Witness—an Autonomous Camera on a Sticker

S. Blanc, M. Crettaz, E. Favre, M. Fretz, C. Gimkiewicz, R. Krähenbühl, P.-F. Rüedi, E. Türetken, P. Nussbaum

Witness is an autonomous ultra-low power image recording device integrated on a flexible palm sized sticker. Powered only by solar energy, it records still pictures of the environment based on a motion detection algorithm and stores them in a local memory for off-line use. The device is primarily dedicated to surveillance *applications, where a surveillance perimeter is created by placing units on walls and ceilings. Due to its autonomy and generic processing capabilities, CSEM expects the Witness platform to find numerous other uses far beyond this scope.*

The Witness project has succeeded in this multi-disciplinary challenge by resolving five key technical challenges.

A highly efficient, flexible and adhesive PV Cell

A flexible disc-shaped Photovoltaic (PV) cell with an adhesive surface was designed and tested. A first prototype of 80 x 80 mm and 0.2 mm thickness has been produced and mechanically tested for bending stress. The power delivered is 2.55 mW @1 kLux.

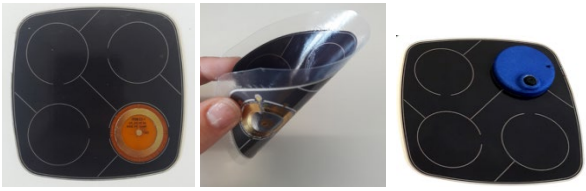

Figure 1: Front side view of the PV cell with the magnetic dock (left) cell flexibility (middle) and camera docked on PV (right).

A patented system for magnetic attachment (dock) of the camera button has been designed and integrated into the PV cell (gold plated disc) while preserving the cell flexibility. It opens the possibility to attach buttons with other functionalities than a camera, as well as mounting the active side of the PV front or back (for mounting on a wall or a window).

Ultra-thin, wide angle optics

An ultra-thin optic with a 120 ° field-of-view has been designed to meet the requirements of the application. The patented approach is based on a macro-lens array (2 x 2) with a lens shift compensating for the small fill factor (20%) of the imager. The lens also compensates the illumination homogeneity with a central obscuration.

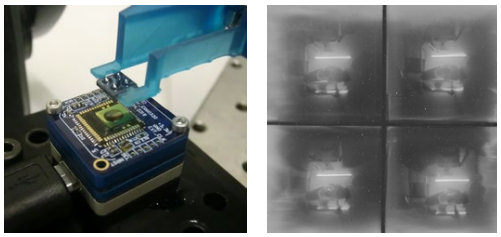

Figure 2: Lens array prototype during assembly on CMOS imager (left) and resulting 4 pictures (right).

The milling process of the diamond-turned prototype didn't reach expectations in terms of sub-pixel alignment of lenses. An alternative approach providing accurate lens alignment consists of wafer-level optics and this is compatible with existing micro-optical fabrication techniques at CSEM.

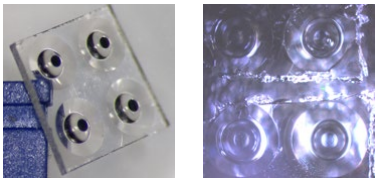

Figure 3: Original lens (left), replicated version (right).

The aspherical shape of the lens requires a diamond-turned mold for the prototype. The measured profile demonstrated the expected shape replication. However, demolding results in a lens sag of 300 µm and as such the manufacture still requires improvement.

Ultra-low power image capture ASIC

An ultra-low power (sub-mW) and high dynamic range (120 dB) QVGA sensor has been developed and tested. The innovation lies in a novel and patented pixel architecture based on the integration time to saturation scheme.

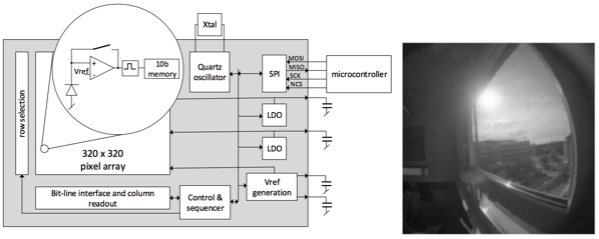

Figure 4: Chip architecture (left) and resulting image (right).

Algorithms to target power efficiency and flexibility

The algorithms dedicated to motion detection, image compression, and storage in local memory are developed and optimized on a Nordic (nRF52) platform for flexibility and power efficiency. The complete system, achieves less than 1 mW consumption on average.

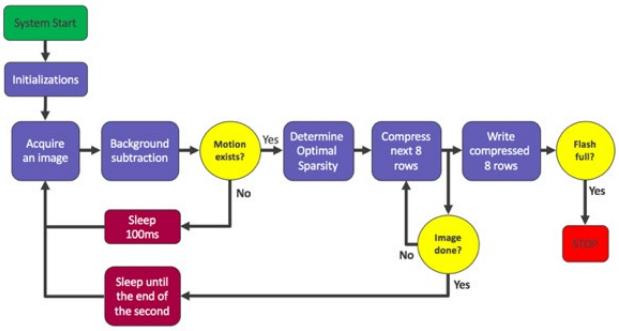

Figure 5: Functional architecture of the software system.

Efficient System Integration

This functioning data logger "Witness" integrates the whole camera functionality into a button of 30 mm diameter and 4 mm thickness. Careful selection of the commercial components (processor, memory, power management unit) ensured reaching the stringent power consumption requirements.