Wear-a-Watt–Energy Autonomy for the Wearables

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CSEM is developing ultra-low power solutions and flexible thin-film silicon photovoltaic cells to prepare for tomorrow's autonomous watches and other wearables. The Wear-a-Watt project demonstrator consists of a wristwatch which can measure the instant power produced by the flexible solar cells in the wristband. The evaluation platform and harvested data will be used to develop autonomous applications for the wearables.

No chargers and no wires anymore: The multdisciplinary project Wear-a-Watt builds on the strengths of CSEM in its five research programs to create ultra-low power wearable systems which can live off the energy harvested from their environment without requiring recharging or wiring. The programs involved in this project cover (i) the nano-textured flexible substrate used for the PV cells, (ii) the production and characterization of the PV cells and their optimization for low-illumination conditions, (iii) the development of an ultra-low-power chip for power management and (iv) the engineering of the complete system.

In the first part of the project, lab prototypes were realized to assess the amount of energy available under different illumination conditions (Figure 1). A first watch prototype was then realized (Figure 2). The project's prototype is equipped with a wristband with custom-made flexible solar cells covering a total area of 9 cm^2 on the watchband. The cells are connected to the measurement circuit through the watchcase. The red hand shows on the dial how much power is harvested by the PV cells in units of milliwatt on a logarithmic scale. Since this harvested energy depends indeed on the habits and the environment of the watch bearers, real life tests 'au porté' are best suited to help estimate the energy that can be collected.

The PV cells are produced onto nano-imprinted flexible polymer foils. These transparent substrates were developed in-house and up-scaled to an area of 300 mm × 300 mm. The thin-film solar cells used in this project are deposited by plasma-enhanced chemical vapour deposition for the active silicon layers and by sputtering for the front and back contacts in CSEM's new cleanroom facilities using processes developed in-house. Shadow masks are used to pattern these flexible solar cells to the required dimensions.

An integration concept for the PV into the wristband has been developed which gives mechanical stability and robustness to the wristband and cell assembly and ensures a good electrical contact of the cells to the contacting lines. The contacting lines transport the current through the watchcase by a watertight feedthrough. Ultra-low power system for energy management and wireless communication has also been designed using in the current stage leading edge commercial off-the-shelf components. The watch can send via the low power communication protocol 'bluetooth low energy' the amount of energy harvested to a smartphone or a tablet for further data analysis.

The resulting PV cells show excellent performance even at low illumination levels. With the first demonstrator, indoor measurements showed that a power of a few tens to hundreds of microwatts is produced. This value can reach to 10 to 15 milliwatts in the sun (indirect exposure). This is considerably more than what can be obtained with mechanical energy harvesting opening therefore new functions.

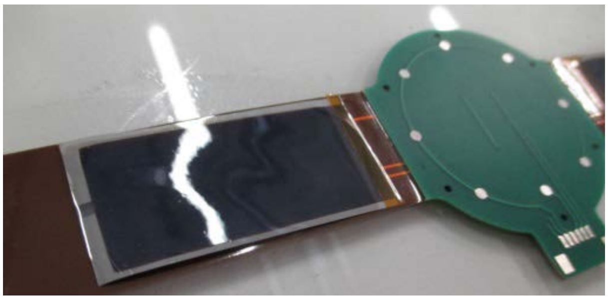

Figure 2: Lab prototpye (2015).

Figure 2: Wearable prototype with thin-film PV cells integrated in the wristband (2016). The cells are put on both parts of the plastic wristband and cover an area of 2.0 × 4.5 cm^2. From indoor to outdoor the light intensity typically varies typically by 3 orders of magnitude which is why the milliwatt units are represented on a logarithmic scale on the watch dial (white and red tick marks) instead of the usual hour ticks.

In parallel, CSEM's IP blocks such as the IcyTRX ultra-low-power RF transceiver, subthreshold microcontroller and a power management unit are developed and integrated.

This wearable test device for the Wear-a-Watt project can accommodate PV cells issued from other PV technologies provided they can fit the required dimensions and tolerances. It can therefore be used to evaluate PV cells from different technologies in real life conditions. Based on the first steps presented here, autonomous systems will further be developed. The applications will target different fields: med-tech, advanced watches, sports watches, and the broader field of the endpoints of the 'internet of things'.