

Wear-a-Watt—Energy Autonomy for the Wearables

J. Bailat, D. Dominé, N. Blondiaux, G. Cattaneo, L. Sansonnens, L.-E. Perret-Aebi, S. Nicolay, R. Pugin, M. Dadras, A. Luu-Dinh, R. Ferrini, M. Correvo, P.-F. Rüedi, J. Deng, M. Morgan, P. Albert, A.-S. Porret, J. Krauss, C. Bosshard, C. Ballif

CSEM is developing ultra-low power solutions and high performance flexible thin film silicon photovoltaic cells to prepare for tomorrow's autonomous watches and other wearables. The project demonstrator will consist of a watch which measures the energy harvested per day and the instant power produced. These data will be used to size autonomous applications for wearables.

No more chargers and no more wires: the multi-interdisciplinary project Wear-a-Watt builds on the strengths of CSEM in its five research programs to create an ultra-low power wearable system which can operate off the energy harvested from its environment only. The device consists of a wristband with custom made flexible solar cells which powers the electronics embedded in the watchcase.

In the first part of the project, lab prototypes (in Figure 1) are designed and produced to assess the amount of energy available under different illumination conditions. Since the amount of harvested energy strongly depends on the habits, the environment of the watch bearers and the seasons, a statistical study from tests 'au porter' will be realized to assess the variability of the amount of energy the bearers may collect.

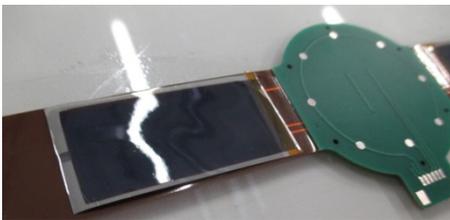


Figure 1: Flexible solar cells and flexible PCB in a lab demonstrator to benchmark the performance of solar cells embedded in wristbands.

The thin film solar cells developed purposely for this study are deposited on nano-imprinted transparent substrates. They show excellent performance even at low illumination levels which is one of the most important features for powering wearables since users may spend very little time out in the sun. A first performance evaluation based on the flexible cells produced at CSEM is presented in Figure 2. At low illumination of 260 lux, the wristband still produces over 140 μW . With two different—winter and summer—scenarios, the energy harvested per day varies from 12 to 40 Joules per day, which is enough to power applications such as activity tracking, notifications, etc.

Table 1: Predictions of harvested power and energy for 12 cm² of flexible solar cells with the performances shown in Figure 1.

Illumination	10% of 1 sun	1000 lux	250 lux	25 lux
1 cm²	0.6 mW	50 μW	12 μW	1 μW
12 cm²	7.2 mW	600 μW	144 μW	12 μW
Scenario 1:	0.2 hour (12min)	5 hours	5 hours	5 hours
5.2 mWh/day				
Scenario 2:	1 hour	8 hours	3 hours	3 hours
12.5 mWh/day				

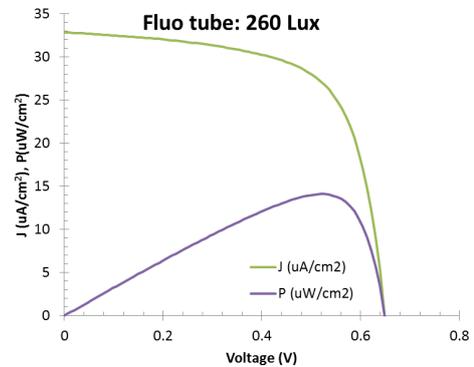


Figure 2: Performance of flexible solar cells at low illumination. A power of 14 μW can be harvested per square centimeter of active PV area under low indoor illumination of 260 Lux.

Based on these first steps, an autonomous wearable system is designed. The applications will target different fields: med-tech, advanced watches, sports watches, internet of things, etc. System integration including feedthrough to the watchcase and cell encapsulation are currently addressed with the aim to comply with the chemical, physical and mechanical conformity standards relevant to watch wristbands. An ultra-low power system for energy management and wireless communication has been designed using, in the current stage, leading edge commercial off-the-shelf components (Figure 3). CSEM is also developing a chip to further optimize energy harvesting from the rigid and flexible photovoltaic cells including several of CSEM's ultra-low power blocks as the icyTRX, an ULP transceiver, and icyflex2, an ULP processor. The chip will be implemented in 2016.

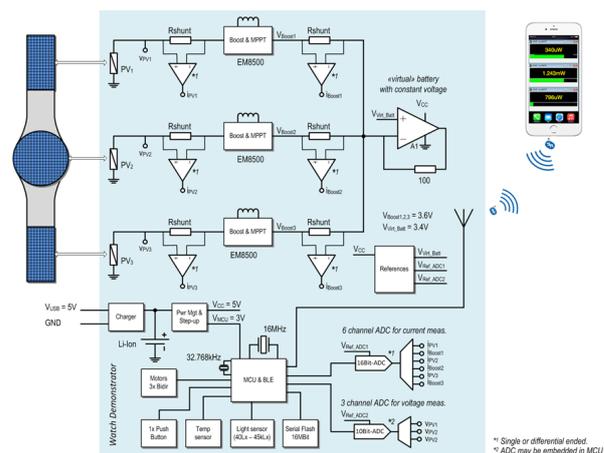


Figure 3: Block-diagram of the energy harvesting monitoring system, taking advantage of the outstanding performances of the new energy harvesting chip EM8500 from EM Marin SA.