



**Sensors**  
Converge

# Sensor Innovations for the Next Generation of Wearables

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# Talk Agenda

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## 1. Twenty years of wearables in 5 minutes

## 2. Sensor Innovations for the:

- Healthcare Market
- Consumer Market
- Deep-Tech

## 3. Closing Remarks/ Q&A



*Dr. Tess Skyrme is a Technology Analyst supporting the company's research and consulting within sensor technology and electronics. Prior to IDTechEx, she was a PhD researcher in the Quantum Sensors group at Cambridge University from which she also obtained an MRes in Sensor Technology.*

# The value proposition of wearables

## The Value Proposition of Wearable Technology

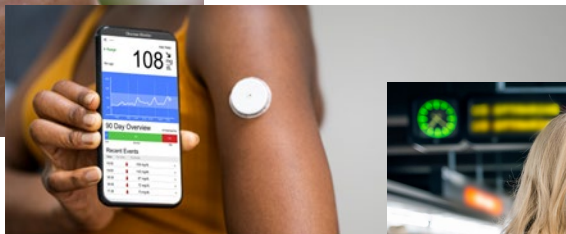
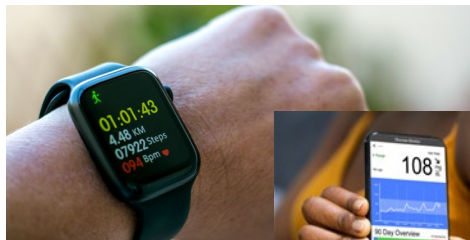
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### EFFICIENT

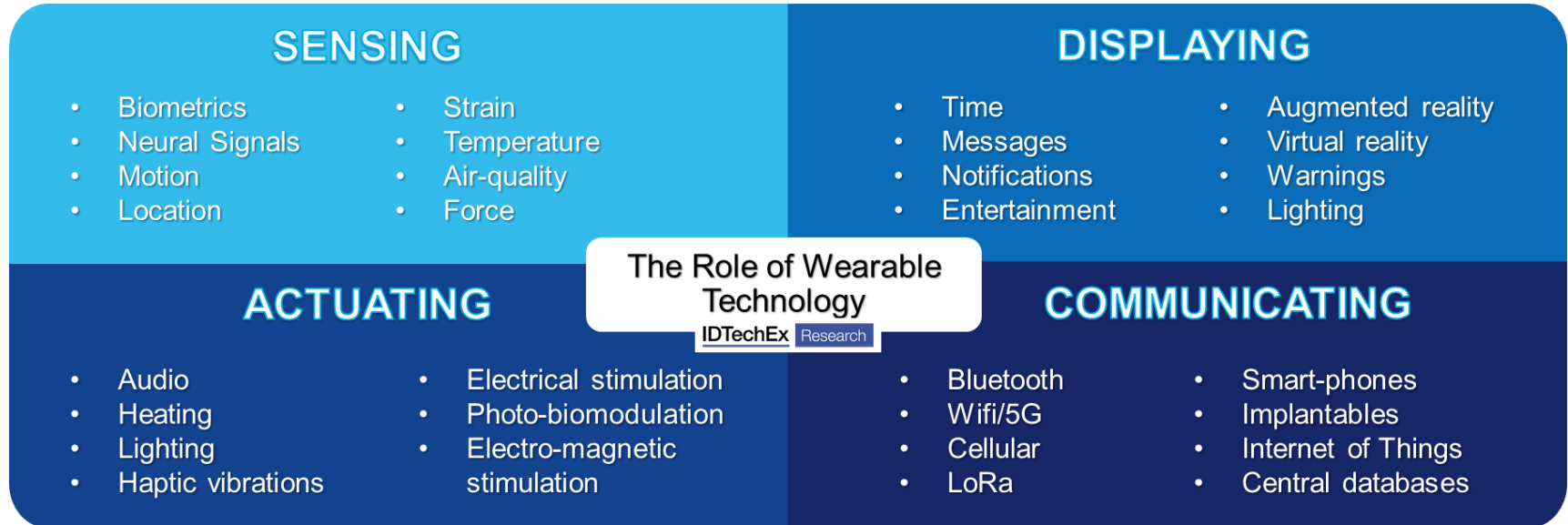
Access to technology is easier

### CONTINUOUS

Access to technology is uninterrupted

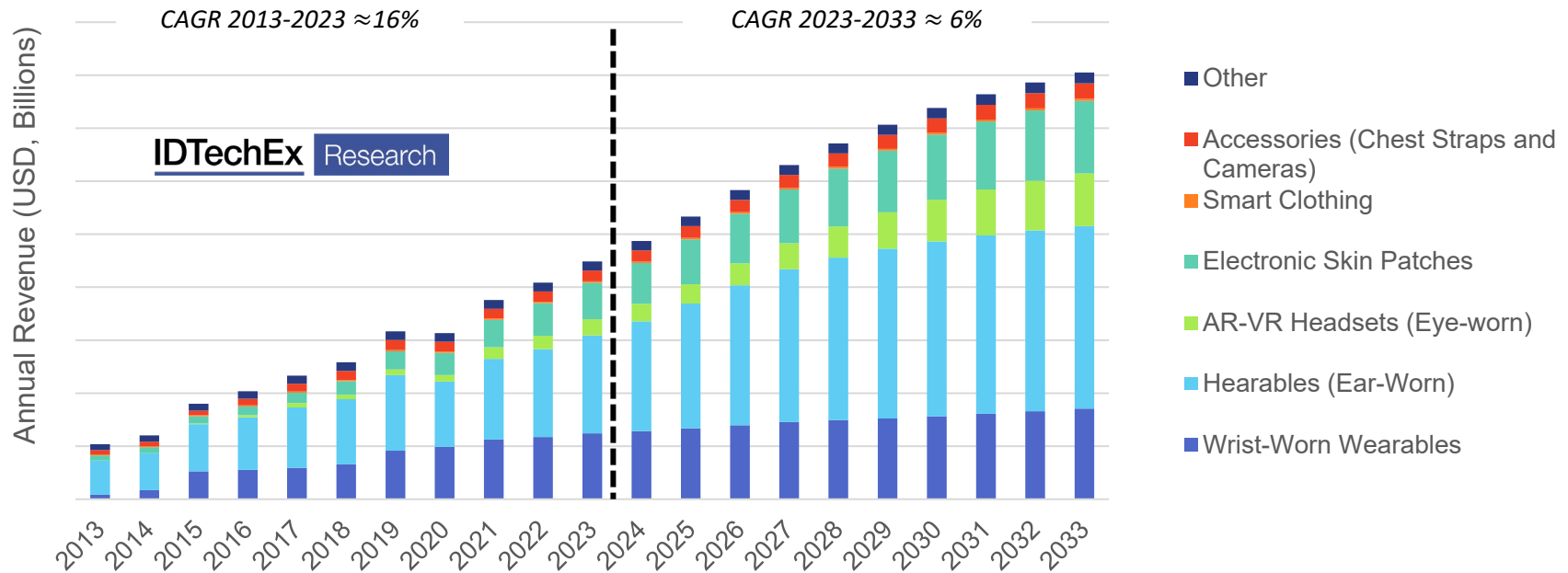


# The value proposition of wearables



# Wearable technology – historic and future trends

Wearable Technology Market 2013-2033, Historic Data and Market Forecasts



# The outlook for the wearables market at a glance

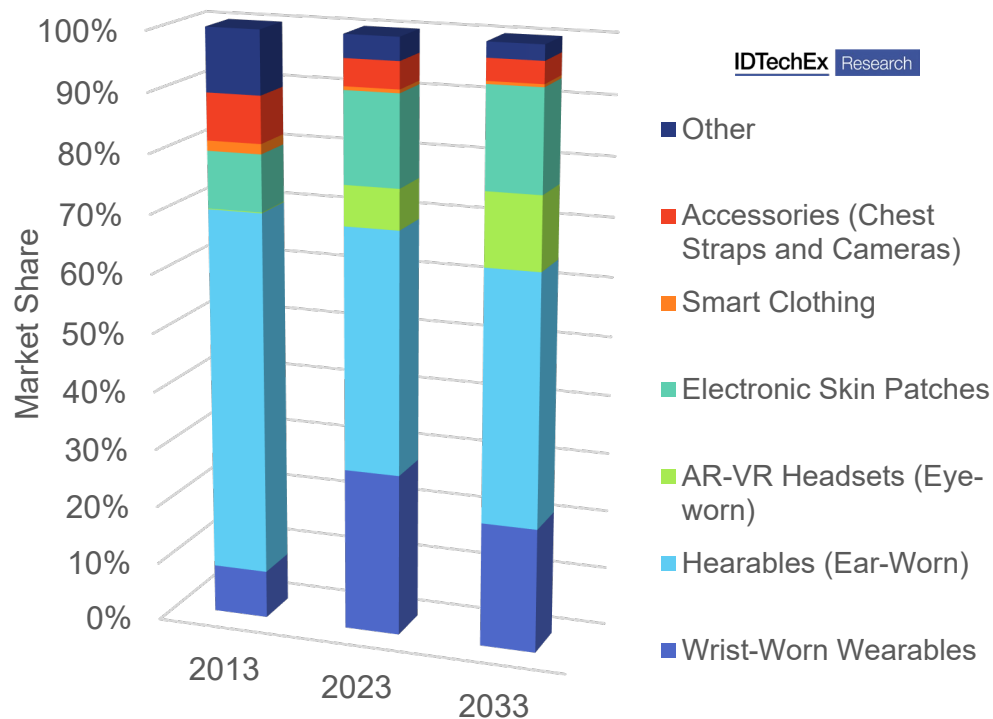
**Wrist-worn device market-share to shrink with maturity**

**Electronic Skin Patch market share stabilized by CGM adoption**

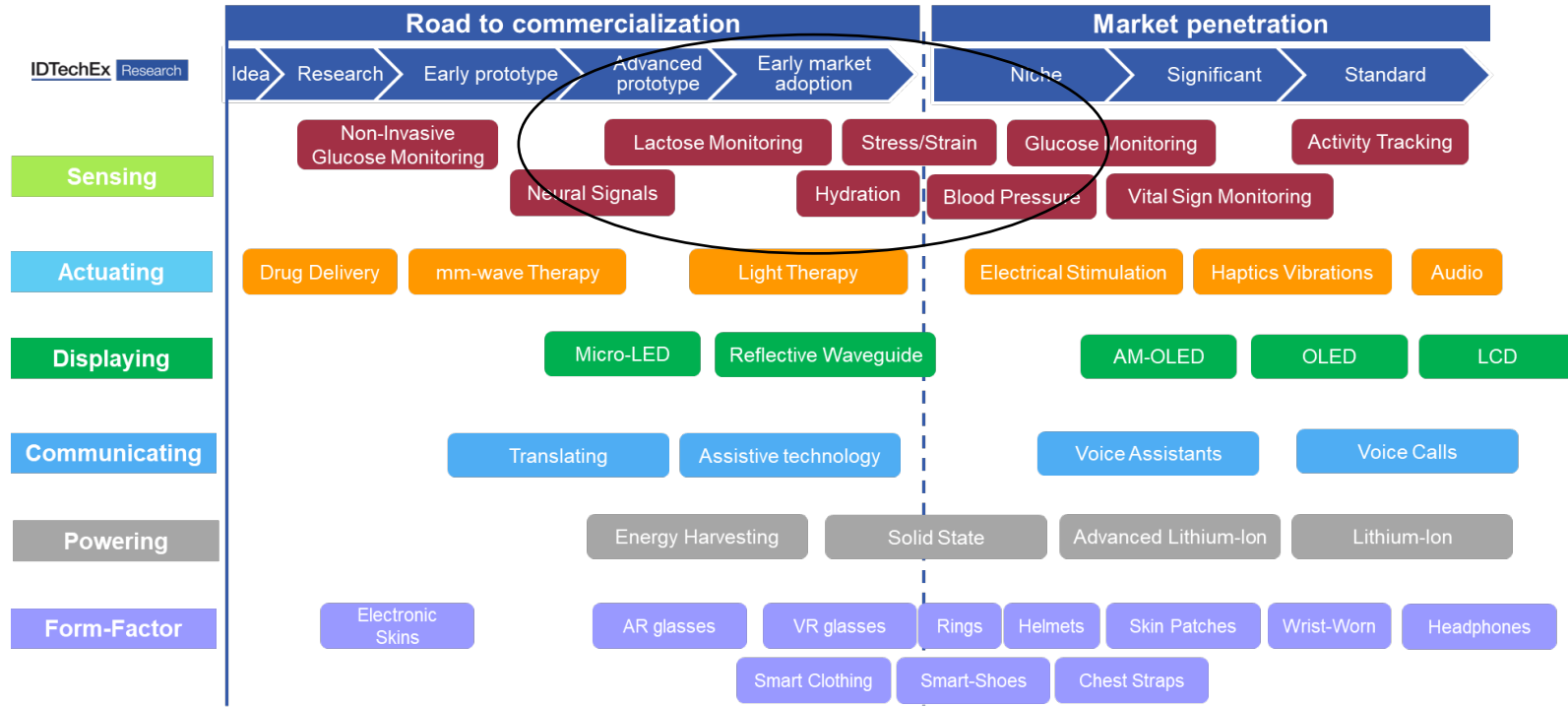
**Hearable market to remain the largest**

**AR-VR technology has emerged from obscurity**

**Smart Clothing market share in decline**



# Which sensor technologies are emerging?



# Where is the growth potential?

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**Healthcare Market: Chronic Disease Management**



**Consumer Market: Immersive Experiences**



**Deep-Tech: Quantum Technology**



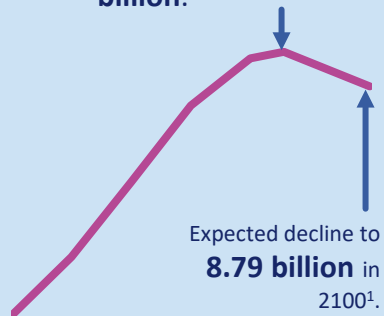


# **Healthcare Market: Chronic Disease Management**

# Megatrends driving healthcare reforms

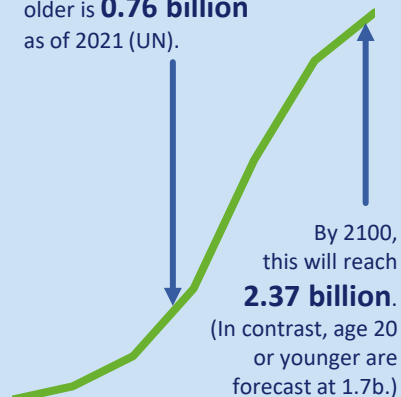
## Population growth

The current world population is 7.75 billion. Expected to peak in 2064 at **9.73 billion**.



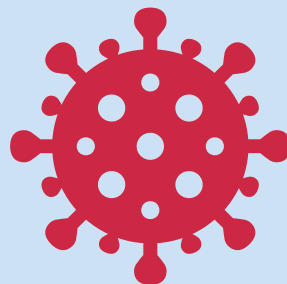
## Ageing population

Population aged 65 or older is **0.76 billion** as of 2021 (UN).



## Infectious disease

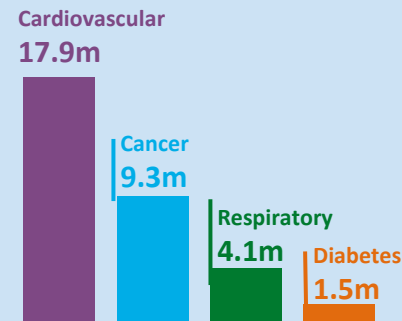
The rise of drug-resistant pathogens in combination with the impact of global pandemics as demonstrated by **COVID-19**. Population density is an exacerbating factor.



## Chronic diseases

Chronic diseases account for **41 million deaths** each year, equivalent to 71% of all deaths globally.

Increasing sedentary lifestyles with population and economic growth are driving this.



Data from: Vollset et al. 2020. The Lancet, 396(10258), pp.1285-1306, United Nations. Image created by IDTechEx.

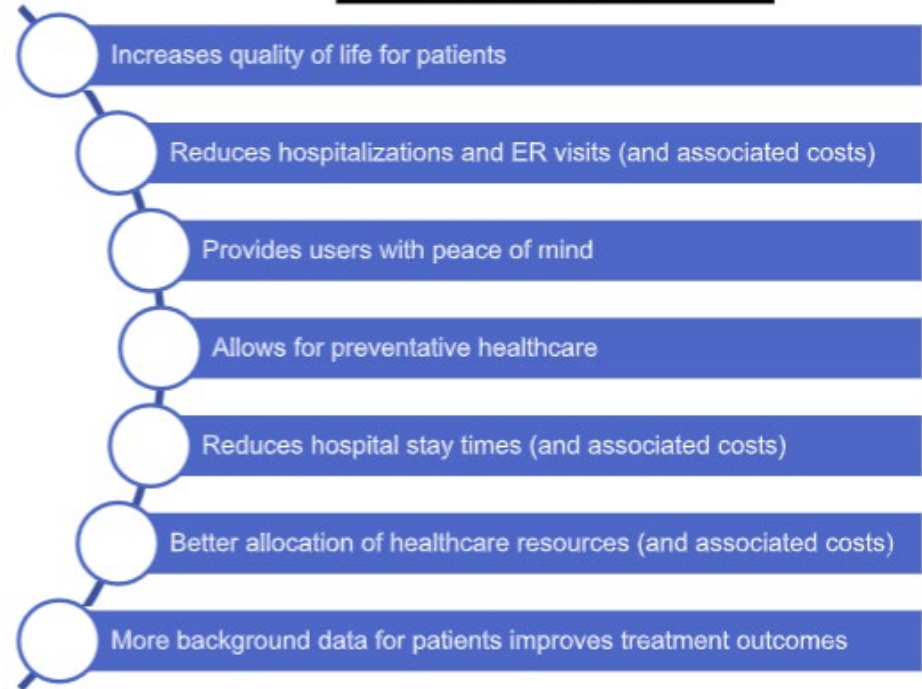
# Wearable devices are playing a growing role in remote patient monitoring programmes

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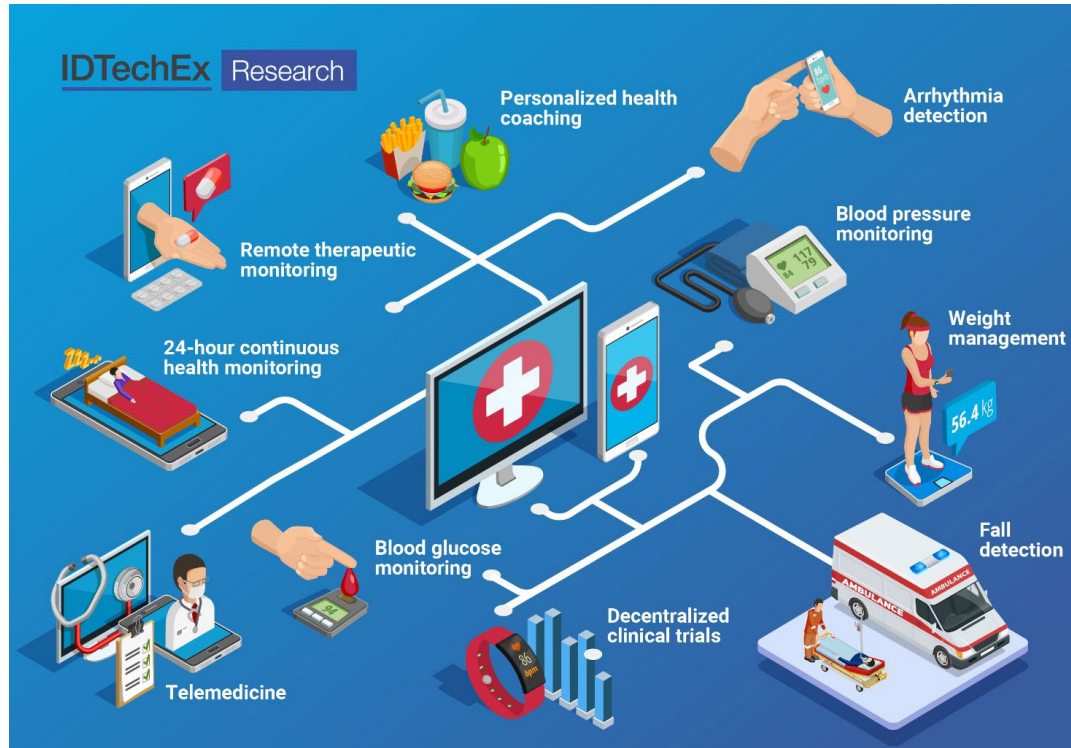
**Remote patient monitoring programs focus on key chronic diseases accounting for 90% of patients:**

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## The Benefits of RPM



# Future RPM programmes are expected to be more dependent on new wearable technology



# Future RPM programmes are expected to be more dependent on new wearable technology



By  
**OMRON**



**Blood Pressure Monitor**



**Body Weight Scale**



**Data Hub**



## The power of integrated chronic condition management

### 5mmHg

average additional decrease in systolic blood pressure among people in multiple programs beyond achievements in a standalone program\*

### \$50

additional per-participant, per-month savings beyond standalone diabetes management program savings\*

### 11%

higher engagement for people enrolled in multiple programs\*

### 0.6% A1c

average additional decrease among people in multiple programs beyond achievements in a standalone program\*



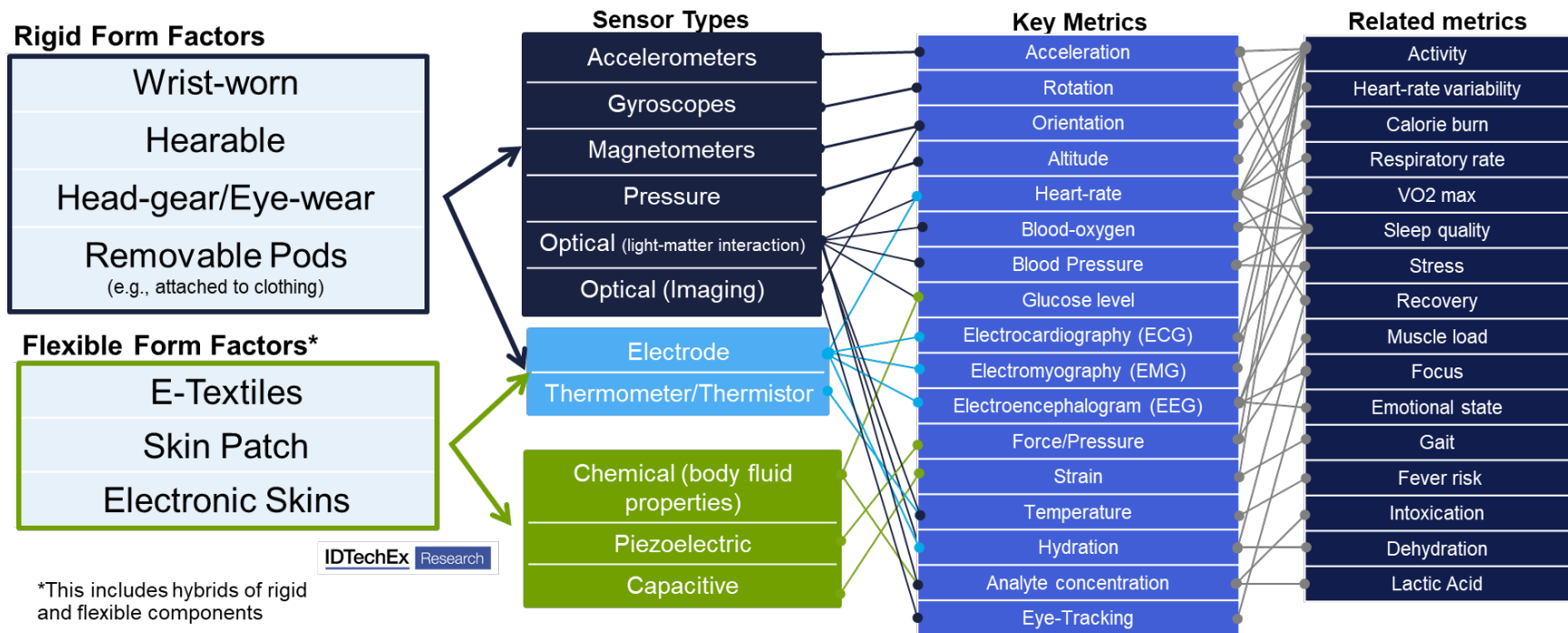
# Future RPM programmes are expected to be more dependent on new wearable technology

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*There is a need for **mass screening and early detection** in developed nations where hypertension may affect up to one in two adults.; hundreds of heart attacks and strokes can be prevented via early detection and management –*

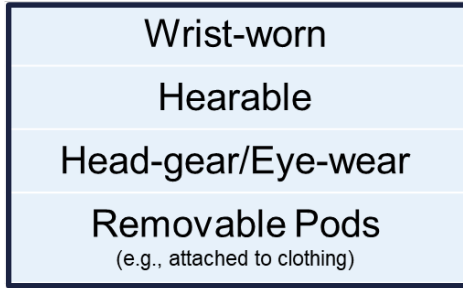
*Dr.Nadia Tsao, IDTechEx*

# Same sensors, more biometrics

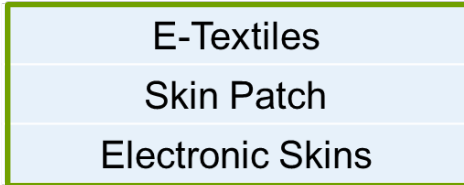


# Same sensors, more biometrics

## Rigid Form Factors



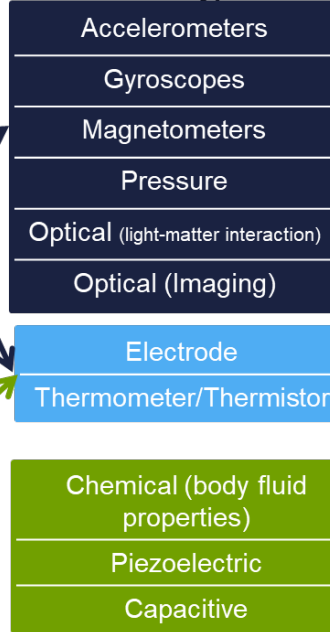
## Flexible Form Factors\*



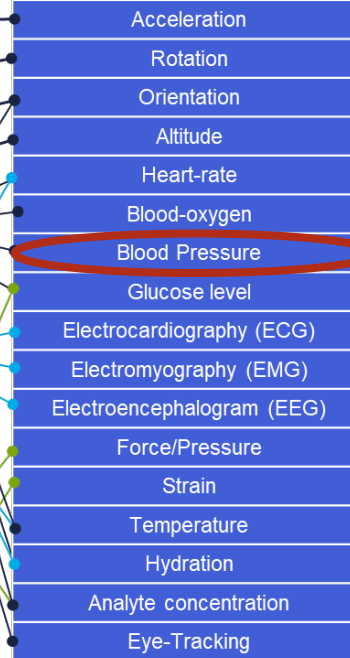
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\*This includes hybrids of rigid and flexible components

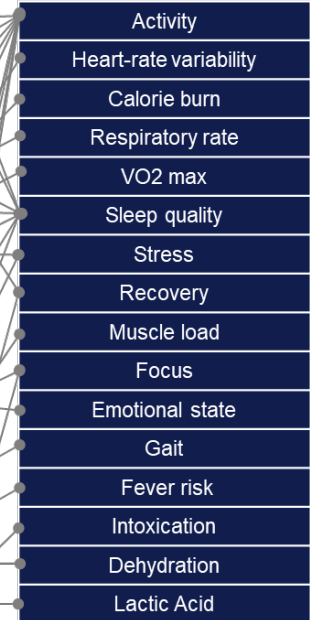
## Sensor Types



## Key Metrics



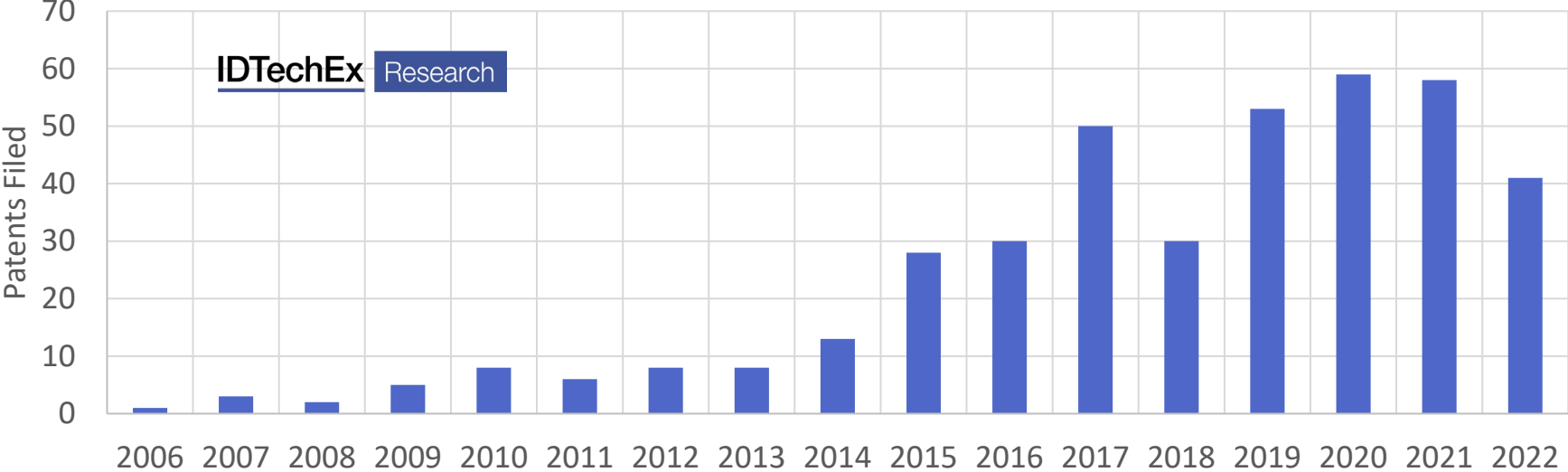
## Related metrics





# A growing number of OEMs recognize the value in wearable blood pressure sensing

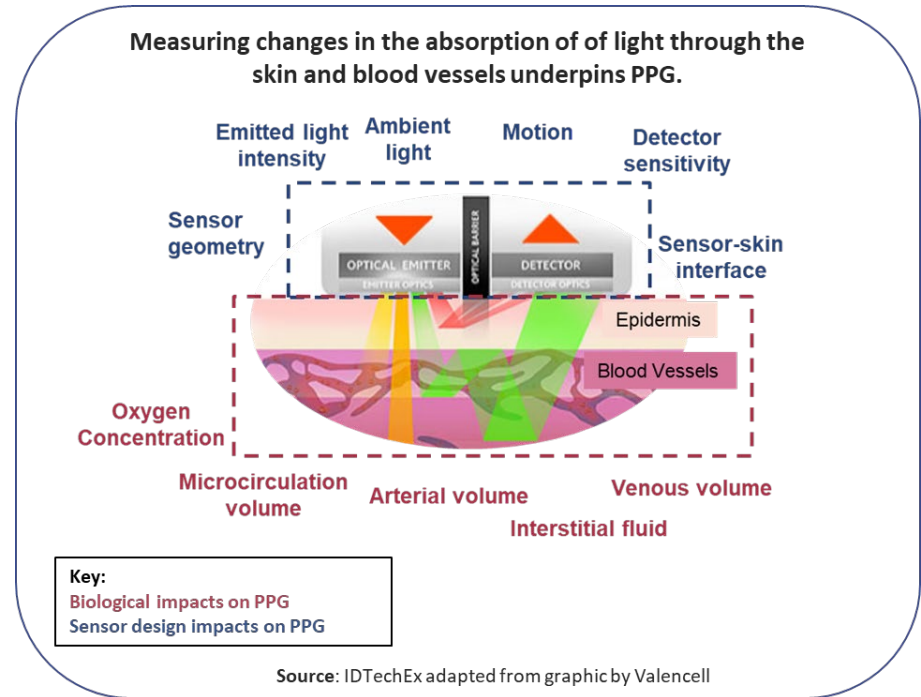
Patents filed concerning 'Wearable blood pressure'



# Calibration and noise mitigation solutions are key in unlocking the potential of the wearable blood pressure market



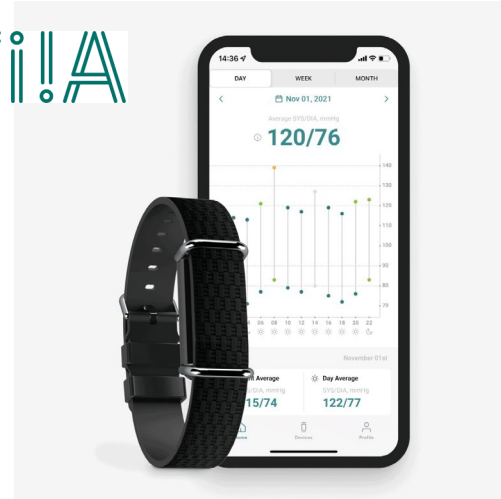
*“The crux of the issue in data collection is a trade-off between the ease of data collection versus noise in the data” – Valencell, 2020*



# Calibration and noise mitigation solutions are key in unlocking the potential of the wearable blood pressure market



AKTi!A

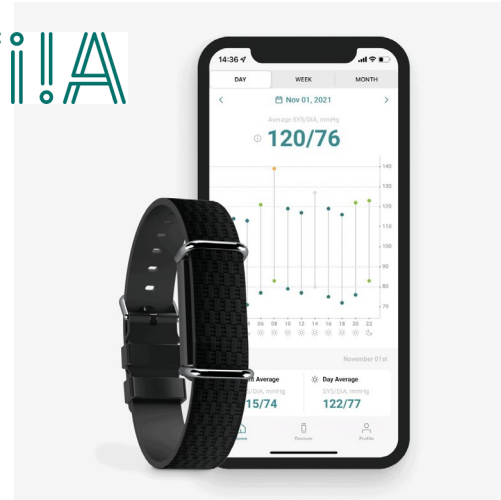


*Aktiia Bracelet G1 is a non-invasive blood pressure (BP) monitor intended to measure optical Photoplethysmography (PPG) **signals on the user's wrist** and to calculate blood pressure values using a Pulse Wave Analysis (PWA) technique, **following a calibration process using an oscillometric blood pressure monitor***

# Calibration and noise mitigation solutions are key in unlocking the potential of the wearable blood pressure market



AKTi!A



*The Biobeat Platform tracks changes in blood pressure based on Pulse Wave Transit Time (PWTT) which is obtained utilizing pulse measurements from the integrated SpO2 sensor, **following a calibration process using an FDA-cleared oscillometric blood pressure monitor.***

# Outlook for wearable blood pressure technology in the healthcare market?

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## Practical proxys

- Encouraging increased blood pressure monitoring with calibrated wearables will still play a key role hyper-tension management with RPM.

## The promise of ML

- Machine learning, and the rapid advancements in AI could overcome the challenges in relating cuff-less, cal-free wearable data proxys to a 'gold-standard' BP measurement

## Regulatory influences

- Essential, slow, and not a guarantee of medical adoption.

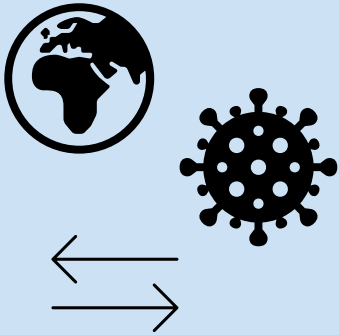


# **Consumer Market: Immersive Experiences**

# Mega-trends driving demand for 'immersive experiences'

## Escapism and Play

Escapism during play may be more valuable with the backdrop of global pressures



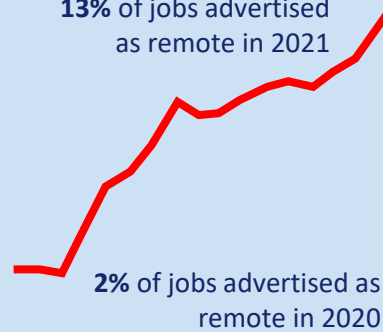
## Efficiency and Convenience



User experience improvements from existing consumer hardware is plateauing

## Remote Working

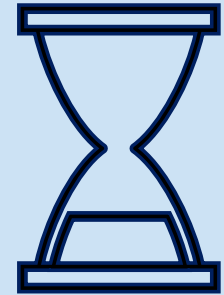
13% of jobs advertised as remote in 2021



2% of jobs advertised as remote in 2020

The number of jobs advertised as remote rose from 2%-13% between 2020 and 2021

## Customer Engagement



More immersive experiences can increase customer engagement time, increase memorability and ease interfacing with online retailers

Data from: LinkedIn.

# Established applications in VR and AR

**Gaming**



**Education**



**Visualisation**



**Retail**



**Design**



**Training**



**Productivity**



**Industrial**



*Image sources: shutterstock*



# Controllers and sensing connect AR and VR devices to the environment and the user

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Growing immersion



Head tracking: what direction is the user looking?

Tracking hand location/ direction: where is the user pointing?

Positional tracking: where is the user in the environment?

Full hand tracking: how are the user's hands interacting with the virtual environment?

*Note that a key additional use of eye tracking is enabling foveated rendering.*

Eye tracking: where exactly is the user looking?

Face tracking: what is the user's facial expression?

Full body tracking: how exactly is the user interacting with the environment?

# Consumer trends: smart-straps could take control in AR/VR

## Motion Sensing



Port 6 demoing their detection of the 'pinch' gesture measured with standard smart-watch sensors (IMUs and optical). IDTechEx photo.

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## 'Surface Nerve Conductance'

  
WEARABLE  
DEVICES



Mudra band brain computer interfacing using a combination of bipotential sensing, including 'surface nerve conductance' IDTechEx photo.

# Electrode innovations for improved neural signal measurements

## 'Dryode' Technology

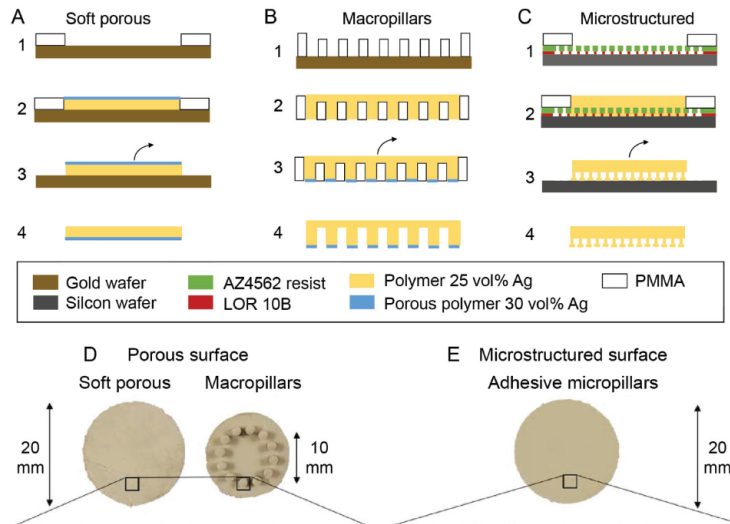
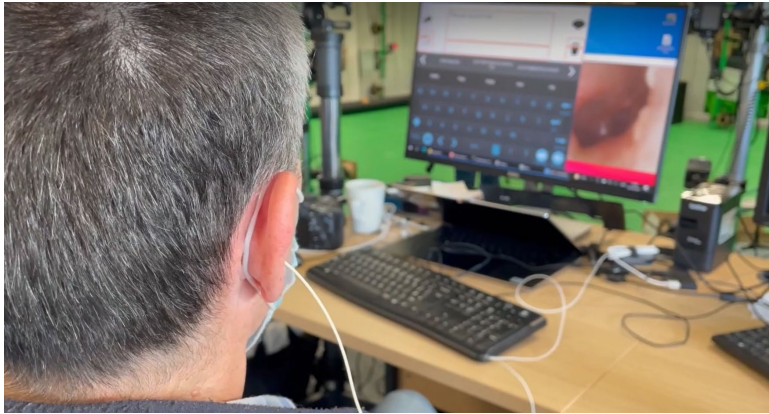


Image Source: IDUN Guardian

Image Source: Skin Conformal Polymer Electrodes for Clinical ECG and EEG Recordings (2018) *Flurin Stauffer et al.*

# Wearables sensors as assistive technology



*EarSwitch showing their in-ear device controlling a gaze-controlled keyboard. Example of a new operating principle, using established hardware*

*Image source: EarSwitch; Strap Tech*



*Strap-tech uses lidar within a chest-strap to improve navigational experiences for the visually impaired.*

# Outlook for sensor technology in the consumer market?

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## Wearable sensors could be key for human machine interfacing


- As AR/VR head-set adoption rises, so will the need for gesture control and hand-tracking. Different use-cases will require some combination of in-built cameras, hand-held controllers or wearables.

## The value sensors enabling 'immersive experiences' will rise

- Those sensors able to maintain and improve immersion will rise in value. For example, wearable control systems could offer a less clunky user experience than controllers – as well as offering that crucial value proposition of efficient and continuous access.

## Dry electrode technology could bring brain-computer interfacing to the mass-market

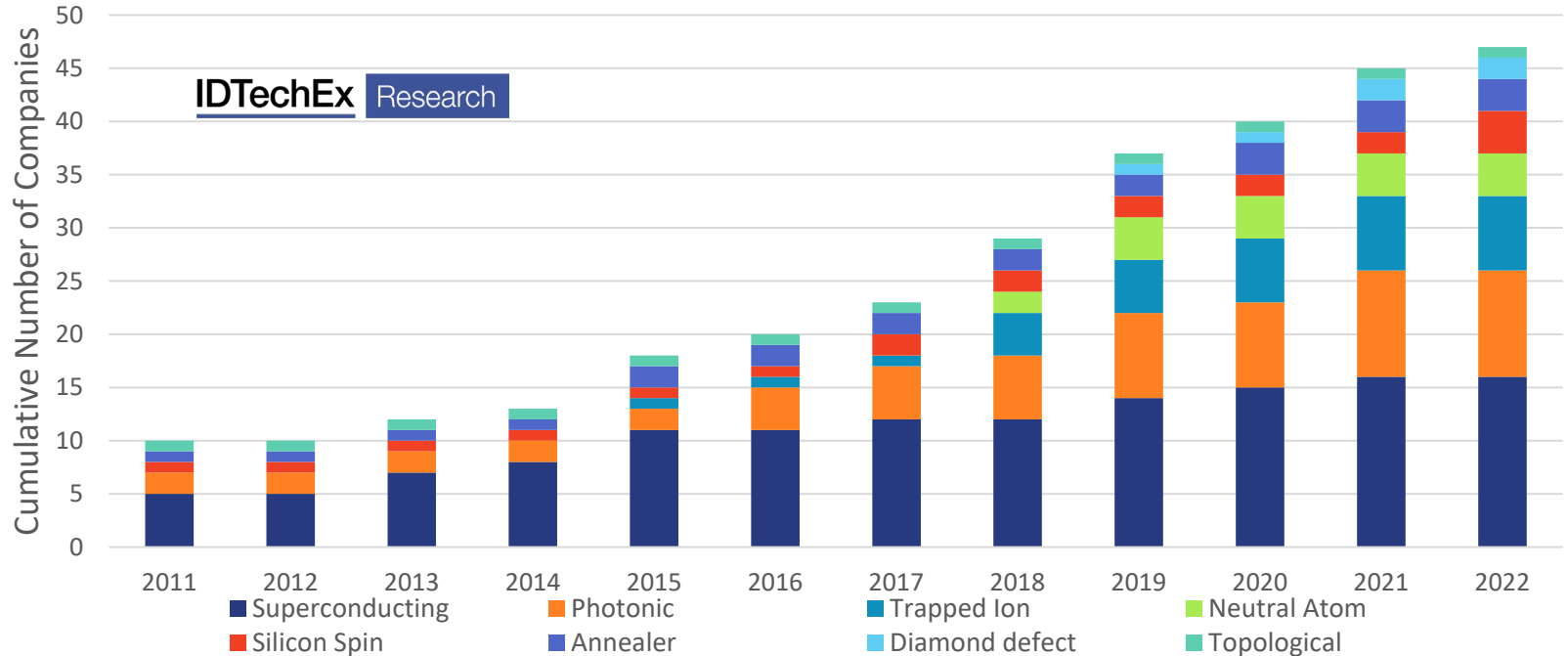
- Interfacing with neural signals via dry electrodes is better suited to the consumer market than wet-electrodes or implants. Improving the signal to noise achievable is a key technological challenge many players are now tackling.



# Deep-Tech (Quantum)

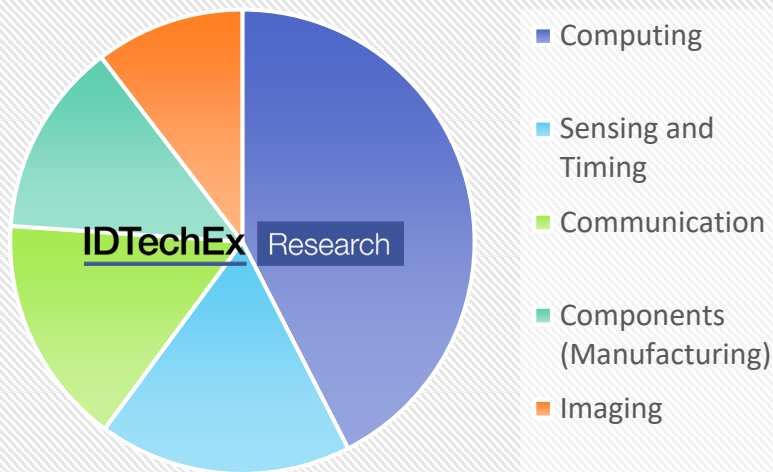
# The quantum technology industry is growing

Cumulative total of companies actively developing quantum computers segmented by technology

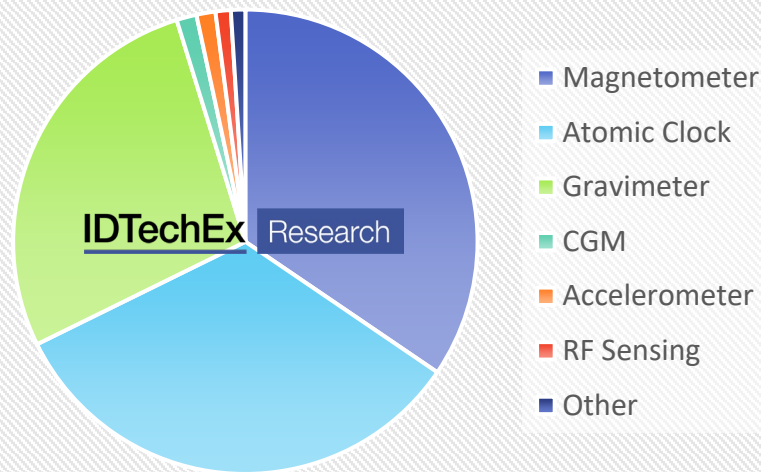


# Government investment in sensing and imaging rivals computing

## Breakdown of UKRI funding in quantum by category

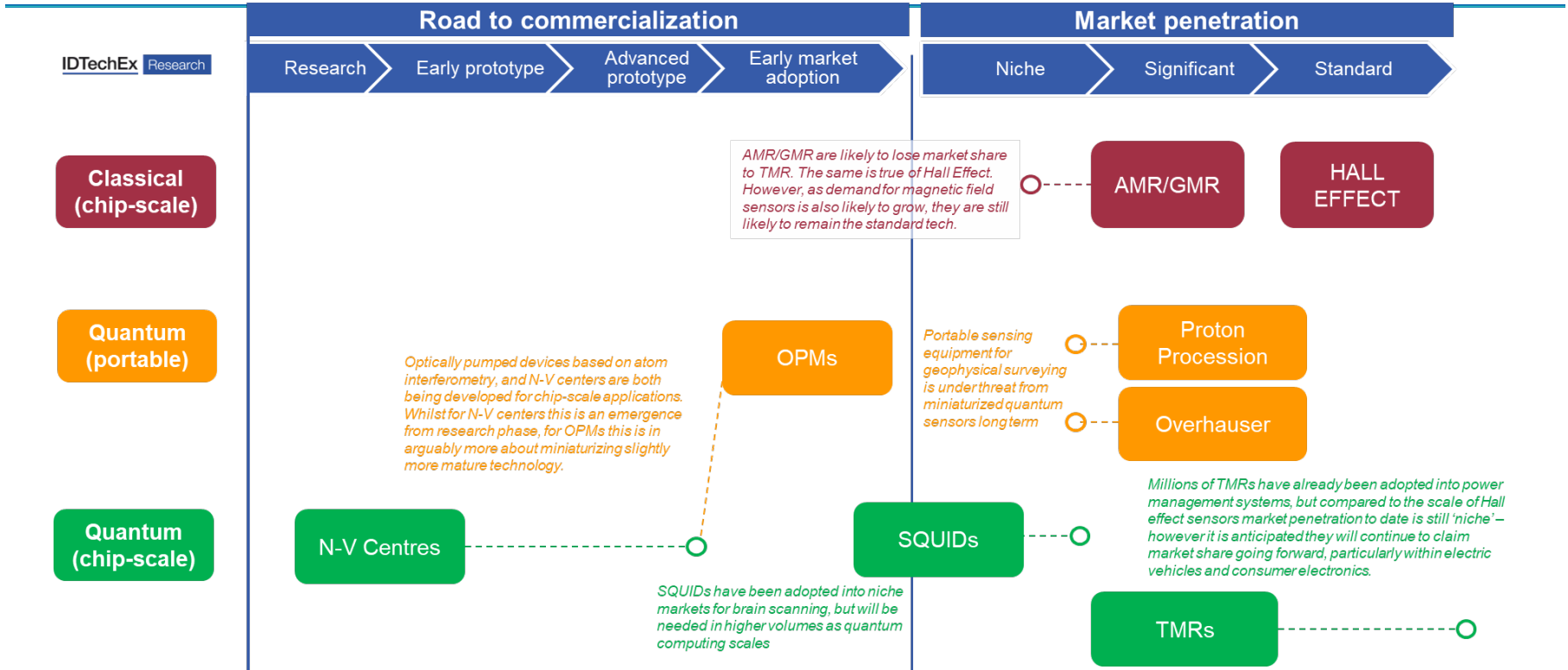


## Breakdown of UKRI funding in quantum sensors





# The trend towards chip-scale quantum sensors



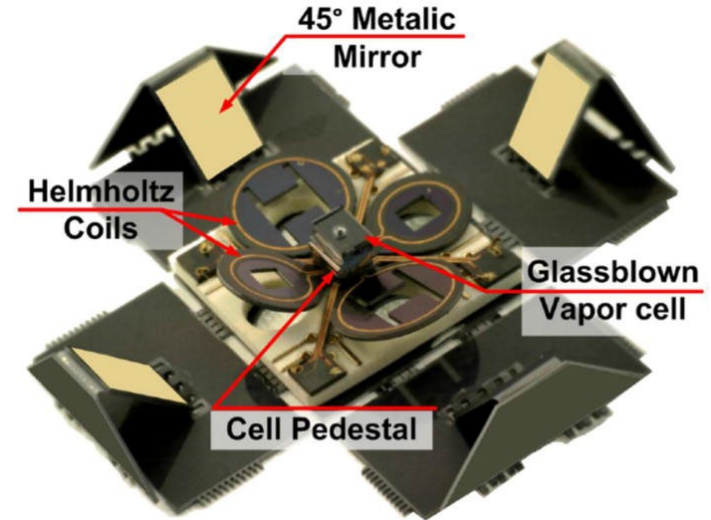
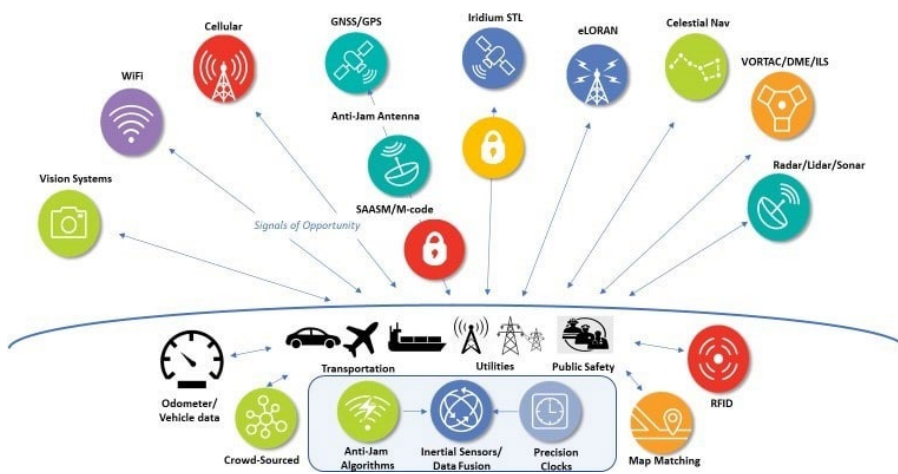
# Long-term opportunities for wearable quantum sensors



Image Source: Cerca Magnetics

*Miniaturized quantum magnetic field sensors for biomagnetic imaging*

# Long-term opportunities for wearable quantum sensors



*MEMS manufacturing for alkali vapor-based quantum sensors could offer more sensitivity, and less drift, valued for navigation in GPS denied environments.*

# Outlook for sensor technology in the consumer market?

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Quantum technology is rapidly commercializing and miniaturizing

Quantum sensing is likely a higher volume hardware opportunity than computing

Wearable quantum sensors could impact both the healthcare and consumer market

# Closing remarks



## Healthcare Market: Chronic Disease Management

- Technical challenges overcoming calibration and noise
- Opportunity for ML

## Consumer Market: Immersive Experiences

- Sensors can add value in immersive control systems for AR/VR
- Immersion can add value through escapism or inclusivity

## Deep-Tech: Quantum Technology

- Quantum sensor technology is being miniaturized to the chip-scale
- There are opportunities for wearable quantum sensors in the consumer and healthcare markets long-term

# Q & A

**Wearable Sensors 2023-2033**

Covering technologies such as motion sensors, optical sensors, chemical sensors, pressure sensors, strain sensors and electronics for applications including continuous health monitoring, fitness tracking and augmented/virtual reality.



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www.IDTechEx.com

[IDTechEx.com/wearables](https://www.IDTechEx.com/wearables)

**Wearable Technology Forecasts 2023-2033**

A comprehensive review of market opportunities across all wearable electronic devices, from smartwatches to skin patches, AR, VR & MR to hearables, smart clothing to smart eyewear, and more.



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[IDTechEx.com/quantumcomputing](https://www.IDTechEx.com/quantumcomputing)

**Quantum Computing 2023-2043**

Market analysis of hardware enabling quantum computing. Includes ten-year quantum computing market forecasts, with superconducting, photonic, silicon-spin, neutral-atom, trapped-ion, diamond defect, topological, and annealing categories.



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