ESTABLISHED IN 1984
MORE THAN 30 YEARS EXPERIENCE IN TOP RESEARCH
IFECA World leading R&D in nanoelectronics & digital technology
- International top talent in a >$1B fab infrastructure
- A trusted partner for companies delivering industry relevant innovation for ICT, Healthcare & Energy markets
- Serving 600+ companies
- 500 M€ R&D revenue, 80% direct from industry
- Human capital: 3500
- HQ in Leuven, Belgium
- Imec sites in USA-EU-Asia
REVENUE

2016: >500M€
IMEC INNOVATION PLATFORM

**Intuitive Internet of Things**
- Sensing & Connectivity Solutions

**Internet of Health**
- Wearables, Diagnostics, Life Sciences

**Internet of Power**
- Photovoltaics, Power Devices, Energy Storage

**Core CMOS**
- Lithography, Devices, Interconnects

**Heterogeneous Integration**
- MEMS, Sensors, Photonics

**Flexible Electronics**
IMEC SMART APPLICATION RESEARCH PROGRAMS

Data Quality
Provenance
Deep Learning
Semantics
Data Visualization

Cloud Security
IoT Security
Data Protection & Privacy

Deterministic Connectivity
Guaranteed Delivery
Reasoning and actuation
IMEC OFFERING END-TO-END R&D SOLUTIONS FOR THE IOT ERA

APPLICATIONS

SYSTEMS

TECHNOLOGY

BUSINESS MODELS

SMART CITIES
SMART MOBILITY
SMART HEALTH
SMART FOOD
SMART LOGISTICS

SMART MANUFACTURING
SMART ENERGY
SMART MEDIA
SMART GOVERNMENT
SMART FINANCE

PILOT TESTING

EVERYTHING CONNECTED

DATA SCIENCE

DISTRIBUTED TRUST
SERVICES: IMEC.ICLINK
COMMITTED TO MAKING GREAT PRODUCTS HAPPEN

- Offers single point of contact into the IC value chain
- Foundry access to >300 SMEs and >700 research institutes
- Tapes-out > 500 IC designs per year
IMEC SUPPORTS THE FULL INNOVATION CHAIN

- Research
- Development
- Prototyping
- Low volume production
- Transfer to HVM
COLLABORATION MODELS

JOINT R&D - OPEN INNOVATION PLATFORM
TRANSFER & LICENSING
ENGINEERING SERVICES
TRAINING - IMEC ACADEMY
COLLABORATION LOCAL INDUSTRY - IMEC INTERACT
SPIN-OFFS
FLEXIBLE BUSINESS MODELS
FROM OPEN RESEARCH PROGRAMS TO BILATERAL PRODUCT DEVELOPMENT

Open Research Programs

Open + Private R&D

Prototype & Product Dev't

SHARED IP
SHARED RISK/COST
GENERIC BUILDING BLOCKS – PRE COMPETITIVE

PROPRIETARY IP
FULL COST
LVM/TECH TRANSFER
OUR VALUES

INTEGRITY

PASSION

CONNECTEDNESS

EXCELLENCE

- Trust
- Respect

- Engagement
- Agility

- Responsibility
- Shared ambition

- Creativity
- Tenacity
IMEC INNOVATION PLATFORM

INTUITIVE INTERNET OF THINGS
SENSING & CONNECTIVITY SOLUTIONS

INTERNET OF HEALTH
WEARABLES, DIAGNOSTICS, LIFE SCIENCES

INTERNET OF POWER
PHOTOVOLTAICS, POWER DEVICES, ENERGY STORAGE

CORE CMOS
LITHOGRAPHY, DEVICES, INTERCONNECTS

HETEROGENEOUS INTEGRATION
MEMS, SENSORS, PHOTONICS

FLEXIBLE ELECTRONICS
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PERFORMANCE & ENERGY EFFICIENCY ROADMAP
PERFORMANCE & ENERGY EFFICIENCY ROADMAP
TRANSISTOR FEATURES DRIVING THE ROADMAP
CORE CMOS: OPEN RESEARCH PROGRAM + PRIVATE R&D

SUPPLIER ECO SYSTEM

LITHOGRAPHY  DEVICES  INTERCONNECTS
IMEC SMART SYSTEMS & ENERGY TECHNOLOGIES

INTUITIVE INTERNET OF THINGS
SENSING & CONNECTIVITY SOLUTIONS

INTERNET OF HEALTH
WEARABLES, DIAGNOSTICS, LIFE SCIENCES

INTERNET OF POWER
PHOTOVOLTAICS, POWER DEVICES, ENERGY STORAGE

CORE CMOS
LITHOGRAPHY DEVICES INTERCONNECTS

HETEROGENEOUS INTEGRATION
MEMS, SENSORS, PHOTONICS

FLEXIBLE ELECTRONICS
VISION: DELIVERING BUILDING BLOCKS FOR PROXIMITY BASED SERVICES TO THE RIGHT USER, AT THE RIGHT PLACE, AT THE RIGHT TIME
CELLULAR & CONNECTIVITY RADIOS

BEST TRADE-OFF BETWEEN PERFORMANCE, FLEXIBILITY & POWER CONSUMPTION

- **SDR Rx with SoTA perf/power/area**
- **Digital Tx** for LTE
- **Phadar 60GHz TRx**
  - >11 dBm TX power
  - >60% TRx efficiency
  - 16 antenna
  - NF 6.5dB at 50 degrees up to 880 MHz

- **Scaldio 2C**
  - Sawless SDR TRx
  - 0.4-6GHz
  - NF down to 1.8 dB
  - <40mW, 0.6mm²
  - Pout:3.2dBm, CIM3: -69dBc, I :36-41mA

- **28nm CMOS**
  - Low power
  - Reconf Rx
  - Digital Tx
  - Connectivity & 802.11p
  - >11 dBm TX power
  - >60% TRx efficiency
  - 16 antenna
  - NF 6.5dB at 50 degrees up to 880 MHz

- **ADC 400Ms/S 14 bits**
  - Best energy efficiency
  - 0.4-10mW 0.8V
  - 6.2fJ/step
  - >10 bit, >4000Msps

- **ADC**
  - <16nm CMOS

- **ADC**
  - 12 ENOB
  - 0.4-10mW 0.8V
  - 6.2fJ/step

- **ADC**
  - >10 bit, >4000Msps

- **ADC**
  - <16nm CMOS
ULTRA LOW POWER SHORT RANGE RADIO
WORLD’S LOWEST POWER WITH STATE-OF-THE-ART PERFORMANCE
IMEC SMART CITY TESTBEDS
REAL LIFE VALIDATION OF IOT APPLICATIONS
RADAR EVOLUTION

yesterday

automotive today

future

fixed

mobile + cost down

imec 79 GHz automotive

imec 140 GHz with antenna-on-chip
COMPACT LIDAR SYSTEMS ENABLED BY INTEGRATED PHOTONICS
TOWARDS SUB $ 500 SYSTEMS

Commercial Lidar system: $ 72000
64 lasers + mirrors + rotation = 360° view

imec photonic LIDAR chips
No mechanical rotation
Distributed locations on car body
More compact system
Lower cost
STATE-OF-THE-ART LARGE-SCALE SILICON PHOTONICS CIRCUITS

Philippe Absil et al. Optics Express 2015, 23(7), 9369–78.
IMEC CMOS IMAGE SENSORS
BUILDING IMAGE SENSORS BY PROCESS & DESIGN INNOVATION ENABLING UNMET NEEDS

Key features:
- High speed
- Low power
- Low noise
- High QE
- Radiation Hard
- Non-Visible sensing
- Spectral sensing

Machine Vision
- High-end transports, security & surveillance
- High dynamic range
- Spectral pixels
- Spectroscopy
- Night vision detection
- Hyperspectral

Industrial Instrumentation
- Visibility
- Advanced detectors
- Fluorescence imaging
- Tissue analysis
- Microscopy
- X-ray radiology
- Flow cytometry
- Earth observation
- Aerial photogrammetry
- Astronomy

Life-Science & Medical Imaging
- High QE
- Spectral sensing
- Radiation Hard
- Non-Visible sensing
- Spectral sensing

Space, Physics & Scientific
- High-QE
- Spectral sensing
- Radiation Hard
- Non-Visible sensing
- Spectral sensing
CIS DEVELOPMENTS FOR CUSTOMERS

- Large area (6cm x 7cm)
- Radiation hardened pixels
- 16Mpix @ 250fps @ 12b

- 4k x 2k
- 2.5um pixel pitch - 4T pixel
- 60fps - 1 Watt
- novel 12bit sigma-delta column ADC

- Medical application
- Low-power architecture
- <1mA @ 30fps
AFFORDABLE SPECTRAL IMAGING IN THE PALM OF YOUR HAND
Mounted on UAVs for precision agriculture
Soil analysis
Nutrient deficiency diagnostics
Grows monitoring
Disease and weeds alerts
Nutrient deficiency diagnostics
Yield prediction
VISION:

MEDICAL QUALITY DATA in EVERYONE’S REACH
HEALTH APPLICATION DRIVERS

IMPROVING CHRONIC DISEASE MANAGEMENT

PERSONAL & PREVENTIVE HEALTHCARE
WEARABLE DEVICES & MOBILE DIAGNOSTIC TESTS
FOR EFFICIENT HEALTHCARE & PREVENTION ENABLED BY SILICON CHIPS

ECG PATCH
ECG & BP SIMBAND
ER MOBILE EEG
CARDIO RESPIRATORY FITNESS

ECG PATCH
ECG & BP SIMBAND
ER MOBILE EEG
CARDIO RESPIRATORY FITNESS

PREGNANCY MONITORING
MULTI-OMIC BLOOD TEST
NEUROPROBES
IMEC SMART SYSTEMS & ENERGY TECHNOLOGIES

**Intuitive Internet of Things**
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- MEMS, Sensors, Photonics

**Flexible Electronics**
GAN POWER DEVICES
EFFICIENT POWER SWITCHING AND SIZE REDUCTION OF POWER SYSTEMS
E-MODE HEMT POWER DEVICE BENCHMARKING
LEADING RON VERSUS LGD FOR E-MODE DEVICES ON 200 MM SI SUBSTRATES

High $V_T$ - drive current

State-of-the-art $R_{on}$ for E-mode with GEN 2
Competitive with D-mode power devices

All data for E-mode unless otherwise indicated
All imec data on 200 mm
N-TYPE PERT SILICON SOLAR CELL
22.6% EFFICIENCY
**PEROVSKITE MODULE – RAPID UPSCALING**

15x15 cm² substrate - blade coated

---

**Module voltage (V) vs. Module current (mA)**

- **24 subcells**
- **156 cm² aperture area**

---

**Table:**

<table>
<thead>
<tr>
<th>Aperture Area</th>
<th>Subcells</th>
<th>$V_{OC}$</th>
<th>$I_{SC}$</th>
<th>FF</th>
<th>MPP Aperture Efficiency</th>
<th>Active Area Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>156 cm²</td>
<td>24</td>
<td>20.3 V</td>
<td>108 mA</td>
<td>73 %</td>
<td><strong>10.3 %</strong></td>
<td>&gt;11 %</td>
</tr>
</tbody>
</table>
IMEC SOLID STATE BATTERY PROGRAM
SAFETY - FAST CHARGING - LOW VOLUME & WEIGHT - RELIABLE
IMEC PLANAR THIN-FILM BATTERIES

Stable cycle-ability achieved for manganate-based (LMO) and titanate-based (LTO) solid-state Li-battery cells on Si wafers

- Lithium
- LiPO(N)
- LiMn$_2$O$_4$

- Lithium
- LiPO(N)
- Li$_4$Ti$_5$O$_{12}$

85 µWh/cm$^2$ LMO-Li battery

- Potential vs Li$^+$/Li (V)
- Capacity (Ah/cm$^3$)
- ~4.1 V
- 0.1C

7 µWh/cm$^2$ LTO-Li battery

- Potential vs Li$^+$/Li (V)
- Capacity (Ah/cm$^3$)
- ~1.55 V
- 0.1C

- Films grown by RF-Sputtering and thermal evaporation

- 85 µWh/cm$^2$ LMO-Li battery

- 7 µWh/cm$^2$ LTO-Li battery
CLUSTERING PV & STORAGE R&D IN FLANDERS ON ONE LOCATION

- Battery management
- Smart grid
- PV systems
- Grid integration

- Smart PV modules
- Energy yield estimation
- Solid state storage

- Solid state storage
- PV system electronics
- Smart grid
- Energy yield estimation

- Solid state storage
- Reliability
- PV-Materials development
- Energy storage materials

COVERING THE WHOLE ENERGY INNOVATION VALUE CHAIN
ENERGYVILLE @ THORPARK

MAIN BUILDING

INCUBATHOR: 2015: start-ups

ENERGYVILLE 1: 6/2016: KULeuven & VITO

ENERGYVILLE 2: 1/2018: imec
THIN-FILM ELECTRONICS ON FOIL

TFT technology
• Plate manufacturing
• α-IGZO TFT
• 4-5 litho-masks
• Low cost
FLEXIBLE ELECTRONIC TECHNOLOGY PLATFORM
DEVELOPED FOR THE NEEDS IN DISPLAYS, HEALTH, INSTRUMENTATION & IOT
embracing a better life