLAY FOUNDRY RANKING

TOP 5

MALAYSIAN-OWNED EXPORTER IN THE ELECTRICAL AND ELECTRONICS SECTOR

100%

MALAYSIAN-OWNED PURE PLAY SEMICONDUCTOR FOUNDRY

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SilTerra's technical expertise is sought after internationally

By companies from China, India, Vietnam, Turkey and Russia

1. We are helping **Yan Dong**, owned by state-owned conglomerate BEHC, to set up their brand new 4.8B yuan fab in Beijing, train their engineers and transfer to them our 0.16 micron and PowerMOS process technology
2. To date, we have trained **81 Yan Dong staff** in Kulim, from engineer to VP
3. SilTerra was also part of a consortium with **HSMC** and **ST Micro** to build a 12" fab in India
4. We have been approached by **CNS Vietnam** and **Turkey's Ministry of Science** to provide our fab expertise to them
5. We signed an MOU with **a** Russian state-owned technology group to help them design and build a 12" fab in Moscow

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AS TECHNOLOGY ADVANCES,
WE TRANSFORM OURSELVES
TO KEEP UP WITH NEW
INNOVATIONS … AND TO SURVIVE
9

Back in the day, we were “King of the Hill” in …

- 1 in 3 smart watches used SilTerra’s driver IC
- 1 in 6 smart phones used SilTerra’s finger print sensor
- 1 in 10 mobile phones used SilTerra’s driver IC

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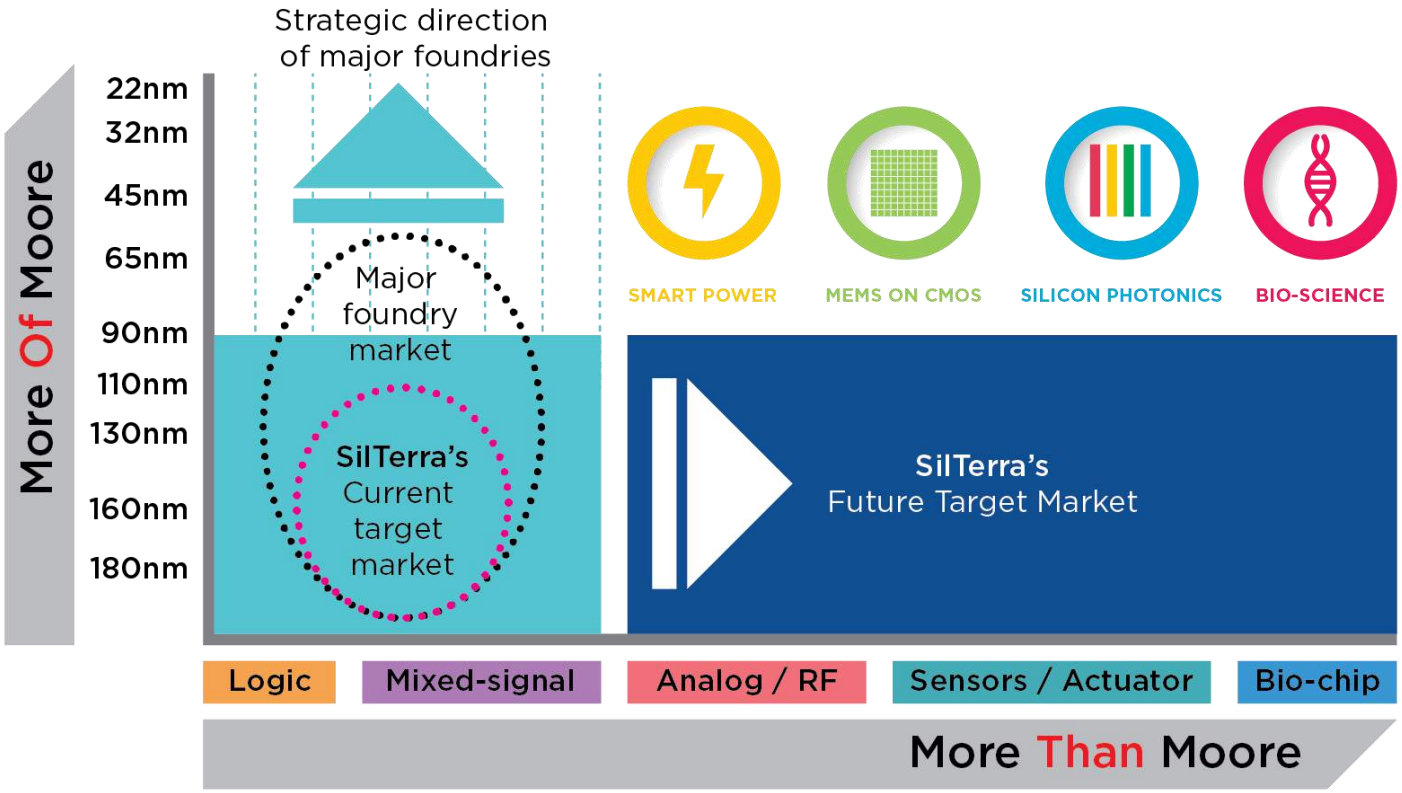
Our shoestring budget has forced us to pivot away from our traditional business and go sideways



Source: International Technology Roadmap For Semiconductors (ITRS), SilTerra

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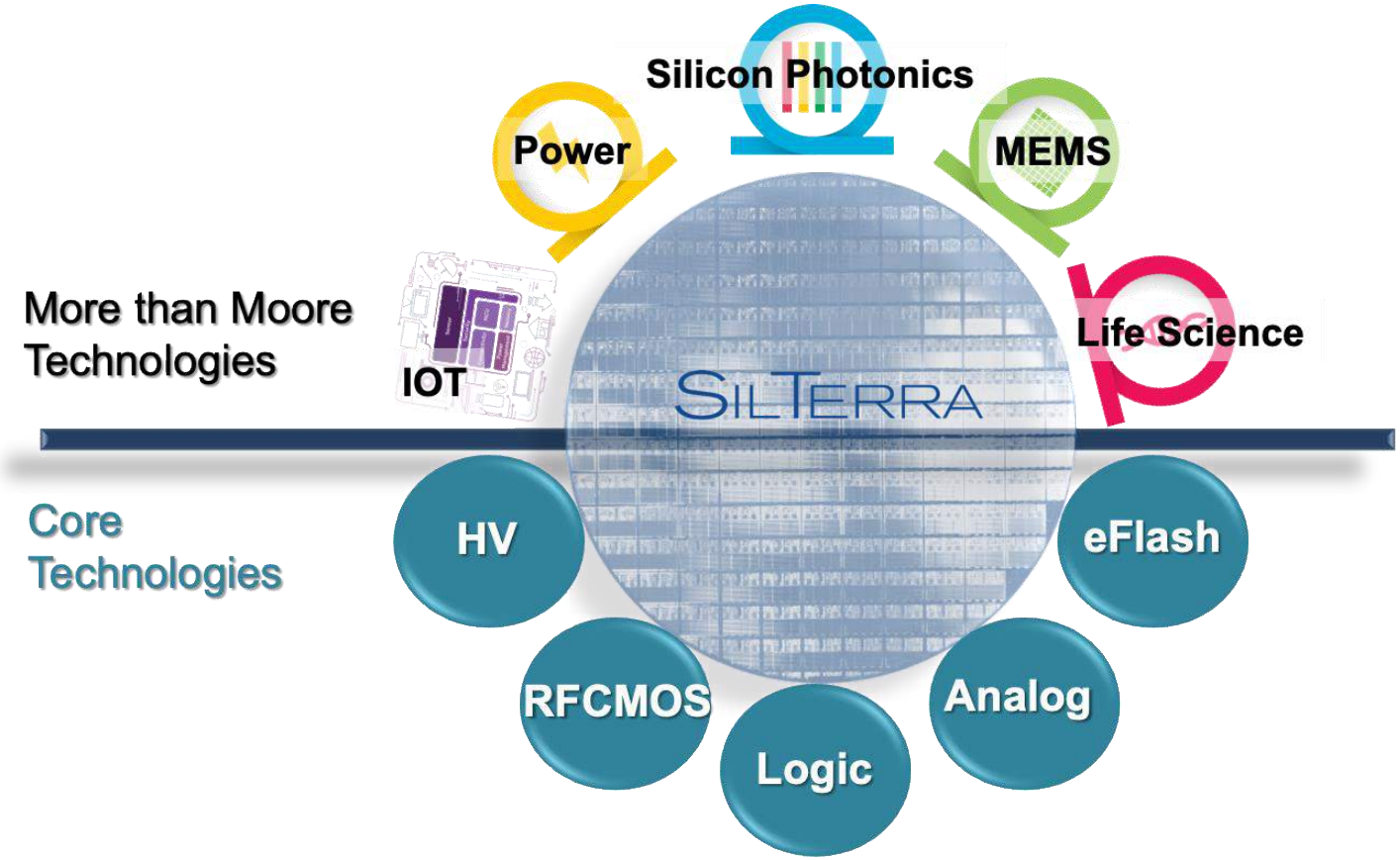
Into More-than-Moore technologies and new physical domains



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… and enter the product and solution space

This requires transforming the core foundry and its product range from low to higher margins, entering the product space and building a sustainable services & consultancy business.

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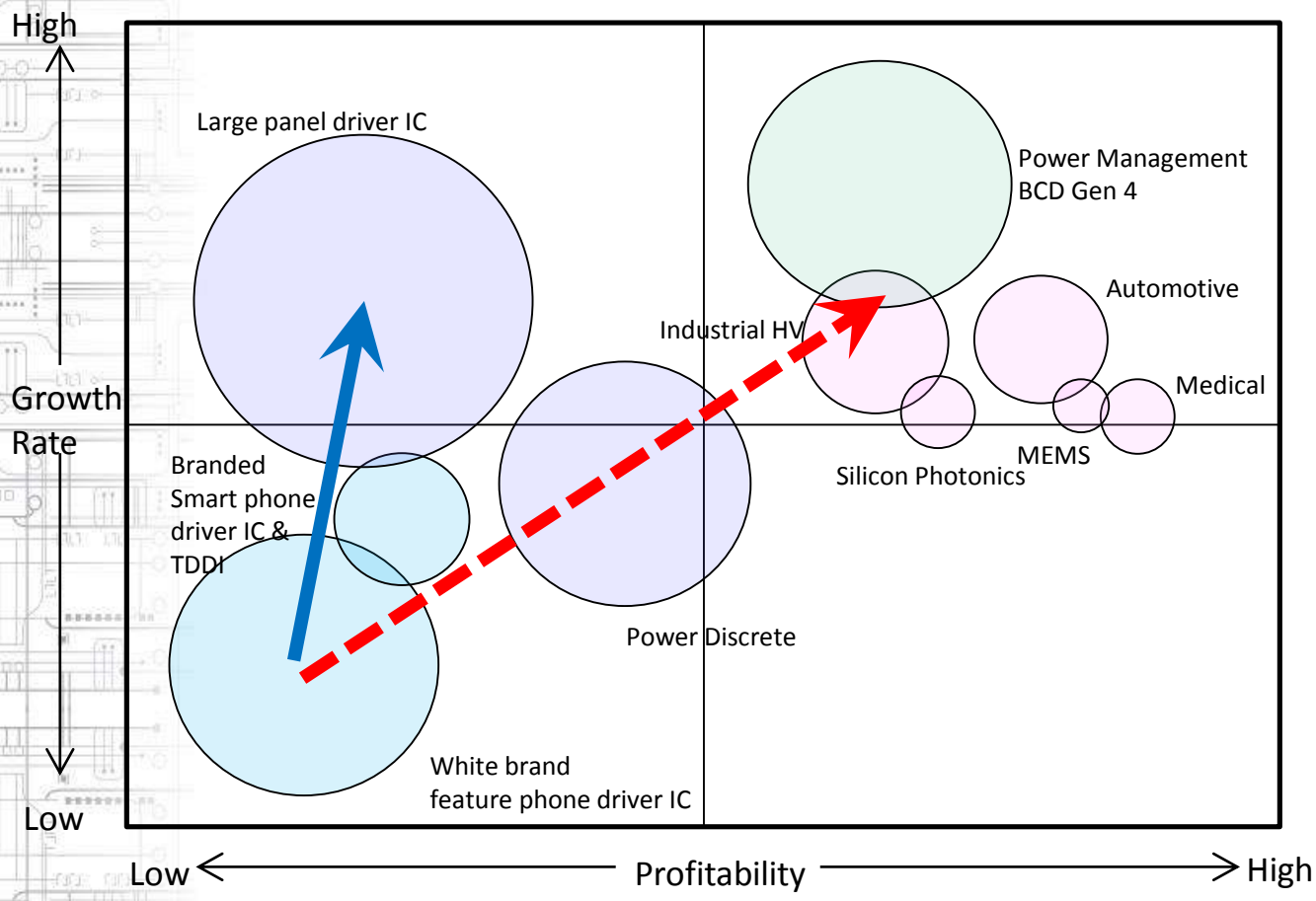
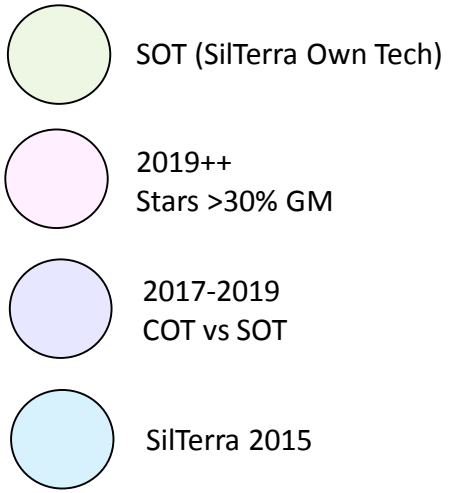
Searching for and building “Stars"





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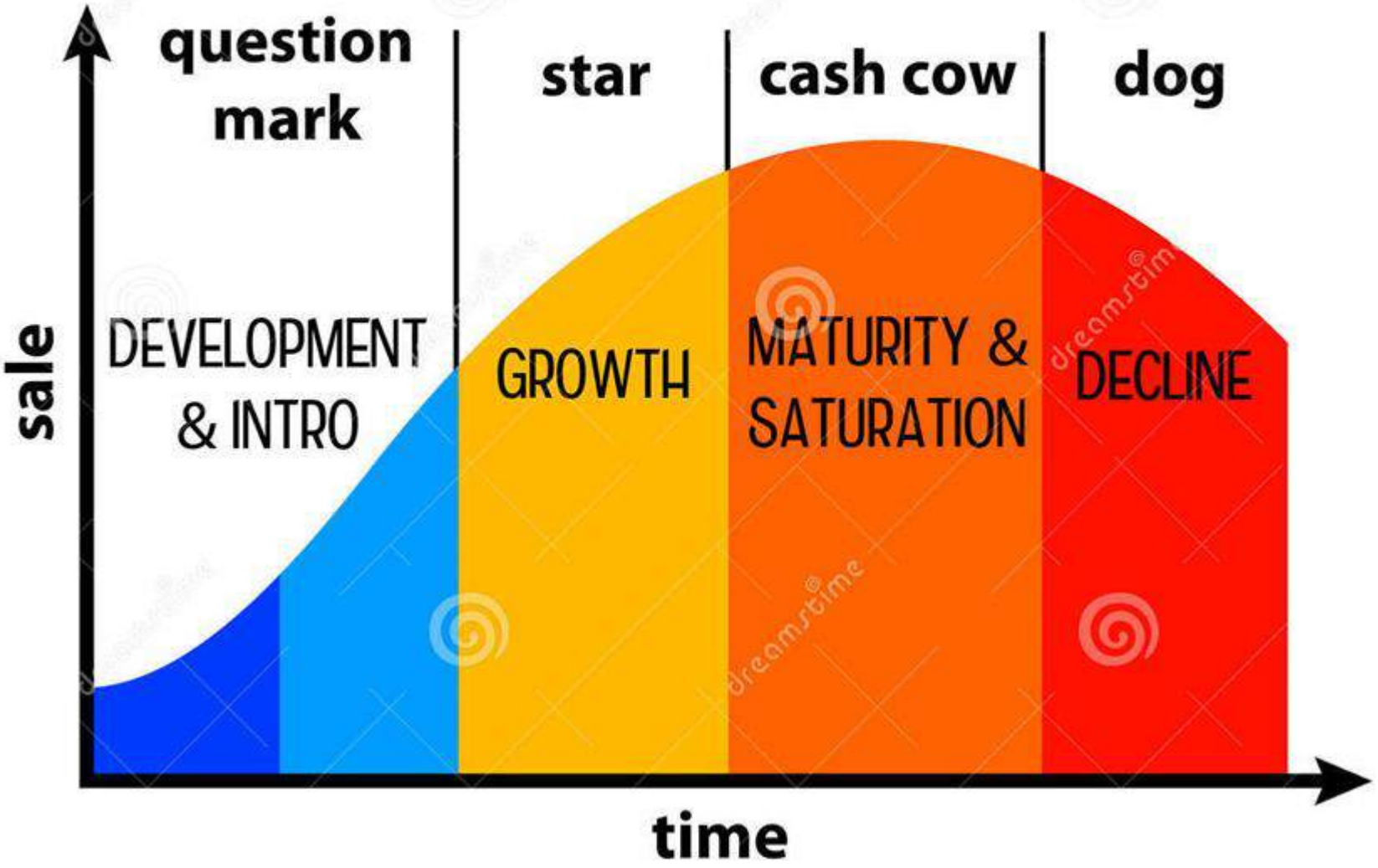
PRODUCT LIFE CYCLE



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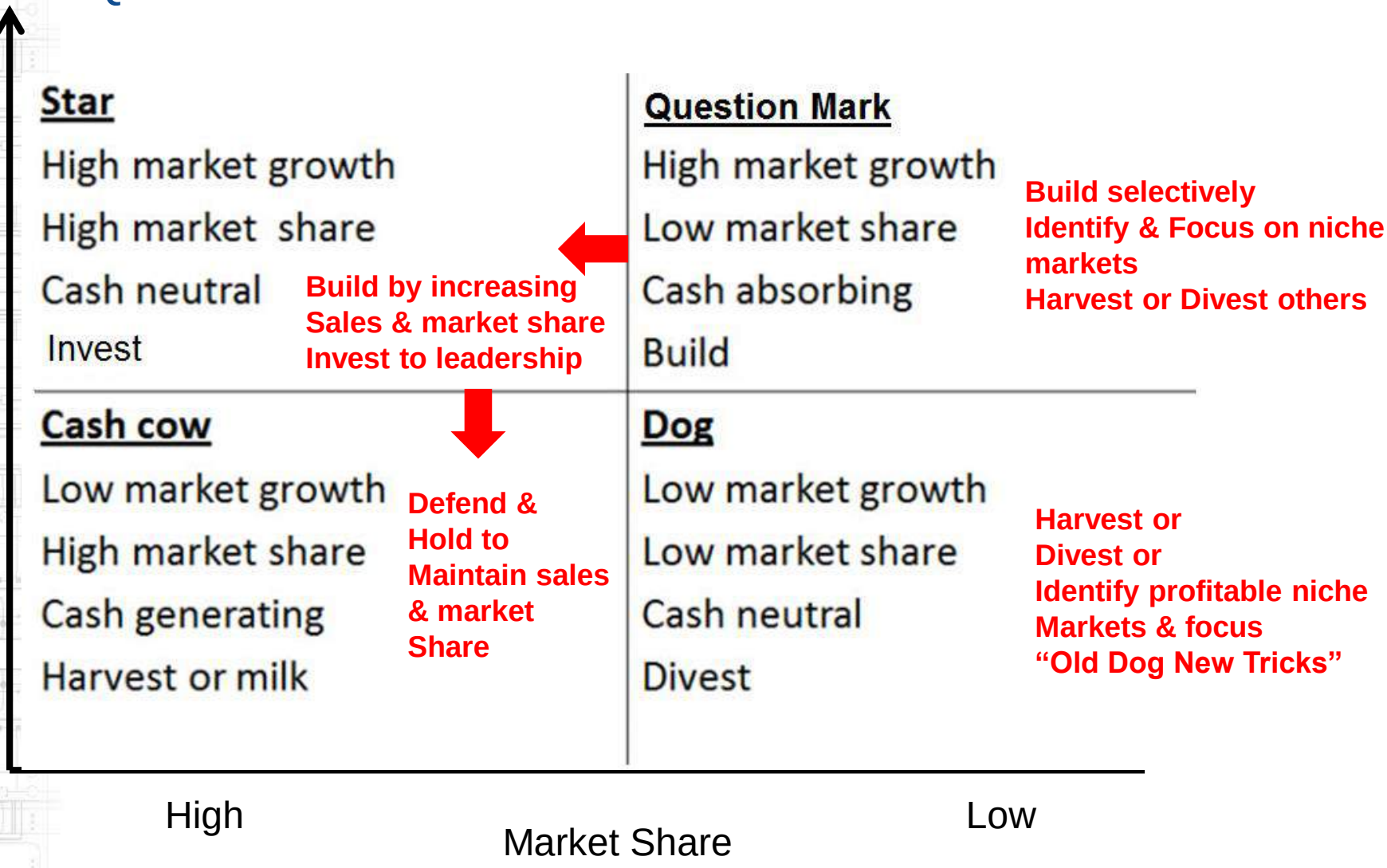
Question Marks into Stars



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SILTERRA

OUR CORE TECHNOLOGIES

CMOS LOGIC

RFCMOS & MIXED-SIGNAL

HIGH VOLTAGE

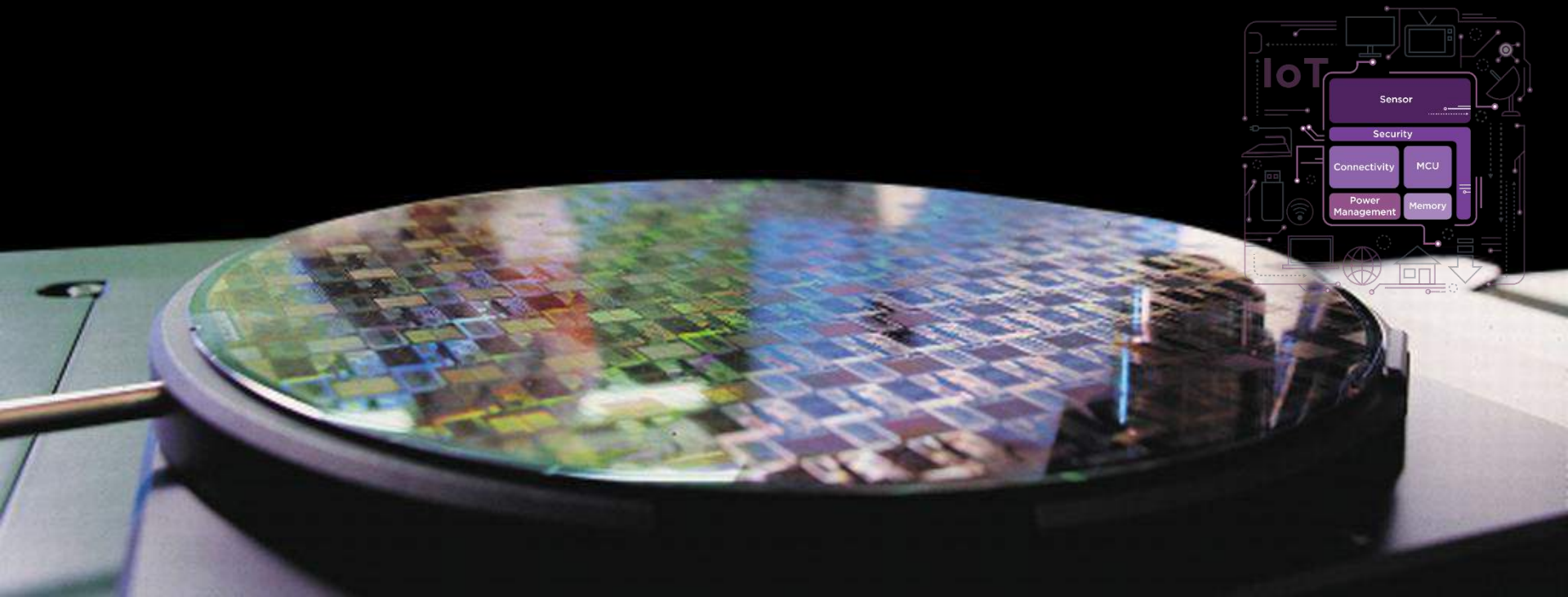
"MORE THAN MOORE" TECHNOLOGIES

SMART POWER

MEMS ON CMOS

SILICON PHOTONICS

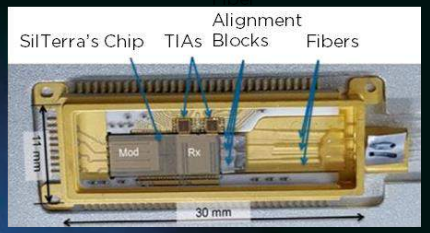
LIFE-SCIENCES

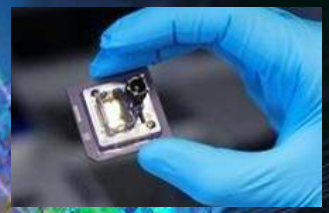


Did you know …

We are working with customers to:

- **Develop next gen photonics chips for data centers enabling speeds of beyond 100Gbps to 400Gbps**
- **Develop chips for life sciences and healthcare to improve the way we diagnose diseases** *e.g. DNA Sequencing Chips, lab on a chip, bioscience sensors & neural probes*
- **Develop sensor technologies and high efficiency power chips for green technology and automotive industry**





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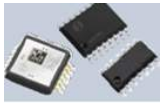
Capabilities

Some products & devices addressable with SilTerra technology

MEMS	**Micromirrors**	• Intelligent headlights
	Sensors	• Various pressure & flow sensors • Motion detectors & inertia sensors
POWER	**SuperJunction MOSFETS**	• EV Charging Station Power Supply • Onboard Charger • HEV Engine Ignition
	180nm BCD 5V Technology	• Motor Driver IC • Power Switch IC • LED Driver IC
MCU	**180nm Logic CMOS 1.8V / 5V Technology**	• 8-bit microcontrollers for: o Aircon / temp control o Audio / FM control o Window lift control o Side mirror control o Sofa seat control o Wiper Speed control o Mutli-function Steering Control o etc
LOGIC	**130nm 1.2V/3.3V Copper Technology**	• Powerline Communication PLC chipset for charging station
HV	**160nm 1.8V/7V/32V HV Technology**	• Heads-Up Display Driver



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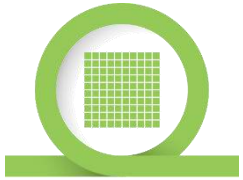
MEMS on CMOS

The basis of many emerging technologies at SilTerra – MEMS sensors are integrated into CMOS, reducing a two chip solution into a single monolithic chip

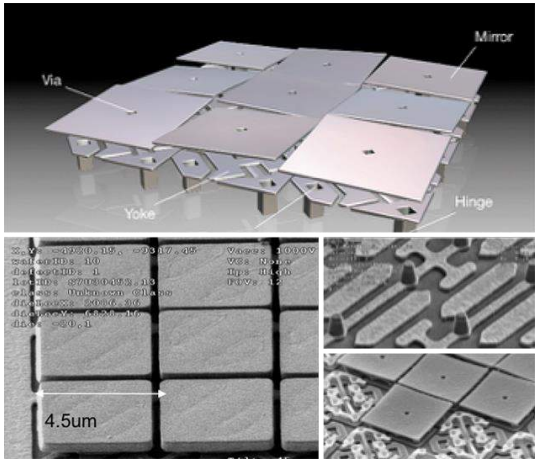


Micro-Electro-Mechanical Systems (MEMS) are miniaturised mechanical and electro-mechanical components fabricated on semiconductor wafers at nano-scale.

SilTerra has been developing various MEMS technologies on CMOS in the areas of: Piezoelectric Micromachined Ultrasonic Transducers (PMUT), Bulk and Surface Acoustic Wave (BAW and SAW) resonators, micro-mirror arrays and nano-wires. Applications include finger print sensors, temperature and other sensing, display systems, clock generation and other IoT applications.

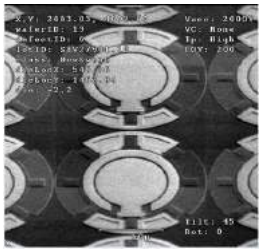
Recently demonstrated viability of:

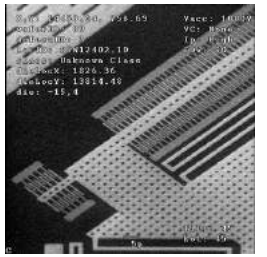
- **4K Ultra High Definition projector for a leading Japanese manufacturer.**
- **Adjustable headlights for next gen automobiles**
- **Timing chip to replace clock/PLL combination**
- **Next generation fingerprint sensors**



Micro-Mirrors

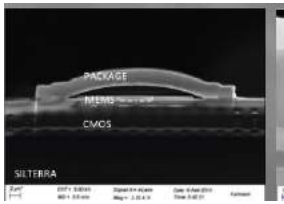
pMUT

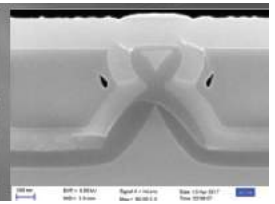




MEMS-based motion detectors

Monolithic crystal-less Acoustic Oscillator





Silicon Nano-wire

Sensors

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Power

Leveraging our HV expertise and building new competencies

SMART POWER:
BCD & POWER MOSFET

Leveraging existing 0.18µm HV and extending to 0.13µm nodes for power management SilTerra is targeting this technology for ICs in wireless chargers, DC-DC converters, load switches, power switches and various power management IC applications.

Recognising the increasing global demand for electric and autonomous vehicles, renewal energy and the demands of Industry 4.0, SilTerra is also focusing new efforts to address the global Power MOSFET market currently valued at US$3.7billion (2016).

- **We currently have more than 20 customers from China, Taiwan and the US working with SilTerra on our V20 power discrete solution**

Additionally, SilTerra is also working on SuperJunction MOSFETS capable of 650V and above for industrial and data center applications

Solar Inverter

Uninterrupted Power Supply (UPS)

Motor drivers for White goods / robotics

Electric Vehicle Charger (E-bike, E-car)

D3 SEMICONDUCTOR®
DEFINING PRECISION POWER

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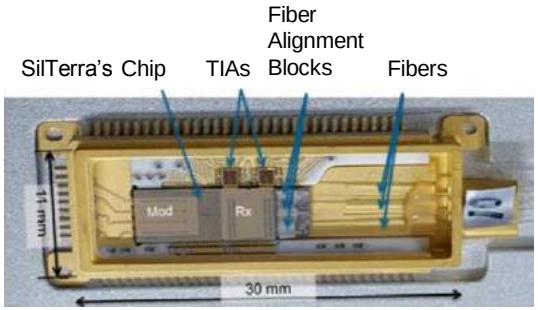
Silicon Photonics

Integrating optical waveguides into silicon-based wafers



The increasing need for high speed networks and next generation optical connectivity in data centers is driving the demand for Silicon Photonics.

Since early 2017, SilTerra has fabricated Silicon Photonics chips on our CMOS line capable of supporting optical transceiver modules handling data bandwidths of 100Gbps.

Ongoing strategic partnerships with **leading edge customers and research institutes** such as imec in Europe will enhance SilTerra's ability to develop chips capable of supporting 400Gbps and beyond.

Optical I/O Module in the Server

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IOT – Internet of Things

Bringing together the best of SilTerra in a single chip

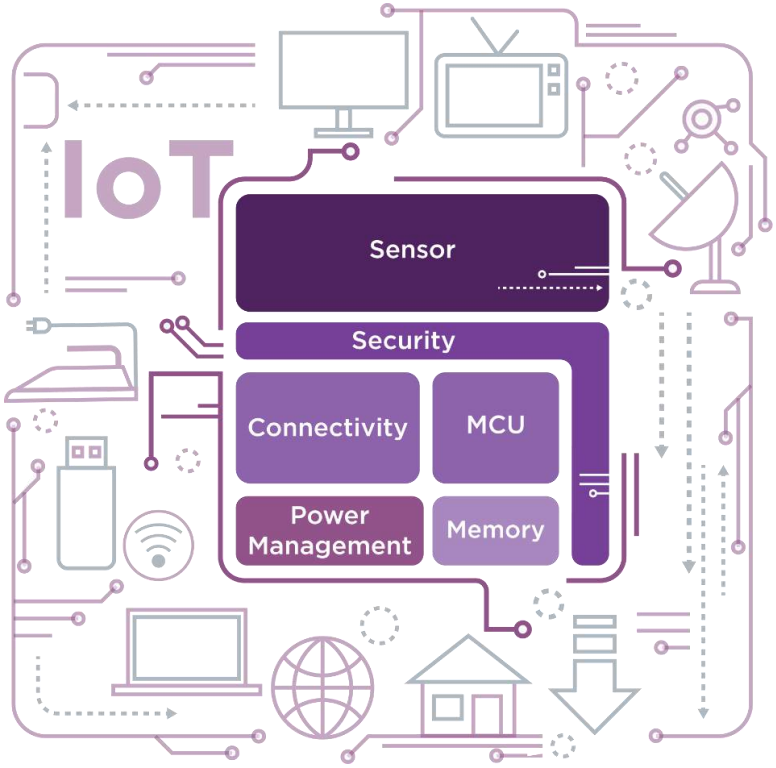
The Internet of Things (IoT) refers to a network of physical objects equipped with embedded technology that is able to sense, interact and communicate with its internal and external environment.

The growth in IoT and its associated technologies is opening up opportunities for the emergence of new market segments that are redefining our everyday lives.

This in turn, is driving the need for ultra low power, smaller form factors and overall cost competitiveness in semiconductor chips.

SilTerra offers the following capabilities to enable IoT applications:

- Sensors
- Microprocessors
- Embedded security
- Power Management
- Embedded e-flash (memory)
- Connectivity (Bluetooth, wifi)
- Ultra low leakage technology
- RFID



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Life Sciences

An exciting new initiative from SilTerra

Our strategic partnership with the world's leading nanoelectronics research institute, **imec**, has allowed Silterra to embark into new areas of lifescience, combining microfluidics with MEMS and nanotechnology.

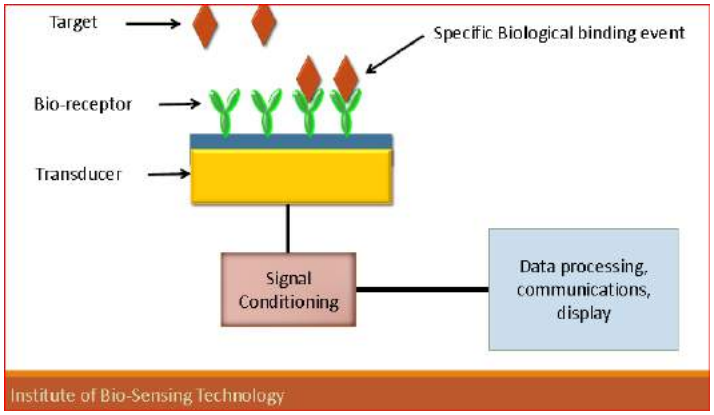
SilTerra own-technologies that can be used for this space, either individually or together:

- **MEMS sensors**
- **Bio-photonics**
- **Microfluidics**
- **DNA sequencing**
- **Silicon Nanowire**
- **pMUT – piezoelectric micromachined ultrasonic transducer**

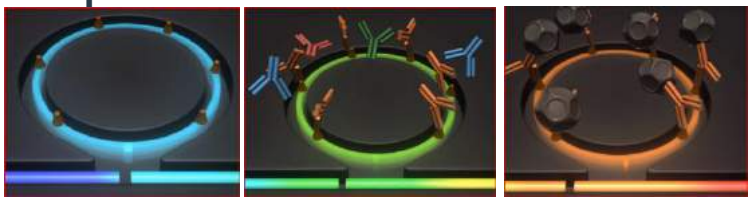
Applications and markets open to this space include: IOT, wearables, medical diagnostics, point-of-care devices, healthcare, automotive sensors, etc

The **MEMS, SENSORS and LIFESCIENCES BU** has been created to address this market

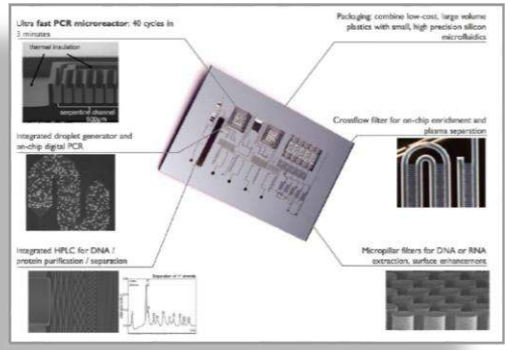
Bio-sensors



Bio-photonics



Microfluidics



Source: imec

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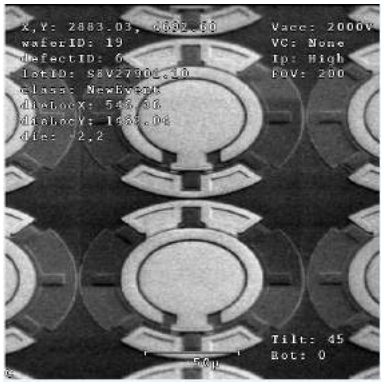
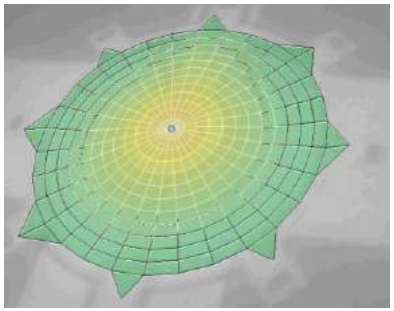
pMUT for Ultrasound Applications

Piezoelectric micromachined ultrasound transducer

- Patented SilTerra-own technology
- Truly monolithic single substrate
- Typical 8 mask process after standard CMOS.
- Top and Bottom electrode connection to the CMOS top metal layers.
- AlN is used as piezo layer with Al as top & bottom electrodes.
- Silicon Nitride is used as an elastic layer.





Finger print sensing

Gesture control

Non-Invasive medical imaging - portable probes

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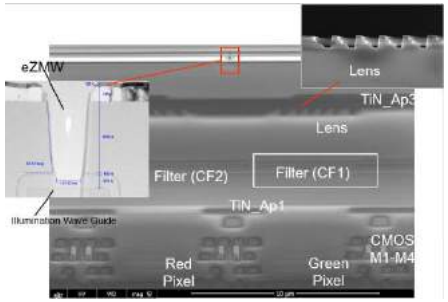
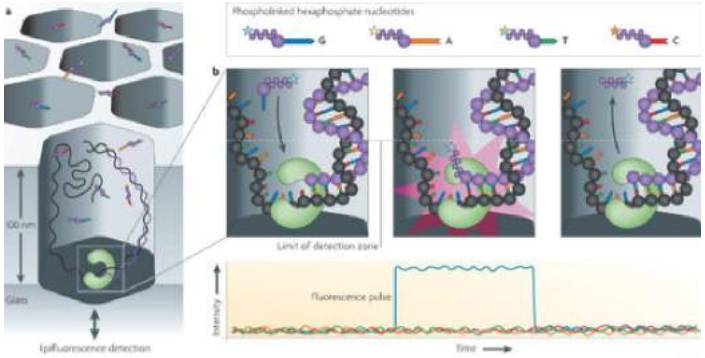
DNA Sequencing Chip

Developed in partnership with imec the first generation chip, is followed by the next generation chip – which will be 8 times faster,

- Bio-photonics chip is quite complex to manufacture
- Shipping volume since 2017
- Currently developing next generation chip
- **Planning to move complete manufacturing ecosystem to Malaysia**

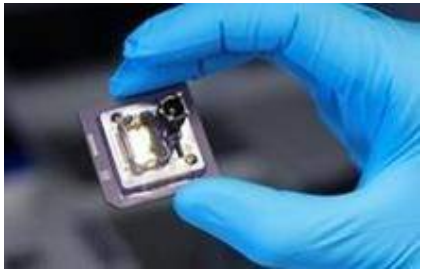
SMRT

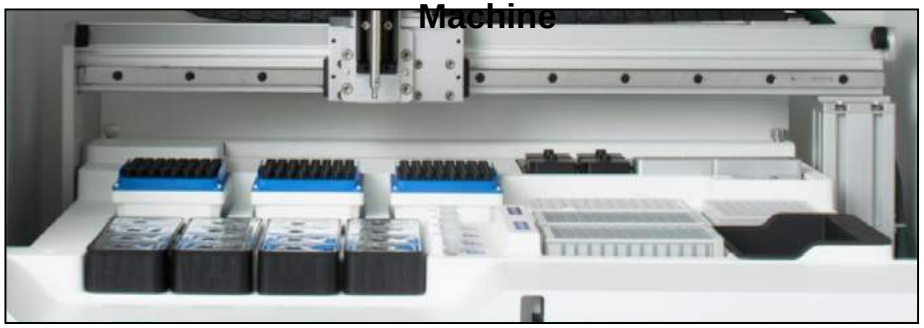




Sequel - DNA Sequencing Machine

Sequel Chip





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Working with SILTERRA

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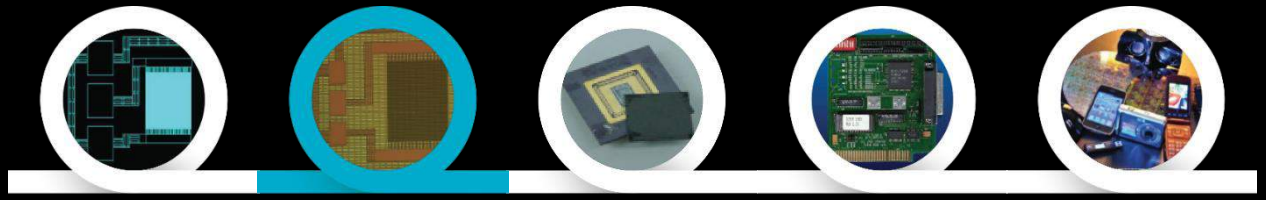
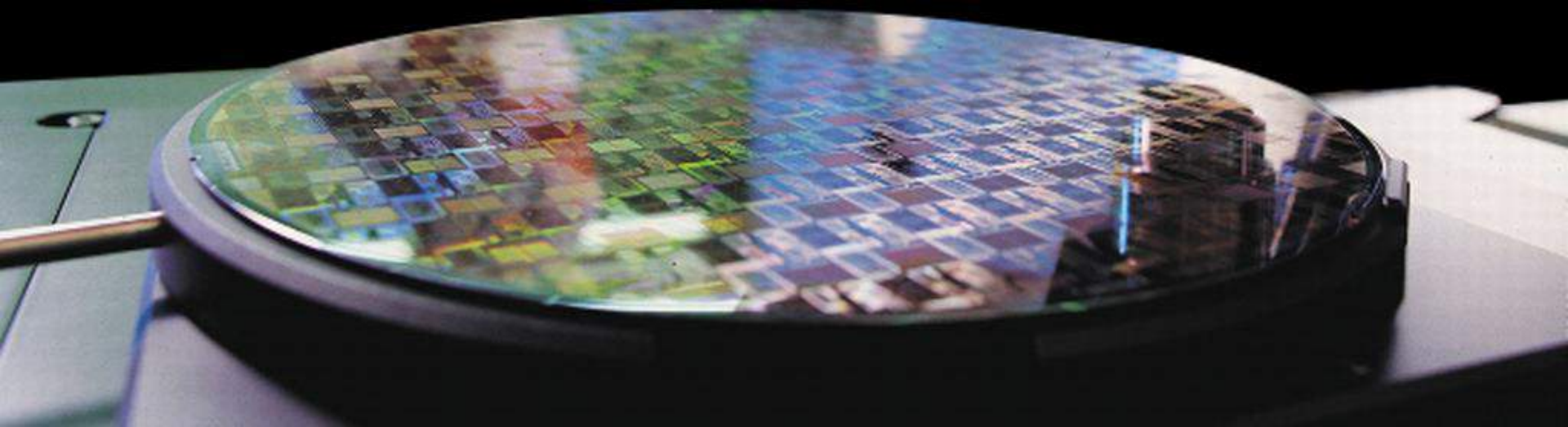
SILTERRA'S ROLE

A critical technology partner in the value chain for companies who want to be innovative



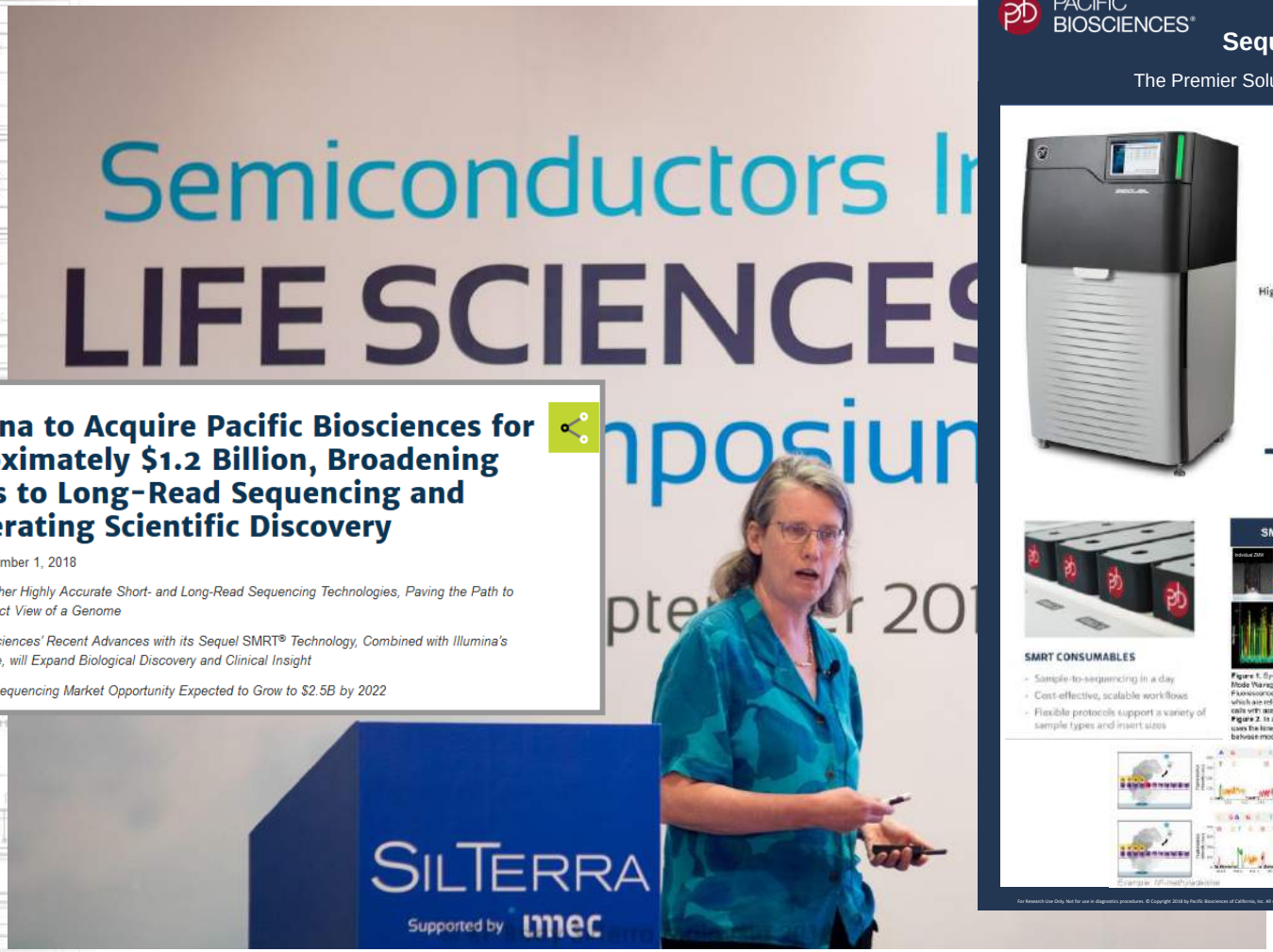
FABLESS IC DESIGN | WAFER FABRICATION | ADVANCED PACKAGING | TEST & PRODUCT ASSEMBLY | END MARKETS



HEALTHCARE

SilTerra helps Pacific Biosciences fab their DNA Sequencing Chip

The fastest consensus read in the industry. In Oct 2018, they announced that they had been acquired by their biggest competitor.



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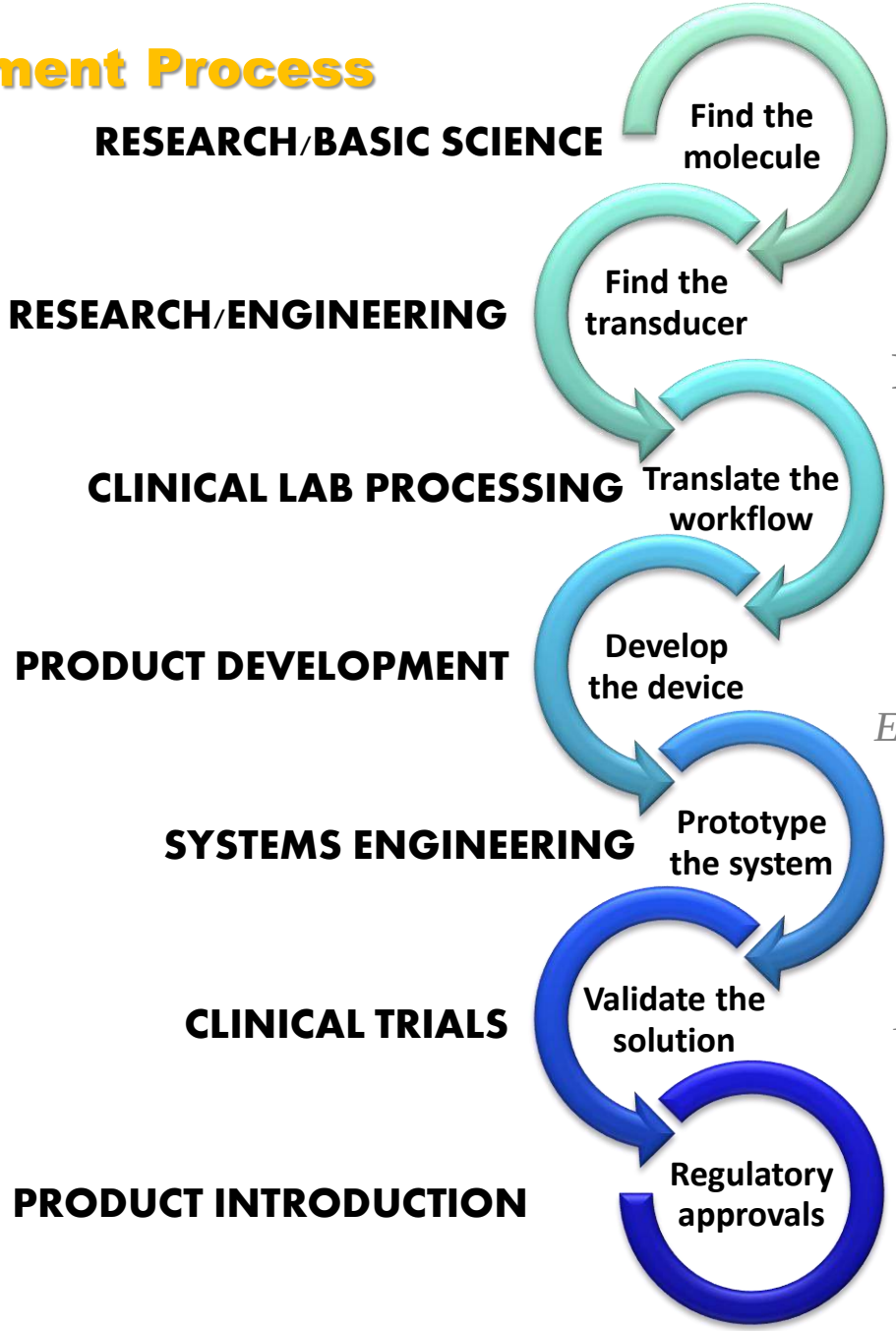
The Development Process



Involving…

Researchers
Universities
Health Practitioners
Doctors
Start-Ups
Research Institutes
Packaging vendors
Pharma Companies
IC Designers
Wafer Fab
Product Companies
Product Developers
Engineers
Suppliers
Antibody suppliers
Hospitals
Certification
Clinicians
Clinical Research
Nurses
Patients
Regulatory Agencies
Regulators
Government

Incorporating…

- A.I.
- IOT
- Big Data
- Data Privacy
- others…

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SEMICONDUCTORS IN LIFE SCIENCES SYMPOSIUM – SEPT 2018

SilTerra, supported by imec, kickstarted the ecosystem to support the development of life sciences in Malaysia by organising a first-in-Asia Semiconductors in Life Sciences Symposium in Penang. This is part of Silterra's continuing drive to transform itself into a leading player in emerging markets which includes Internet Of Things (IOT), MEMS sensors, power semiconductor devices, and silicon photonics.

Semiconductors In LIFE SCIENCES Symposium

18th September 2018

84 Delegates
22 Companies
12 Speakers
10 Research Institutes
8 Countries

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LIFESCIENCES WORKING GROUP – NOV 2018

In addition to international project proposals from USA, Europe and Asia, several organisations in Malaysia have also expressed Interest to pursue research using SilTerra's pMUT patented technology

Companies	Institutes
Aemulus	NTU
Globetronics Manufacturing	INFORMM, USM
Inari Semiconductor Labs	CEDEC, USM
Innov8tive Solutions	USM
Oppstar Technology	NANOCAT, UM
PI (Physik Instrumente)	UniMAP
SilTerra	CREST
Symmid	
Toyota Assembly	

Follow up meeting attended by
42 participants from 16 organisations

SilTerra's pMUT technology for:

1. Real-time tissue imaging during surgery – using ultrasonic imaging
2. A portable 3-D ultrasound device for medical diagnostics
3. A more secure next generation fingerprinting sensor for fintech applications and smartphone
4. A handheld point-of-care diagnostic device for blood analysis
5. An improved security screening apparatus using SSD
6. A maintenance-free methodology for generating energy from the environment

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Introducing SilTerra's Newest Technologies

KETI Korea Electronics Technology Institute 전자부품연구원

SILTERRA

REVOLUTIONIZING POINT-OF-CARE TESTING (POCT) WITH SILICON NANOWIRE (SiNW)-BASED PHOTODETECTORS

Applications

Biosciences
- Disease biomarkers detection
  - Acute virus (Dengue, Zika, MERS, SFTS, etc.)
  - Cancer (Breast, Ovarian, Colon, Lung, etc.)
  - Various diseases (Myocardial infarction, etc.)
- DNA sequencing
- Acute toxicity testing
- Small molecule detection

Medical Technologies
- Dental panorama
- Bone density measurement
- PET-CT* system

* Positron Emission Tomography and Computed Tomography (PET-CT)

Dental Panorama

PET-CT System

Fabrication

Monolithic integration of SiNW photodetector and Readout Integrated Circuit (ROIC)

Advantages

Cheap, robust and miniaturized POCT device
- High sensitivity at low illumination
- Low bias voltage (~ 1 V)
- High optical responsivity (> 10^2 A/W) over wide spectral range
- Low cost

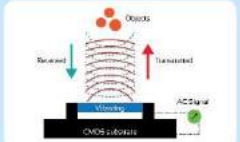
AO Poster - 841mm(W) x 1189mm(H) - Scale 1:2 Poster 3

SILTERRA

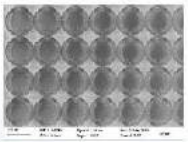
CUTTING-EDGE PMUT ARRAY FOR MEDICAL IMAGING APPLICATIONS

Working Principle

Piezoelectric micromachined ultrasonic transducers (PMUT) are MEMS-based ultrasonic transducers. They generate ultrasound waves using piezoelectricity and sense the echo for spatial detection.



SILTERRA'S INNOVATIVE PMUT ON CMOS PLATFORM



- Advanced signal processing and reduced power consumption due to the monolithic integration
- High density arrays with thousands of sensors for small spatial resolution (40μm)
- High sensitivity in liquid media : 3.2kPa/V
- Also applicable in other areas : fingerprint sensing, range finding, gesture sensing

www.silterra.com/technologies.html#tab_e

AO Poster - 841mm(W) x 1189mm(H) - Scale 1:2 Poster 2

MOBILITY

TECHNOLOGIES IN MOBILITY SYMPOSIUM – MAR 2019

Mobility is Everywhere - Smartphones, wearable gadgets, portable healthcare devices, point-of-care diagnostics. Mobility is about portability, IOT, miniaturisation, intelligent navigation and longer battery life as well as transportation and next-generation automobiles. Following the success of the first Semiconductors in Life Sciences Symposium, SilTerra brought together another set of industry leaders and experts from the Malaysian E&E sector and from around the world to speak in Kuala Lumpur about initiatives that will enable the mobility ecosystem in Malaysia and around the world.

SILTERRA

Technologies in MOBILITY Symposium

13th March 2019

122 Delegates
40 Companies
15 Govt Agencies
12 Speakers
6 Universities

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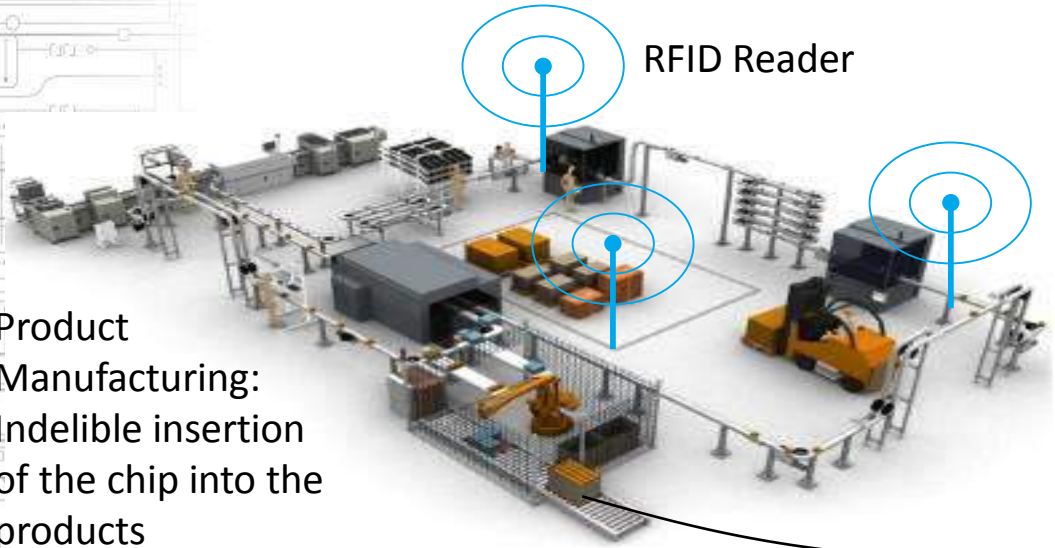
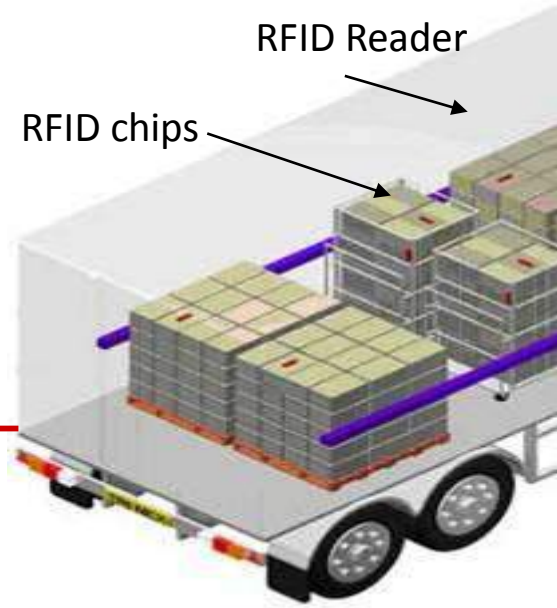
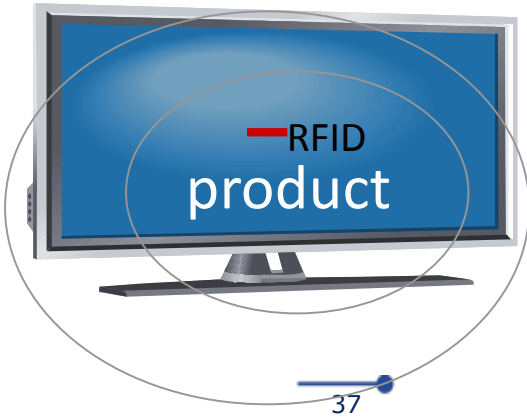
RFID solutions that cover the complete life-cycle of a product from manufacturing, logistics, payment, transportation, payment, and support



Product Manufacturing: Indelible insertion of the chip into the products



Automated Vehicle Identification (AVI) in use in more than 60 Concessionaires all over Brazil (bigger than continental US). SilTerra chips generated more than 4 billion payment transaction events so far in the country



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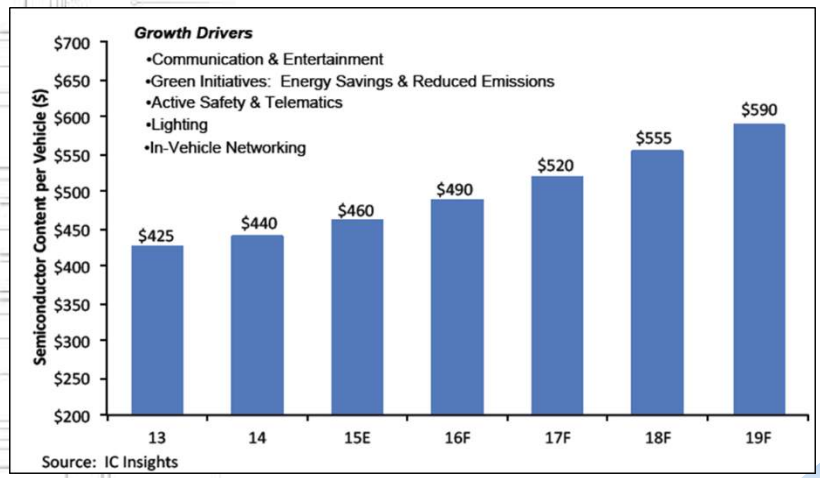
AREAS OF OPPORTUNITY IN THE AUTOMOTIVE MARKET

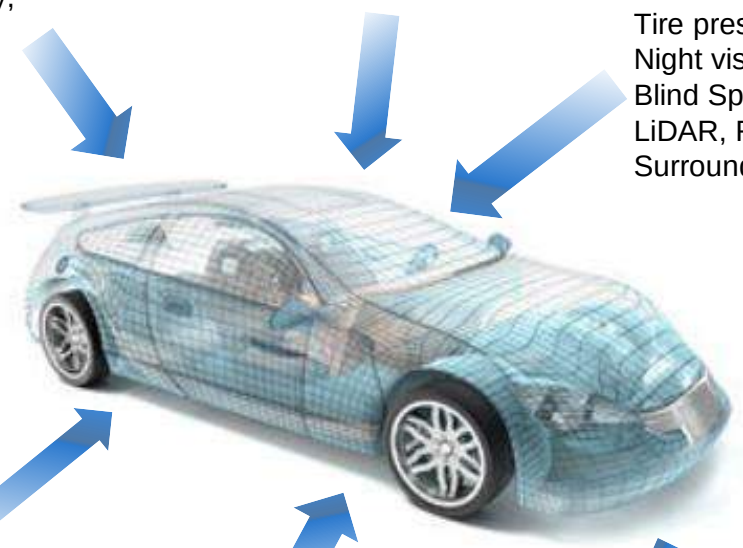
As an IATF-16949 Automotive Certified company, opportunities open up in the global automotive market, particularly in a fully electric vehicle



In-Vehicle Networking
Ethernet bus, CAN bus, LIN bus, Bluetooth, Flexray, V2X,

Infotainment & Telematic
Dashboard, AV player, Smart voice command, GPS, Car navigation display, USB, Head-Up Display

Safety & ADAS
ADAS Processor
Airbag, ABS, Anti-slip
Collision warning,
Auto-Cruise, Auto parking,
Tire pressure monitor,
Night vision sensor,
Blind Spot Detection
LiDAR, Radar,
Surround View Cameras



Electrification Module
Main Drive, HV Loads
Onboard Battery Charger
HV/48V AC-DC Converter
48V/12V DC-DC Converter
Battery Management

Body Control Module
Power Door, Power Window, Wiper & Mirror ControlSofa , Seat Control, Lighting Control, Start/Stop Control. Power Steering, Head-light Levelling,

Power Train
Hybrid/EV Motor ,
Engine Control,
Engine Transmission,
Fuel Injection

Powerline Communication PLC chipset (inside EV charging station)

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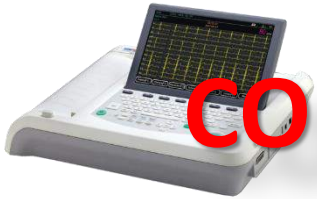
FASHION
CONSUMER
RETAIL
COMMUNICATIONS
IOT
HEALTHCARE
MEDICAL DIAGNOSTICS
WEARABLES
HOME AUTOMATION
AUTOMOTIVE
TRANSPORTATION



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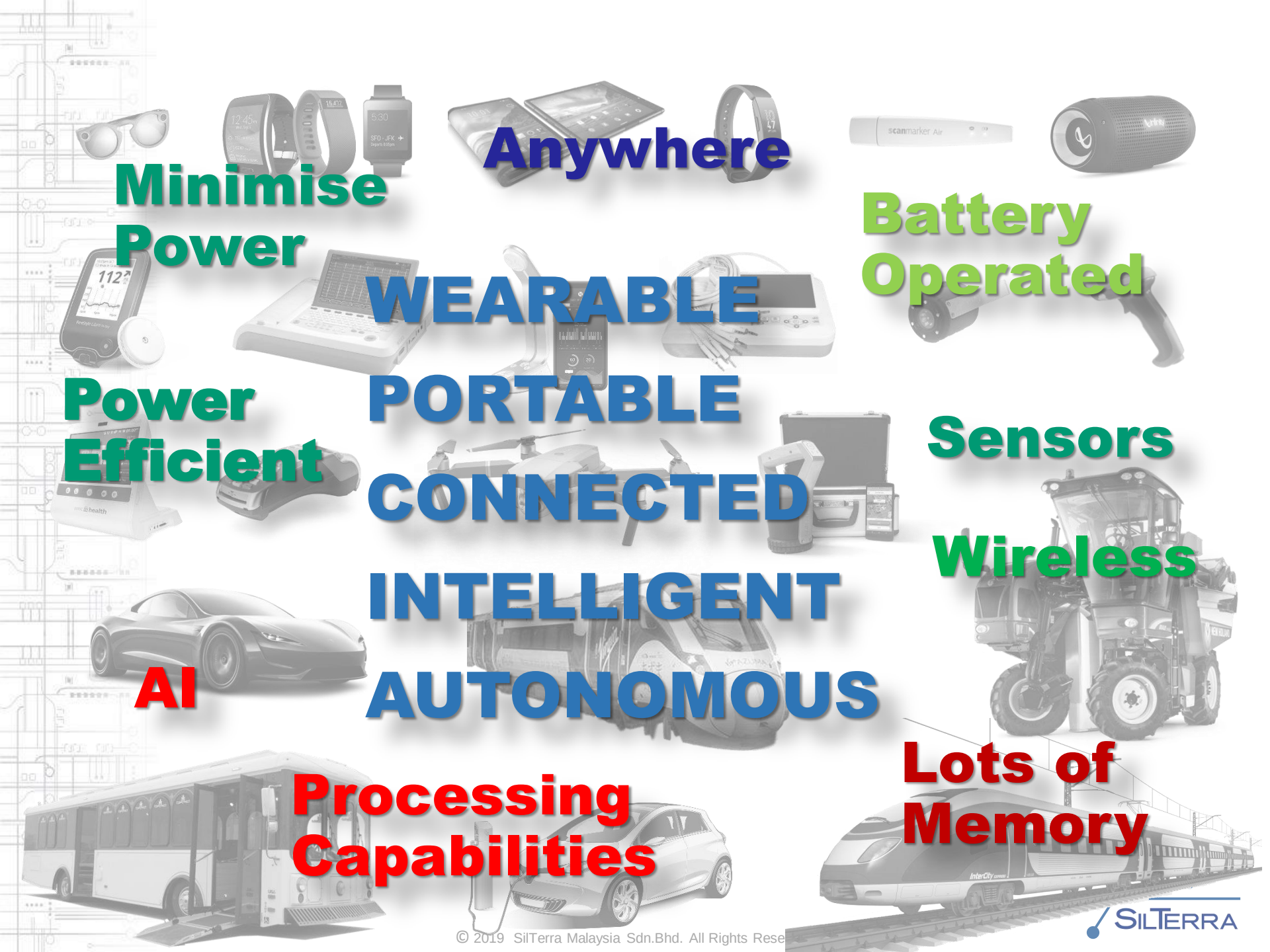

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SENSORS

PROCESSING UNITS

COMMUNICATIONS ICs

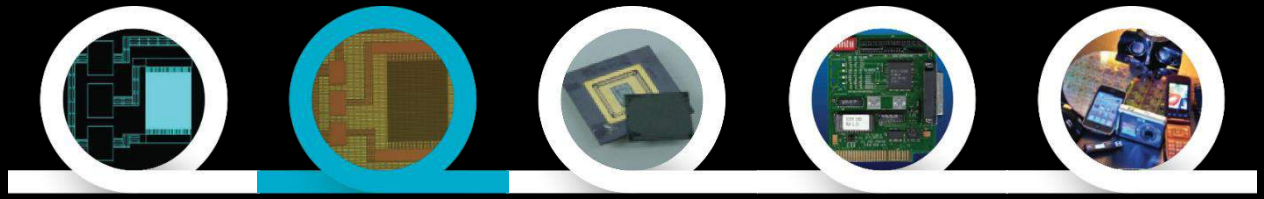
POWER CHIPS

POWER MANAGEMENT ICs

SEMICONDUCTORS

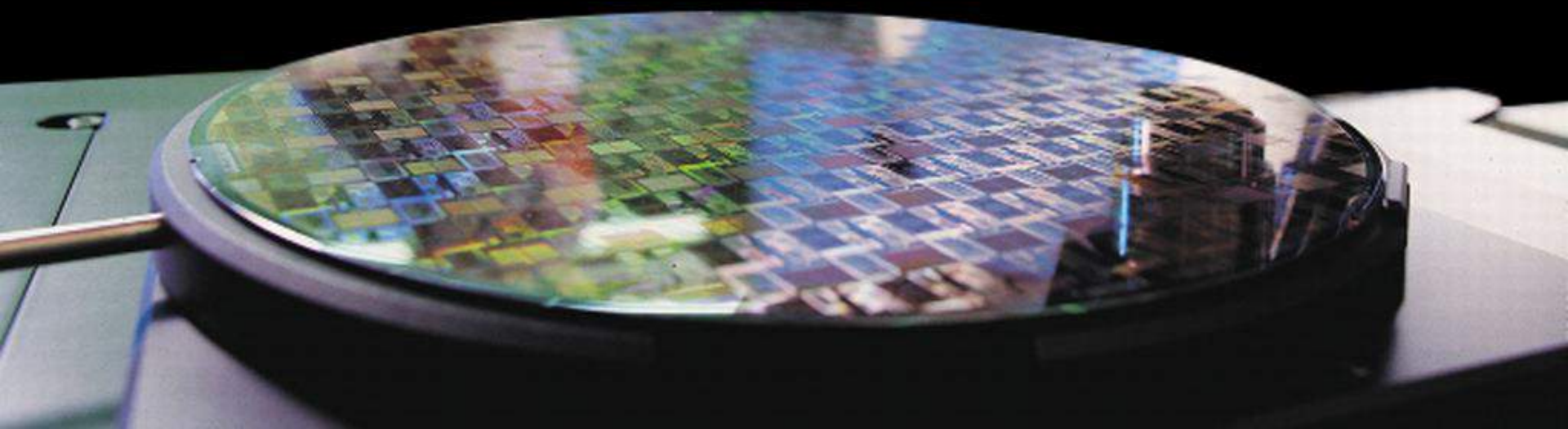
SILTERRA'S ROLE with SMEs

An opportunity to work with a Malaysian semiconductor fab with the mission to build a local ecosystem of innovation.



FABLESS IC DESIGN | WAFER FABRICATION | ADVANCED PACKAGING | TEST & PRODUCT ASSEMBLY | END MARKETS

FASHION
HEALTHCARE
WEARABLES
CONSUMER
RETAIL
IOT
MEDICAL DIAGNOSTICS
COMMUNICATIONS
HOME AUTOMATION
AUTOMOTIVE
TRANSPORTATION



THANK YOU

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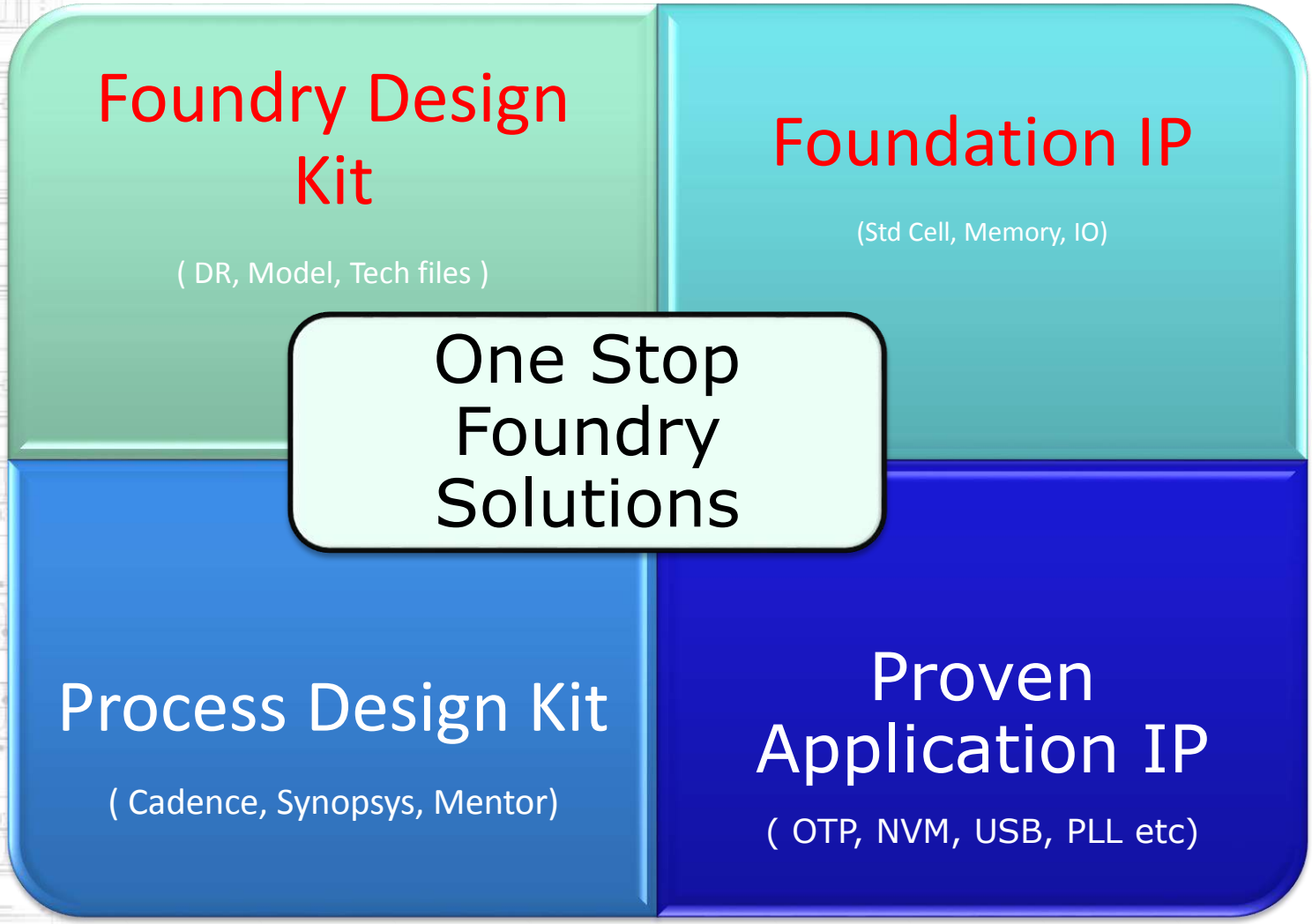
Complete Design Ecosystem



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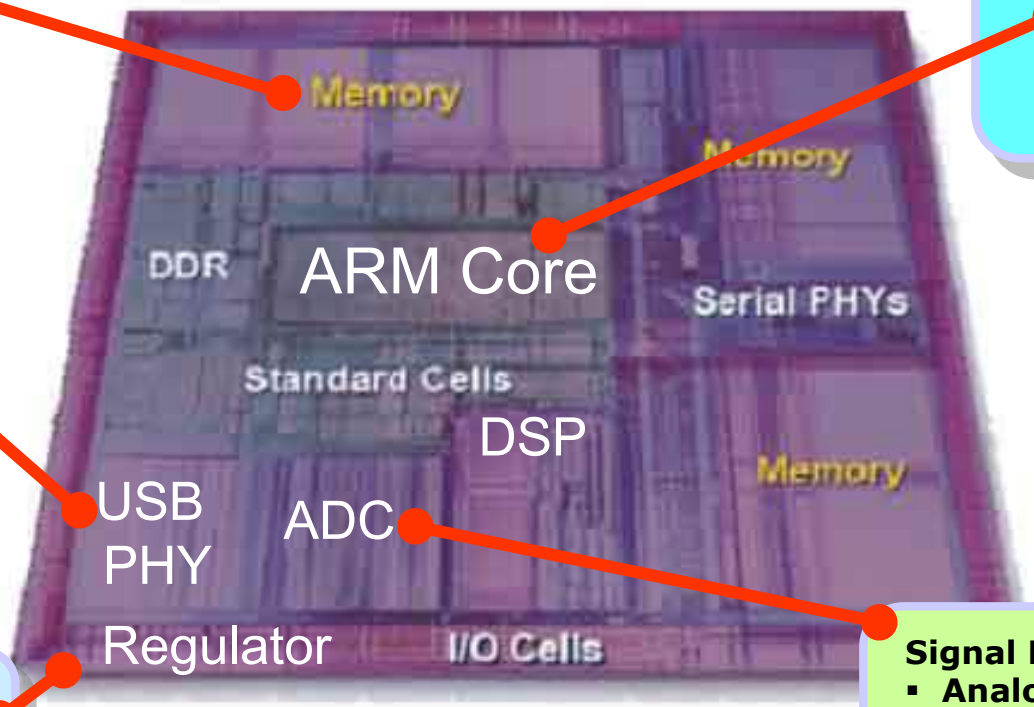
Enabling System on Chip

Pervasive SoC IP

Library Platform
- Standard Cells
- Embedded Memory
- I/O Functionality

CPU
- ARM7
- ARM9
- MIPS 4Kc



High Speed Interfaces
- DDR
- Serial PHYs
  - USB 2.0 PHY
  - SSTL1.8
  - LVDS

Analog IP
- Voltage regulator
- Bandgap Reference
- Analog MUX

Signal Data Conversion
- Analog-Digital Converter
- Digital-Analog Converter
- Delay Locked Loop
- Phase Locked Loop

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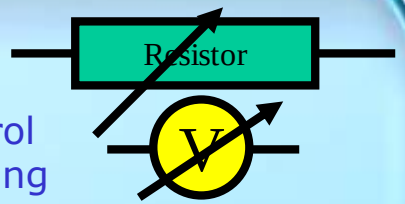
Non-Volatile Memory Solutions

Partner	Tech	Applications
OTP — eMemory	All Logic All HV	ROM Code Fuse Trim Gamma Control Analog Matching
MTP — SYNOPSYS, MT	C18G/C16G C13HV/C11HV	RFID Touch Controller
eFlash — SST	C18G	Smart Card MCU



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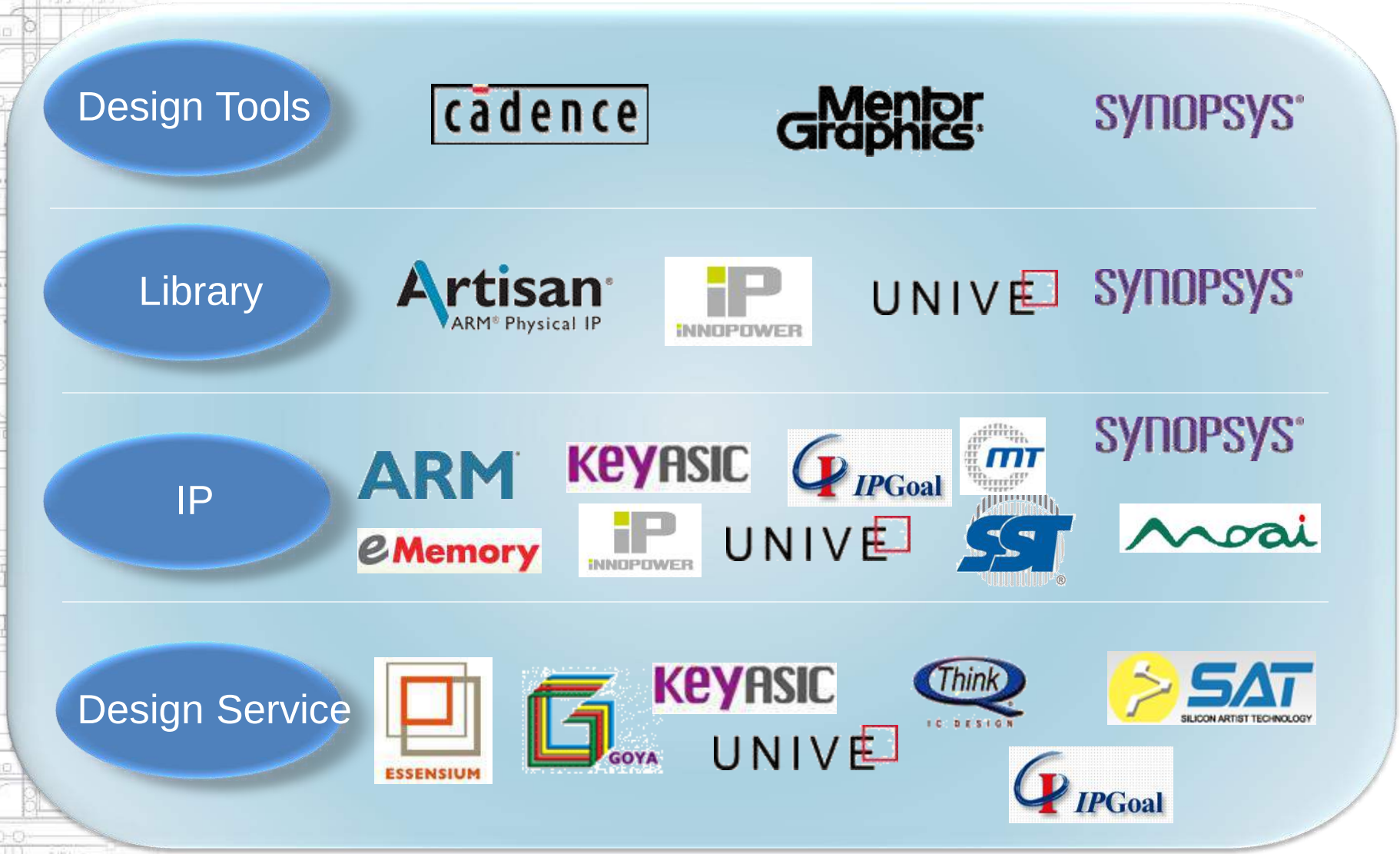
Design Solutions Partners



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