Nano-enable Autonomous Sensor System

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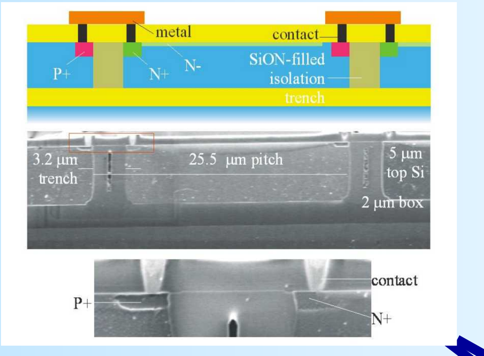
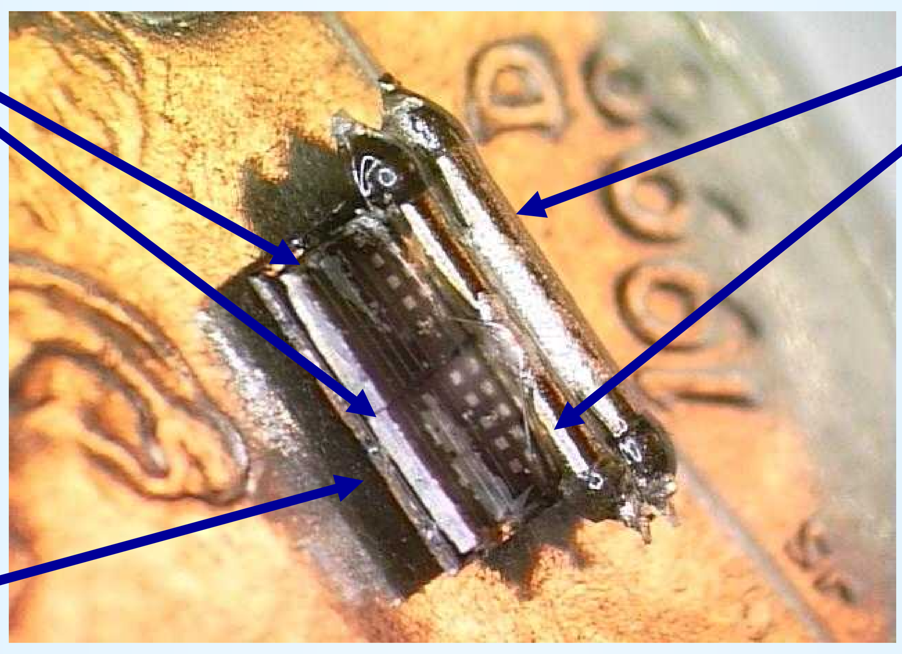
The recent development of nano-enabled devices has opened the door for the development of autonomous sensor systems with lateral dimensions on the order of 1 mm. Due to their small size and the ability to fabricate large numbers of devices using parallel processing many new applications, such as in-vivo sensing and highly disperse sensing will be possible. However, the implementation of nano-enabled devices has been hampered due to the difficult in integrating individual components together and the extremely limited power-budgets at this size scale. In this work, we surveyed the available nano-enabled components to determine the most compatible set. Based on these results we assembled prototype systems capable of sensing, and recording information of interest. This system formed the bases for a conceptual design of a fully integrated parallel-processed system that will collect, store, and transmit the data of interest.

Photo-voltaic
MDL fabricated SOI photo-voltaic that we backside thinned to use in a backside illumination mode.

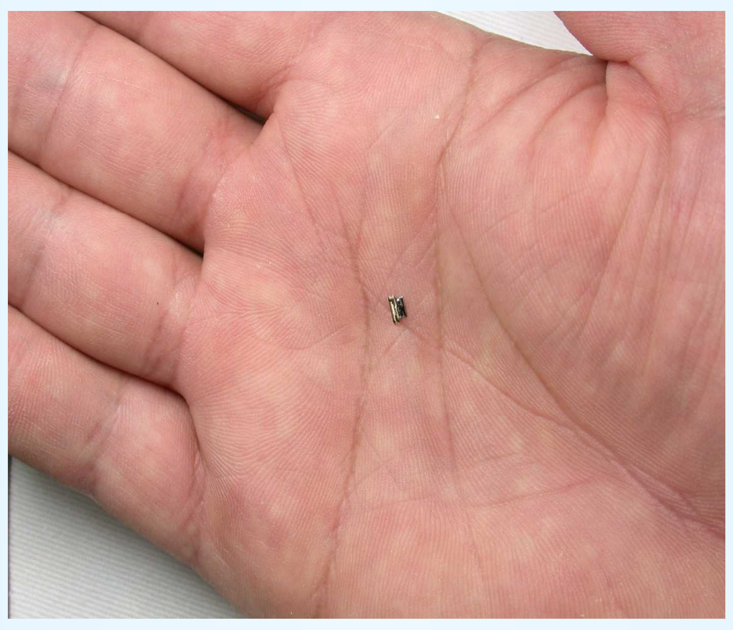


Battery
Nano-enabled Li-ion battery from Rutgers University. Note, the image is of a 5 mm long battery rather than the 2 mm that we used in the final device.

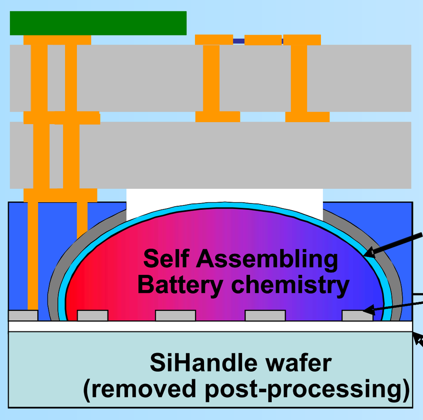


Programmable Integrated Circuit (PIC)
formed the bottom plain of the system and was fabricated out of a commercial MicroChip 16C622 PIC. The chip was programmed prior to de-packaging and thinning to nominally 100 microns.

2 mm^3 Total volume



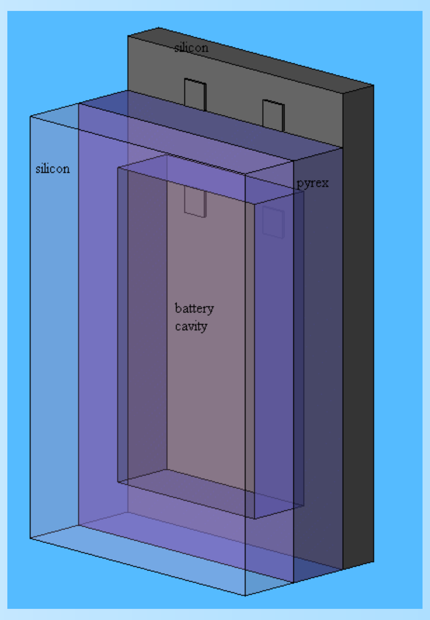
Integration and Testing
Each unit was hand assembled and wire bonded together. The batteries were charged using the PV and then the system ran solely using the batteries for greater than an hour. The PIC was programmed so that it would use the photo-voltaic as both the energy harvesting and the sensor in the prototypes.



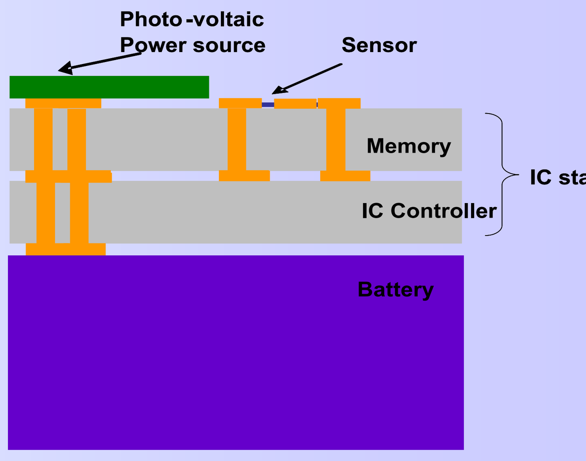
Future Direction

The long term objective of the program was to develop a roadmap for a parallel process flow such that thousands of devices could be fabricated at low cost. These system would include logic, memory, a sensor package, energy harvesting and storage, and communication. This objective is in only achievable using parallel processing techniques.

Based on the learning from this project we developed a notional process flow and to develop an 3D integrated nano-enabled microsystem that could be fabricated using parallel processing techniques, such as flip-chip bonding, and through via electrodeposition.



In this project, we demonstrated that a nano-enabled device containing power sources, memory, logic, and a sensor could be fabricated using standard packaging techniques. This integrated system, conclusively demonstrated that a complete system could be fabricated and electrically tested and that the demonstrated power budget and impedance matching of the PIC, PV, and battery where all acceptable. This work formed the bases for the development of a three year roadmap for the fabrication of a fully integrated device using parallel processing techniques.



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