



Aiming to participate at this year's METRO Marathon in Düsseldorf on April 28, sixteen runners are in the midst of preparation. All of the runners are equipped with stick-on smart Health Patches using cutting edge printed electronics. These patches are worn 24/7 and do continuously measure and record motion (IMU), electrocardiogram (ECG) and respiration (RES).

Preparing for a 42-km race is stretching the capabilities of the human body and the Health Patch makes the journey towards the marathon more safe, personalized and efficient.

Three companies have engaged to develop the smart Health Patch for this project: Henkel, a multinational bringing expertise in functional materials used in the patch, Quad Industries, a Belgian SME specialized in printed electronics and the manufacturing thereof and Byteflies, a Belgian wearable health startup with extensive experience in the design and production of high-quality and versatile wearable devices.



Figure 2: Athlete wearing the smart Health Patch.

The smart Health Patch consists of a peel-and-stick disposable part that is adhered to the skin on the chest, and a reusable part, the *Byteflies Sensor Dot* that snaps into the sticker. Battery, communication and data

storage is all included into the Sensor Dot that can be used up to 24 hours, after which the dot must be put in a docking station to recharge and transmit the data to the cloud.

The disposable patch is designed and manufactured by *Quad Industries* using *Henkel's* innovative printed electronic conductive inks. The patch is a two lead ECG device that can be worn up to 24 hours currently using standard electrolyte gel to capture the ECG signal from the heart. Moving forward the electrolyte gel will be replaced by Henkel's new, self-adhering dry electrode technology allowing the patch can be worn continuously for a week before renewing the disposable sticker. Skin-friendly adhesives robustly stick the patch to the chest and cause no itching or irritation. Stretchable conductive silver inks transport the electrical signal to the Sensor Dot while allowing the sticker to stretch while breathing.

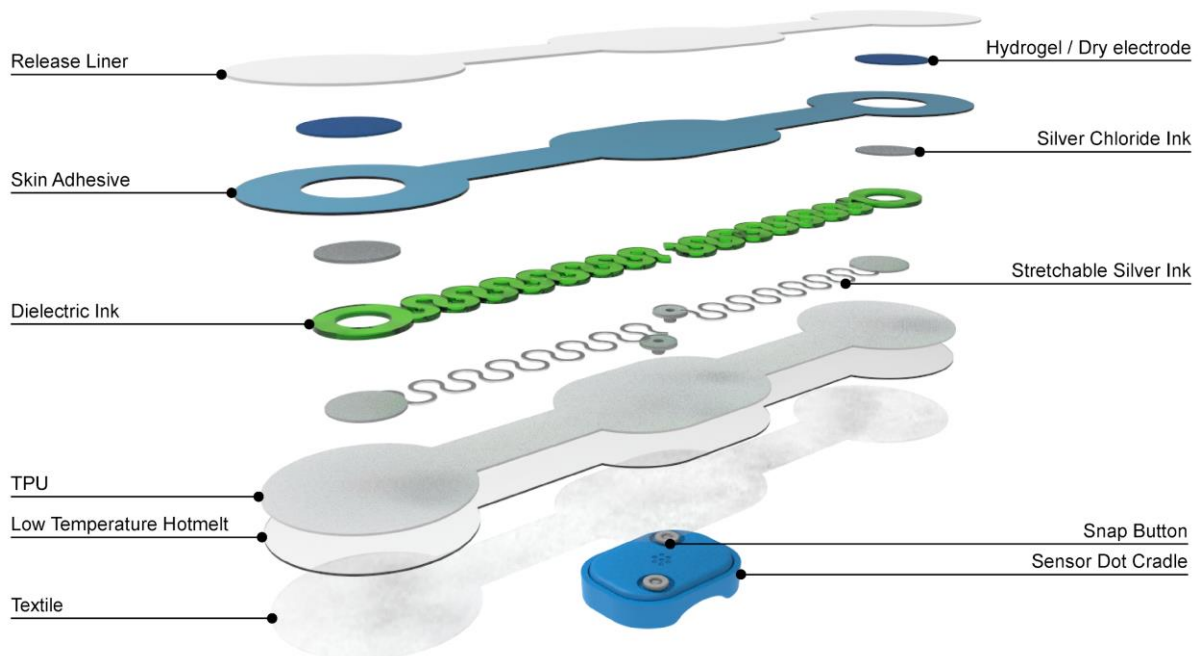


Figure 3: Exploded view of the Health Patch showing the different materials used.

The complete device is built on an ultra-thin, breathable TPU substrate that is laminated against a high-end sport textile. Quad Industries has overcome many challenges to integrate printed circuits on skin-compatible materials, including automated screen printing and handling of these stretchable substrates, skin adhesive and electrode integration, textile lamination and reliable interconnection technologies. These developments enable Quad to offer a full new range of printed electronic solutions and to serve new markets for wearable sensor and electronics applications.

The Sensor Dot, the software platform and the cloud storage with data analysis are performed by Byteflies. This health-tech company has built up a team of specialists in the field of wearable health, Machine Learning, and the development of digital biomarkers. With a proprietary platform to set up wearable health solutions instantly, Byteflies targets companies that want to push new wearable technology to the market, researchers that are looking for new ways to monitor patients, and pharmaceutical companies that are making the transition towards a value-based healthcare model. Byteflies' goal is to revolutionize healthcare, and the Sensor Dot capabilities for 24/7 synchronized vital sign acquisition outside the hospital, and large and accurate data sets, will be a key player in achieving improved prevention, prediction, and personalized care.

The Sensor Dot snaps magnetically into an adhesive disposable Health Patch, which are used to affix the device to the user's skin. The docking station is used to charge the Sensor Dots and transfer the recorded data to the cloud.



Figure 4: Magnetic connection between the Sensor Dot and the Health Patch. Docking station charging 5 Sensor Dots.

What insights does the smart Health Patch provide?

On top of the standard heart rate (HR), the athlete will get a clear overview of other vital signs that are hardly monitored by existing wearables (e.g. smart watches). Heart rate variability (HRV) for example is a very important parameter indicating general fitness and stress levels of the body. Also, a much more accurate determination of $VO_2\text{max}$ (maximal oxygen consumption) is possible using the Health Patch. Next to that, the ECG and respiration waveforms can be analysed for more accurate insights into, for example, cardiac function, sleep apnea and sleep patterns. Overall, this makes the Health Patch a much more complete monitoring solution as it records continuously, and guides the runner towards optimal recuperation period based on individual vital signs.



Figure 5: Measured ECG signal.

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