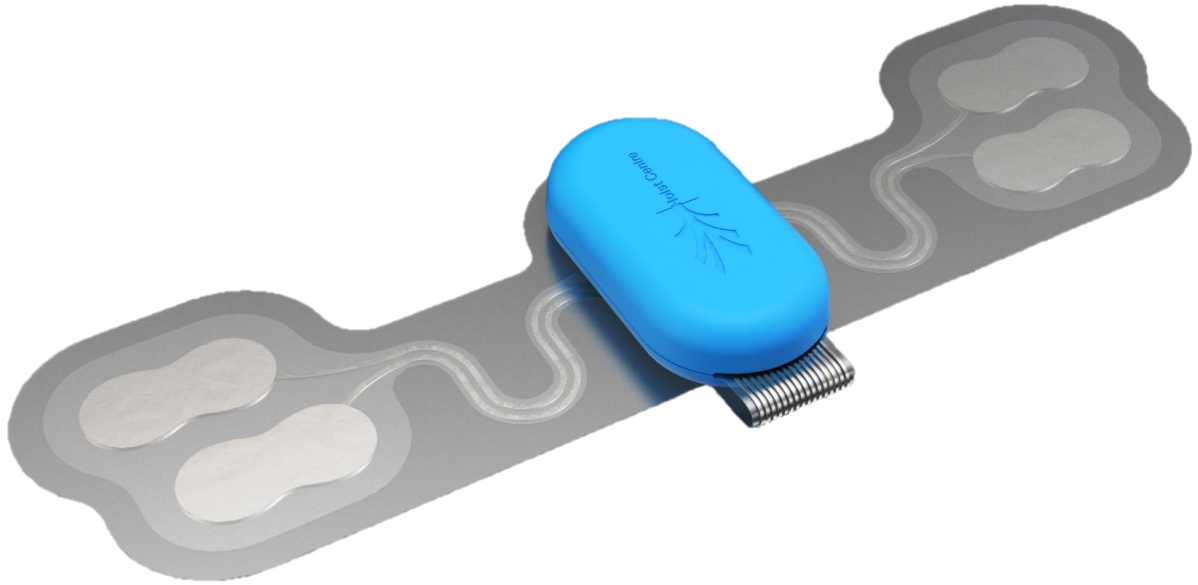
Holst Centre



Next-generation wearables for remote monitoring of vital signs & beyond

MEDISCHE ELEKTRONICA
Ontwikkelingen, normen en toepassingen

7 februari 2023 | FHI Leusden

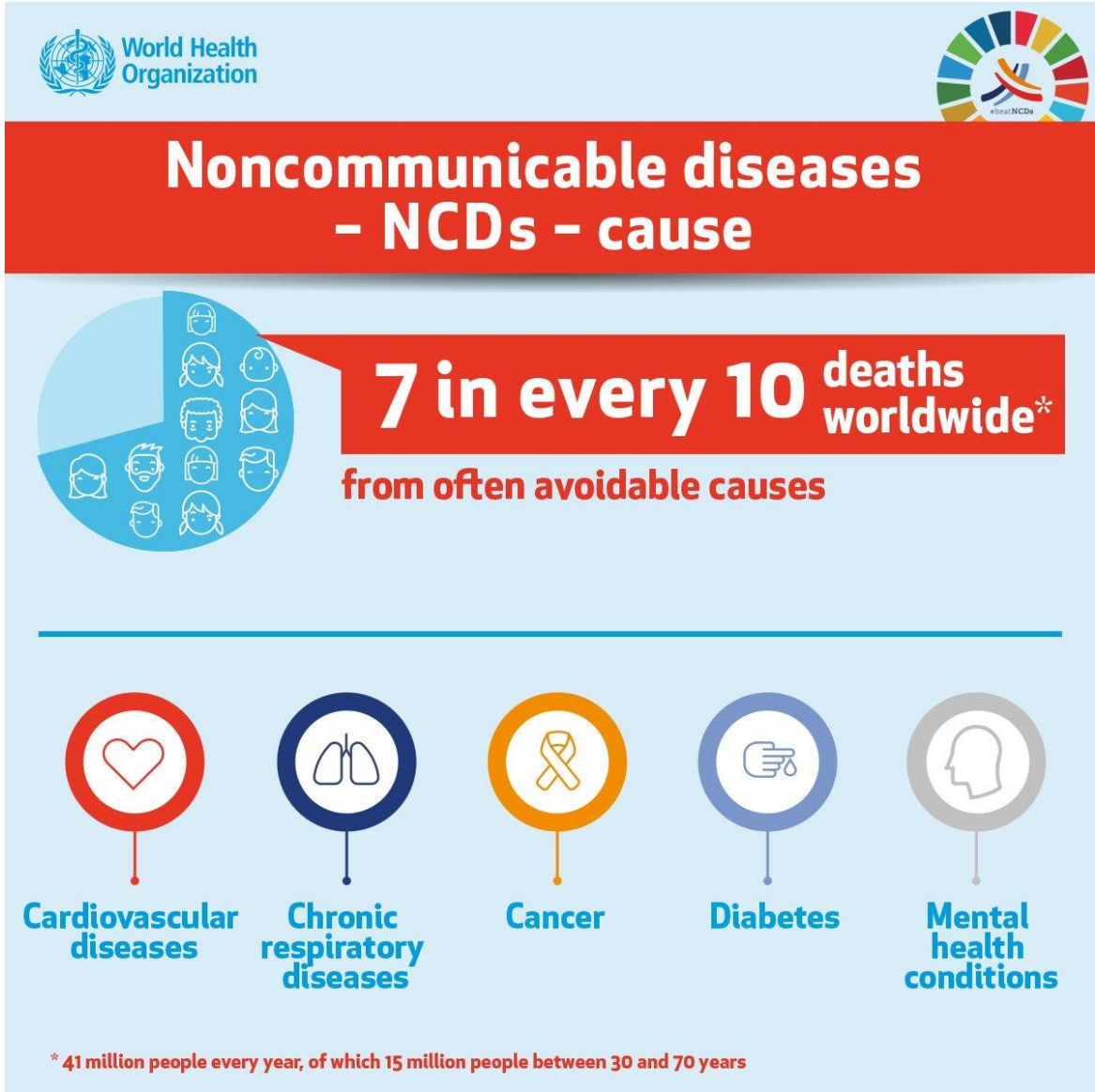
- **Research & innovation** partner
- Founded in **2005** by leading research institutes **TNO** & **IMEC**
- Specialised in **health technologies**, **flexible** and **wireless** electronics
- Located on the **High Tech Campus, Brainport** area

Holst Centre
Powered by imec & TNO

Chronic diseases: ‘invisible epidemic’

- Chronic diseases or “**invisible epidemic**” are responsible for **71% of annual deaths** globally (41 million)

- **Healthcare** system is under **pressure**, increasing **costs** & depleting **resources**

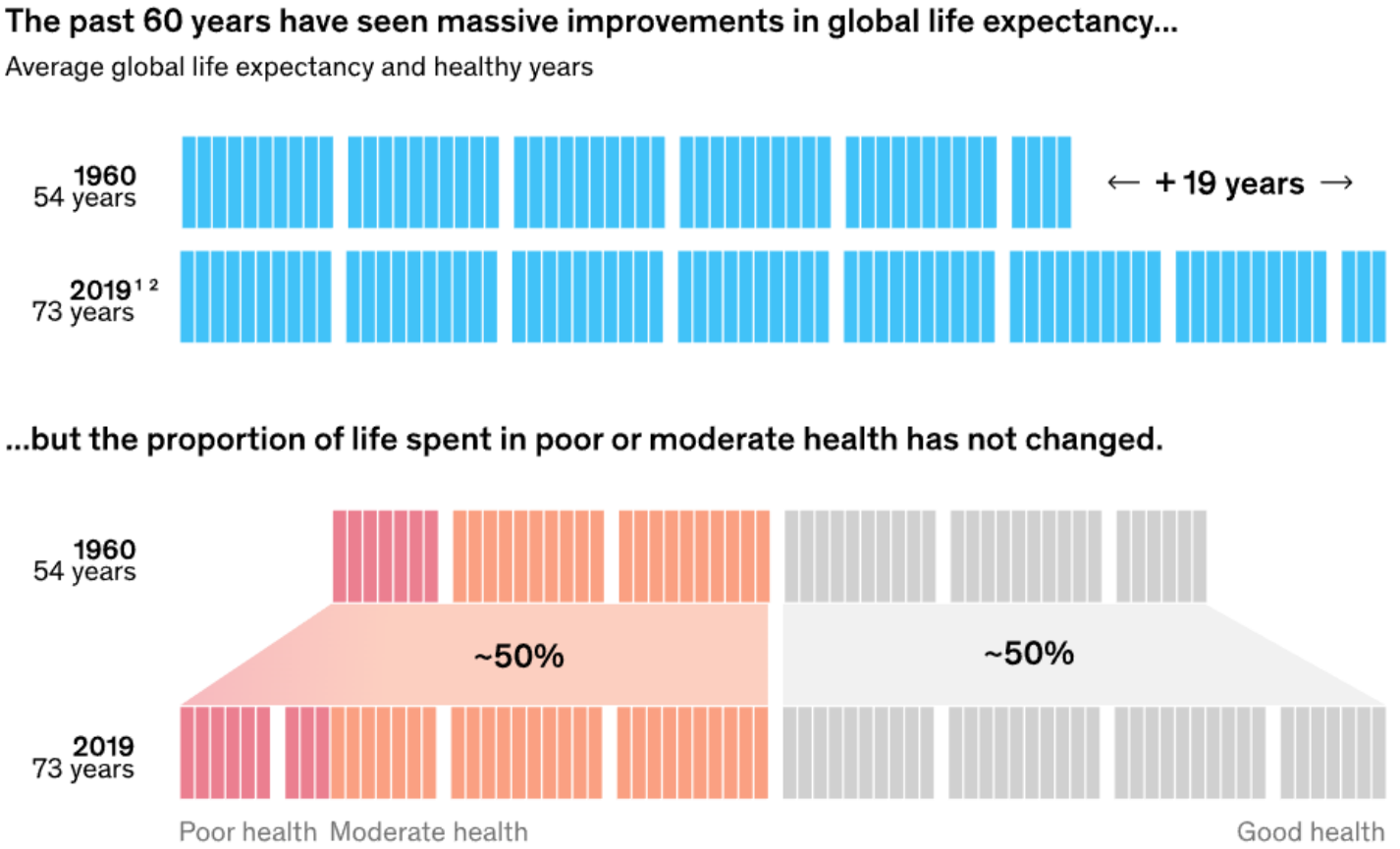


People spend 50 % of lives in less-than-good health

- Global **life expectancy** more than **doubled** (1800-2017)

- People spend **~ 50%** of their lives in **less-than-good health**,

  including 12% in **poor health**



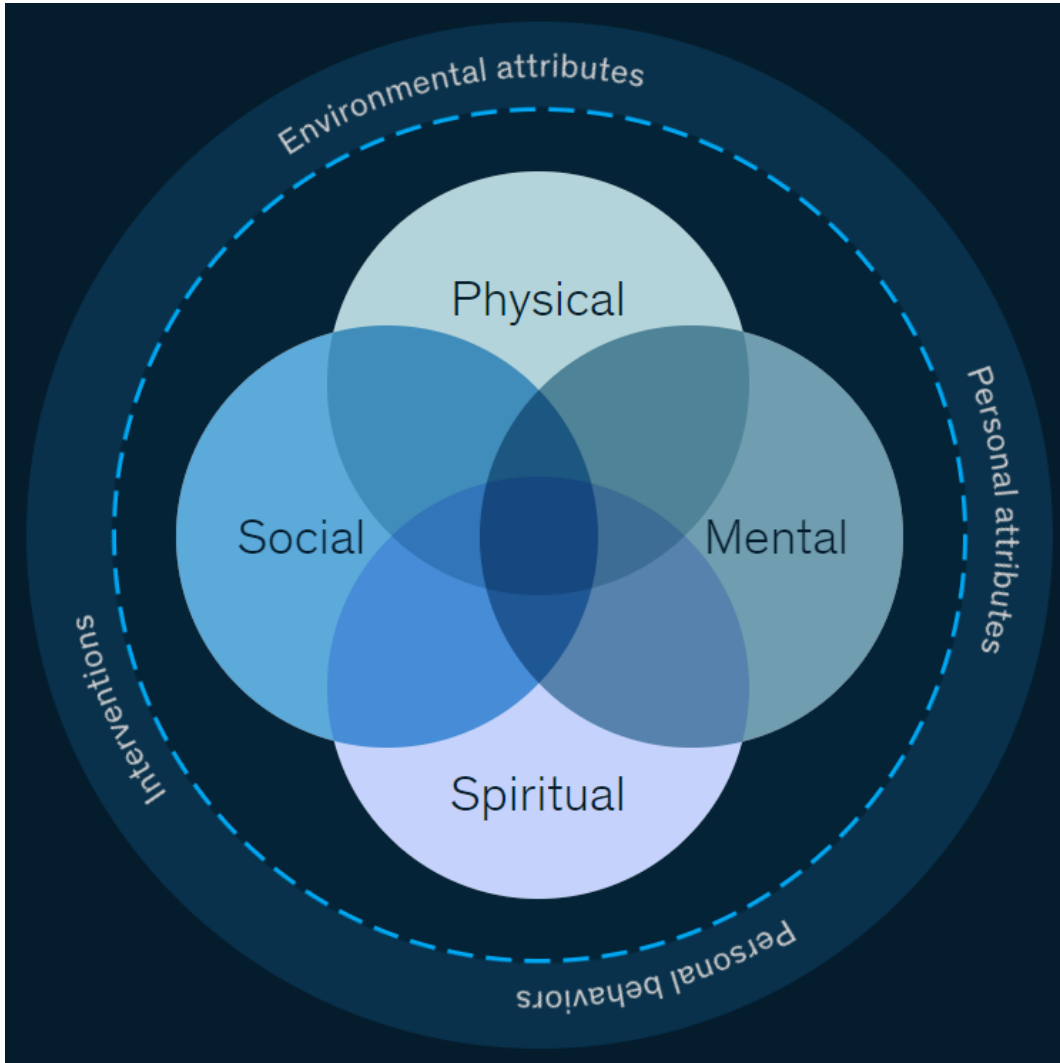
Source: McKinsey Health Institute 2022

Mission: adding 45 B years of higher-quality life

Embrace **holistic** definition of **health**:

Health is a state of complete **physical**, **mental**, **social** & spiritual **well-being**

Act on it: Improve **measurement** of **health** with **better data**



Source: WHO, 1948;
Source: McKinsey Health Institute 2022

Measurement of health with better data

Customer segments

- Consumers / patients
- Medical doctors
- Pharma / researchers

Use-cases

Prevention

Early diagnosis

In-hospital monitoring

Surveillance

Products & services

- Vital signs patches
- Platforms, software, AI
- Services

Wearables: opportunity for quantify self
consumer-, clinical- & medical grade wearables

Consumer-grade

- General wellness, fitness, nutrition tracking
- Data not suitable for disease diagnosis
- Garmin, Huawei, Samsung, Withings, Apple, Fitbit, …

Garmin

Fitbit

Apple

Clinical-grade consumer

- E.g. AF detection
- Have regulatory-approved features
- Samsung, Withings, Apple, Fitbit, …

Fitbit

Apple

Medical grade

- For medical monitoring, diagnostics, therapeutics
- Under regulatory approval
- Clinically-actionable data
- Medtronic, Abbot, Philips, Boston Scientific, Masimo, …

Medtronic

Biobeat

Philips

Boston Scientific

Medical grade wearable patches
key user requirements

- High **quality** medical-grade data
- **Long-term** monitoring, >> 2 wks
- Patient **comfort** & compliance
- **Modularity** / acquisition of **multiple parameters**

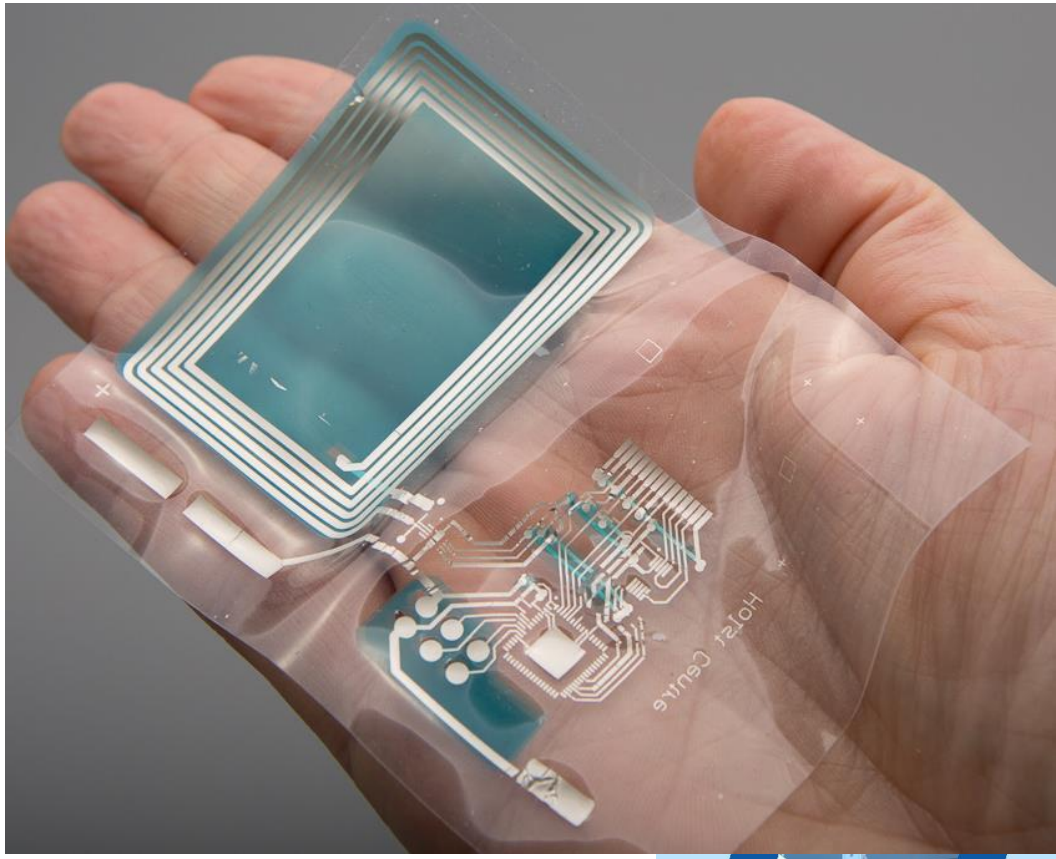
Flexible electronics
enabling technology for medical grade patches

User benefits:

- **Conform** to the skin → High **quality** signal
- **Thin**, **flexible**, **stretchable** → **Comfortable** to wear on **long term**

Manufacturing benefits & design freedom:

- **Low cost** & easily multipliable
- Highly **scalable** in size (from cm2 to m2)
- High **design freedom**
- Ease of **integration**, e.g., with photonics



Flexible electronics & hybrid integration
enabling unique functionalities

Sensors:

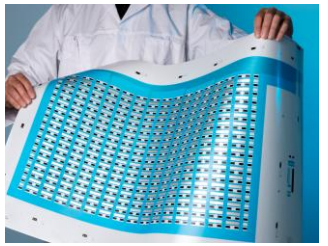
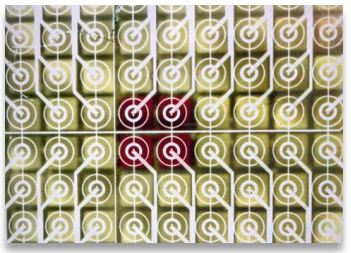
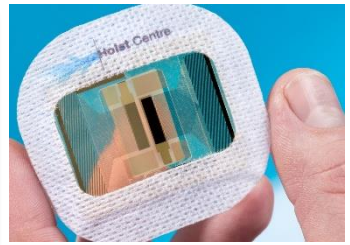
- (Bio)-impedance
- Temperature
- Pressure
- pH
- Ultrasound
- Vis / NIR spectroscopy & imaging

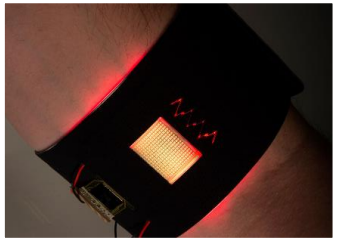
Actuators / manipulators:

- Micro-fluidics
- Ultrasound
- Light sources for phototherapy
- Electric stimulation

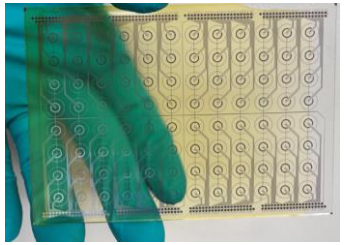
Sensors



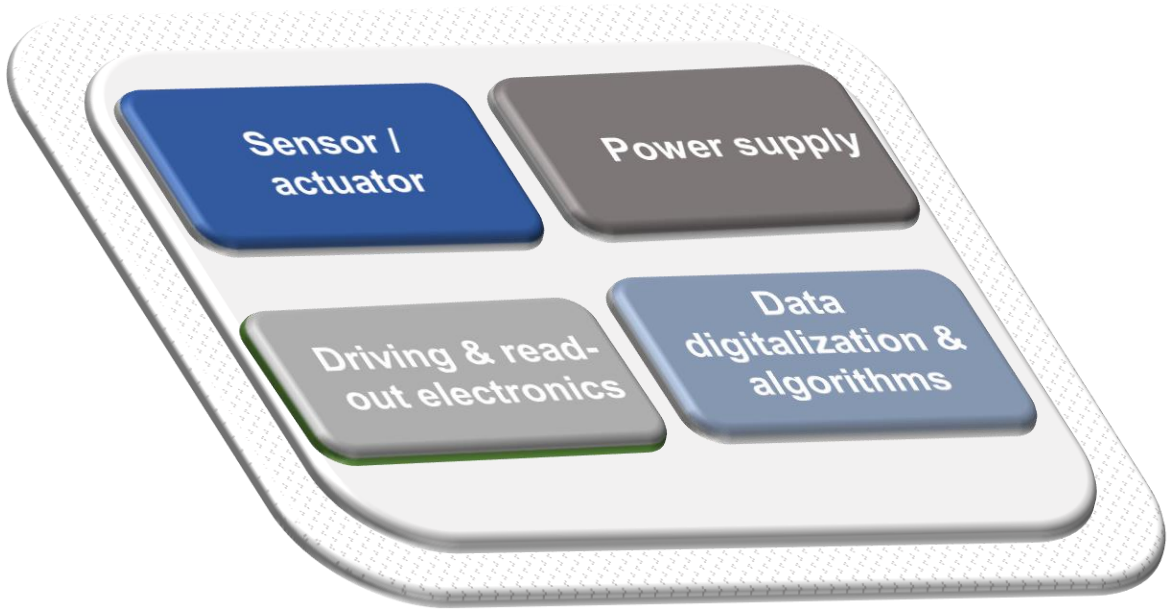


Actuators



Medical grade wearable patches
complex electronic device

- Sensors / actuators
- Electronics circuitry
- Data digitazation & processing
- Algorithms
- Integration in a wearable patch
- Power supply
- …

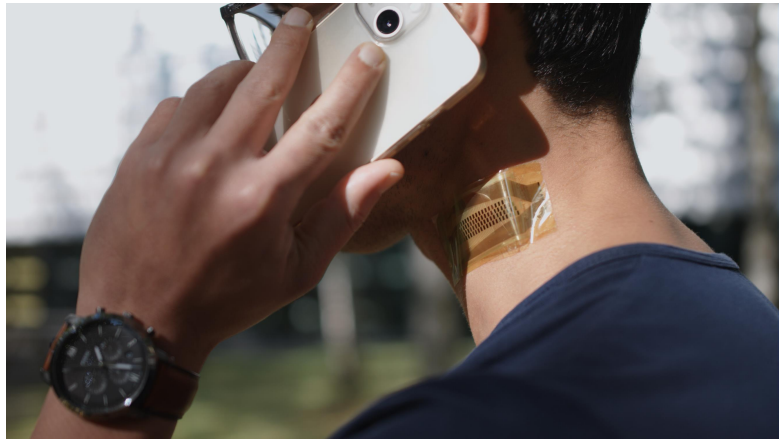


Flexible electronics:
enabling medical grade patch technology platforms

Vital Signs patch platforms

Flexible 2D optical array

Flexible large area ultrasound



Vital Signs patch platform

high quality data over long term, comfort, sensor modularity

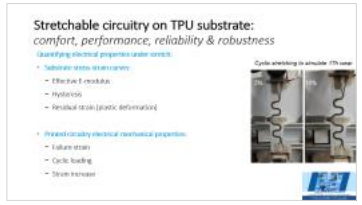
- Clinical grade ECG
- Accelerometry
- Respiration rate
- Skin temperature

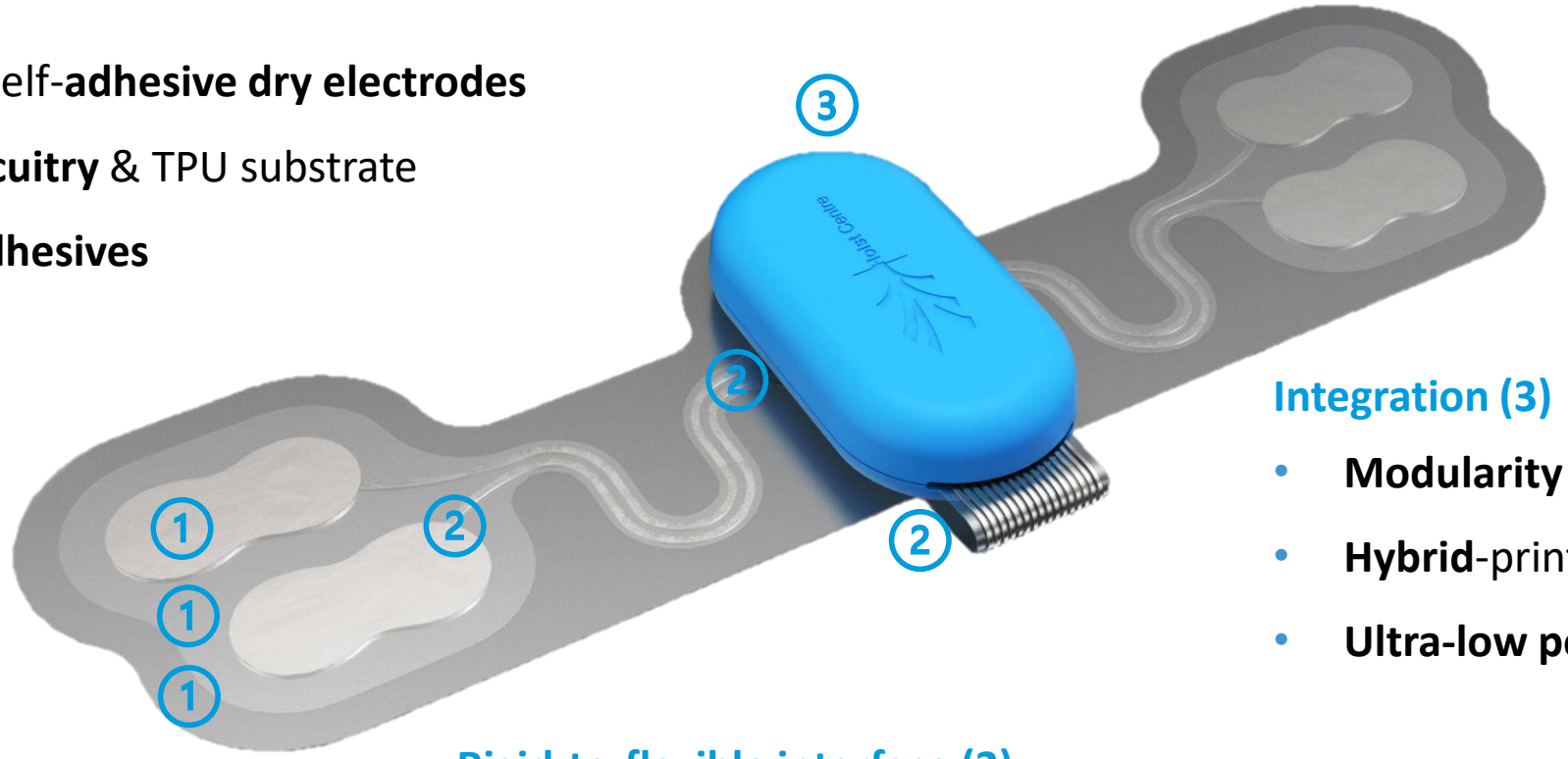
- Blood pressure
- Calibration free SpO2
- Core body temperature
- Fall detection

Vital Signs patch platform
key enabling technologies

Skin interface (1)

- Skin **conform**, self-**adhesive dry electrodes**
- **Stretchable circuitry** & TPU substrate
- Optimal skin **adhesives**





Integration (3)

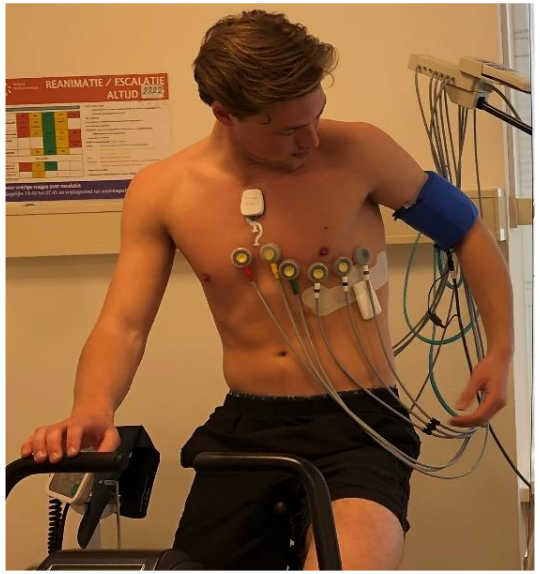
- **Modularity** of sensor platforms
- **Hybrid**-printed electronics
- **Ultra-low power** electronics

Rigid-to-flexible interface (2)

- **No sharp radii** for stress dissipation
- **Redundancy** in conductive lines for robustness
- Vibration / **motion damping** for lifetime

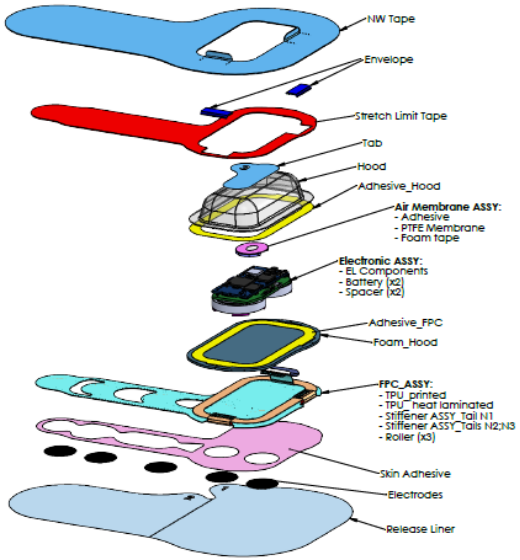
Vital Signs patch platform
validation on different use-cases on human subjects

Patients with arrythmia



máxima medisch centrum

COPD



PHILIPS

Military pilots

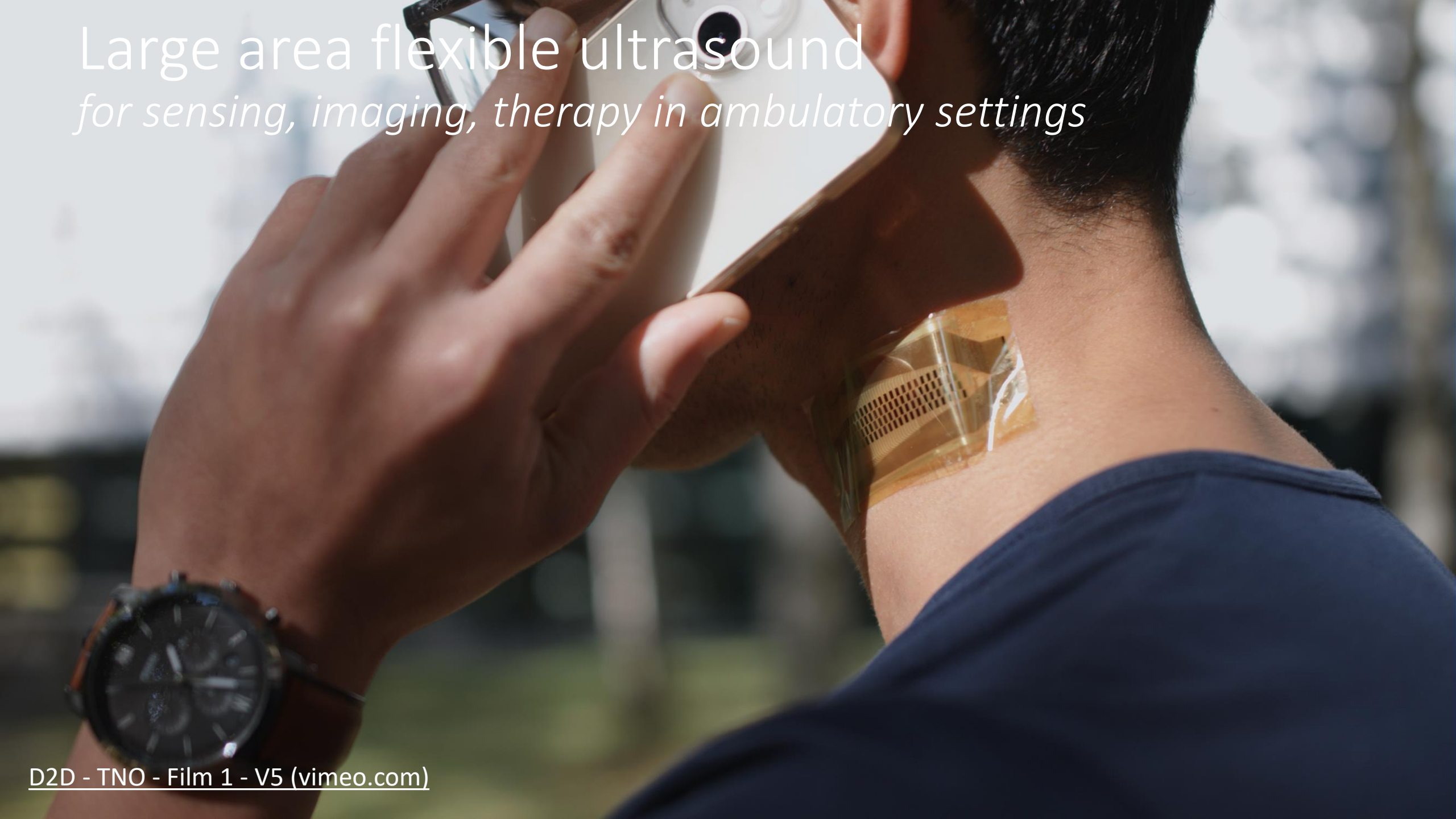
CML
SCIENTIA ET VOLATUS

TNO

Aeolus
Human performance Innovation

Large area flexible ultrasound

for sensing, imaging, therapy in ambulatory settings



D2D - TNO - Film 1 - V5 (vimeo.com)

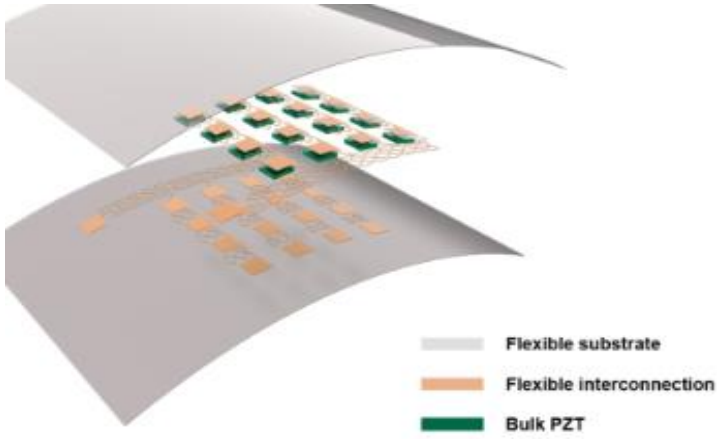
Medical ultrasound:
from hand held probe to in-body devices

Low frequency		Medium frequency				High frequency		
								
Eco-cardiography	**Abdominal**	**Therapeutic**	**Gynaecology**	**Trans-esophageal TEE**	**Vascular**	**Intra-cardiac ICE**	**IVUS**	**Dermatology imaging**
1 – 5 MHz	2 – 5 MHz	4 – 8 MHz	5 – 10 MHz	5 – 10 MHz	5 – 15 MHz	5 – 20 MHz	20 – 50 MHz	10 - 40 MHz

- Usage by a trained healthcare professional
- Occasional inspection or therapy / intervention

Flexible large area ultrasound:
for sensing, imaging, therapy in ambulatory settings

Rigid elements on flexible substrate



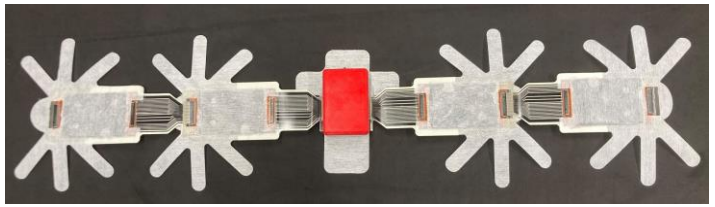
**Liu et al, MDPI Sensors, 2020, doi:10.3390/s20010086*

+ Very suitable for limited / large elements

- Bandwidth limitations

- Tough to scale to many elements

Rigid arrays on flexible back plane



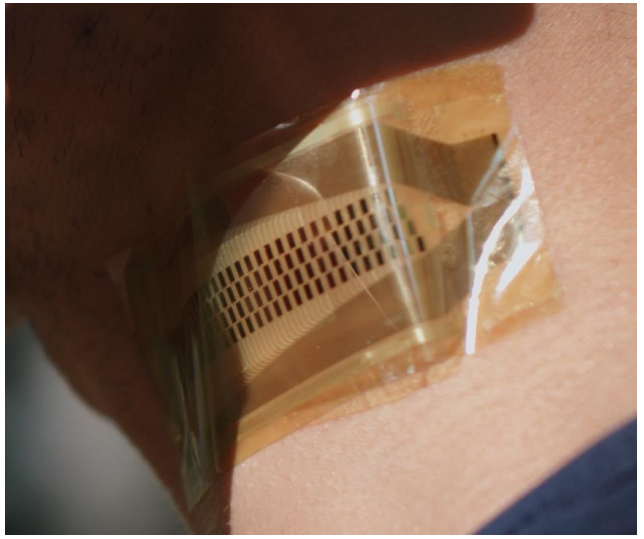
ULIMPIA Smart Body Patches

\+ Can use ‘standard’ arrays

\- Not fully flexible

\- Costly for large area

Truly fully flexible & large-area



\+ Cost effective scaling to large area’s

\+ Fully flexible

\+ Much higher sensitivity vs. PZT

Flexible large area ultrasound
enabling a wide range of applications

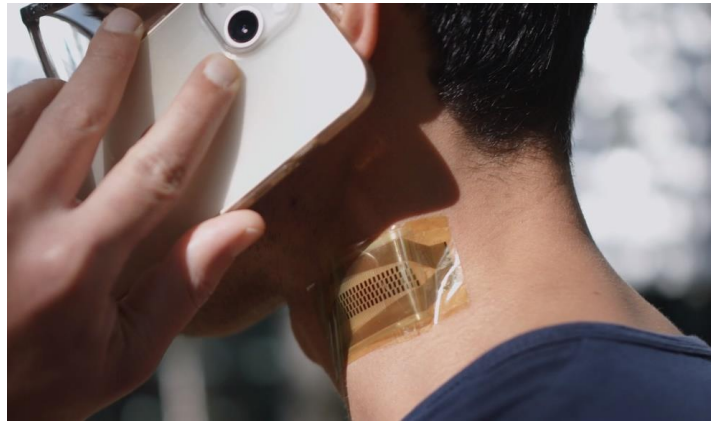
Benefits

- **Best-in-class sensitivity: 7x better** vs. top-end PZT
- Excellent **pulse-echo efficiency**, greater than CMUT
- Tunable between **3 MHz and 30 MHz** for **real-time** imaging
- **Pressures** of 100 kPa/V feasible in MHz range for **therapy**

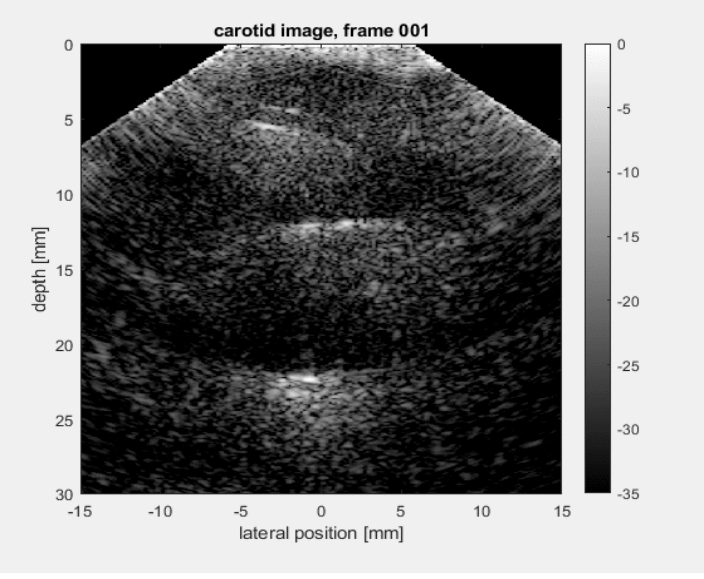
Applications:

- **Cardiac & vascular**: first ***in vivo*** imaging of **carotid artery**
- **Obstetrics and gynecology:** pregnancy monitoring
- **Urology**: bladder monitoring
- **Therapy**: wound healing; drug delivery, bone stimulation
- … and more

Truly fully flexible & large-area

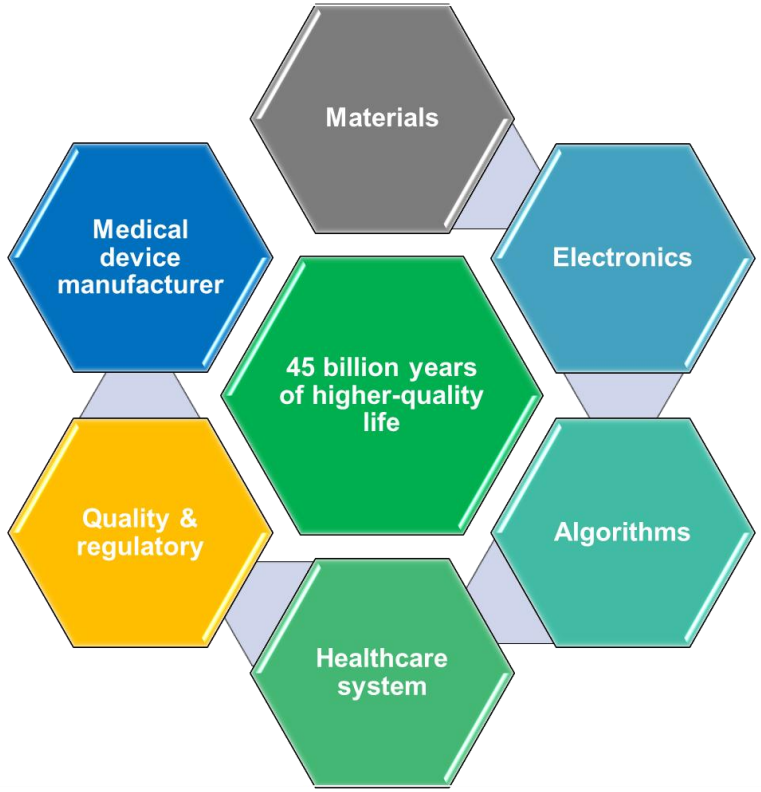


In vivo imaging of carotid artery



Next-generation wearable patches for remote monitoring

- **Healthcare** transformation requires **data** about health
- **Medical** grade **wearables** allow for **real-time remote monitoring**
- **Flexible electronics** and **hybrid integration** creates unique **functions** & enables next generation **technology platforms**
- Success requires **team-work** of **industry** with complementary expertise, **research** centers & **healthcare** professionals



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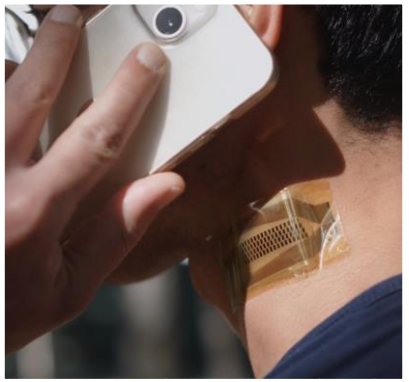

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