interview

Paul Berger

"We aim to facilitate the detection of organ transplant rejection before it is too late"

Professor Paul Berger from Ohio State University in the US talks about the research behind his group's Letter: 'Towards in vivo biosensors for low-cost protein sensing' on page 450.

What are your main research interests?

Over the years I have studied active semiconductor devices, often exploring ways to use new materials or modify a material's properties to create enhanced device performance. My work has studied every major semiconductor device, including HBT, MODFET, tunnel diodes, LEDs, laser diodes, solar cells, photodetectors, and optical modulators. Currently, our group explores both inorganic and organic semiconductors and spans the gamut from Si/SiGe to III-V's, polythiophene etc. and graphene. The most reoccurring theme involves quantum tunnelling based devices which is represented in three funded programs and covers three distinct semiconductor material systems (SiGe, III-nitrides and polymers).

What has motivated you to research *in vivo* protein biosensors?

Open discussions with a colleague in the biomedical engineering discipline piqued my curiosity, which excited me to their specific need and the opportunity I could exploit by judicious engineering. Their team was developing a nitride-based sensor, but its cost and yield clearly was going to temper their long-term impact. They had even shown in preliminary experiments that Si-based sensors drifted too much to be usable. That triggered me to examine why the silicon sensor drifted and how we could improve upon that and test it in a facile manner. The biocapacitors described in our Letter are a result of a streamlined analytical analysis of this ion percolation into the sensor.

Can you explain the advance that you have reported in your *Electronics Letters* paper?

Essentially, when a generic *in vivo* silicon based sensor is used it will drift with its threshold voltage constantly moving as alkali ions (i.e. Na and K) intercalate into the standard silicon dioxide gate oxide. Here we report on a drift-free bio-capacitor that can be the platform for drift-free biosensors. The substitution of silicon dioxide with aluminium oxide deposited by atomic layer deposition already shows extreme promise in blocking ion penetration. Our exploration of other alternatives is just commencing.

Which particular applications could benefit most from this result?

In working with various teams within our medical school, we aim to facilitate the detection of organ transplant rejection before it is too late, allowing proper dosing of patients with anti-rejection medicines, as well as laying a foundation for developing artificial neurons. In essence, there are many implanted electronics, such as pace makers, but these are always encapsulated and the electronics is never in direct contact with bodily fluids. Advances, such as this, could open the door to electronics interacting directly with the human body, both sensing and stimulating.

What are you doing to continue and build on this work?

Next we are building the biosensor for targeted protein recognition.

What other related projects is your group working on?

We are also exploring plasmonically assisted plastic solar cells for energy harvesting. These plastic solar cells could be almost 'painted' atop any curved surface and allow greater penetration of photovoltaics into society as point-of-use power generation.

How do you see *in vivo* biosensing technology progressing over the next few years?

We aim to demonstrate a facile approach for *in vivo* protein sensing that could be decorated along the shaft of a diagnostic needle and used to measure and map transplanted organ health in real-time, as readily as an expectant mother has amniocentesis (also referred to as amniotic fluid test or AFT) testing. We aim to embark upon a further materials study of the gate oxide alternatives and take the best performers in the biocapacitor platform and translate that to working biosensors that can be pre-qualified.

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