SynCells - Electronic Microparticles for Sensing Applications

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Autonomous electronic systems smaller than the diameter of a human hair (<100 µm) presents a great opportunity for sensing applications because they allow us to interact with the environment at a much smaller scale. These microsystems could be used for example to detect chemicals in very confined spaces like the human body or microfluidic channels. Alternatively, they are small enough to be sprayed on surfaces to form distributed sensor networks or even be incorporated into fibers to make smart clothing. However, fabricating and designing such microsystems is difficult due to integration challenges and a limited power budget.

In this work, we present a 60x60x2 μm^3 electronic platform, called Synthetic Cell or SynCell, that overcomes these issues by leveraging the straight-forward integration capabilities of 2D material on an SU-8 substrate and the use of functional materials to reduce power. We integrated several components on this platform including molybdenum disulfide based transistors and chemical sensors, analog timers based on eroding germanium films, and magnetic iron pads (see Figure 1). These building blocks represent a broad set of capabilities and enable functions like computation, sensing, time tracking and remote actuation, respectively. Over the past years, we have optimized the SynCell fabrication and lift-off process and recently demonstrated a yield close to a hundred percent of fully working SynCells.

To show the potential of SynCells in confined spaces, we magnetically positioned several SynCells in a microfluidic channel to detect putrescine in a proof-of-concept experiment, see Figure 2. After we extracted them from the channel, we successfully read out the timer and sensor signal, the latter of which was amplified by an onboard transistor circuit. In the future, SynCells may be useful in a wide variety of fields, from clinical research to printable/sprayable sensor coatings.

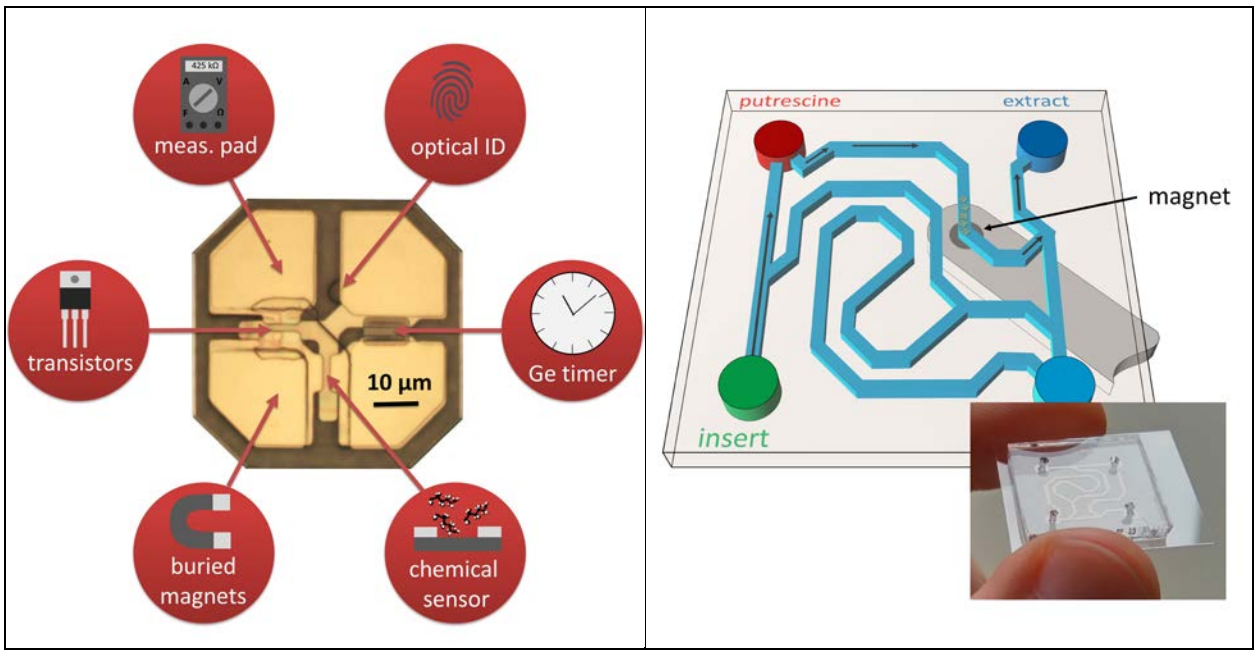

Figure 1: Microscope image of a SynCell (60x60x2 μm^3) with building blocks like molybdenum disulfide-based transistors and amine sensors, germanium analog timer, magnetic iron pads, measurement pads and optical identifier.	Figure 2: Schematic of a complex SynCell demonstration. SynCells are introduced into a microfluidic channel, positioned precisely using a magnet to detect local chemical concentration and then extracted (actual microfluidic channel in inset).

Further Reading

- V.B Koman, P. Liu, D. Kozawa, A. Liu, A.L. Cottrill,Y. Son, J.A. Lebron, M.S. Strano, "Colloidal nanoelectronic state machines based on 2D materials for aerosolizable electronics." Nature Nanotechnology, vol. 13(9), 819-827, 2018.
- S. Lee, A. Cortese, A. Gandhi, E. Agger, P.L. McEuen, and A.C. Molnar, "A 250 µm × 57 µm Microscale Opto-Electronically Transduced Electrodes (MOTEs) for Neural Recording.", IEEE Transactions on Biomedical Circuits and Systems, 2018.

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