Wearable Sensors 2018-2028: Technologies, Markets & Players

Including progress from 21 sensor technologies across 42 wearable product types.

By IDTechEx research, James Hayward

IDTechEx's report on wearable sensors offers a thorough characterisation and outlook for each type of sensor used in wearable products, both today and in the future. The report has been compiled over three years of research, leveraging IDTechEx's expertise in areas such as wearable technology, sensors, IoT, energy storage & harvesting and materials. The report covers 21 different types of sensor, across 9 groups, characterising the technology, applications and industry landscape for this. The report describes the activity of over 115 companies, including primary content (e.g. interviews, photographs, visits, etc.) with more than 80 key players in the industry. Finally, the report provides detailed quantitative market forecasts for each type of wearable sensor, leveraging unique primary data from interviews, collated financial statistics and industry trends alongside IDTechEx's parallel forecasting for 42 different wearable technology product types.

Table of Content

1. EXECUTIVE SUMMARY
1.1. Introduction to wearable sensors
1.2. Sensors enable key product value propositions
1.3. 9 major wearable sensor categories (by function)
1.4. 21 types of wearable sensor used today
1.5. Wearable sensors in three waves
1.5.1. The first wave: "The originals"
1.5.2. The second wave: "Made-wearable" sensors
1.5.3. The third wave: "Made-for-wearable" sensors
1.6. Market forecast 2018 - 2028: Wearable sensors (Volume)
1.7. Companies mentioned in this report
2. INTRODUCTION
2.1. Wearables 2014-2016: potential, growth and hype
2.2. Illustrating the fading hype for wearables today
2.3. Metrics for hype: Google trends
2.3.1. Metrics for hype: Funding and M&A
2.3.2. Metrics for hype: Patent trends
2.4. Wearables 2016-2018: Commoditisation, shakeout, maturity
2.5. Wearables as a sum of it's parts
2.6. Wearables 2018-onwards: core value shines through
2.7. Sensors enable key product value propositions
2.8. Definitions
2.9. Common wearable sensors deployed today
2.10. Sensors on the body: what do we want to measure?
2.11. Appropriate data for the desired outcome
2.11.1. Appropriate data: Example
2.11.2. Example: effort and reward in heart monitoring
2.11.3. Example: Useful data at different levels of inference
2.12. Sensor fusion is essential and expected
2.12.1. Sensor fusion is essential and expected

2.13. Different product types from the same sensors
2.14. Wider industry context for each sensor type
2.15. Wearable sensors in three waves
3. SENSOR TYPES FOR WEARABLE PRODUCTS
3.1. Contents
4. INERTIAL MEASUREMENT UNITS (IMUS)
4.1. IMUs - Introduction
4.2. MEMS - Background
4.3. MEMS - Manufacturing techniques
4.4. MEMS - Becoming a commodity
4.5. MEMS Accelerometers
4.6. MEMS Gyroscopes
4.7. Overcoming power consumption challenges with gyroscopes
4.8. Digital compasses
4.9. Magnetometer types
4.10. Magnetometer suppliers and industry dynamic
4.10.1. Magnetometer suppliers by type
4.11. MEMS Barometers
4.12. Pressure sensors in wearable devices
4.12.1. Example: Interview with Bosch Sensortec
4.13. Limitations and common errors with MEMS sensors
4.14. MEMS manufacturers: characteristics and examples
4.15. Case study: ST Microelectronics
4.15.1. Case study: Invensense
4.15.2. Apple: iPhone sensor choice case study
4.16. Conclusion: IMUs are here to stay, with some limitations
5. OPTICAL SENSORS
5.1. Optical sensors - introduction
6. OPTICAL SENSORS - HRM
6.1. Photoplethysmography (PPG)
6.2. Transmission-mode PPG
6.3. Reflectance-mode PPG
6.4. Reflectance-mode PPG for fitness wearables
6.5. Key players for OHRM in fitness wearables
6.6. The ear as an optimal sensing location: "Hearables"
6.7. Example: Valencell
6.7.1. Example: "Circumission" PPG from Cosinuss
6.7.2. Examples: APM Korea
6.7.3. Example: ActiveHearts™ by WBD101 in the Actywell One
7. OPTICAL SENSORS - VISION & DEPTH
7.1. 3D imaging and motion capture
7.2. Application example: Motion capture in animation
7.3. Stereoscopic vision
7.4. Time of flight
7.5. Structured light
7.6. Comparison of 3D imaging technologies
7.7. Example: Leap Motion
7.7.1. Example: Microsoft; from Kinect to Hololens
7.7.2. Example: Intel's RealSense™
7.7.3. Example: Occipital
7.8. Commercial 3D camera examples
8. WEARABLE CAMERAS

8.1. Cameras in wearable devices
8.2. Established players exploiting profitable
8.3. Applications in safety and security
8.4. Other applications: Enhancing sports media
8.5. Cameras in smartwatches?
8.6. Social applications: drivers and challenges
8.7. Example: Spectacles by Snap Inc.
8.8. Other applications: Automatic digital diary
9. OPTICAL SENSORS - OTHER EXAMPLES
9.1. Optical chemical sensors
9.2. Implantable optical glucose sensors
9.3. Optical method for non-invasive glucose sensing
9.4. Start-up example: eLutions
9.5. Related platform: UV exposure indicators
9.6. Speech recognition using lasers - VocalZoom
10. ELECTRODES
10.1. Electrodes: Introduction
11. ELECTRODES - BIOPOTENTIAL
11.1. Measuring biopotential
11.2. ECG
11.3. EEG
11.4. EMG
11.5. Circuit construction for measuring biopotential
11.6. Circuit construction for measuring biopotential (cont.)
11.7. Properties of wearable electrodes
11.8. Dry electrodes: Challenges and solutions
11.9. Established wearable product types: Chest strap HRM
11.10. HRM in apparel and skin patches
11.11. Consumer EMG products and prototypes
11.12. Consumer EEG products and prototypes
11.13. Approaches for improving wearable electrode performance
11.14. Performance through design: Thalmic Labs
11.15. Performance through design: Samsung
11.16. Electrode ink innovation: Gunma University, Japan
11.17. Electronic tattoos: Seoul National University
11.18. Electronic tattoos: Seoul National University
11.19. Examples: IMEC and the Holst Centre
11.19.1. Examples: Conscious Labs
11.19.2. Example: Freer Logic LLC
12. ELECTRODES - BIOIMPEDANCE
12.1. Measuring bioimpedance
12.2. Galvanic skin response
12.3. Bioelectrical impedance analysis (BIA)
12.4. Bioelectrical impedance analysis (BIA)
12.5. Example: Inbody
12.6. Case study: marketing the potential of bioimpedance
12.7. Case study: marketing the potential of bioimpedance
13. ELECTRODES - OTHER EXAMPLES
13.1. Gastric electrolyte
13.2. Example: Proteus Digital Health
13.2.1. Example: Proteus Digital Health
14. FORCE / PRESSURE / STRETCH SENSORS

14.1. Different modes for sensing motion
14.2. Resistive force sensors
14.3. Players and industry dynamic
14.4. Quantum tunnelling composite: QTC®
14.5. QTC® vs. FSR™ vs. piezoresistor?
14.6. Capacitive pressure sensors
14.7. How they work
14.8. Dielectric elastomer electroactive polymers (DE EAPs)
14.9. Commercialisation of DE EAPs
14.10. Key players in DE EAP commercialisation today
14.10.1. Players with EAPs: Parker Hannifin
14.10.2. Players with EAPs: Stretchsense
14.10.3. Players with EAPs: Bando Chemical
14.11. Textile-based pressure sensing
14.12. Knitting as a route to textile sensors
14.12.1. Example: Knitted conductors by Gunze, Japan
14.13. Early examples of wearable textile FSRs: socks
14.13.1. Examples: BeBop Sensors
14.13.2. Examples: Sensoria
14.13.3. Examples: Sensing Tex
14.13.4. Examples: Vista Medical
14.13.5. Examples: Yamaha and Kureha
14.14. Other examples: Polymatech
14.14.1. Other examples: InnovationLab
14.14.2. Other examples: Tacterion
14.15. Research with emerging advanced materials
14.16. Academic examples: Stanford University
14.16.1. Academic examples: UNIST, Korea
14.16.2. Academic examples: Bio-integrated electronics for cardiac therapy
14.16.3. Academic examples: Instrumented surgical catheters using electronics on balloons
14.17. Other novel types of pressure sensor
15. TEMPERATURE SENSORS
15.1. Two main roles for temperature sensors in wearables
15.2. Types of temperature sensor
15.3. Approaches and standards for medical sensors
15.3.1. Examples: Blue Spark
15.4. Core body temperature
15.5. Ear-based core body temperature measurements
15.6. Measuring core body temperature: new approaches
15.7. Measuring core body temperature: new approaches
15.8. Temperature sensor deployment and suppliers
16. MICROPHONES
16.1. Using sound to investigate the body
16.2. Types of microphones
16.2.1. Example: MEMS microphones
16.3. The need for waterproof, breathable encapsulation
16.3.1. Example: Electret microphones
16.4. Bioacoustics
16.5. Bioacoustics using IMUs
16.6. Microphones and AI for respiratory diagnostics
16.7. Microphones in social and clinical trials
17. CHEMICAL SENSORS

17.1. Introduction
17.2. Selectivity and signal transduction in chemical sensors
17.3. Selectivity and signal transduction in chemical sensors
17.4. Analyte selection and availability
17.5. Analyte selection: Reliability vs practicality vs relevance
17.6. Time dependence
17.6.1. Example: Analytes in the sweat
17.7. Use of nanomaterials to enhance chemical sensors
17.7.1. Example: Graphene and carbon nanotubes
17.7.2. Example: Nanostructured copper
17.8. Optical chemical sensors
17.9. Diagnostics with chemical sensors
17.10. Monitoring blood cholesterol using biosensors
17.11. Towards wearable cholesterol monitoring
17.12. Increasingly portable diagnosis of bovine and human TB
17.13. Wearable diagnostic tests for cystic fibrosis
17.14. Other applications for wearable chemical sensors
17.14.1. Example: sweat alcohol detection
17.15. Case study: Wearable diabetes monitoring
17.15.1. Anatomy of a CGM sensor
17.15.2. Continuous vs Flash glucose monitoring
17.15.3. Abbott Libre
17.15.4. Abbott Libre glucose detection mechanism
17.15.5. Dexcom
17.15.6. Dexcom glucose monitoring mechanism
17.15.7. Medtronic
17.15.8. A new generation of glucose monitoring watches
17.15.9. Comparison of wearable/implanted glucose sensors
17.15.10. The potential for non-invasive testing
17.15.11. Google contact lens- an eye on glucose monitoring
17.15.12. Problems with a glucose contact lens
17.15.13. Non-invasive glucose monitoring- A first device to market
17.15.14. Single use vs ambulatory monitoring: future directions
17.15.15. The future for glucose test strips
17.15.16. Advanced glucose monitoring leads to an artificial pancreas
17.16. Measuring lactic acid
17.16.1. Lactic acid monitoring for athletes
17.16.2. Traditional lactic acid monitors
17.16.3. Microneedles to analyse lactic acid in interstitial fluid
17.17. Examples of players developing wearable chemical sensors
17.17.1. Example: Kenzen
18. 18. GAS SENSORS
18.1. Introduction: Wearable gas sensors
18.2. Concentrations of detectable atmospheric pollutants
18.3. Five common detection principles for gas sensors
18.4. Technology requirements for wearable gas sensors
18.5. Introduction to Metal Oxide (MOS) gas sensors
18.6. Introduction to electrochemical gas sensors
18.7. Transition to new manufacturing methods
18.8. Current research in gas sensors: Carbon Nanotubes
18.9. Current research in gas sensors: Zeolites
18.10. Current research in gas sensors: Graphene

18.11. Future opportunities with wearable gas sensors
19. GPS
19.1. Prominent wearable GPS devices
19.2. Challenges with GPS power consumption
20. APPLICATION AND COMPANY CASE STUDIES
20.1. Environmental gas sensors integration in wristwear
20.2. HiCling
20.3. Gameen Intel
20.4. Wearable Sensors As Part Of Modular Wrist Straps
20.5. TZOA
20.6. Plume labs
20.7. Drayson Technology
20.8. Environmental sensor integration in fashion accessories
21. MARKET FORECASTS
21.1. Forecasting: Introduction and definitions
21.2. 2015-2017: Historical data
21.3. Market forecast 2018 - 2028: Wearable sensors (Volume)
21.4. Table of data (all sensors, volume)
21.5. Market forecast 2018 - 2028: Wearable sensors (Revenue)
21.6. Table of data (all sensors, revenue)
21.7. Sensors in wearable sports and fitness tracking devices
21.8. Trends in the broader device ecosystem for personal tracking
21.9. Sensors in wearable sports & fitness devices: Volume
21.10. Table of data (sports & fitness, volume)
21.11. Sensors in wearable sports & fitness devices: Revenue
21.12. Table of data (sports & fitness, revenue)
21.13. Sensors in wearable medical devices
21.14. Sensors in wearable medical devices: Volumes
21.15. Table of data (medical devices, volume)
21.16. Sensors in wearable medical devices: Revenue
21.17. Table of data (medical devices, revenue)
21.18. Sensors in AR / VR / MR / XR devices
21.19. Sensors in AR / VR / MR / XR devices: Volumes
21.20. Table of data (AR, VR, MR, XR, volume)
21.21. Sensors in AR / VR / MR / XR devices: Revenue
21.22. Table of data (AR, VR, MR, XR, revenue)
21.23. Sensors in wearable industrial & military products
21.24. Sensors in military & industrial wearables: Volumes
21.25. Table of data (industrial & military, volume)
21.26. Sensors in military & industrial wearables: Revenue
21.27. Table of data (industrial & military, revenue)
21.28. Wearable gas sensors: Volume
21.29. Wearable gas sensors: Revenue
21.30. Table of data (gas sensors, volume & revenue)
21.31. Table of data (sensor types and pricing)