論 文 の 内 容 の 要 旨

2D Planar Biosensors Utilizing Impedance Spectroscopy on a Thin Film Transistor Plate

（薄膜トランジスタ基板を用いたインピーダンス特性計測に基づく２次元平面型バイオセンサ）

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In this work, we present the design, characterization and implementation of a multi-modal 2D addressable non-mutative sensing platform for biological systems. We have demonstrated the differentiation of a variety of different media as well as the detection of the presence or absence of cells. We have also demonstrated the detection of the viability of cell viability on our platform as well as building predictive models. Furthermore, we have extended this presence to the detection of electrogenic cell state changes so as to build chemical sensors on our device. We have also applied the same principle to the antibody/antigen biological complex in order to detect the presence of antigens by depositing antibodies on our substrate. Most importantly, we have accomplished all of this while maintaining device transparency, meaning that conventional fluoroscopic measurements can still be made!

Real-time In-vitro characterization of cells and cell cultures is an instrumental aspect of modern biological science. While conventional fluoroscopy is an extraordinarily versatile technique, it suffer many critical drawbacks. The optical measurement apparatuses are bulky, expensive, and difficult to scale. Additionally, the necessary image analysis is computationally expensive to automate and can be difficult to reproduce. Furthermore, fluorescent dyes are inherently damaging to living cells forcing either the use of complex sampling apparatuses or time limited experimentation.

Electrical measurements are more limited in the scope of properties they can measure, but they have the significant advantage of being non-mutative obviating the need for sampling or experiment termination. Additionally they can be trivially integrated with conventional MEMS and microfluidic devices. While electrical measurements can measure most mechanisms involving ion transfer, complementary measurements are needed for many experiments. Thus the creation of a transparent electrode substrate is necessary for the utilization of simultaneous optical and electrical measurement. Unfortunately current transparent devices are either limited in scale(MEA), opaque(CMOS/ISFET) or require sampling in order to function(sandwich electrodes).

An example of our results for the detection of cell state is shown below demonstrating the concentration specific detection of the number of living cells using our device.

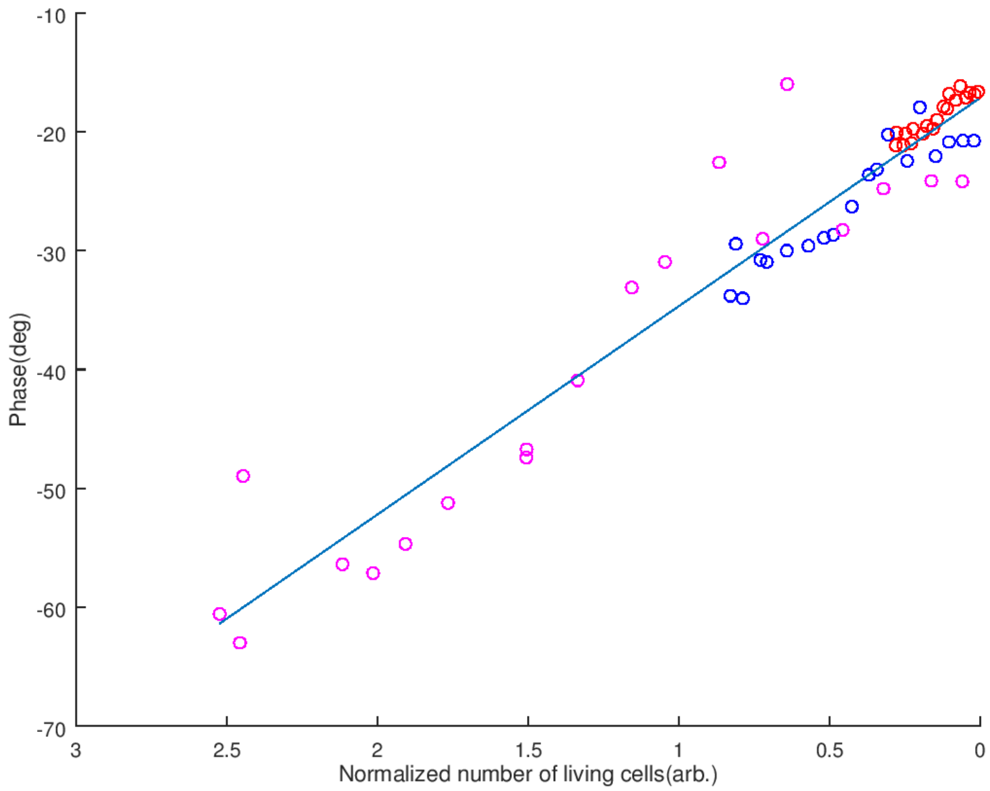

Figure 1: Yeast viability detection

This demonstrates that the number of living cells within a culture can be linearly determined via the phase lag between an incident voltage and an exigent current.

One of the chemical constructors we constructed using our device involved the adhesion of antibodies to our device for the detection of antigens. The results of one such experiment is shown below.

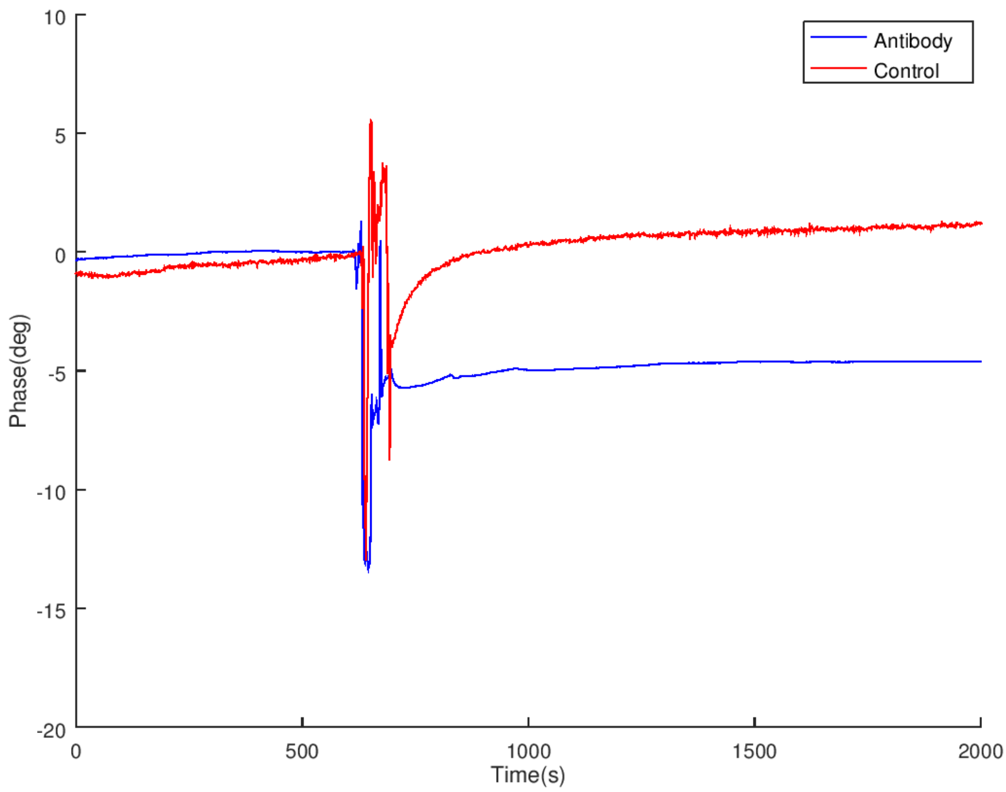

Figure 2: Albumin detection using our device

This demonstrates that our device can detect the adhesion of human albumin through the use of impedance measurements and thus the potential creation of a wide variety of antibody based sensors.

We have demonstrated the measurement of a wide variety of properties using impedance spectroscopy on a novel transparent TFT device at 100um spatial resolution across a cm^2 substrate.