PNNL-24263

Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by Battelle Since 1965

Responder Technology Alert (March 2015)

April 2015

JF Upton
SL Stein

Prepared for the U.S. Department of Homeland Security
Science and Technology Directorate
under Contract HSHQPM-14-X-00058

U.S. DEPARTMENT OF ENERGY

PACIFIC NORTHWEST NATIONAL LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC05-76RL01830

Printed in the United States of America

Available to DOE and DOE contractors from the
Office of Scientific and Technical Information,
P.O. Box 62, Oak Ridge, TN 37831-0062;
ph: (865) 576-8401
fax: (865) 576-5728
email: reports@adonis.osti.gov

Available to the public from the National Technical Information Service
5301 Shawnee Rd., Alexandria, VA 22312
ph: (800) 553-NTIS (6847)
email: orders@ntis.gov <http://www.ntis.gov/about/form.aspx>
Online ordering: http://www.ntis.gov


This document was printed on recycled paper.
(8/2010)

PNNL-24263

Responder Technology Alert (March 2015)

JF Upton
SL Stein

April 2015

Prepared for the Department
of Homeland Security Science and
Technology Directorate under Contract
HSHQPM-14-X-00058.

Pacific Northwest National Laboratory
Richland, Washington 99352

Contents

1.0 Introduction

The Pacific Northwest National Laboratory (PNNL) is supporting the Department of Homeland Security (DHS) to advance technologies to enhance responder health and address complex and changing threat environments. The DHS Science and Technologies First Responders Group established the Responder Technology Alliance (RTA) to accelerate the development of solutions to first responder needs and requirements by identifying, analyzing, and recommending solutions that improve responder safety, enhance their ability to save lives, and minimize property loss. The end goal is for RTA to develop and implement strategies that will make effective solutions available to first responders.

As part of technology foraging for the RTA, this report summarizes technologies that are relevant in the area of "wearables," with the potential for use by first responders. The content was collected over the previous month(s) and reproduced from a general Internet search using the term wearables. Additional information is available at the websites provided. The content is organized by technology function including:

- Sensors – Devices that detect physiological, particle, and chemical activity
- Displays – Heads-up and body-worn visual displays
- Power – Wearable power systems including chargers, batteries, self-powering or harvesting technologies, and power supplies
- Integrated Communications – Voice and data communications systems utilizing Bluetooth, wireless, hands-free, ergonomically optimized systems, noise-filtering digital speakers or microphones, etc.
- Cameras – Body-worn photo and video cameras
- Breathing Apparatus – Wearable air supply and monitoring devices
- Exoskeletons – Whole or partial body suit that enhances mobility and physical performance
- Wearable Computers – Body-worn data processing devices
- General – Miscellaneous technologies as well as emerging trends or recent advances in the field of wearables.

This report is not meant to be an exhaustive list nor an endorsement of any technology described herein. Rather, it is meant to provide useful information about current developments in the area of wearable technology.

A spreadsheet summarizing these technologies is available in Appendix A. For an electronic copy, contact Jaki Upton at jaki.upton@pnnl.gov.

2.0 Sensors

2.1 Physiological

2.1.1 Brain Sentry

Technology name: Helmet sensors

Description: Brain Sentry wearable sensors are placed in helmets to collect data from physical impacts: "The sensor is able to estimate direction, peak acceleration and duration of impacts, while also being able to track head acceleration from any point. The integrated sensor battery doesn't need to be recharged and can last an entire season, able to turn on and off after motion is detected."

Status: Available

Funding:

Product link: http://brainsentry.com/

Source: Brain Sentry wearable sensors will continue to be used by AFL football http://www.tweaktown.com/news/44039/brain-sentry-wearable-sensors-continue-used-afl-football/index.html

Photo Source: http://www.tweaktown.com/news/44039/brain-sentry-wearable-sensors-continue-used-afl-football/index.html

2.1.2 Chinese Academy of Sciences

Technology name: Large-Area Nanocrystal Arrays of Metal–Organic Frameworks

Description: This research focuses on achieving highly sensitive and large-area pressure sensor arrays for electronic skin that can be used for health monitoring: "Pressure sensors based on solution-processed metal–organic frameworks nanowire arrays are fabricated with very low cost, flexibility, high sensitivity, and ease of integration into sensor arrays. Furthermore, the pressure sensors are suitable for monitoring and diagnosing biomedical signals such as radial artery pressure waveforms in real time."

Status: Evolving

Funding: Supported by National Natural Science Foundation of China (Grant Nos. 51033006,

51222306, 61201105, and 91222203), the China-Denmark Co-project (Grant No. 60911130231), the Ministry of Science and Technology of China (Grant Nos. 2011CB808400, 2011CB932300, 2013CB933403, and 2013CB933500), Beijing NOVA Program (Z131101000413038), and the Strategic Priority Research Program (Grant No. XDB12030300) of the Chinese Academy of Sciences.

Product link:

Source: Solution-Processed Large-Area Nanocrystal Arrays of Metal–Organic Frameworks as Wearable, Ultrasensitive, Electronic Skin for Health Monitoring
http://onlinelibrary.wiley.com/doi/10.1002/smll.201402890/abstract

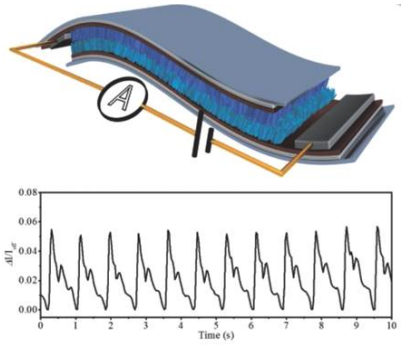


Photo Source: http://onlinelibrary.wiley.com/doi/10.1002/smll.201402890/abstract

2.1.3 Darta Systems: EMVIO

Technology name: EMVIO stress-tracking watch

Description: This smartwatch measures your pulse rate to calculate your stress index on a scale of 1 to 10 and alerts you when stress levels are high. The device utilizes a highly sensitive optical pulse sensor, touch sensor for skin contact, accelerometer, indicator light, Bluetooth low-energy connection, and an "improved algorithm to calculate calories burned, using heart rate measurement."

Status: Evolving

Funding: Crowdfunding

Product link: https://www.kickstarter.com/projects/993110774/emvio-the-first-watch-to-measure-and-manage-your-s

Source: Stress-Measuring Wearable Comes to Kickstarter
http://www.mobilemarketingwatch.com/stress-measuring-wearable-comes-to-kickstarter-48922/

2.1.4 LifeQ

Technology name: LifeQ Lens, Core, and Link

Description: LifeQ combines "computational systems biology and continuous body monitoring to create an on demand record of one's personal physiology and health." The company is developing three products: LifeQ Lens, a multi-wavelength optical sensor that can measure various health metrics like heart rate and can be integrated into almost any wearable device to measure; Life Core, which uses data

streams from Lens with mathematical modelling to create computer simulations of the wearer's physiology, helping the user to better understand biochemical reactions (i.e., calorie burn); and LifeQ Link, an open-source platform that "allows app developers, health insurance companies and others to integrate their devices or apps into the system to give users insight into the functioning of their bodies."

Status: Evolving

Funding:

Product link: http://lifeq.com/

Source: SA's LifeQ breathes life into wearables
http://www.techcentral.co.za/sas-lifeq-breathes-life-into-wearables/55519/

2.1.5 MultiSense Memory patch

Technology name: MultiSense Memory patch

Description: The MultiSense Memory patch is a "flexible, sensor-rich-patch that attaches to the sternum of a patient with adhesive (like a Band-Aid), takes a baseline vital rating — heart rate, temp and oxygen saturation -– and then measures all changes from the baseline." The device was designed with applications for treating Ebola patients. While the prototype uses a USB cable, the final version will employ Bluetooth to transmit data and allow doctors to monitor patience from a distance. The disposable device also features a 7-10 day battery life.

Status: Available

Funding:

Product link:

Source: This smart 'band-aid' could help the world beat Ebola
http://mashable.com/2015/03/14/smart-band-aid-ebola/

Photo Source: http://mashable.com/2015/03/14/smart-band-aid-ebola/

2.1.6 North Carolina State University Advanced Systems of Integrated Sensors and Technologies (ASSIST) Center

Technology name: Self-powered health/fitness monitors and wearable air-monitoring sensors

Description: Students with ASSIST Center on North Carolina State University's Centennial Campus are working with various industries and researching devices to convert body energy into fitness trackers to measure a variety of health metrics. Potential devices include a wired wristband or an EKG heart monitor embedded in a T-shirt to measure and analyze physiological activity. The devices would also be powered from body heat and body motion. The students propose that "data gathered gives a long view, whereas a doctor visit offers only a snapshot of health." Students are also using "nanotechnology to develop small, wearable sensors that monitor a person's immediate environment, as well as the wearer's vital signs. These sensors would monitor environmental concerns, such as ozone, carbon monoxide and nitrogen dioxide levels at the same time that they are monitoring vital signs, such as heart rate and hydration. The sensor's data would be transmitted wirelessly to the wearer's cell phone, and even to a doctor. The goal is to help people avoid exposure to the environmental conditions that exacerbate asthma and other health concerns." The team is also exploring "devices that don't use batteries and instead harvest power from the human body, relying on heat and motion to generate the energy they require."

Status: Evolving

Funding: $18.5 million over five years from the National Science Foundation

Product link:

Source: Health tracker in a T-shirt? It's in the works at NC State
http://www.wral.com/health-tracker-in-a-t-shirt-it-s-in-the-works-at-nc-state/14551919/

Wearable Sensors To Monitor Triggers For Asthma, And More
https://www.nsf.gov/news/special_reports/science_nation/wearablenano.jsp

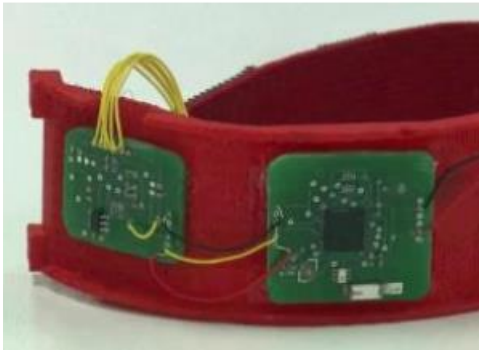


Photo source: http://www.wral.com/lifestyles/healthteam/image/14552066/?ref_id=14551919

Photo Source: https://www.nsf.gov/news/special_reports/science_nation/popup/wearablenano/insoles.jsp

2.1.7 STEMP

Technology name: STEMP Smart Temperature Patch

Description: STEMP Smart Temperature Patch is a wearable thermometer that inserts into a disposable medical-grade adhesive patch that is placed under the arm and "is Bluetooth-connected, so parents and patients can monitor their temperature with an accompanying iPhone app. If a fever spikes, the app will send a notification." The device provides "immediate, accurate, continuous body temperature measurement." It has a 30-day charge life and 7-10 day adhesive life. Developers are exploring how to integrate the device into clothes.

Status: Evolving

Funding: Crowdfunding

Product link: https://www.indiegogo.com/projects/stemp-smart-temperature-patch

Source: This Temperature Patch Will Notify Your iPhone When You Have A Fever
http://www.fastcoexist.com/3044318/fund-this/this-temperature-patch-will-notify-your-iphone-when-you-have-a-fever#9

Photo Source: https://www.indiegogo.com/projects/stemp-smart-temperature-patch

2.1.8 TechBeach

Technology name: Wearable baby monitor

Description: This wearable baby monitor is a "sensor-filled onesie that tracks everything from temperature to heart rate and how many times a child moves in their sleep" and synchs the information to your smartphone. The device also has reported uses in smart garments for athletes.

Status: Evolving

Funding:

Product link:

Source: New superhero baby suit to give mums peace of mind
http://www.dailytelegraph.com.au/news/nsw/new-superhero-baby-suit-to-give-mums-peace-of-mind/story-fni0cx12-1227242916011

2.1.9 Texas Instruments

Technology name: Temperature sensors

Description: Texas Instruments developed a temperature sensor for wearables with 0.13C temperature accuracy, fast thermal response, and USB form factor PCB board.

Status: Available

Funding:

Product link:

Source: Temperature Sensor for Wearable Devices Reference Design
http://www.ti.com/tool/TIDA-00452

2.1.10 University of California San Diego Center for Wearable Sensors

Technology name: Wearable sensors

Description: Researchers are developing wearable sensors that use electro-chemical detection and measure a cadre of physiological metrics such as metabolic functions, glucose levels, and pH levels. Researchers also developed a "functional biofuel cell that can generate electricity from sweat," reportedly enough electricity to power an LED or wristwatch.

Status: Evolving

Funding:

Product link:

Source: UC San Diego Researchers Develop Next Generation Of Wearable Medical Devices
http://www.kpbs.org/news/2015/mar/23/uc-san-diego-researchers-develop-next-generation-w/?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+kpbs%2Ftv+(KPBS+TV%3A+Program+Hightlights)

2.1.1 University of Illinois et al.

Technology name: Wearable electrodes

Description: Researchers are exploring the use of soft, flexible, wearable electrodes to read brain signals. These temporary-tattoo-style sensors can withstand activities and stay on for more than two weeks. Researchers propose "the invention could be used for a persistent brain-computer interface (BCI) to help people operate prosthetics, computers, and other machines using only their minds." The flexible device molds onto the ear and comprises "a soft, foldable collection of gold electrodes only 300 nanometers thick and 30 micrometers wide mounted on a soft plastic film. This assemblage stays stuck to the body using electric forces known as van der Waals interactions—the same forces that help geckoes cling to walls." In demonstrations, the device "helped record brain signals well enough for the volunteers to operate a text-speller by thought, albeit at a slow rate of 2.3 to 2.5 letters per minute."

Status: Evolving

Funding: Startup funding from the School of Engineering and research development support from Center for Rehabilitation Science and Engineering, Virginia Commonwealth University.

Research link: http://www.pnas.org/cgi/doi/10.1073/pnas.1424875112

Source: A Brain-Computer Interface That Lasts for Weeks
http://spectrum.ieee.org/tech-talk/biomedical/bionics/a-braincomputing-interface-that-lasts-for-weeks

Photo Source: http://www.pnas.org/content/112/13/3920

2.1.1 VSP Global: Project Genesis

Technology name: Project Genesis health-tracking optical frames

Description: Project Genesis integrates health-tracking technology into a pair of optical frames: "Housed within the temple of a pair of Dragon Alliance frames, the current prototype accurately tracks steps, calories burned, and distance traveled. Wearers can monitor their stats in real time through the accompanying Android app." The prototype features "high-tech sensors found in many other fitness trackers on the market today, including an accelerometer, a magnetometer, and a gyroscope to track steps, calories burned and distance traveled. The accompanying Android app lets the wearer track his or her progress in real time. Bluetooth syncs Genesis to the app; an embedded battery offers a three-day run time between 30-minute charges." The device helps users contextualize and monitor health data over time.

Status: Evolving

Funding:

Product link:

Source: VSP Develops Wearable Tech with Project Genesis
http://vspblog.com/projectgenesis/

Photo Source: http://vspblog.com/projectgenesis/

2.2 Other

2.2.1 Infineon Technologies AG

Technology name: DPS310 Micro Electro Mechanical Systems (MEMS) pressure sensor

Description: DPS310 is an ultra-high resolution, miniature MEMS "low-power digital barometric pressure sensor that enables the development of new and enhanced navigation, location, well-being, gesture recognition and weather monitoring applications." The device's captive sensing "guarantees high precision across a broad range of temperatures even when temperature changes rapidly," performance at pressures from 300hPa to 1200hPa and at temperatures from -40°C to 85°C. The device can "measure heights within ±5cm enabling the exact detection of transient states," which is ideal, for example, for "identifying when a person is moving from one floor of a building to another and triggering the download of a new floorplan." The device is fit for "outdoor navigation where it can help to improve navigation accuracy or support 'dead reckoning' when GPS signal is not available. In addition, the ability to provide accurate data for calculating elevation gain and vertical speed suits activity tracking in mobile and wearable health and sports gadgets, while ultra-precise pressure measurement opens up new possibilities for gesture recognition and the detection of rapid weather changes."

Status: Available

Funding:

Product link: https://www.infineon.com/dgdl/Infineon-PB_DPS310_Digital_Barometric_Pressure_Sensor-PB-v01_00-EN.pdf?fileId=5546d4624bbf60fb014bc100f8150839

Source: Low-Power Barometric Pressure Sensor For Mobile And Wearable Gadgets, IoT Devices
http://phys.org/news/2015-02-low-power-barometric-pressure-sensor-mobile.html

2.2.2 Kionix Inc.

Technology name: KX112, KXCJB

Description: KX112 is a thin, tri-axis accelerometer measuring 2-mm x 2-mm x 0.6 mm, ideal for wearables, with 16-bits of resolution and "built-in digital algorithms for detecting motion for power management, free fall for device protection or warranty monitoring, an orientation engine for portrait/landscape detection, and tap/double-tap for user interface functionality." The device balances power and performance, offering 2048 bytes that allow the rest of the system to sleep while still recording data. Additionally, the device features "low power consumption, lead-free solderability, excellent temperature performance, high shock survivability, factory programmed offset and sensitivity, as well as a self-test function." The KXCJB accelerometer measures 3-mm x 3-mm x 0.45-mm thick, which is "half the thickness of most accelerometers on the market. This brings the ability to embed motion detection and motion sensing capabilities into a host of new devices such as badges, access cards, and payment/smart cards, while also opening up possibilities of maintaining low profiles when mounting on or in glass, plastic and other thin structures."

Status: Available

Funding:

Product link: http://kionix.com/accelerometers/kx112, http://kionix.com/accelerometers/kxcjb

Source: Ultra-thin full-functional tri-axis accelerometers target mobile and wearable applications
http://www.microwave-eetimes.com/en/ultra-thin-full-functional-tri-axis-accelerometers-taget-mobile-and-wearable-applications.html?cmp_id=7&news_id=222905929

2.2.3 National Applied Research Laboratories

Technology name: Single-chip sensor

Description: Researchers are integrating different sensors on a single chip for more energy-efficient chips for wearable devices: "One type of sensors registers temperature, humidity, pressure and other weather data, while another measures the user's heartbeat, blood pressure, blood sugar, and the third type records the user's speed of movement and other physical factors." According to researchers, "The new technology will help save energy and costs for makers of smart phones and wearables by packing various sensors and other functions into one system-on-chip, that is half the size of a rice grain."

Status: Evolving

Funding:

Product link:

Source: Taiwan unveils technique to combine sensors on a chip
http://www.wantchinatimes.com/news-subclass-cnt.aspx?id=20150326000012&cid=1204&MainCatID=12

Photo Source: National Applied Research Laboratories

2.2.1 New Mexico State University

Technology name: Low-powered wearable micro-devices

Description: Researcher Wei Tang at New Mexico State University is using "current sensor technology [with] a new design strategy to construct better circuits to build a bridge between the human body and the environment. The broad goal of his work is to extend our ability to sense the world and better respond to the environment and to develop medical devices that can be used for rehabilitation or to prevent and detect disease." Drawing on the way existing computers run off code, he "proposes to replace synchronous devices with devices that work more efficiently, like the human brain." His team is creating "a very small integrated circuit, 3 millimeters by 3 millimeters. After testing this device, [they] want to put it on a hat with a small battery to extract EEG brain wave information. A patient or someone could wear it for a day or even up to a week. It would provide doctors with information to analyze." Tang is exploring an "energy-harvesting device, using energy from vibrations or solar energy technology," and his work is also being applied in a "study of electric fish that are able to produce weak electric fields and use this ability to sense their environment, choose a mate and identify members of their own species. Tang is developing a tiny device that can be placed on the fish to collect data about their behavior."

Status: Evolving

Funding:

Product link:

Source: NMSU Engineer Develops Wearable Microsensors
http://krwg.org/post/nmsu-engineer-develops-wearable-microsensors

2.2.2 Samsung Advanced Institute of Technology

Technology name: Image sensor

Description: Developer Jaehyuk Choi is developing a low-power, 15 frames-per-second image sensor for always-on mobile and wearable devices. The image sensor offers an ultra-low power always-on resolution mode and a mode for photographic quality resolution. Additionally, "An eye tracking app does feature extraction for face detection and face alignment to locate the eyes. In various tests, the app achieved 100 percent eye detection in always-on mode at 0.9 V."

Status: Evolving

Funding:

Product link:

Source: Low Power CMOS Image Sensor for Mobile and Wearable
http://mandetech.com/2015/03/07/low-power-cmos-image-sensor-for-mobile-and-wearable/

2.2.3 University of California, San Diego

Technology name: Enzyme-based inks

Description: Researchers are developing enzyme-based inks for use as low-cost wearable sensors and for "rapid fabrication of high-quality, flexible, and inexpensive bio-sensors which can be easily applied to a wide variety of surfaces and textures with minimal user training." Researchers developed the sensors while exploring lactate and glucose sensing and estimate one ink-based roller pen can be used to draw the equivalent of 500 glucometer test strips. The enzyme ink was "optimized for ensuring good biocatalytic activity, electrical conductivity, biocompati-bility, reproducible writing, and surface adherence. The inks offer rapid fabrication of high-quality, flexible and inexpensive bio-sensors which can be easily applied to a wide variety of surfaces and textures with minimal user training."

Status: Evolving

Funding:

Research link:
http://onlinelibrary.wiley.com/doi/10.1002/adhm.201400808/abstract;jsessionid=B2B01B324CCBD3D75D274D5E32F3E1B7.f01t02

Source: Draw-On Wearable Sensors Enabled by Enzymatic Inks
http://www.medgadget.com/2015/03/draw-wearable-sensors-enabled-enzymatic-inks.html

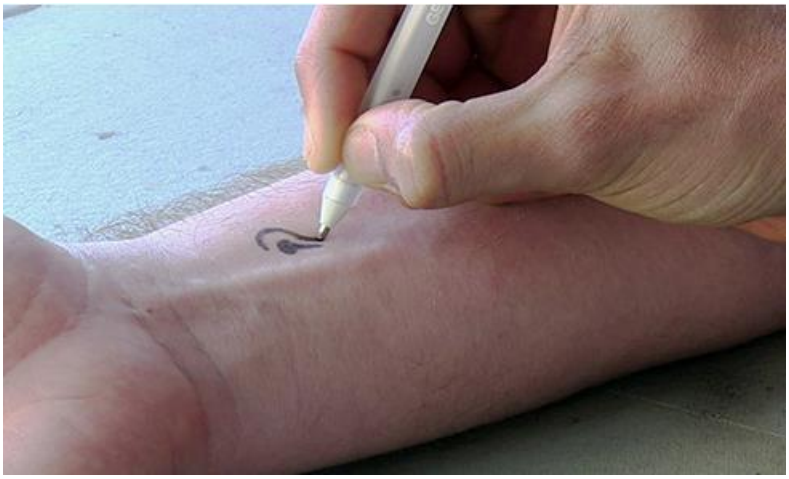


Photo Source: http://www.medgadget.com/2015/03/draw-wearable-sensors-enabled-enzymatic-inks.html

3.0 Displays

3.1 Heads-up

3.1.1 Buckham and Duffy

Technology name: Heads-up display glasses

Description: Backed by Google, Buckham and Duffy's display technology can "overlay a huge range of data in the user's view using glass" with potential applications such as "patient health data for doctors and nurses or GPS data for surveyors" and having anticipated benefits in "increasing public safety, efficiency for organizations, with key areas of focus for us in agriculture, healthcare, security and education."

Status: Evolving

Funding:

Product link:

Source: Queensland start-up eyes Google Glass
http://www.smh.com.au/digital-life/wearables/queensland-startup-eyes-google-glass-20150319-1m2zlz.html

3.1.1 Epson: Moverio BT-200

Technology name: Moverio BT-200 augmented reality goggles

Description: Moverio is "Epson's second generation binocular, see-through smart glasses with AR capabilities. Key features include a front-facing camera and motion trackers, a 'floating' 80-inch perceived screen, Wi-Fi and Bluetooth connectivity and an interactive track pad." Compared to other augmented reality devices, Moverio is "aimed more at niche uses (like drone flying or work-related training)" and features "a pair of large, thick glasses with embedded transparent screens. The pair of screens means the BT-200 can display images in 3D. But the lenses are roughly a centimeter thick." The device's processor, battery, and other components are housed in a handheld device that plugs into the glasses and it features a "textured touchpad, which you can use to move a cursor around the screen, or do some basic multitouch gestures." The device offers a 6-hour battery life, audio jack, and 960 × 540 screen resolution.

Status: Evolving

Funding:

Product link: http://www.epson.com/cgi-bin/Store/jsp/Landing/moverio-bt-200-smart-glasses.do

Source: Epson Moverio BT-200 review
http://www.digitaltrends.com/wearable-reviews/epson-moverio-bt-200-review/
Unlocking the potential of augmented reality today
http://betanews.com/2015/03/20/epson-unlocking-the-potential-of-augmented-reality-today-qa/

Photo Source: http://www.digitaltrends.com/wearable-reviews/epson-moverio-bt-200-review/

3.1.2 General Motors

Technology name: In-vehicle heads-up display

Description: General Motors is refining technology to help reduce driver distraction, proposing that "By projecting pertinent information onto the windshield and into the driver's line of sight, head-up display systems allow drivers to keep their eyes on the road ahead instead of glancing at gauge clusters, infotainment screens and other devices." GM vehicle heads-up displays allow users to "select from screens that focus on navigation, audio information, a tachometer, or simply a speedometer."

Status: Available

Funding:

Product link:

Source: Head-Up Display on GM Cars Keeps Eyes on the Road
http://www.netnewsledger.com/2015/03/15/head-up-display-on-gm-cars-keeps-eyes-on-the-road/

3.1.3 HTC: Vive

Technology name: Vive virtual reality headset

Description: The Vive virtual reality headset "offers full 360-degree immersion, tracking controllers and high-quality graphics running at 90 frames-per-second" and combines "Valve's Steam VR tracking and input technologies with HTC's world-renowned design and engineering talent."

Status: Evolving

Funding:

Product link: http://htcvr.com

Source: HTC Has A New Flagship Smartphone, Wearable And VR Headset On Show

http://readwrite.com/2015/03/01/htc-at-mwc-2015

Photo Source: http://readwrite.com/2015/03/01/htc-at-mwc-2015

3.1.4 U.S. National Aeronautics and Space Administration (NASA), Osterhout Design Group

Technology name: Augmented reality glasses

Description: NASA and the Osterhout Design Group (ODG) are developing augmented reality glasses equipped with "a system where how-to guides can be uploaded to the glasses, allowing astronauts to follow directions while their hands are full." The technology addresses the need to provide an easy way for astronauts to access numerous guidance materials while in space. ODG brings to the partnership experience developing augment reality devices for military and industrial uses: "ODG's heavy-duty headset, called the R6, is designed to stand up to the rigors of life in the military and make digital maintenance manuals, service guides, and construction information readable even in harsh environments."

Status: Evolving

Funding:

Product link:

Source: NASA Is Developing Wearable Tech Glasses for Astronauts
http://www.bloomberg.com/news/articles/2015-03-11/nasa-is-developing-wearable-tech-glasses-for-astronauts

3.1.5 VidyoWorks

Technology name: Smart glass application

Description: The VidyoWorks mobile client application program interfaces are available for smart glasses to embed real-time video, audio, content communication, and collaboration into applications. VidyoWorks used on Vuzix smart glasses "enables hands-free video communication and collaboration for augmented reality and see-what-I-see applications. VidyoWorks delivers the only scalable video coding platform for outstanding error resiliency and the ability to combine workflow integration, reliable performance and scalability to deliver an affordable, wearable visual engagement solution."

Status: Available

Funding:

Product link: http://www.vidyo.com/

Source: VidyoWorks on Smart Glasses Enables Video Engagement for Wearable Platforms
http://www.businesswire.com/news/home/20150309005225/en/VidyoWorks-Smart-Glasses-Enables-Video-Engagement-Wearable#.VQsh7E0cRmM

Photo Source: http://www.businesswire.com/news/home/20150309005225/en/VidyoWorks-Smart-Glasses-Enables-Video-Engagement-Wearable#.VQsh7E0cRmM

3.1.6 Virgin Atlantic, Sony

Technology name: SmartEyeGlass

Description: Virgin Atlantic is using Sony's SmartEyeglass Developer Edition SED-E1, tablet, mobile phone and SmartWatch 3 to "help its engineers maintain aircraft in an eight-week long trial, starting next week at Heathrow." Airline engineers will "use the smartglasses to stream real-time videos to technicians to speed up technical assistance and smartwatch, on the other hand, will provide engineers with notifications and technical details, including instant feedback if they have a query." The goal is to "eliminate use of paper from some engineering processes and will ensure engineers remain on the craft while working, potentially expediting turnaround."

Status: Evolving

Funding:

Product link:

Source: Virgin Atlantic to equip aircraft engineers with Sony's wearable gadgets
http://www.techienews.co.uk/9724268/virgin-atlantic-equip-aircraft-engineers-sonys-wearable-gadgets/

4.0 Power

4.1 Chargers

4.1.1 Apple

Technology name: Power management for inductive charging systems

Description: Apple's recent patent involves "techniques for delivering useful power to a portable electronic device that does not deplete the battery of the portable electronic device. More specifically, the patent covers electromagnetic inductive power transfer, and in particular to adaptive power control systems for maximizing the efficiency of power transfer." The system may include an inductive charging station to transmit power and a portable electronic device to receive power and be partially controlled/influenced by "periodic reports from the portable electronic device itself. For example, a portable electronic device may include a wireless transmitter configured to transmit information to an inductive charging station. Such information may include identifying information, authentication information, or power state information." The device may feature a display of "current or future power requirements, time estimations until a battery is fully charged, the current charge of the battery, or other power related information," it may send periodic updates, and feature a wireless transmitter (i.e., Wi-Fi, radiofrequency, Bluetooth, near field communication, or infrared.

Status: Evolving

Funding:

Product link:

Source: A New Apple Patent Surfaces in Europe Covering Inductive Charging for Wearables, Electric Vehicles & Beyond
http://www.patentlyapple.com/patently-apple/2015/03/a-new-apple-patent-surfaces-in-europe-covering-inductive-charging-for-wearables-electric-vehicles-beyond.html

4.1.2 Texas Instruments

Technology name: bq25100 single-cell Li-ion charger, TIDA-00318 wireless charger, TIDA-00334 wireless power transmitter

Description: Texas Instruments is developing several options to extend the battery life of wearables. The bq25100 single-cell Li-ion charger "is half the size of existing charger solutions, while supporting low cost unregulated adapters, which may be used in the cost-sensitive wearables market." Maxim's MAX14676/76A includes "a linear battery charger, but also numerous low-power power management peripherals to save system board space while extending battery life." Both devices "can be paired with a wireless power receiver/transmitter solution to provide wireless charging capability to a wearable device design." The TIDA-00318 "pairs the bq25100 single-cell Li-ion linear charger described earlier, with a bq51003 Qi compliant wireless power receiver for an overall Qi compliant wireless charger solution. Qi is an international standard for interoperability of wirelessly charged devices; Any Qi certified wireless power receiving device, such as the Moto 360 smartwatch, can work with any Qi certified charging base. Thus, any wearable implementing the TIDA-00318 design should be able to gain Qi certification and

work with any Qi charging base. The TIDA-00318 is for 135mA charge current applications and is ultra small, fitting in just 5x15mm^2." Lastly, the TIDA-00334 wireless power transmitter or charging solution "employs the bq500212A IC in a small form factor suitable for wearable devices. The power source to the unit is 5V from a Micro USB connector. The low power design supports output power at the receiver up to 2.5W."

Status: Available

Funding:

Product link:

Source: Extending the Battery Life of Wearable Devices
http://www.mouser.com/pdfdocs/PublicRelations_TechArticle_ExtendingBatLifeWearables_2015Final.PDF?cm_mmc=PressRelease-PR-_-MOUSER-_-Extending_the_Battery_Life_of_Wearable_Devices-_-2015-03-26

4.2 Self-powering (Harvesters)

4.2.1 Sungkyunkwan University

Technology name: Energy-generating cloth

Description: Sungkyunkwan University is developing "durable, flexible cloth that harnesses human motion to generate energy. It can also self-charge batteries or supercapacitors without an external power source and make new commercial and medical applications possible." The team "turned to the emerging technology of 'triboelectric nanogenerators,' or TNGs, which harvest energy from everyday motion. The researchers created a novel TNG fabric out of a silvery textile coated with nanorods and a silicon-based organic material. When they stacked four pieces of the cloth together and pushed down on the material, it captured the energy generated from the pressure. The material immediately pumped out that energy, which was used to power light-emitting diodes, a liquid crystal display and a vehicle's keyless entry remote. The cloth worked for more than 12,000 cycles."

Status: Evolving

Funding: This work was financially supported by Basic Science Research Program (2012R1A2A1A01002787, 2009-0083540) and the Center for Advanced Soft-Electronics as Global Frontier Project (2013M3A6A5073177) through the National Research Foundation (NRF) of Korea Grant funded by the Ministry of Science, ICT & Future Planning.

Research link: http://pubs.acs.org/doi/abs/10.1021/nn507221f

Source: Energy-generating cloth could replace batteries in wearable devices
http://www.rdmag.com/news/2015/03/energy-generating-cloth-could-replace-batteries-wearable-devices

4.2.2 Texas Instruments

Technology name: bq25570 Ultra Low-Power Harvester Power Management IC with Boost Charger, and Nanopower Buck Converter

Description: The bq25570 Ultra Low-Power Harvester Power Management IC with Boost Charger can take the 300 to 400 millivolts collected by energy harvesters and boost this power to 3 to 5 volts, which is enough to charge a battery. The device also features "a highly efficient nano-power buck converter to provide the option of a second power rail to the system."

Status: Available

Funding:

Product link: http://www.ti.com/product/bq25570

Source: Extending the Battery Life of Wearable Devices
http://www.mouser.com/pdfdocs/PublicRelations_TechArticle_ExtendingBatLifeWearables_2015Final.PDF?cm_mmc=PressRelease-PR-_-MOUSER-_-Extending_the_Battery_Life_of_Wearable_Devices-_-2015-03-26

4.2.3 Ulsan National Institute of Science and Technology (UNIST)

Technology name: Triboelectric generators

Description: Researchers are exploring "triboelectric generators with high-power generation achieved using flexible and lightweight textiles or miniaturized and hybridized device configurations" and the "developments and future prospects of triboelectric energy harvesters and sensors, which may enable fully self-powered wearable devices with significantly improved sensing capabilities."

Status: Evolving

Funding: This work was supported by the Center for Advanced Soft Electronics under the Global Frontier Research Program (2012M3A6A5055728) and by the National Research Foundation of Korea (NRF-2011-0014965, NRF-2012-K1A3A1A20031618) of the
Ministry of Science, ICT & Future Planning, Korea.

Product link:

Source: Triboelectric Generators and Sensors for Self-Powered Wearable Electronics
http://pubs.acs.org/doi/abs/10.1021/acsnano.5b01478

4.3 Power supplies

4.3.1 Ams AG: AS3701

Technology name: AS3701 integrated power management unit

Description: The AS3701 micro, integrated power management unit offers a small footprint with "a low quiescent current, [and] implements multiple power-regulation, power-saving, battery-charging, protection and start-up functions in a chip-scale package (WL-CSP) measuring just 2mm x 2mm x 0.4mm." The design offers space savings and advance power management with its single lithium-ion cell, making it optimal for "smart watches, sport bands, wearable medical devices, handheld GPS units and

mobile phones." Additionally its battery charger "can operate in trickle-charge, constant current and constant voltage modes and supplies a maximum charging current of 500mA. Its power path management allows a device to start up with a dead battery, and optimizes power distribution between the battery charging circuit and the system power supply when plugged in to the mains." The device also features "integrated battery temperature monitoring, power-on reset and over-current protection [that] help to ensure reliable and safe operation."

Status: Available

Funding:

Product link: http://ams.com/eng/Products/Power-Management/Power-Management-Units/AS3701

Source: ams Launches Tiny 4mm2 Integrated Power Management Solution for Wearable Devices http://www.virtual-strategy.com/2015/03/23/ams-launches-tiny-4mm2-integrated-power-management-solution-wearable-devices#axzz3VMtxKTNj

4.3.2 Holst Centre, TNO, Pauline van Dongen: Solar Shirt

Technology name: Solar Shirt

Description: Holst Centre, TNO, and fashion designer Pauline van Dongen are developing Solar Shirt to combine "solar panels and flexible electronics into an attractive, off-the-peg T-shirt for everyday wear that can charge your smartphone or other portable devices." The shirt "generates power from 120 thin-film solar cells integrated into the fabric itself. In bright sunlight, it produces around 1 W of electricity - enough to charge a typical phone in a few hours. Indoors, the shirt generates enough power to keep a battery charged - so your phone or other device is always ready when you need it. The shirt can charge smartphones, MP3 players, cameras, GPS systems and other USB-compatible handheld or portable devices. And if all your devices are charged, the electricity can be stored in the shirt's battery pack for later use."

Status: Evolving

Funding:

Product link: http://www.holstcentre.com/news---press/2015/solar-shirt/

Source: Solar Shirt: the phone charger you wear http://www.printedelectronicsworld.com/articles/7559/solar-shirt-the-phone-charger-you-wear

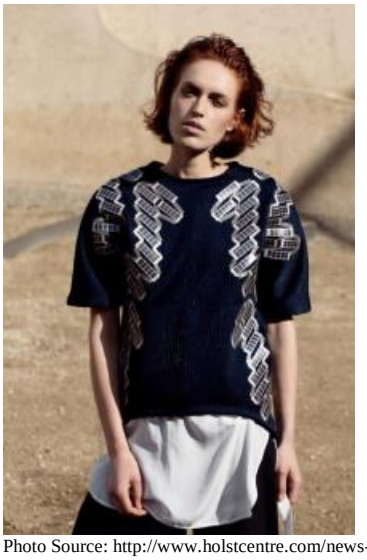


Photo Source: http://www.holstcentre.com/news---press/2015/solar-shirt/

4.3.3 Imprint Energy

Technology name: Printable batteries

Description: Imprint Energy is pioneering printable batteries for which "Zinc is used for the anode part of the battery, and combines that with a solid polymer electrolyte and a cathode made of a metal oxide."

Status: Evolving

Funding:

Product link: http://www.imprintenergy.com/

Source: Wearable and flexible batteries
http://smartables.io/wearable-flexible-batteries/

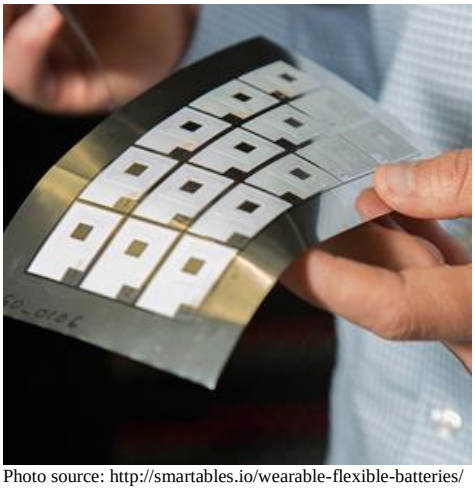


Photo source: http://smartables.io/wearable-flexible-batteries/

4.3.4 ROHM, Kobe University

Technology name: Small, ultra-low-power technology

Description: ROHM and Kobe University are developing a small**,** ultra-low-power technology for wearable biosensors that uses "non-volatile memory in order to suppress standby power generation by enabling the power supply to be turned off when no processing/operation is required." The technology enables wearable biosensors "to easily measure the heart rate by spotting small potential discrepancies on the skin's surface (EKC/ECG waveforms) using only 6uA of current" and its built-in communications functions "enable biosensor control capabilities via a mobile device and to facilitate data input/output. All operations only require 38uA, which is five times lower than conventional products." ROHM is adopting the technology with power-saving measures to "achieve the lowest power consumption in the industry, including reducing the power consumption of heart rate acquisition block by 20-fold, decreasing the average power consumption of the memory block to less than 1/10th conventional levels, and lowering the power consumption of the logic block by more than half."

Status: Evolving

Funding:

Product link:

Source: ROHM, Kobe University develops low power technology for wearable biosensors
http://www.biometricupdate.com/201503/rohm-kobe-university-develops-low-power-technology-for-wearable-biosensors

4.3.5 STMicroelectronics: Enfilm

Technology name: Enfilm thin-film battery

Description: The Enfilm thin-film battery is a bendable, rechargeable 700microAh battery "about a fifth of a millimeter thick and as large as a standard US postage stamp." The battery is being used in a "watch cuff from Central Standard Timing to power an inch-high E-Ink display; ST says the charge will last a month." Enfilm is also exploring a flexible version. Enfilm demonstrated the battery "on an EMV (chip) credit card that contained a small E-ink display and keypad. The power that's used by the card is replaced by the EMV payment terminal; the battery is recharged every time the card gets used, so it never runs out during the two-to-three year time that the card is valid."

Status: Available

Funding:

Product link: http://www.st.com/web/catalog/sense_power/FM142/CL848/SC1107?sc=enfilm

Source: MWC Day 3: Flat Bendable Components from ST
http://wearablesinsider.com/2015/03/09/mwc-day-3-flat-bendable-components-from-st/

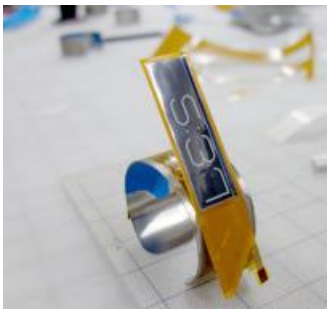


Photo Source: http://wearablesinsider.com/2015/03/09/mwc-day-3-flat-bendable-components-from-st/

5.0 Communications

5.1 Short-range, low-power Bluetooth

5.1.1 Bluetooth

Technology name: Bluetooth version 4.2 standard

Description: Bluetooth 4.2 is anticipated to be beneficial for the Internet of Things and wearable devices. The technology "allows smart wristbands batteries to last months." Version 4.2 provides low power, faster data throughput ("2.5 times faster than Bluetooth 4"), IPv6, and mesh networking, which allows for Cloud-connectivity and improved wireless range. Each device is also a repeater.

Status: Soon to be released

Funding:

Product link: http://www.bluetooth.com/SiteCollectionDocuments/4-2/bluetooth4-2.aspx

Source: Does Bluetooth take it all Wearable and IoT?
http://smartables.io/does-bluetooth-take-it-all-wearable-and-iot/

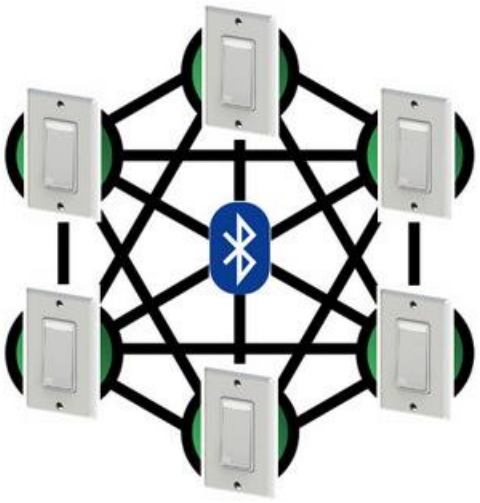


Photo Source: http://smartables.io/does-bluetooth-take-it-all-wearable-and-iot/

5.2 Hands-free operation

5.2.1 MUV Interactive: Sphere, Bird

Technology name: Sphere, Bird

Description: Bird is a ring that turns a user's surroundings into an interactive workspace with remote touch, hovering, depth sensing, gesture control, and mouse functionality. Sphere "is installed on the ceiling (like a light bulb) to project content from connected devices onto any surface via touch, motion and voice. Coupled with Bird, Sphere will enable users to answer the phone by tapping on a chair, or watch TV on a kitchen counter, heralding a new way of living enhanced by the Internet of Things."

Status: Evolving

Funding:

Product link: http://www.muvinteractive.com/

Source: Israeli Startup Develops Wearable Sensor to Allow Interaction with Virtually Any Device http://www.thetower.org/1784oc-israeli-startup-develops-wearable-sensor-to-allow-interaction-with-virtually-any-device/

Photo Source: http://www.thetower.org/1784oc-israeli-startup-develops-wearable-sensor-to-allow-interaction-with-virtually-any-device/

5.2.2 TheEyeTribe

Technology name: Eye-tracking technology

Description: TheEyeTribe is combining "eye-tracking with an accelerometer which would allow the display of the watch to turn on only when you are looking at the watch, thus helping to conserve battery life, which has been an issue on some devices. You could also use your eye movement to switch through applications or to navigate within them. This is very handy to those of us who may have larger fingers that make operating such a tiny screen a bit problematic." The technology is proposed to "make navigation easier, help those who may be disabled" and "make for a more immersive gaming experience make for more interesting and immersive experiences for this emerging mobile space."

Status: Evolving

Funding:

Product link: https://theeyetribe.com/

Source: TheEyeTribe Wants To Bring Eye-Tracking Capabilities To Your Smartwatch
https://androidheadlines.com/2015/03/theeyetribe-wants-to-bring-eye-tracking-capabilities-to-your-smartwatch.html

6.0 Cameras

6.1.1 Nixie

Technology name: Nixie drone-camera wristband

Description: Nixie is a "drone that doubles as a wrist band." The wearable, flyable camera, targeted at rock climbers, can be worn on the wrist but also flies as a drone camera: "While hovering over you it captures video and will follow you until you are ready to place it back on your wrist. If you are a rock climber for instance and want to have your climb recorded with incredible aerial views without the noise of a helicopter, Nixie will do the trick. Once video is captured, you will be able to instantly share the video." After the device leaves your wrist, "Nixie finds its way using motion-prediction algorithms and sensors and also has 360-degree panorama and follow modes. The camera shoots with clear imagery and in 1080p video."

Status: Soon to be released

Funding: $500,000 from Intel's "Make it Wearable" contest

Product link: http://flynixie.com/

Source: Is Nixie One Step Further Than GoPro?
http://clapway.com/2015/03/08/one-step-gopro123/

6.1.2 QueTel: TraQ

Technology name: TraQ

Description: The Bellevue Police Department in Nebraska turned to QueTel for solutions to its audio/visual evidence capturing needs: "QueTel's TraQ Suite components Evidence TraQ and Digital TraQ. Digital TraQ is a secure, easily-searched single repository for the growing volume of digital evidence—still images, videos and voice recording. Evidence TraQ automates the process of seizing, managing and disposing of guns, drugs, money and other physical evidence." The technology improved their processes, thus "removing the burden of storing, managing and copying CD/DVDs and replaces the cumbersome and hard to access storage of files on less than secure servers," compiling the digital evidence in one searchable place, and saving costs by streamlining processes – the team estimates just eliminating DVD duplication saves 10 staff hours a week.

Status: Available

Funding:

Product link: www.quetel.com

Source: How a Nebraska police department integrated wearable camera videos, digital evidence and physical evidence
http://www.policeone.com/police-products/body-cameras/articles/8475409-How-a-Nebraska-police-department-integrated-wearable-camera-videos-digital-evidence-and-physical-evidence/

7.0 Exoskeletons

7.1.1 Alfred I. duPont Hospital for Children: Wilmington Robotic Exoskeleton

Technology name: Wilmington Robotic Exoskeleton (WREX)

Description: WREX is a 3D-printed "wearable upper-limb device with linear elastic bands that give multidimensional movement to little arms limited by orthopedic and neuromuscular disabilities." WREX uses "mechanical linkage powered by rubber bands [and] removes the gravity that weighs limbs down." The device "can be attached to a body jacket for children who walk or may be attached to a wheelchair for non-ambulatory kids. . . . It allows children and adults with weak arm muscles to move their arm in space with minimal effort, even specific and direction motion that enables them to play, feed themselves, and brush their hair." Creators also developed "a small chip, not much bigger than a quarter, embedded into the brace. The device responds to temperature and records the brace-wear time and pattern of brace-wear, according to Rahman, who sees crossover possibilities in the engineering behind almost everything."

Status: Available

Funding:

Product link: http://jaecoorthopedic.com/products/products/WREX%3A-Wilmington-Robotic-EXoskeleton-Arm.html

Source: Wearable exoskeleton helps children to walk at duPont Hospital's pediatric engineering lab http://www.delawarebusinesstimes.com/wearable-exoskeleton-helps-children-to-walk-at-dupont-hospitals-pediatric-engineering-lab/

Photo Source: http://www.delawarebusinesstimes.com/wearable-exoskeleton-helps-children-to-walk-at-dupont-hospitals-pediatric-engineering-lab/

7.1.2 Harvard University

Technology name: Soft wearable robotics

Description: This work focuses on applying soft robotic systems to help individuals overcome disabilities, and to augment the performance of able-bodied people." The research team is pursuing "lightweight, soft robotic glove that could become an alternative to a therapist manipulating a patient's fingers and thumb to rehabilitate impaired hand function, or provide a patient with assistance in performing activities of daily living. Equipped with soft actuators with integrated sensors, the robotic glove device will mimic the way that the human hand contracts, extends, bends, and twists. The project will allow the team to test improvements in key components of a soft robotics platform, including sensing, calibration, actuation, and control." They are also developing "a soft exosuit that can assist an individual with locomotion as part of the DARPA Warrior Web project" as well as "modeling and design of fluidic-based soft robotics for cardiac applications and applying meso-scale manufacturing approaches to the design of smart medical tools for the minimally invasive diagnosis and treatment of disease."

Status: Evolving

Funding: $500,000 National Science Foundation award

Product link:

Source: Soft robotics expert Conor J. Walsh receives NSF CAREER Award
https://www.seas.harvard.edu/news/2015/03/soft-robotics-expert-conor-j-walsh-receives-nsf-career-award

7.1.3 Noonee: Chairless Chair

Technology name: Chairless chair

Description: Noonee's Chairless Chair is a hydraulic powered chair with "a titanium frame [that] hugs the back of the worker's leg like a flexible brace, while a support belt is strapped around their torso. Workers can stand and walk like normal, but when they want to sit, pushing a button locks the frame into place at the desired angle. The weight the body is transferred through the frame to the floor or the heels." The device essentially allows the user to carry a seat with them at all times and is designed to be "a task-specific tool that will help workers at the engine, door and center console assembly stations. The company says the chair will let employees take 'micro breaks' of 3 to 10 seconds while working, easing muscle fatigue and increasing productivity."

Status: Evolving

Funding:

Product link: http://www.noonee.ch/index.php/why-chairless-chair

Source: An Exoskeleton that Acts Like a Wearable Chair
http://www.wired.com/2015/03/exoskeleton-acts-like-wearable-chair/

Photo Source: http://www.wired.com/2015/03/exoskeleton-acts-like-wearable-chair/

7.1.4 ReWalk Personal Exoskeleton System

Technology name: ReWalk Personal Exoskeleton System

Description: ReWalk Personal Exoskeleton System is a "wearable robotic [suit] that provides powered hip and knee motion to individuals with spinal cord injuries. The device, developed by ReWalk Robotics in Marlborough, MA, is helping give freedom back to people with paraplegia and is the first exoskeleton with FDA approval for patient use at home and in their community." The device is described as "user-initiated, giving patients' mobility through the integration of a wearable brace support, a computer-based control system and motion sensors. The system allows for independent, controlled walking while mimicking the natural movement of the legs, like that of an able-bodied person."

Status: Evolving

Funding:

Product link: http://www.rewalk.com/

Source: See How the ReWalk Robot Gave a Paralyzed Man Working Legs For the 1st Time in 13 Years http://chicagoinno.streetwise.co/2015/03/24/rewalk-exoskeleton-helps-the-paralyzed-walk-again/

7.1.5 University of Southampton

Technology name: Soft robotic trousers

Description: Rehabilitation technologists are developing soft robotic trousers prototype that "will include trousers and socks that are easy to use, comfortable, adaptable and meet each user's individual mobility needs." The device is anticipated to help people avoid falls, gain bionic strength to move from sitting/standing positions, and assist in stair climbing. The device features "artificial 'muscles' made from

smart materials and reactive polymers which are capable of exerting great forces. They will be developed using the latest wearable soft robotic, nanoscience, 3D fabrication, functional electrical stimulation and full-body monitoring technologies, all driven by the need of the end users, who will also be directly involved in the project. They will include control systems that monitor the wearer and adapt to give the most suitable assistance, working with the body's own muscles. For patients needing rehabilitation the smart clothing can initially provide strong support and subsequently reduce assistance as the patient recovers mobility and strength."

Status: Evolving

Funding: £2 million from the Engineering and Physical Sciences Research Council

Product link:

Source: Wearable Soft Robotics for Independent Living
http://www.ecs.soton.ac.uk/news/4660

8.0 Other

8.1.1 BAE Systems, Intelligent Textiles Design: Broadsword

Technology name: Broadsword, Spine

Description: Broadsword comprises Intelligent Textile Design's Spine technology, which "uses so-called e-textiles to wirelessly charge military equipment - and this energy use can be monitored using a smartphone app." The technology "can power up and transfer data to and from equipment such as radios, cameras, smart helmets and torches, as well as smart weapons - effectively working as a portable hotspot." BAE also "created an inductive seat charger that automatically transfers energy from a vehicle to the vest. This means the Spine never runs out of energy and can be charged as soldiers travel around battle zones. And all this power usage can be managed using a smartphone app." It can host eight devices plugged in at one time. The technology also includes the Q-Warrior "see-through augmented reality display [that] integrates with the Spine and smartphone to overlay useful information such as GPS locations, temperatures and other data." BAE and Intelligent Textiles Design propose the device will benefit armed forces, fire and rescue, and the police.

Status: Evolving

Funding:

Product link:

Source: Rise of the iSoldier: British military kitted out with high-tech vests, augmented reality helmets and wearable chargers
http://www.dailymail.co.uk/sciencetech/article-3009288/Rise-iSoldier-British-military-kitted-high-tech-vests-augmented-reality-helmets-wearable-chargers.html

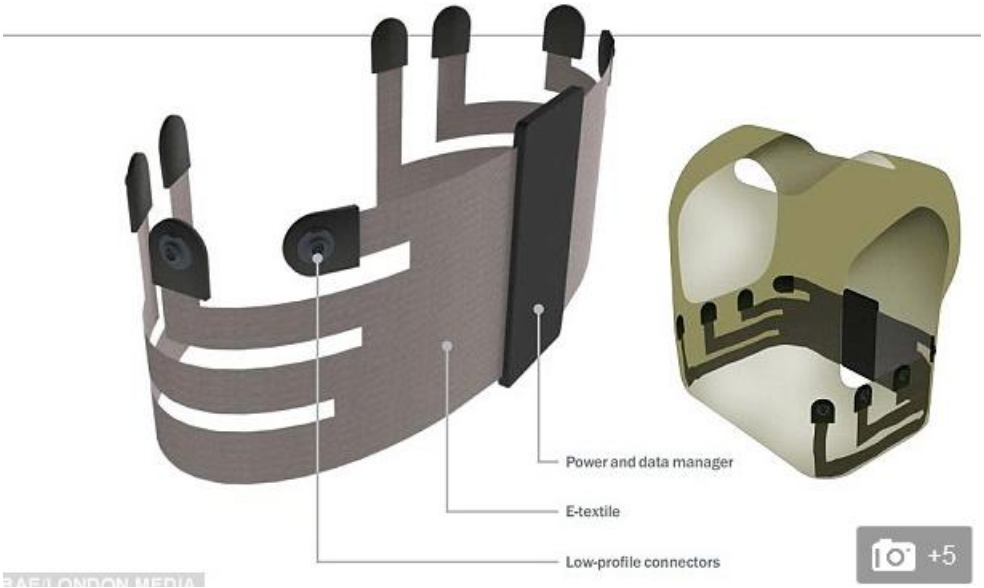


Photo Source: http://www.dailymail.co.uk/sciencetech/article-3009288/Rise-iSoldier-British-military-kitted-high-tech-vests-augmented-reality-helmets-wearable-chargers.html

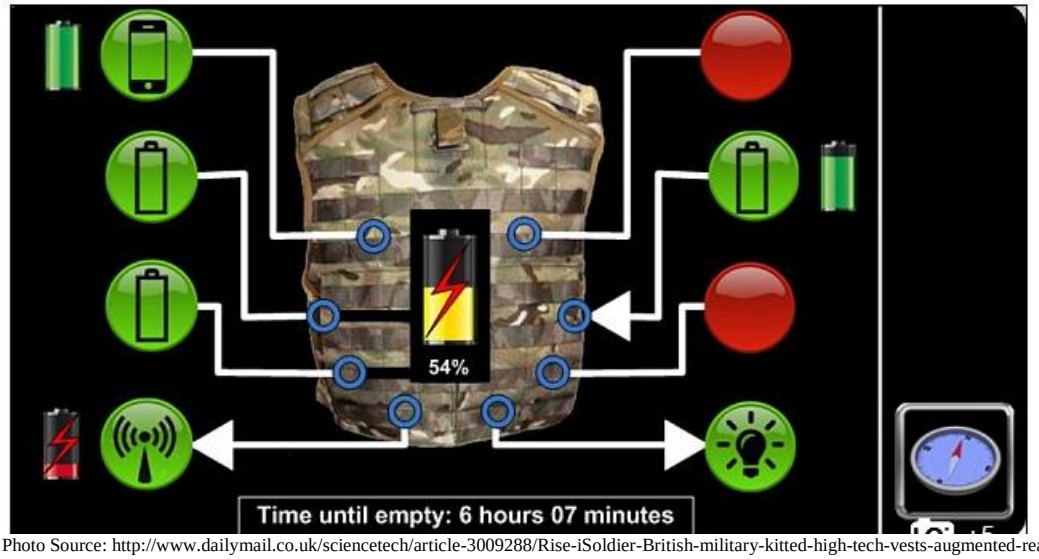


Photo Source: http://www.dailymail.co.uk/sciencetech/article-3009288/Rise-iSoldier-British-military-kitted-high-tech-vests-augmented-reality-helmets-wearable-chargers.html

8.1.2 BiiSafe Buddy

Technology name: BiiSafe Buddy

Description: BiiSafe Buddy combines "lost item tracking, location sharing and distress signal functionalities. A simple press of a button shares a user's location with their trusted circle, sends a help request or a pre-defined message. Paired with the free app for iOS and Android, BiiSafe Buddy is also a convenient way to instantly find lost things." BiiSafe is partnering with Samsung and Array Acquisitions.

Status: Available

Funding:

Product link: http://biisafe.com/

Source: BiiSafe Buddy is Ready to Capture the US Wearable Market, Company Expecting 10-fold Sales Increase
http://www.marketwatch.com/story/biisafe-buddy-is-ready-to-capture-the-us-wearable-market-company-expecting-10-fold-sales-increase-2015-03-23

8.1.3 Catapult: Clearsky

Technology name: Clearsky indoor athlete tracker

Description: The Clearsky athlete tracker integrates with Catapult's Optimeye T5 location-positioning tracking to provide "pinpoint accuracy, high update rates, portability, quick setup, no cabling required, and operates in the most severe and dense multipath radio environments." The system "uses triangulation to track a player's every move via nodes. Nodes are small, portable, wireless devices that . . . act as satellites within a stadium, constantly sending and receiving signals." The device does so with 15-20 cm absolute positional accuracy. The device also uses OpenField athlete analytics platform to interpret and analyze the data.

Status: Soon to be released - ClearSky will be officially launched for purchase by teams in the US following the MIT Sloan Sports Analytics Conference in Boston

Funding:

Product link: http://www.catapultsports.com/us

Source: CATAPULT CLEARSKY: WEARABLE ATHLETE TRACKING APPLIED INDOORS http://www.catapultsports.com/united-states/media/catapult-clearsky-wearable-athlete-tracking-applied-indoors

8.1.1 Connectivity AB, Broadcom Corporation

Technology name: Connectivity Reference Design (CRED) platform for wearables

Description: The CRED platform "features a 32x30mm form factor and encompasses Broadcom's latest low-power platform for Android Wear" as well as an advanced application processor and Broadcom's leading Wi-Fi and Bluetooth combo chip, so that "customers can choose to integrate GPS with Sensor Hub processing, near field communication, wireless charging support and camera support based on their specific product needs." Key features include a complete feature set in an ultra-compact design, low cost and fast time-to-market, access to highly competitive cellular and connectivity technologies, and customizability.

Status: Available

Funding:

Product link: http://sigmaconnectivity.se/cred/

Source: Sigma Connectivity Announces Cooperation with Broadcom on Wearable Reference Design http://sigmaconnectivity.se/pressrelease/sigma-connectivity-announces-cooperation-with-broadcom-on-wearable-reference-design-2/

8.1.2 Creative Materials

Technology name: Electrically conductive inks and adhesives

Description: Creative Materials is developing electrically conductive inks and adhesives for wearable devices. Anticipated applications include "medical devices such as fetal heart rate monitoring, sleep analysis and critical patient care; health and fitness activity tracking; GPS tracking of emergency response and security/intelligence personnel. The devices are placed either on the skin or on clothing and communicate wirelessly through smart phone integration." Creative Materials' products include "125-19FS [which] is a flexible screen-printable silicone-based conductive ink that offers low-temperature performance to minus 70 degrees C, and high temperature properties up to plus 325 degrees C. Its stretch-ability far out performs standard functional inks, while maintaining acceptable conductivity. 120-07 is a screen-printable extremely conductive ink with excellent creasing resistance and wash-ability features. 124-33 is a screen-printable conductive adhesive with excellent adhesion to fabric substrates, combined with excellent flexibility and resistance to creasing. Conductive adhesives are used to bond active components to a circuit."

Status: Available

Funding:

Product link: https://server.creativematerials.com/datasheets/DS_125_19FS.pdf
https://server.creativematerials.com/datasheets/DS_120_07.pdf
https://server.creativematerials.com/datasheets/DS_124_33.pdf

Source: Electrically conductive inks and adhesives for wearable electronics
http://www.printedelectronicsworld.com/articles/7612/electrically-conductive-inks-and-adhesives-for-wearable-electronics

Photo Source: http://www.printedelectronicsworld.com/articles/7612/electrically-conductive-inks-and-adhesives-for-wearable-electronics

8.1.3 Delft University of Technology

Technology name: Wearable human-computer interface (HCI)

Description: Researchers looking for "an innovative wearable HCI interface for a particular application based on the integration of HCI technologies" and thus developed "a wearable device that combines brain imaging, eye tracking and gaze detection technologies in a single headband. It uses these technologies to analyze its user's study performance and supply you with unobtrusive feedback through a smartphone, tablet or PC."

Status: Evolving

Funding:

Product link:

Source: Development of an Innovative Wearable Human-Computer Interface
http://repository.tudelft.nl/view/ir/uuid:d598ada3-8f53-425f-9da0-5704b9931bc1/

8.1.4 Ford Motor Co.

Technology name: Vehicle Internet of Things capabilities

Description: Ford Motor Co. is "trying to figure out how to accommodate a bevy of new internet-connected devices such as fitness bands and smartwatches in its vehicles" and "exploring a variety of ways to bring safety, health and wellness into its vehicles by connecting consumer wearable devices to its

vehicles." For example, a driver's smart devices could connect with the vehicle. Ford proposes that it "would be respectful of privacy and health-care regulations by encrypting the data, not storing it and only sharing it in the ways the owner authorizes. For example, drivers may want to be alerted through Ford Sync, its in-vehicle multimedia system, if their blood glucose levels start to drop or to monitor a diabetic child sleeping in the back seat or perhaps share the information with physicians. The company is interested in working with manufacturers of those devices and software developers to determine the best ways to get that information out of the devices."

Status: Evolving

Funding:

Product link:

Source: Ford Grapples With Wearables and the Future of IoT
http://blogs.wsj.com/cio/2015/03/31/ford-grapples-with-wearables-and-the-future-of-iot/

8.1.1 Google

Technology name: Cancer-detecting wristband

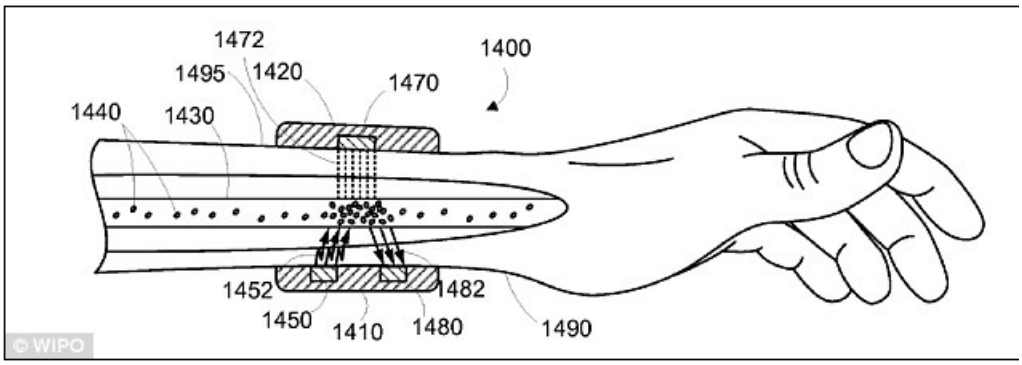
Description: Google is developing a patented wristband to detect cancer and is testing the device on human skin molds. The technology will use an external energy source such as ultrasound or radio frequencies to modify or destroy targets in the blood. Researchers propose that new technologies that measure chemicals (enzymes, hormones, proteins, etc.) in a person's blood could indicate a medical condition and that Google's wearable would target substances by transmitting energy (via infrared signals, radio frequency, acoustic pulse, magnetic field, etc.) into the vessels: "The energy used would depend on what the band is targeting, but it would be designed to alter the chemical composition of the analyte." Google is also exploring the capacity to "work with nanoparticles that circulate around the body looking for cells. After travelling around the body, these nanoparticles would then be collected, using a magnet, to reveal what cells they encountered. The nanoparticles would cause the cancer cells to light up, for example, allowing the wristband to record whether there are dangerous cells in the body. The system relies on light emitted from the cells as a result of the nanoparticles, so scientists must understand how light passes through skin."

Status: Evolving

Funding:

Product link: https://patentscope.wipo.int/search/en/detail.jsf?docId=US130905048

Source: Google wins patent for wristband that could treat CANCER: Wearable would target unhealthy cells using bursts of energy
http://www.dailymail.co.uk/sciencetech/article-2999173/Google-wins-patent-wristband-treat-CANCER-Wearable-target-unhealthy-cells-using-bursts-energy.html



Google's patent explained its wearable (illustrated) could target any substances or objects that, when present in the blood, may affect the health of a wearer by transmitting energy into the vessels. This could include infrared signals, a radio-frequency or acoustic pulse, or a magnetic field

Photo Source: http://www.dailymail.co.uk/sciencetech/article-2999173/Google-wins-patent-wristband-treat-CANCER-Wearable-target-unhealthy-cells-using-bursts-energy.html

8.1.2 IBM

Technology name: Internet of Things business unit

Description: IBM is investing $3 billion in the Internet of Things business, particularly for industry-specific cloud-based services and tools to "help developers populate applications with data from Internet-connected devices." IBM also announced a partnership with forecast provider The Weather Company to "help industries operationalize their understanding of the impact of weather on business outcomes and take action systemically to optimize those parts of their businesses." The move addresses the increasing consumer demand for collecting, analyzing, and acting on data from wearable sensors and other devices.

Status: Evolving

Funding:

Product link:

Source: IBM commits $3B for new Internet of Things business unit
http://venturebeat.com/2015/03/30/ibm-commits-3b-for-new-internet-of-things-business-unit/

8.1.3 Intelligent Textiles Ltd

Technology name: Woven electronics

Description: Intelligent Textiles Ltd is exploring the use of smart textiles to lighten soldiers' load. The company combines electronics engineering, product design, and knitting to weave electronics into fabric: "That allows technology to soup up items traditionally made from fabric, for example in fine-tuning which parts of a glove or deep-sea diver's suit are heated, ensuring the wearer is warm enough where needed without wasting the heating system's power. And it also allows versatile fabric to replace traditional hardware." Using the "high tech fabric," the company developed a full QWERTY keyboard in a single piece of fabric for use in the Stryker, replacing a traditional hardware keyboard that involved 100 components." The company has also worked on SWIPES ("a chest-mounted Samsung Galaxy Note 2 smartphone") and BAE's Broadsword, including the vest which features an inductive charging station that

draws power from charging plates in vehicle seats. The company's current project is Spirit, a wearable system for the US Army and Marine Corps.

Status: Evolving

Funding:

Product link:

Source: Wearables at war: How smart textiles are lightening the load for soldiers
http://www.cnet.com/news/wearables-at-war-how-smart-textiles-are-lightening-the-load-for-soldiers/

A soldier wearing the BAE Broadsword power and data distribution harness, which uses e-textiles embedded within the uniform.

BAE Systems

Photo Source: http://www.cnet.com/news/wearables-at-war-how-smart-textiles-are-lightening-the-load-for-soldiers/

8.1.4 Massachusetts Eye and Ear, Schepens Eye Research Institute

Technology name: Collision warning device

Description: Researchers are developing a pocket-sized wearable collision warning device that may help patients with vision loss avoid collisions with high-level obstacles. The device predicts impending collisions based on time to collision, giving warnings when users approach obstacles. In a density obstacle course test, "Twenty five patients with tunnel vision or hemianopia completed the obstacle course study and the number of collisions and walking speed were measured. Compared to walking without the device, collisions were reduced significantly by about 37% with the device and walking speed barely changed. No patient had more collisions when using the device than when not using it."

Status: Evolving

Funding: This research was supported by Department of Defense grant DM090201.

Research link: http://www.ncbi.nlm.nih.gov/pubmed/25788655

Source: Wearable device helps vision-impaired avoid collision
http://www.eurekalert.org/pub_releases/2015-03/meae-wdh032615.php

8.1.5 MediaTek: Cloud Sandbox

Technology name: Cloud Sandbox platform

Description: The Cloud Sandbox platform features "data storage and visual charting, data monitoring (including notifications), remote control of devices, over the air firmware upgrades, web or mobile application access and RESTful API support including TCP socket connection." The platform is available to MediaTek customers "provides the convenient storage of and access to data from wearable and IoT devices during the prototype stages. The benefit to developers is that they won't need to invest time, money and energy setting up and managing their own web server, or sourcing third party cloud platform services, whilst working on IoT or wearable devices. This should reduce the time it takes to bring a product from the prototype or proof-of-concept stage to the market because it means the development team can concentrate on developing the product rather than administering the back office systems."

Status: Available

Funding:

Product link: https://mcs.mediatek.com/

Source: MediaTek Opens Up Cloud Sandbox To Help Developers Test New Wearable and Internet of Things Products
http://androidheadlines.com/2015/03/mediatek-opens-up-cloud-sandbox-to-help-developers-test-new-wearable-and-internet-of-things-products.html

8.1.6 MIT Media Lab

Technology name: Finger-mounted text-to-audio converter

Description: Researchers prototyped a device "that can be mounted on the fingers, has a built-in camera and converts text into audio for users that cannot see. The user has to move their fingers over the text, the camera reads the word that the user is pointing to and converts it into audio which the user can hear. . . . The key essence of the working is the algorithm that converts camera's feed to audio. When the user keeps their finger at a start of a new line, the algorithm will try and make a number of guesses about the baseline (the point of reference) of letters." As they move their finger along the line, the camera captures the words and the algorithm continues to realign and improve its baseline. Researchers are also addressing the challenge of how visually impaired users will know that their finger is on the word: "One solution is that the device on the reader's fingers will have two haptic sensors, one on the top of the finger and the other below it. The vibration of the respective motors will indicate whether the reader should move their hand up or down to reach the actual line of text. The second solution is in the form of audio. The volume of musical tone that will play will increase if the reader's finger moves away from the text. If the finger moves towards the text, the volume will decrease."

Status: Evolving

Funding: MIT Media Lab Consortia and the MITSUTD International Design Center funded this work.

Research link: http://fluid.media.mit.edu/sites/default/files/FingerReaderCHI15%20Camera%20Ready-fonts%20embedded.pdf

Source: Wearable Device That Allows The Visually Impaired To Read
http://www.crazyengineers.com/threads/wearable-device-that-allows-the-visually-impaired-to-read.79497/

Photo Source: http://www.crazyengineers.com/threads/wearable-device-that-allows-the-visually-impaired-to-read.79497/

8.1.7 Nottingham University: SenSei Glove

Technology name: SenSei Glove

Description: The SenSei Glove, designed to assist visually impaired users, "senses the proximity of objects and allows for safe navigation." The gloves feature an ultrasonic sensor that beeps when objects are within a certain distance.

Status: Evolving

Funding: $1,540 from the Nottingham Business School Entrepreneurship and Business Competition

Product link:

Source: SenSei Glove Is A Wearable Gadget That Helps The Blind Navigate Easily
http://wonderfulengineering.com/sensei-glove-is-a-wearable-gadget-that-helps-the-blind-navigate-easily/


Photo Source: http://wonderfulengineering.com/sensei-glove-is-a-wearable-gadget-that-helps-the-blind-navigate-easily/

8.1.8 Philips, Leiden University Medical Center

Technology name: Wearable sensors to support elderly people

Description: Philips and Leiden University Medical Centre "will fit people over 50 with wearable sensors, such as 'smart' bandages, clothing, and watches. These will collect data to monitor and help improve the participants' health. The data will be used to develop algorithms that help determine to what extent patients are adhering to their medical treatment plans and personal health goals." The partners are "also working on programmes involving neurological image forming for research into Alzheimer's disease."

Status: Evolving

Funding:

Product link:

Source: Philips partners Leiden medical school on wearables research
http://www.telecompaper.com/news/philips-partners-leiden-medical-school-on-wearables-research--1073442

8.1.9 Sensoplex Inc.: Rocket

Technology name: Rocket platform

Description: Sensoplex's Rocket platform "will be available as an evaluation and development kit platform (EVK and SDK) that will allow customers to quickly develop innovative wearable applications that can combine inertial, bio and environmental sensors, Bluetooth Low Energy, and ANT+ wireless protocols with ultra low-power processing." Key components include inertial, bio, and environmental sensors; wireless data communications over low-energy Bluetooth or ANT+; microcontrollers with low-power management for battery-powered applications; flash memory; a single-chip solution for accurate bio-signal detection and processing; microphone; wireless charging. The platform reportedly "enables companies in the wearables and IOT space to develop vertically integrated devices, using holistic techniques similar to Apple's, with a fraction of the resources -- freeing them up to focus on differentiating factors such industrial design, app development, and marketing."

Status: Soon to be released

Funding:

Product link: http://www.sensoplex.com/sensoplex-rocket-platform/

Source: Sensoplex Unveils Rocket Platform, Allowing IOT and Wearable Companies to Build Fully Integrated Devices with Apple-Style Design Philosophy
http://www.webwire.com/ViewPressRel.asp?aId=196313#.VQxbsk0cRmM

8.1.10 Stanford University

Technology name: Machine learning to benefit wearable data analytics

Description: In this project, researchers use "machine learning to classify user activity, and [they] compare the strengths and weaknesses of supervised and unsupervised learning approaches using LDA, SVM and Random Forest classifiers, and K-means clustering classifiers, respectively. [The researchers] then discuss which of these algorithms show the best performance for general activity recognition." The researchers propose applications in activity recognition to benefit healthcare such as fall detection.

Status: Evolving

Funding:

Product link:

Source: Modeling Activity Recognition Using Physiological Data Collected from Wearable Technology http://cs229.stanford.edu/proj2014/Cezanne%20Camacho,%20Jennifer%20Li,%20Jeffrey%20Yang,%20Modeling%20Activity%20Recognition%20Using%20Physiological%20Data%20Collected%20from%20Wearable%20Technology.pdf

8.1.11 State Key Laboratory of Molecular Engineering of Polymers et al.

Technology name: Light-emitting fibers

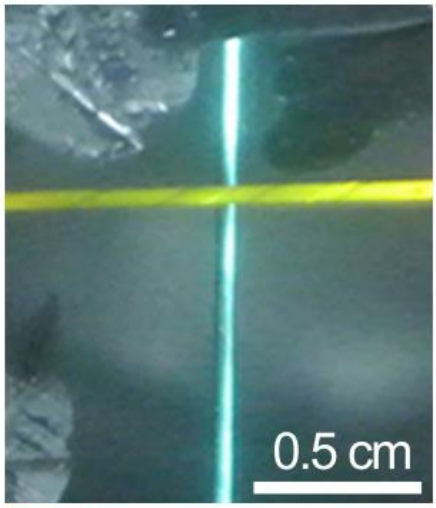
Description: Scientists are integrating light-emitting devices into fabric by working with polymer light-emitting electrochemical cells (PLECs): "Like many other light-emitting devices, PLECs have a structure that is composed of two metal electrodes connected to a thin organic layer that acts as a semiconductor. Because PLECs have mobile ions incorporated into the semiconductor, they have many benefits compared to other light-emitting diodes (LEDs): low operating voltage, high efficiency in converting electrons to photons, and high power efficiency. PLECs are also a good option because they do not require the use of metals that are sensitive to air and they can be used on rougher surfaces; these characteristics make them suitable for large-scale manufacturing." Scientists found that the "fibers gradually light up over a 21-minute period and gradually dim over a four-hour period; in these studies, the light emitted by the fibers was blue. The fiber lit up when a voltage of 5.6V was applied and reached a peak intensity at 13V. When the fiber is pre-charged, it displays a rapid turn-on response that is similar to conventional LEDs." The research project demonstrated "light-emitting fibers can be woven into fabrics without compromising their luminescence, which makes them a promising candidate for the development of wearable electronics and other fabric-based electronics in the future."

Status: Evolving

Funding: This work was supported by the Ministry of Science and Technology of China (2011CB932503), the National Natural Science Foundation of China (21225417, 61136003), the Science and Technology Commission of Shanghai Municipality (12nm0503200), the Fok Ying Tong Education Foundation, the Program for Special Appointments of Professors at Shanghai Institutions of Higher Learning and the Program for Outstanding Young Scholars from the Organization Department of the CPC Central Committee.

Research link: 10.1038/NPHOTON.2015.37

Source: Organic LEDs, carbon nanotubes may light up future fabrics http://arstechnica.com/science/2015/03/organic-leds-carbon-nanotubes-may-light-up-future-fabrics/



Enlarge / A prototype glowing fiber.

Photo Source: Huisheng Peng

Appendix A

Technology Summary

Appendix A

Technology Summary

The following spreadsheet provides a summary of the technologies compiled in this report. For an electronic copy, please contact Jaki Upton at jaki.upton@pnnl.gov. *This information is not meant to be an exhaustive list nor an endorsement of any technology described herein.*

Company	Technology	Description	Status
Sensor			
Physiological			
Brain Sentry	Helmet sensors	Wearable sensors are placed in helmets to collect data from physical impacts	Available
Chinese Academy of Sciences	Large-Area Nanocrystal Arrays of Metal–Organic Frameworks	Pressure sensors based on solution-processed metal–organic frameworks nanowire arrays are fabricated with very low cost, flexibility, high sensitivity, and ease of integration into sensor arrays	Evolving
Darta Systems	EMVIO stress-tracking watch	Smartwatch that measures your stress using an optical pulse sensor, touch sensor, accelerometer, and algorithms to calculate calorie burn and heart rate.	Evolving
LifeQ	LifeQ Lens, Core, and Link	Devices that combine computational systems biology and continuous body monitoring to create an on demand record of one's personal physiology and health.	Evolving
MultiSense Memory patch	MultiSense Memory patch	A flexible, sensor-rich-patch that attaches to the sternum of a patient with adhesive that measures heart rate, temperature, and oxygen saturation. Disposable with a 7-10 day battery life.	Available
North Carolina University ASSIST	Self-powered health/fitness monitors	Exploring devices to convert body energy into fitness trackers. Potential devices include a wired wristband or an EKG heart monitor embedded in a T-shirt to measure and analyze physiological activity. The devices would also be powered from body heat and body motion.	Evolving
North Carolina University ASSIST	Wearable air-monitoring sensor	Powered by the user's body heat and motion, this device will monitor the wearer's vital signs and surrounding environment	Evolving
STEMP	Smart Temperature Patch	Wearable thermometer that inserts into a disposable medical-grade adhesive patch that is placed under the arm. The device is Bluetooth-connected and features a 30-day charge life and 7-day adhesive strength.	Evolving
TechBeach	Wearable baby monitor	Sensor-filled onesie that tracks everything from temperature to heart rate and how many times a child moves in their sleep and synchs the information to a smartphone.	Evolving
Texas Instruments	Temperature sensors	Temperature sensor for wearables with 0.13C temperature accuracy, fast thermal response, and USB form factor PCB board.	Available
University of California San Diego Center for Wearable Sensors	Wearable sensors	Wearable sensors that use electro-chemical detection and measure a cadre of physiological metrics such as metabolic functions, glucose levels, and pH levels. Researchers also developed a functional biofuel cell that can generate electricity from sweat, reportedly enough electricity to power an LED or wristwatch.	Evolving

University of Illinois et al.	Wearable electrodes	soft, flexible, wearable electrodes to read brain signals	Evolving
VSP Global	Project Genesis health-tracking optical frames	Integrates health-tracking technology into a pair of optical frames, with three-day battery life.	Evolving
	OTHER		
Infineon Technologies AG	DPS310 Micro Electro Mechanical Systems (MEMS) pressure sensor	Ultra-high resolution, miniature MEMS “low-power digital barometric pressure sensor that enables the development of new and enhanced navigation, location, well-being, gesture recognition and weather monitoring applications. Can handle performance at pressures from 300hPa to 1200hPa and at temperatures from 40°C to 85°C.	Available
Kionix Inc.	KX112, KXCJB accelerometers	KX112 is a thin, tri-axis accelerometer measuring 2-mm x 2-mm x 0.6 mm, ideal for wearables, with 16-bits of resolution and built-in digital algorithms for detecting motion for power management. The KXCJB accelerometer measures 3-mm x 3-mm x 0.45-mm thick with the ability to embed motion detection and motion sensing capabilities into a host of new devices such as badges.	Available
National Applied Research Laboratories	Single-chip sensor	Research exploring integrating different sensors on a single, "rice-sized" chip for more energy-efficient chips for wearable devices.	Evolving
New Mexico State University	Low-powered wearable micro-devices	A new design strategy to construct better circuits to build a bridge between the human body and the environment, drawing on the concept of computer code.	Evolving
Samsung Advanced Institute of Technology	Image sensor	A low-power, 15 frames-per-second image sensor for always-on mobile and wearable devices. The image sensor offers an ultra-low power always-on resolution mode and a mode for photographic quality resolution.	Evolving
University of California, San Diego	Enzyme-based inks	Enzyme-based inks for use as low-cost wearable sensors and for rapid fabrication of high-quality, flexible, and inexpensive bio-sensors which can be easily applied to a wide variety of surfaces and textures with minimal user training.	Evolving
	DISPLAYS		
	Heads-up Displays		
Buckham and Duffy	Heads-up display glasses	Technology that can overlay a huge range of data in the user's view using glass.	Evolving
Epson	Moverio BT-200 augmented reality goggles	Binocular, see-through smart glasses with augmented reality capabilities. Includes a front-facing camera and motion trackers, a ‘floating’ 80-inch perceived screen, Wi-Fi and Bluetooth connectivity and an interactive track pad.	Evolving
General Motors	In-vehicle heads-up display	Technology to help reduce driver distraction, such as a heads-up displays that allow users to select from screens that focus on navigation, audio information, a tachometer, or simply a speedometer.	Evolving

HTC	Vive virtual reality headset	Virtual reality headset with full 360-degree immersion, tracking controllers and high-quality graphics running at 90 frames-per-second	Evolving
NASA, Osterhout Design Group	Augmented reality glasses	Augmented reality glasses equipped with a system where how-to guides can be uploaded to the glasses, allowing astronauts to follow directions while their hands are full.	Evolving
Vidyoworks	Smart glass application	VidyoWorks mobile client application program interfaces are available for smart glasses to embed real-time video, audio, content communication, and collaboration into applications.	Evolving
Virgin Atlanti, Sony	Sony SmartEyeGlass	Virgin Atlantic airline engineers are using Sony's SmartEyeglass Developer Edition SED-E1, tablet, mobile phone and SmartWatch 3.	Available
POWER			
Charges			
Apple	Power management for inductive charging systems	Patented techniques for delivering useful power to a portable electronic device that does not deplete the battery of the portable electronic device. The patent covers electromagnetic inductive power transfer, and in particular to adaptive power control systems for maximizing the efficiency of power transfer.	Evolving
Texas Instruments	bq25100 single-cell Li-ion charger, TIDA-00318 wireless charger, TIDA-00334 wireless power transmitter	Various options to maximize battery life of wearables including small single-cell lithium ion charger, linear battery charger, wireless power transmitter.	Available
Self-Powering (Harvesters)			
Sungkyunkwan University	Energy-generating cloth	Durable, flexible cloth using triboelectric nanogenerators to harness human motion to generate energy. It can also self-charge batteries or supercapacitors without an external power source and make new commercial and medical applications possible.	Evolving
Texas Instruments	bq25570 Ultra Low Power Harvester Power Management IC with Boost Charger, and Nanopower Buck Converter	Ultra low-power harvester power management IC with boost charger that takes the 300 to 400 millivolts collected by energy harvesters and boost this power to 3 to 5 volts, which is enough to charge a battery. The device also features "a highly efficient nano-power buck converter to provide the option of a second power rail to the system."	Available
Ulsan National Institute of Science and Technology (UNIST)	Triboelectric generators	This research explores the use of riboelectric generators with high-power generation to achieve using flexible and lightweight textiles or miniaturized and hybridized device configurations and the developments and future prospects of triboelectric energy harvesters and sensors, which may enable fully self-powered wearable devices with significantly improved sensing capabilities.	Evolving
Power Supplies			

Ams AG	AS3701 integrated power management unit	The AS3701 micro, integrated power management unit offers a small footprint with a low quiescent current, multiple power-regulation, power-saving, battery-charging, protection and start-up functions in a chip-scale package (WL-CSP) measuring just 2mm x 2mm x 0.4mm. Its power path management allows a device to start up with a dead battery, and optimizes power distribution between the battery charging circuit and the system power supply.	Available
Holst Centre, TNO, Pauline van Dongen	Solar Shirt	Solar Shirt combines solar panels and flexible electronics into a T-shirt that can charge your smartphone or other portable devices. The shirt generates power from 120 thin-film solar cells integrated into the fabric itself. In bright sunlight, it produces around 1 W of electricity - enough to charge a typical phone in a few hours	Evolving
Imprint Energy	Printable and flexible batteries	Imprint Energy is pioneering printable batteries for which “Zinc is used for the anode part of the battery, and combines that with a solid polymer electrolyte and a cathode made of a metal oxide.” Additionally, the Pebble watch offers “weeks” of battery life with a passive resolution colored display and low-cost 130mAH lithium battery.	Evolving
ROHM, Kobe University	Small, ultra-low-power technology	A small, ultra-low-power technology for wearable biosensors that uses non-volatile memory in order to suppress standby power generation by enabling the power supply to be turned off when no processing/operation is required.	Evolving
STMicroelectronics	Enfilm thin-film battery	Bendable, rechargeable 700microAh battery about a fifth of a millimeter thick and as large as a standard US postage stamp.	Available
COMMUNICATIONS			
Short-range, low-power Bluetooth			
Bluetooth	Bluetooth 4.2	Provides low power, faster data throughput (“2.5 times faster than Bluetooth 4”), IPv6, and mesh networking, which allows for Cloud-connectivity and improved wireless range.	Soon to be released
Hands-free operation			
MUV Interactive	Sphere, Bird	Bird is a ring that turns a user’s surroundings into an interactive workspace with remote touch, hovering, depth sensing, gesture control, and mouse functionality. Sphere is installed on the ceiling to project content from connected devices onto any surface via touch, motion and voice.	Evolving
TheEyeTribe	Eye-tracking technology	Combines eye-tracking with an accelerometer to allow the display of the watch to turn on only when you are looking at the watch, thus helping to conserve battery life.	Evolving
CAMERAS			

Nixie	Nixie drone-camera wristband	Wearable, flyable camera, targeted at rock climbers, can be worn on the wrist but also flies as a drone camera.	Soon to be released
QueTel	Traq	Digital TraQ is a secure, easily searched single repository for the growing volume of digital evidence—still images, videos and voice recording. Evidence TraQ automates the process of seizing, managing and disposing of guns, drugs, money and other physical evidence. Currently in use by Nebraska's Bellevue Police Department.	Available
EXOSKELETON			
Alfred I. duPont Hospital for Children	Wilmington Robotic Exoskeleton	3D-printed wearable upper-limb device with linear elastic bands that give multidimensional movement to little arms limited by orthopedic and neuromuscular disabilities. Mechanical linkage powered by rubber bands removes the gravity that weighs limbs down.	Available
Harvard University	Soft wearable robotics	Combining robotics, design, chemistry, advanced manufacturing, and the mechanics of materials, focusing on applying soft robotic systems to help individuals overcome disabilities, and to augment the performance of able-bodied people.	Evolving
Noonee	Chairless Chair	Hydraulic powered chair with a titanium frame that hugs the back of the worker's leg like a flexible brace, while a support belt is strapped around their torso. Workers can stand and walk like normal then push a button that locks the frame into place at the desired angle, creating a chair.	Evolving
Rewalks	ReWalk Personal Exoskeleton System	Wearable robotic suit that provides powered hip and knee motion to individuals with spinal cord injuries. Integrates wearable brace support, a computer-based control system, and motion sensors to allow for independent, controlled walking while mimicking the natural movement of the legs.	Evolving
University of Southampton	Soft robotic trousers	Trousers and socks that feature artificial 'muscles' made from smart materials and reactive polymers which are capable of exerting great forces. The device features the latest wearable soft robotic, nanoscience, 3D fabrication, functional electrical stimulation and full-body monitoring technologies. The device will include control systems that monitor the wearer and adapt to give the most suitable assistance, working with the body's own muscles.	Evolving
OTHER			
BAE Systems, Intelligent Textiles Design	Broadsword, Spine, Q-Warrior	Spine uses e-textiles to wirelessly charge military equipment - and this energy use can be monitored using a smartphone app. BAE also created an inductive seat charger that automatically transfers energy from a vehicle to the vest. Additionally, Q-Warrior is a see-through augmented reality display that integrates with the Spine and smartphone to overlay useful information such as GPS locations, temperatures and other data.	Evolving

BiiSafe	BiiSafe Buddy	Combines lost item tracking, location sharing and distress signal functionalities. A simple press of a button shares a user's location with their trusted circle, sends a help request or a pre-defined message. Paired with the free app for iOS and Android, BiiSafe Buddy is also a convenient way to instantly find lost things.	Available
Catapult	Clearsky indoor athlete tracker	Athlete tracker integrating with Catapult's Optimeye T5 location-positioning tracking to provide pinpoint accuracy, high update rates, portability, quick setup, no cabling required, and operates in the most severe and dense multipath radio environments. Uses triangulation to track players via nodes (small portable devices that act as satellites in a stadium) with 15-20cm accuracy.	Soon to be released
Connectivity AB, Broadcom Corporation	Connectivity Reference Design (CRED) platform for wearables	Platform with 32x30mm form factor, Broadcom's latest low-power platform for Android Wear, advanced application processor and Broadcom's leading Wi-Fi and Bluetooth combo chip. Customers can choose to integrate GPS with Sensor Hub processing, near field communication, wireless charging support and camera support based on their specific product needs.	Available
Creative Materials	Electrically conductive inks and adhesives	electrically conductive inks and adhesives placed either on the skin or on clothing and communicate wirelessly through smart phone integration. Products include a flexible screen-printable silicone-based conductive ink that offers low-temperature performance to minus 70 degrees C, and high temperature properties up to plus 325 degrees C; a screen-printable extremely conductive ink with excellent creasing resistance and wash-ability features; and a screen-printable conductive adhesive with excellent adhesion to fabric substrates, combined with excellent flexibility and resistance to creasing.	Available
Delft University of Technology	Wearable human-computer interface (HCI)	A wearable device that combines brain imaging, eye tracking and gaze detection technologies in a single headband. It uses these technologies to analyze its user's study performance and supply you with unobtrusive feedback through a smartphone, tablet or PC.	Evolving
Ford Motor Co.	Vehicle Internet of Things capabilities	Ford Motor Co. is exploring how to accommodate internet-connected devices such as fitness bands and smartwatches in its vehicles and ways to bring safety, health and wellness into its vehicles by connecting consumer wearable devices to its vehicles.	Evolving
Google	cancer-detecting wristband	Patented wristband to detect cancer and is testing the device on human skin molds. The technology will use an external energy source such as ultrasound or radio frequencies to modify or destroy targets in the blood.	Evolving
IBM	Internet of Things business unit	investing in the Internet of Things business, particularly for industry-specific cloud-based services and tools to help developers populate applications with data from Internet-connected devices. Partnered with The Weather Company.	Evolving

Intelligent Textiles Ltd	Woven electronics	use of smart textiles to reduce soldier's load: combines electronics engineering, product design, and knitting to weave electronics into fabric. The company's working on Spirit, a wearable system for the US Army and Marine Corps.	Evolving
Massachusetts Eye and Ear, Schepens Eye Research Institute	Pocket-sized wearable collision warning device	A pocket-sized wearable collision warning device that may help patients with vision loss avoid collisions with high-level obstacles. The device predicts impending collisions based on time to collision, giving warnings when users approach obstacles.	Evolving
MediaTek	Cloud Sandbox	Data storage and visual charting, data monitoring (including notifications), remote control of devices, over the air firmware upgrades, web or mobile application access and RESTful API support including TCP socket connection.	Available
MIT Media Lab	Finger-mounted text-to-audio converter	A finger-mounted device with a built-in camera that converts text into audio for users that cannot see.	Evolving
Nottingham University	SenSei Glove	A glove designed to assist visually impaired users by sensing the proximity of objects and allows for safe navigation. An ultrasonic sensor is incorporated into the gloves' back side and beeps when the distance between the wearer and nearby object is too less.	Evolving
Philips, Leiden University Medical Center	Wearable sensors to support elderly people	A study outfitting 50 elderly users with wearable sensors (smart bandages, clothing, watches) from which data will be used to develop algorithms to determine to what extent patients are adhering to their medical treatment plans and personal health goals.	Evolving
Sensoplex Inc.	Rocket platform	An evaluation and development kit platform (EVK and SDK) that will allow customers to quickly develop innovative wearable applications that can combine inertial, bio and environmental sensors, Bluetooth Low Energy, and ANT+ wireless protocols with ultra low-power processing. Features inertial, bio, and environmental sensors; wireless data communications over low-energy Bluetooth or ANT+; microcontrollers with low-power management for battery-powered applications; flash memory; a single-chip solution for accurate bio-signal detection and processing; microphone; wireless charging.	Soon to be released
Stanford University	Machine learning to benefit wearable data analytics	Researchers explore machine learning to classify user activity, and [they] compare the strengths and weaknesses of supervised and unsupervised learning approaches using LDA, SVM and Random Forest classifiers, and K-means clustering classifiers, respectively.	Evolving
State Key Laboratory of Molecular Engineering of Polymers et al.	Light-emitting fibers	Integrating light-emitting devices into fabric by working with polymer light-emitting electrochemical cells, proposing that light-emitting fibers can be woven into fabrics without compromising their luminescence, which makes them a promising candidate for wearables.	Evolving

Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by **Battelle** *Since 1965*

U.S. DEPARTMENT OF
ENERGY

902 Battelle Boulevard
P.O. Box 999
Richland, WA 99352
1-888-375-PNNL (7665)

www.pnnl.gov