



Thank you, Things.

Jo De Boeck - Senior Vice President and CTO imec



**MOBILE**  
REVOLUTION



**INFRASTRUCTURE**  
MOBILES > PEOPLE



ZERO LATENCY  
**ALWAYS ON**



EXABYTES PER MONTH

## CONSUMERS DRIVE DATA, DATA, DATA

2012

2017



## ACCESS TO DATA STIMULATES MANY INDUSTRIES

## PLATFORM ENABLES NEED CREATION



- TOUCH
- HUMIDITY
- AMBIENT LIGHT
- TEMPERATURE
- RF ENHANCEMENT
- PROXIMITY
- COMPASS
- MICROPHONE
- PRESSURE
- LOCATION
- GYROSCOPE
- ACCELEROMETER



## SUPPORTIVE AWARE PROACTIVE SERVICE

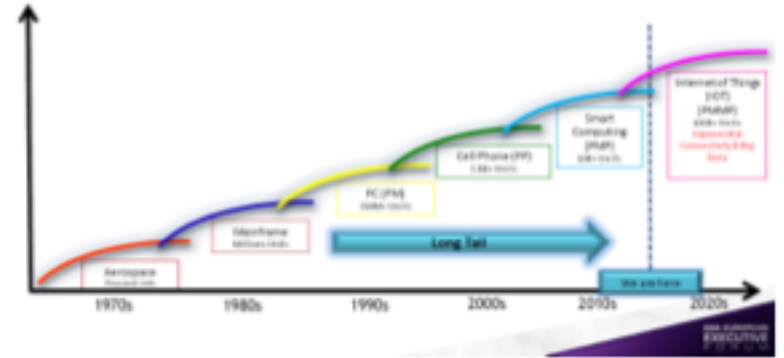
## THE NEXT WAVE OF CONSUMER NEEDS

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## NEXT DRIVER

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Volume Paradigm: 10X in 10Y, accelerating



## INTERNET OF THINGS CHALLENGES

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ULTRA LOW POWER

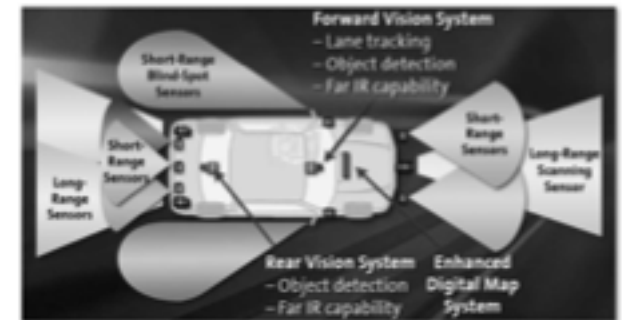
INTEROPERABILITY

MASSIVE DATA PROCESSING

EASE OF USE

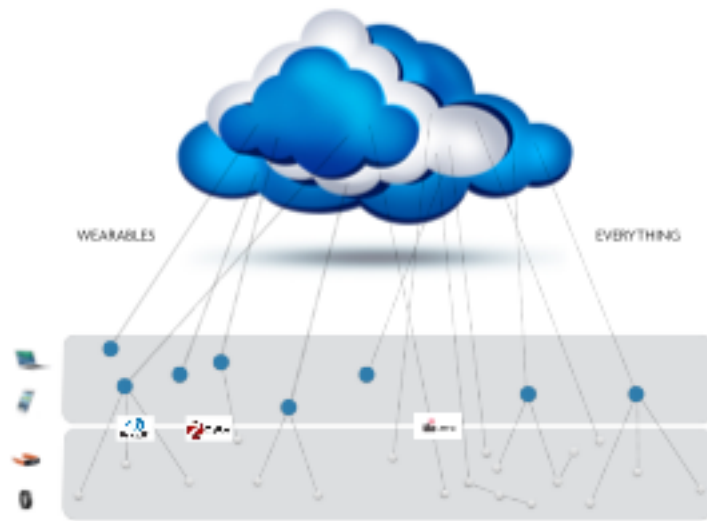
## AUTOMOTIVE SMART MOBILITY

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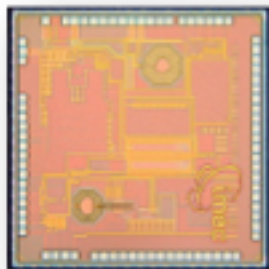




## NEXT-GENERATION WIRELESS



## LOW POWER RADIO FOR SMART INFRASTRUCTURE



RECORD LOW POWER 4mW RX  
10X BETTER THAN OFF THE SHELF

BEST IN CLASS PERFORMANCE  
-120dBm SENSITIVITY

MULTI-STANDARD

HIGH LEVEL OF INTEGRATION

M-Bus  KNX

## WIFI FOR SENSORS SMART BUILDINGS

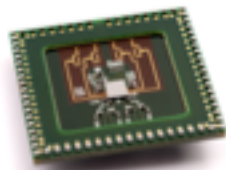




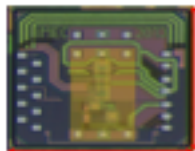
LOWEST POWER: ACTIVE AND DEEP SLEEP

>1KM DISTANCE

PRE-STANDARD COMPLIANT SYSTEM  
IEEE 802.11ah

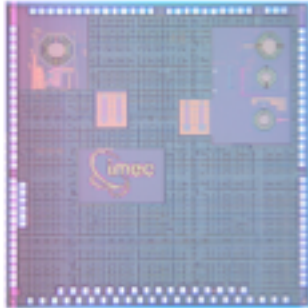


60GHz PHASED ARRAY RADIO  
TECHNOLOGY IN 28nm CMOS



79GHz RADAR TX  
IN 28nm CMOS

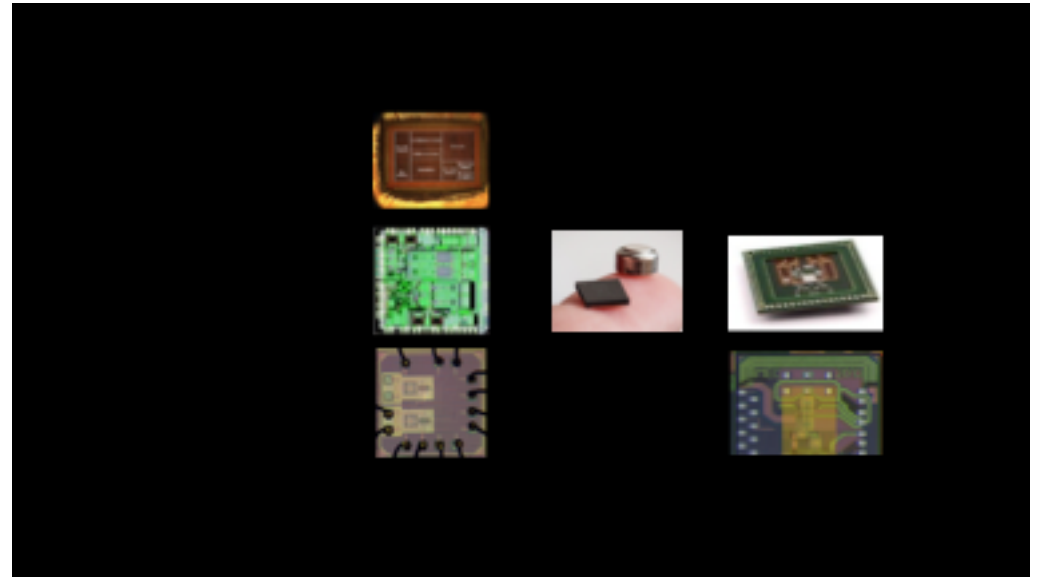


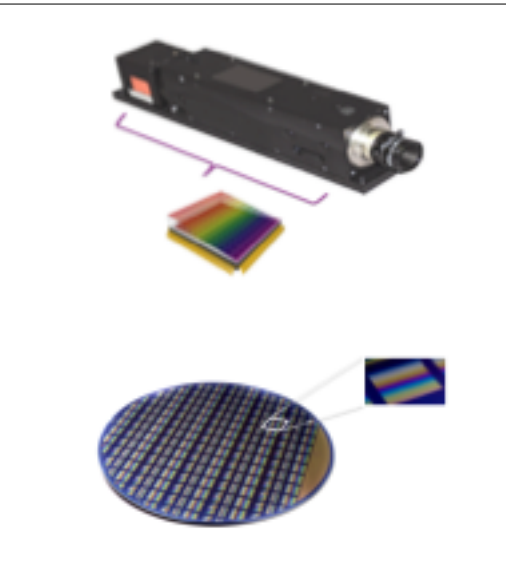


RECORD LOW POWER 5mW  
2X BETTER THAN OFF THE SHELF

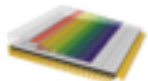


STATE-OF-THE-ART PERFORMANCE:  
-95dBm SENSITIVITY

MULTI-STANDARD





## Hyperspectral imaging platform

<p><b>Linescan</b> "wedge" design</p> 	<p><b>Snapshot tiled</b> "area" design</p> 	<p><b>Snapshot mosaic</b> "pen-pend" design</p> 	<p><b>Adimec</b> Aerial</p> <p><b>Bluewin</b></p> <p><b>BaySpec</b></p> 
<p><b>Industrial</b> high resolution, fast &amp; flexible</p>	<p><b>Handheld</b> compact, user-friendly</p>	<p><b>Consumer</b> extremely compact, robust, specialized</p>	<p><b>3D ONE</b></p> <p><b>ximea</b></p>





## RETAIL AND LOGISTICS

SMART RFID TAGS

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## RETAIL AND LOGISTICS

SMART RFID TAGS

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## PLATFORM ?

MULTI-FUNCTIONALITY  
HETEROGENEITY  
MANUFACTURABILITY  
DESIGN  
ECOSYSTEM

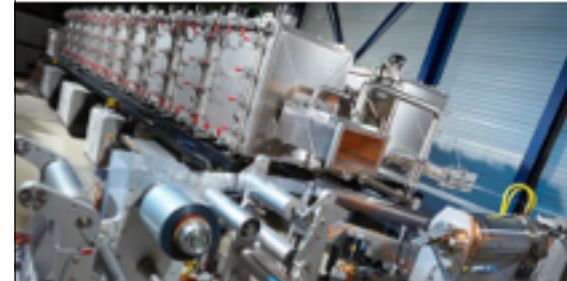
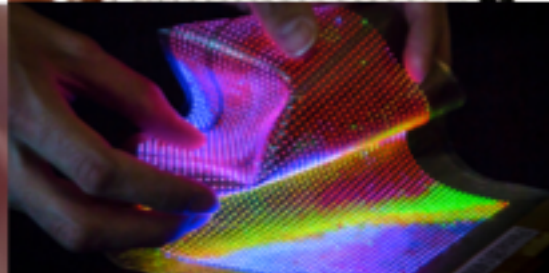
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## PLATFORM ?

MULTI-FUNCTIONALITY  
HETEROGENEITY  
MANUFACTURABILITY  
DESIGN  
ECOSYSTEM

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## WEARABLE HEALTH MONITORING

DEAL WITH RISING HEALTHCARE COST

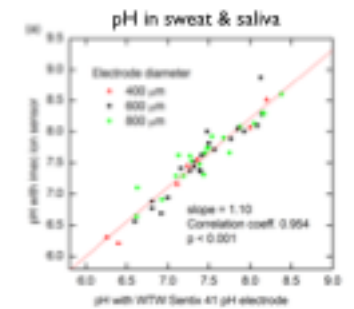


## Multi-ion 'one-drop' analysis platform

- Multiple ions: pH, Cl<sup>-</sup>, Na<sup>+</sup>, K<sup>+</sup>
- 2-10 pH range, 0.1 – 1 M Cl<sup>-</sup> range

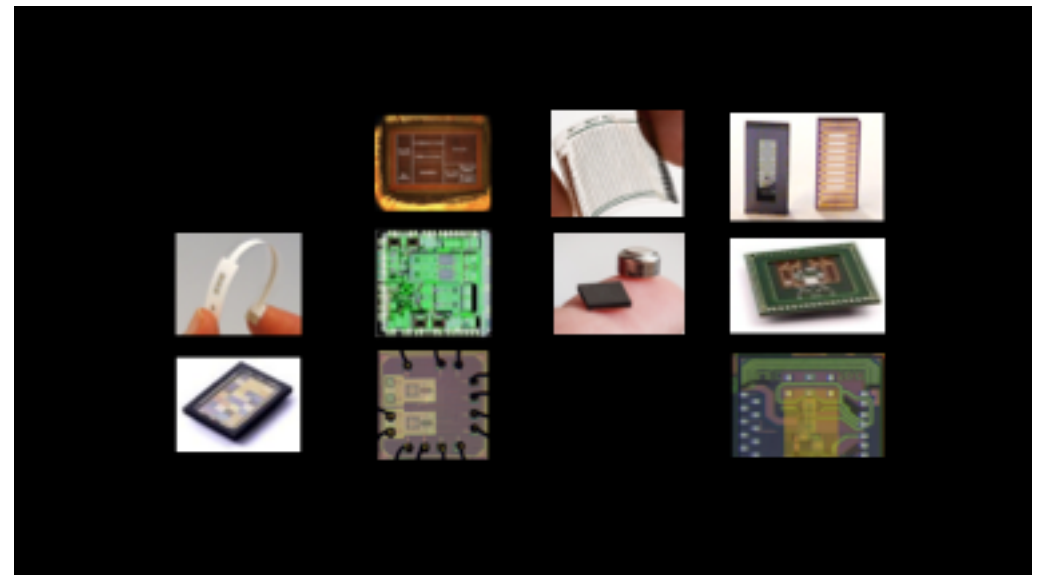
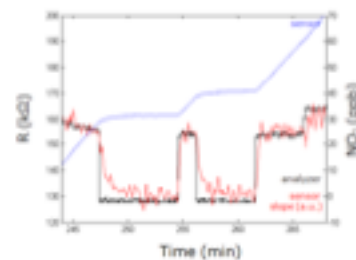


Protection Sensing Reference  
electrodes electrode



## Multi-gas analysis platform

- 2 ppb limit of detection
- <200mW active mode power consumption
- High selectivity
- Continuous measurements
- Multi-gas sensing: NO<sub>2</sub>, NO, O<sub>3</sub><sup>\*</sup>, NH<sub>3</sub><sup>\*</sup>...





Company	Headquarters	Name of smartwatch	Units shipped 2014	Market volume 2014 (\$MM)	Market share 2014 (%)
Garmin	United States	Garmin Vivoactive	400,000	140 million	11.4%
Apple	USA	Apple Watch (1st Gen)	400,000	400 million	32.4%
Garmin	Netherlands	Forerunner 220/235/245/255	200,000	80 million	6.5%
Fitbit	USA	Fitbit Force	400,000	50 million	4.1%
Sony	Japan	SmartWatch	200,000	50 million	4.1%
Fitbit	USA	Fitbit Smartwatch	300,000	40 million	3.3%
Umidigi	China	Umidigi Watch	300,000	30 million	2.5%
Moto Alpha	Canada	Moto Racer Sport Watch	300,000	20 million	1.6%
Progear	China	Progear One	500,000	10 million	0.8%
Lenovo	Japan	Lenovo Smartwatch	500,000	10 million	0.8%
Other	All companies		4,000,000	1,000 million	81.4%
<b>Total</b>			<b>5,000,000</b>	<b>250 million</b>	<b>100%</b>

Definition of smartwatch: wearable device with indication of time and wireless internet connection.

**Market Volume (M\$)** <http://www.smartwatchgroup.com/>

Year	Market Volume (M\$)
2013	~700
2014	~2500

**BECOME A HEALTH COACH**  
 CHANGE YOUR LIFE

MOVING FROM  
TRADITIONAL CARE TO  
**PREDICTION  
PREVENTION**



EMPOWER PEOPLE FOR  
**DISEASE PREVENTION AND  
HEALTHIER LIFESTYLE**

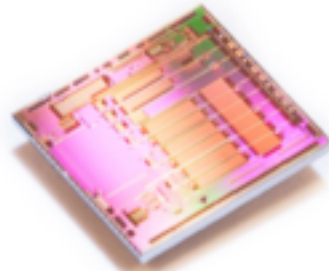


**ACCURATE**

FITNESS GADGETS



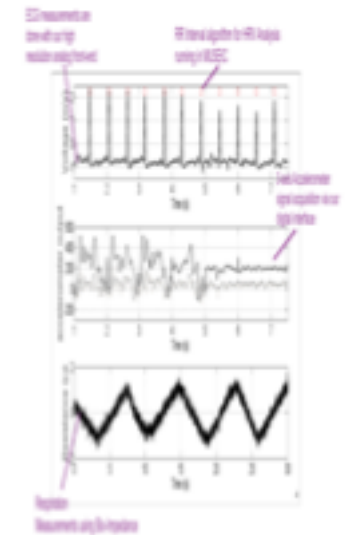
ULTRA-LOW POWER  
MULTI-SENSOR PLATFORM  
**MEDICAL QUALITY DATA**



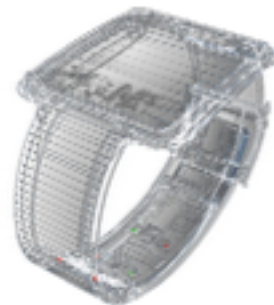
ULTRA-LOW POWER  
MULTI-SENSOR PLATFORM



LOWEST POWER BIOMEDICAL SENSOR PLATFORM:  
750uW total power consumption



SAMSUNG  
**DIGITAL HEALTH PLATFORM**



Samsung **SIMBAND**

*\*Investigational device. Not available for sale.*

SAMSUNG  
**DIGITAL HEALTH PLATFORM**





ENABLING TRUE  
**MOBILE HEALTH**

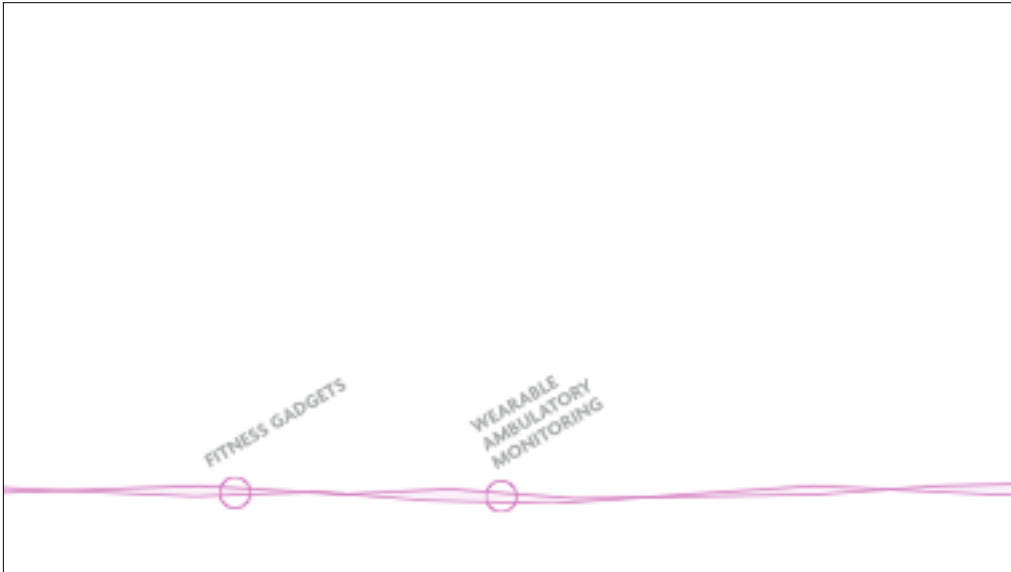


NANOELECTRONICS ENABLE  
**DISRUPTIVE INNOVATIONS  
IN HEALTHCARE**



FITNESS GADGETS

WEARABLE  
AMBULATORY  
MONITORING



**iLAB**  
MULTIPLE TESTS UNDER 10USD



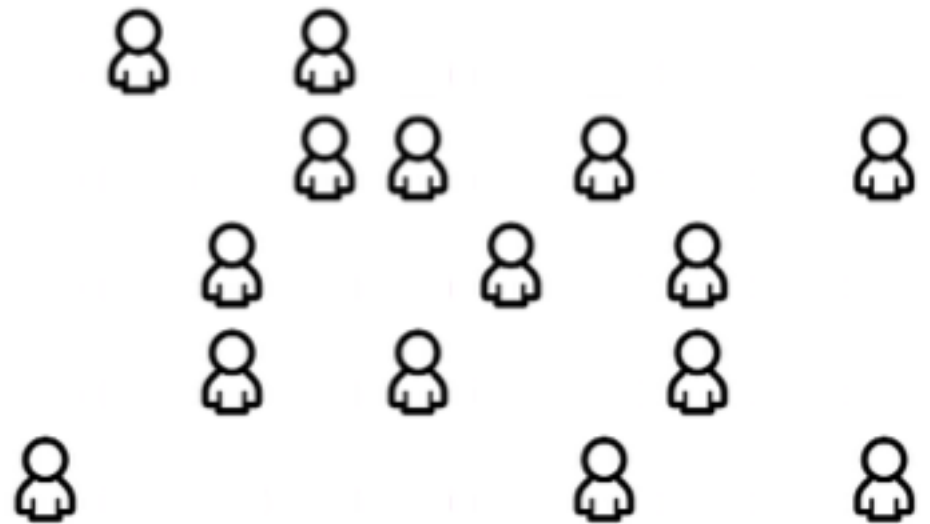
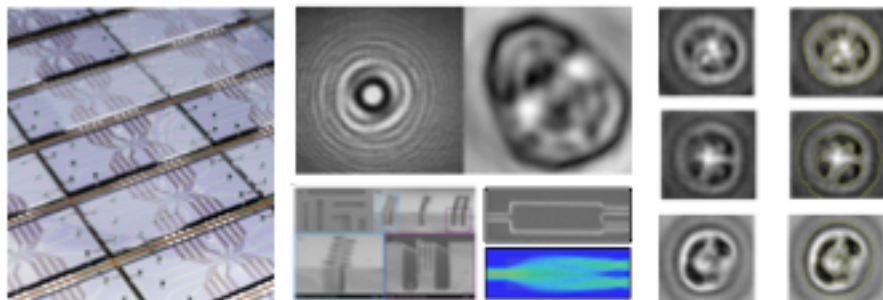
**iLAB**  
MULTIPLE TESTS UNDER 10USD



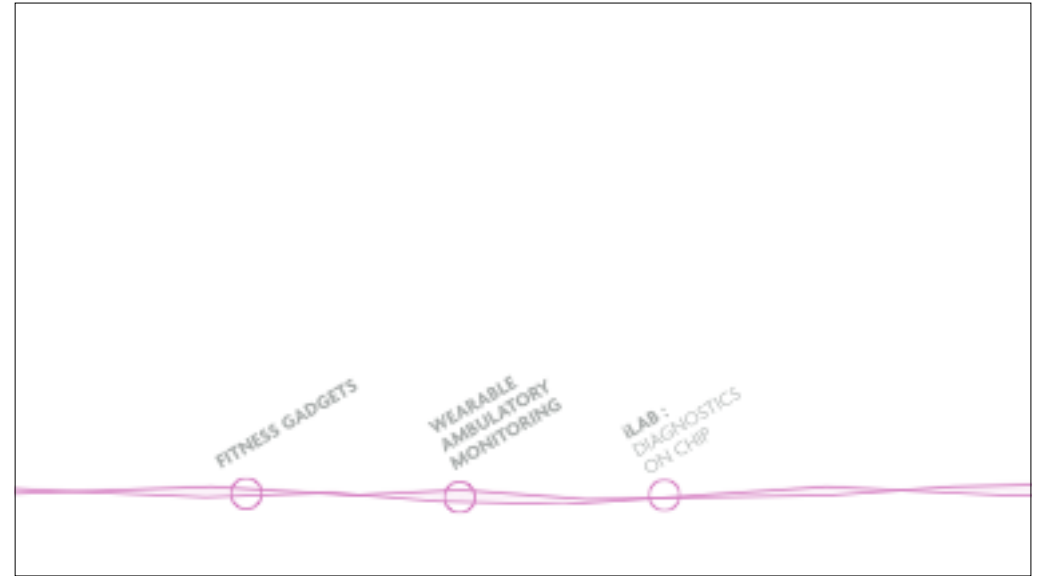
**DIAGNOSTICS**  
FOR INFECTIOUS DISEASES



**Diagnostics-on-a-Chip platform**

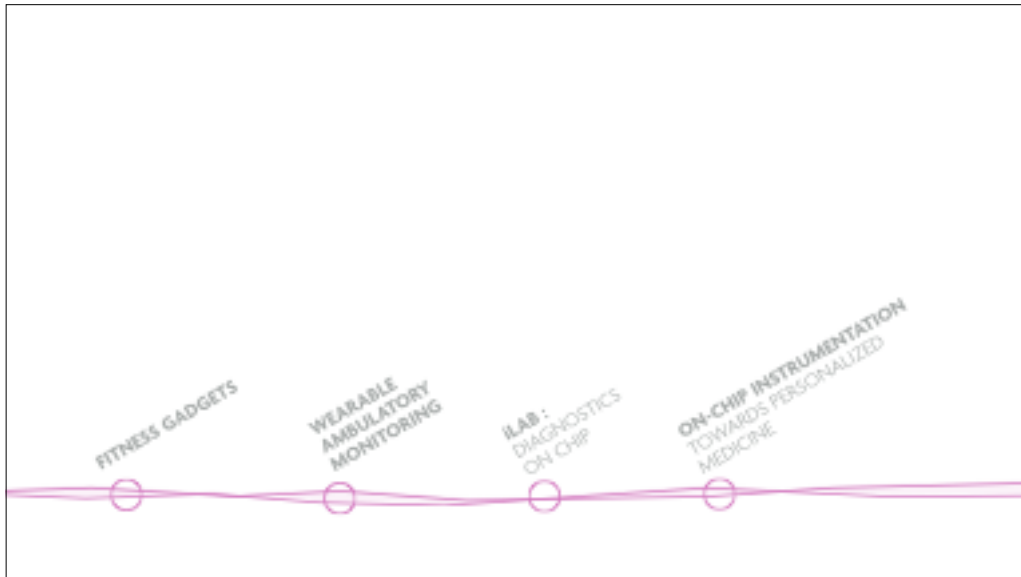
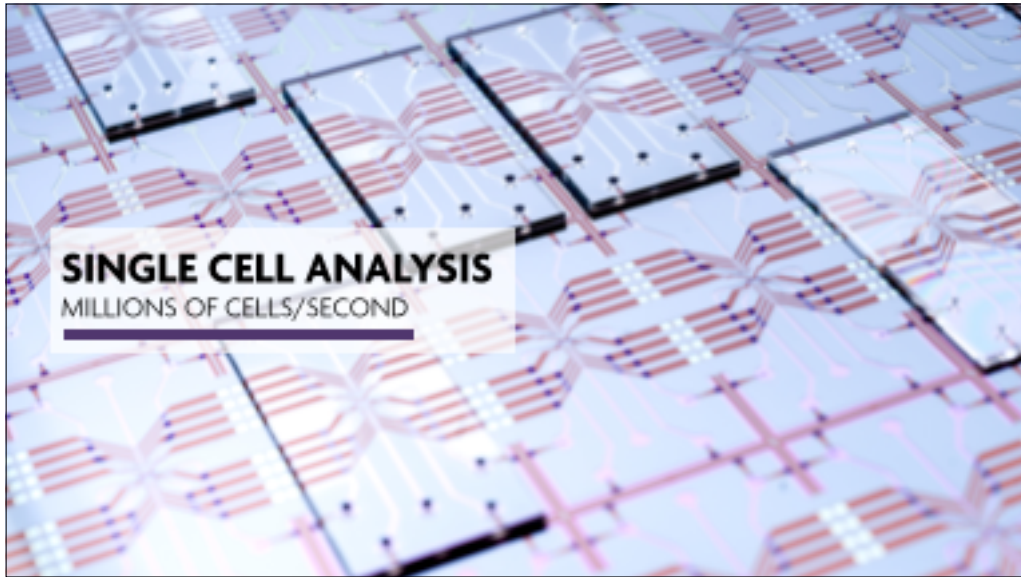






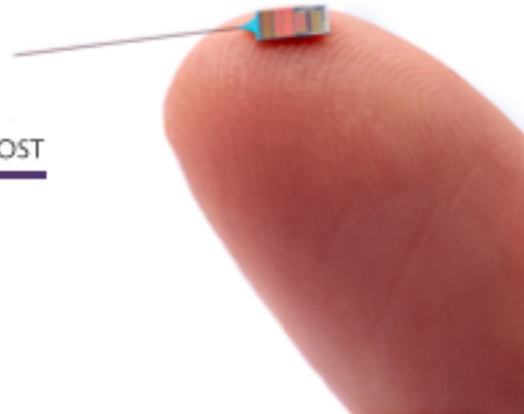
### On-chip genome analysis platform

The first image shows a small, square microchip next to a coin for scale. The second image shows a microchip with a DNA double helix structure overlaid on it. The third image shows a scientist wearing sunglasses and a white lab coat working in a laboratory setting, with a sign for 'PROFC BIOGENCES' visible in the background.



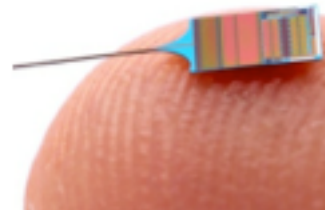
## BRAIN PROBES

COMPACT & INTELLIGENT & LOW COST



## Neuron interface platform

Signal filtering (LFPs, APs)  
Analog-to-digital conversion  
Digital interface to small PCB  
Direct link to PC



100  $\mu\text{m}$  x 50  $\mu\text{m}$  shank  
456 electrodes and amplifiers  
52 channels  
Low noise: 4  $\mu\text{V}$  rms  
Recording + stimulation



## Neuromorphic computing

Application know-how

Deep learning algos

Organic - Silicon  
neural architecture

<http://www.research.ibm.com/ibm/ibm-brain-chip.shtml>

## Exascience life challenge

Java, Python, R, BASH, Javascript, ...  
the Cloud, Hadoop, REST, ...  
ASCII Files, NoSQL, ...  
Multi-Core ?  
Call C/Fortran Libraries

Fortran, C, ASM, Stencil Compilers, ...  
GASPI, MPI, ...  
HDF, Lustre, ...  
Threads, OpenMP, Fork/Join, Cilk+, ...  
Vectorization, SIMD Intrinsic, ...



INTERNET OF  
**EVERY**THING



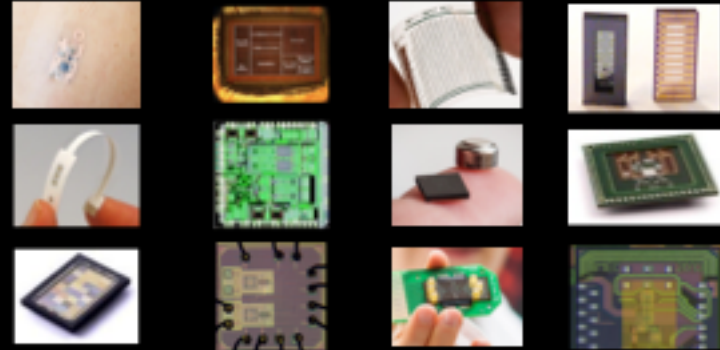
PERSON CENTRIC



VEHICLE CENTRIC



INFRASTRUCTURE CENTRIC



Thank you, Things



SHARING IDEAS  
SHARING THE FUTURE