The Evolution and Near-term Expected Uses for Body-adapted Wearable Electronics

1. Abstract

First we must understand what is meant by body-adapted wearable electronics and cover the various uses. This includes the difference between clip-ons and adaptable. Then understanding the different possible devices and sensors that makeup this category their purpose, their benefits, and how they should work. As with any technology, it will also be necessary to cover any concerns such as privacy issues. Lastly, the paper will cover at what stage the technology is in, whether the emerging technology will continue to advance or falter, and finally how likely will there be acceptance.

2. Introduction

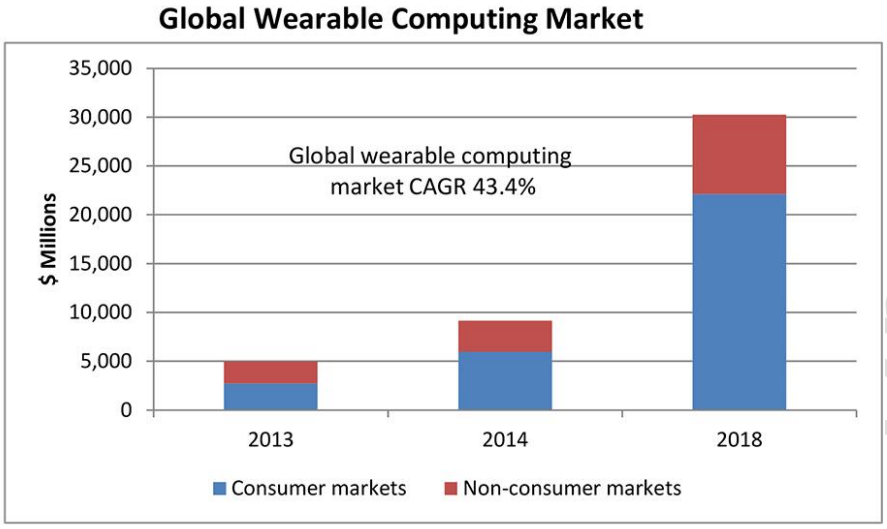
For years consumers have clamored for the next newest gadget. There have been many that have made life easier such as Bluetooth headsets, sports bands that monitors and transfers data to smartphone apps, glasses, and watches just to name a few. Wearable tech sales have skyrocketed over the last few years. It has been estimated that sales have risen to about 1,886% in the last four years (Bleeker). The possibilities for wearable electronics has no ends. It has even invaded the medical industry. It is not possible to wear sensors that monitor and collect various health data that can be used not only by medical staffs buy patience alike. The question, is this a trend or does wearable devices have a place for the long term. Based on the numbers, there seems to be a need and it is increasing. The first place to start is to understand what a wearable electronics is and the numbers that have and will be driving the market.

3. What is a body-adapted wearable electronics?

A body-adapted wearable electronic is a piece of technology that adapts to the body's shape. It is generally small and unobtrusive. These are devices that have evolved sort of speaking from wearable and clip on devices such as Bluetooth headsets and sports bands to devices that adhere to the skin or can be placed inside the body. A good many of these body-adapted devices are becoming more related to the health industries but there are a few ideas that will improve consumer personal use.

To understand how relevant these technologies will be over time and not just a fad, we need to look at the wearable device numbers. From 2009 to 2013 wearable fitness device sales went through the roof. Sales in wearable fitness bands jumped from $43 million in 2009 to $854 million in 2013. These are increasable returns over a five year span. This year it is estimated that sales will increase again to $1.2 billion with an annual growth of 35% (Bleeker). Consumers are always looking for the next gadget that offers them an advantage. Being able to monitor physical fitness efforts, has been what consumers have been wanting for years and they have it. When it comes to the wearable computing market, BCC research have found that the compound annual growth rate has increased from $5 billion in 2013 to $9.2 billion in 2014. That is an increase of 43.4% with an expectation to increase to $30.2 billion by 2018. The consumer market is expected to reach $22.1 billion while the non-customer market to reach $8.1 billion by 2018 (BCCResearch). This can be seen in figure 1. Gartner also released number showing the growth over the last few years and where profits should be by 2016. These are shown in figures 2 and table 1.

Figure 1. Global Wearable Computing Market.



Source: BCC Research (IFT107A), 2014

Figure 2. Income Statement Evolution.

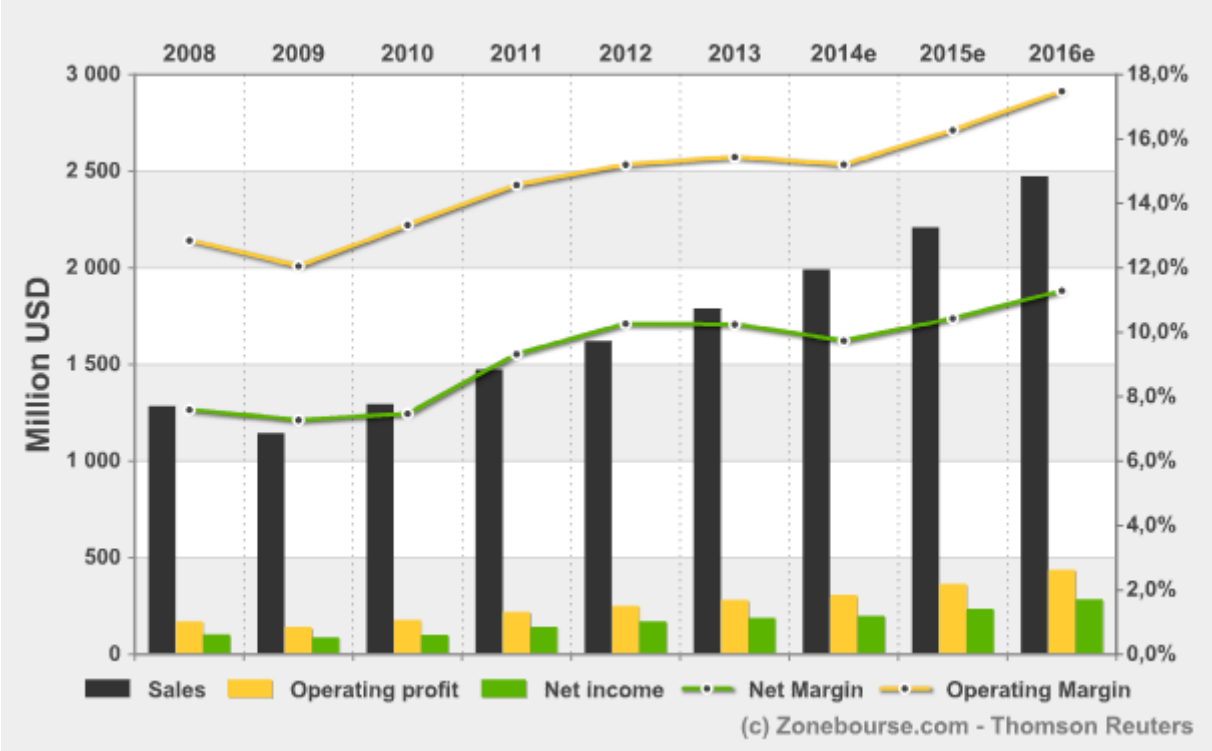


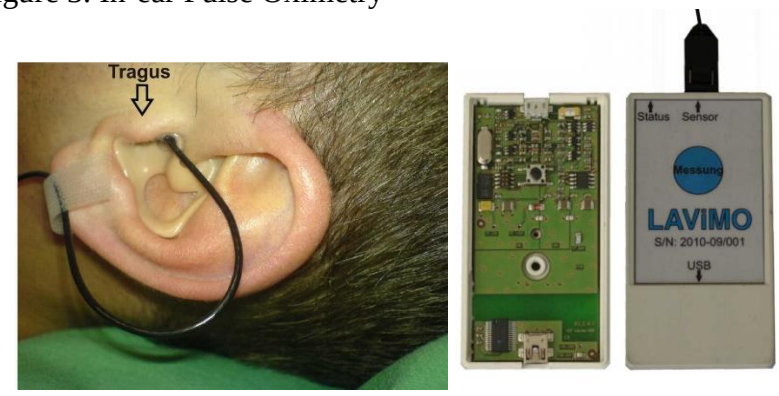
Table 1. Annual Income.
Annual Income Statement Data

	Actuals in M $			Estimates in M $		
Fiscal Period **December**	2011	2012	2013	2014	2015	2016
Sales	**1 469**	**1 616**	**1 784**	**1 988**	**2 204**	**2 469**
Operating income (EBITDA)	**246**	**275**	**310**	**343**	**401**	**475**
Operating profit (EBIT)	**214**	**246**	**275**	**302**	**359**	**432**
Pre-Tax Profit (EBT)	**-**	**236**	**266**	**-**	**-**	**-**
Net income	**137**	**166**	**183**	**194**	**230**	**279**
EPS ($)	**1,39**	**1,73**	**1,93**	**2,10**	**2,56**	**3,17**
Dividend per Share ($)	**-**	**-**	**-**	**-**	**-**	**-**
Yield	**-**	**-**	**-**	**-**	**-**	**-**
Announcement Date	02/07/2012 12:00pm	02/07/2013 12:00pm	02/06/2014 12:00pm	-	-	-

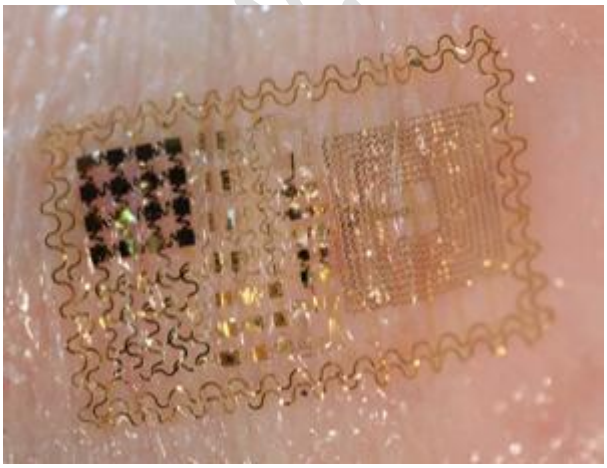
4. Body-adapted wearable devices

In-Ear Pulse Oximetry – The first group of devices are those that assist in monitoring vital health data. These come in several forms with more adaptations on the rise. The first is an earbud device that monitors the cardiovascular and pulmonary system for patience with sleeping disorders. This device is placed in the ear where the sensor element is placed at the inner tragus and then linked to the monitoring system. The ear piece itself is molded to the patient's ear to limit any discomfort. The ear piece gathers the data and transfer it to the sensor interface device. This device is connected to the ear piece by wire. The device can connect to any PC through USB so the collect data can be analyzed. This technology allows for heart rate, O_2 sensing, noise level sensing of both snoring and respiration (Venema). Device has long term need as current methods for monitoring sleep disorders are complicated, accurate only if the technician is capable, and the equipment is cumbersome to the patient. The In-ear pulse Oximetry device is considerably more accurate and easier for the patient to wear. Figure 3 show how the device fix a patient's ear with minimal wiring and elements.

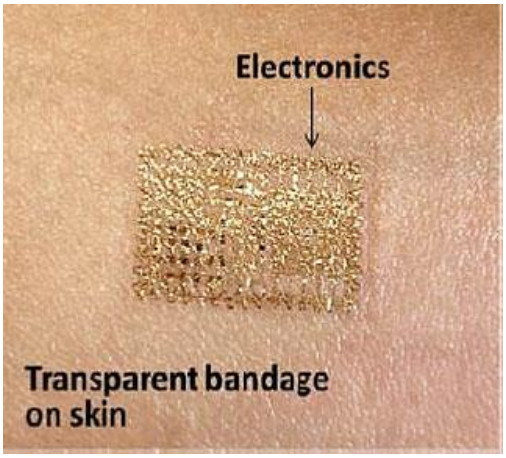
Figure 3. In-ear Pulse Oximetry



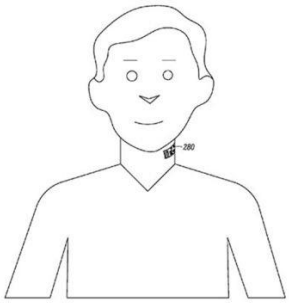
Smart Tattoos – The next technology being developed are temporary tattoos that can monitor a patient's vitals. These are small epidermal electronics that are flexible and elastic. They adhere to the skin and because of their flexibility, they move with the patient making them unrestrictive. The wires that make up the tattoo are created with bends throughout making the tattoo able to flex with the patients skin and not break. The device stays in place for several days before it can no longer maintain it contact with the skin. Current designs require a wired connection for data dump but the next generations will be designed to be wireless. Currently, these tattoos only have a passive monitoring role such as electrophysiological signals from the heart, brain, and other muscles. As the next generation are designed to go beyond these passive features, patients will greatly benefit from the new roles these tattoos will play (Hamzelou). By viewing the earlier passive tattoos, one can see the circuitry and how they are laid out. As the next generations are designed, patients with heart disease will not long have to wear the bulky devices that were needed to monitor to monitor the patient's vital signs. With the new tattoos all of those electrodes and wires will be



thing of the past (Watts). In time, these new tattoos will be able to assist a patient with the inability to speak. They will be able to place a specialized tattoo on their throats and through muscle movements, the patient will be able to communicate. Medical tattoos will also help a blind person read without brail through electrotactile stimulations on the figure tips. These new



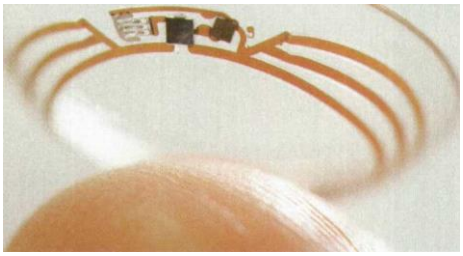
advancements in temporary tattoos are not just confined to the medical field. Motorola and google are collaborating to design a tattoo that can be used a microphone. These tattoos will have wireless connectivity to smartphones or other devices through Bluetooth. The tattoo will pick up vibrations and fluctuations of the throat muscles (Morris). This is said to be like noise cancelation and create a clearer voice signal transfer. This technology has a ways to go because with anything thing related to electronics especially wireless, there has to be a power format and no one is sure how that will be solved.



Haptic Shoe – The next technology with a good deal of promise is haptic shoe. Currently, this technology has been designed with the blind and visually imparts in mind. The

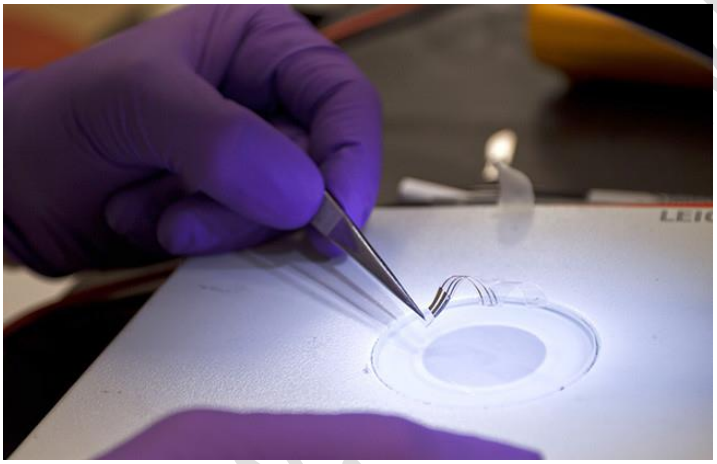
technology work by utilizing a GPS capable smartphone that sends signals to the shoe providing alerts to the wearer about obstacles and directions. Why a shoe? A shoe was selected because on a person, it is almost always facing forward. The shoe works by receiving signals from the proprietary app that causes certain areas of the shoe to vibrate based on the desired direction. The wearer inputs the desired location and the app guides the wearer. If the wearer is supposed to turn left, then the left side of the shoe vibrates. The technology has great potential especially providing freedom for the visually imparted. There are still quite a few bugs to work out such as obstacle detection especially those that move and whether to work on a single shoe method (Healio). This technology is also being used to create the same affects using magnetic field sensors. Instead of using the shoe as the guiding medium, the sole insert will be used. This technology is in its earliest stages and have failed to provide a decent showing. The up side is that the prosed design is to do more than just navigate but possibly provide length and duration based on a wearer's stride (Kikuchi).

Smart Contact Lens – Another adaptive technology that should have lasting results and use are smart contact lens. It seems the Swiss drug maker Novartis and Google have pared up to create a contact lens that can monitor blood glucose levels while assisting in restoring a wearer's ability to focus. The device measures the wearer's glucose by sampling the tear fluid. The sensors and microchips are embedded between contact materials making it comfortable for the user. Diabetics will find this method of glucose monitoring considerably easy than today's methods of testing blood. The two companies hope to



have the technology on the market within the next 4 years. The design implications may move past glucose monitor into possibly remote patient monitoring in heart failure (Wiegmann).

Adaptive Organic Transistors – Adaptive organic transistors is a small device that can be implanted into a patient to monitor different vitals from within. It will provide health care professionals with another avenue to find out what is going on inside of their patient. Another application of the device is to stimulate the body for various treatments (ScienceDaily). What makes the device so remarkable besides it intended use is the fact the device is able to change shape to adapt the items/location that it is being placed on. In a nutshell, the device's structure is so flexible and adaptive it will be able to cling to most 3-D structure such as a blood vessel, tissue, or ligament. This adaptability allows the device to work while the attached structure



works as intended without any interference from the device. The device material is rigid at first outside the body prior to implant but under a certain amount of heat the adaptive material changes its shape to conform to the structure the device is attached to. As stated this leaves the device fully functioning while not causing harm to the location (ScienceDaily).

Wearable Computers – With all of the advancement in technologies, why not wearable computers? Of course with many of the emerging technologies, some can be a little out there is its initial attempts. One of these is from Sony. Sony has been working on a technology where sensors, communication interfaces, and a tactile feedback actuator were integrated into a

hair piece or wig. Sony's vision for the smart wig is to be used as a navigate tool, monitor health vitals, with a camera it could be used like Google Glass or as a remote control by using facial expression. One application for navigation uses sensors and ultrasound to detect objects. To help with navigation the wearer would either receive small electric shocks o vibrations to notify the wearer to change direction (Harris). The reasoning for a wig is the fact that it can hide the electric components and users may be more comfortable wearing a hair piece.

The other application for wearable electronics or adaptive electronics is brain-computer interfaces. The technology is to incorporate this technology with the brain. This technology allows a computer to read and interpret signals from the brain. Some of the applications that if successful will allow individuals to control wheel chairs or drink coffee by sending signals to a robotic arm (World Economic Forum). One significant event to note is that this technology has already helped some visually imparted people to gain partial sight. This technology has also been able to link to brains together. In this case, two mice were linked together through the internet and completed simple tasks. There are possible applications for this technology. Researchers have implanted false memories into a mouse's brain. For humans, this could mean having the ability to treat post-traumatic stress disorder by manipulating memories. Of course in the long run, it could also be possible to upload information into the brain like computer files. However, there could be ethical issues when dealing with the possibilities from this technology.

5. Conclusion

There have been a great many advancements in technologies over the last few years in wearable devices. The industry has raked in the benefits. Body-adaptive electronics will continue to make great strides as there is a demand for their applications. At this time, the medical field seems to reaping the benefits because of their various uses. These devices are smaller than what

is currently used. They are more comfortable and un-obtrusive in wear-ability and provide easier methods in complete their tasks compared to their predecessors. Based on the current paths these technologies are taking and their many uses, there's no doubt that this will be a successful field of research.

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