Electrical Impedance Spectroscopy on TFT for Determination of Cell State

G. Cathcart, A. Tixier-Mita, S. Ihida, F. Shaik, H. Toshiyoshi

Transparent Thin Film Transistor arrays are an extremely versatile platform for electrical analysis of cells without interfering with optical characterization. We present the use of impedance spectroscopy to analyze the state of cells using such a device. We were capable of differentiating the state of yeast cells in real time through both impedance phase, and impedance magnitude.

Introduction

- The most commonly used methods for determining the states of cells is through fluoroscopy.
- This requires cumbersome equipment and is often mutative.
- Electrical analysis provides complementary and supplementary information with minimal mutative effects.

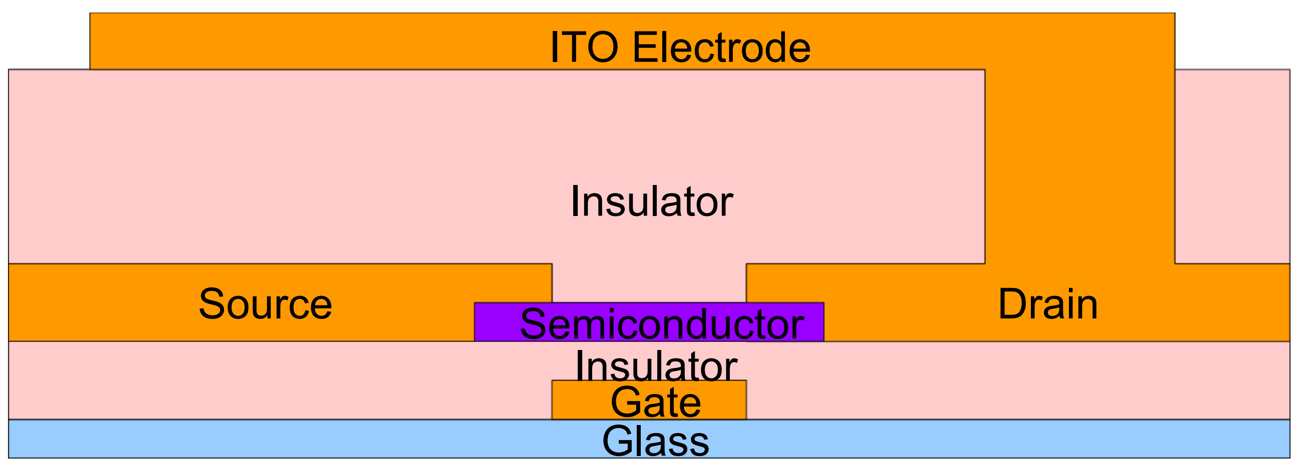

Figure 1. Structure of a Thin Film Transistor(TFT)

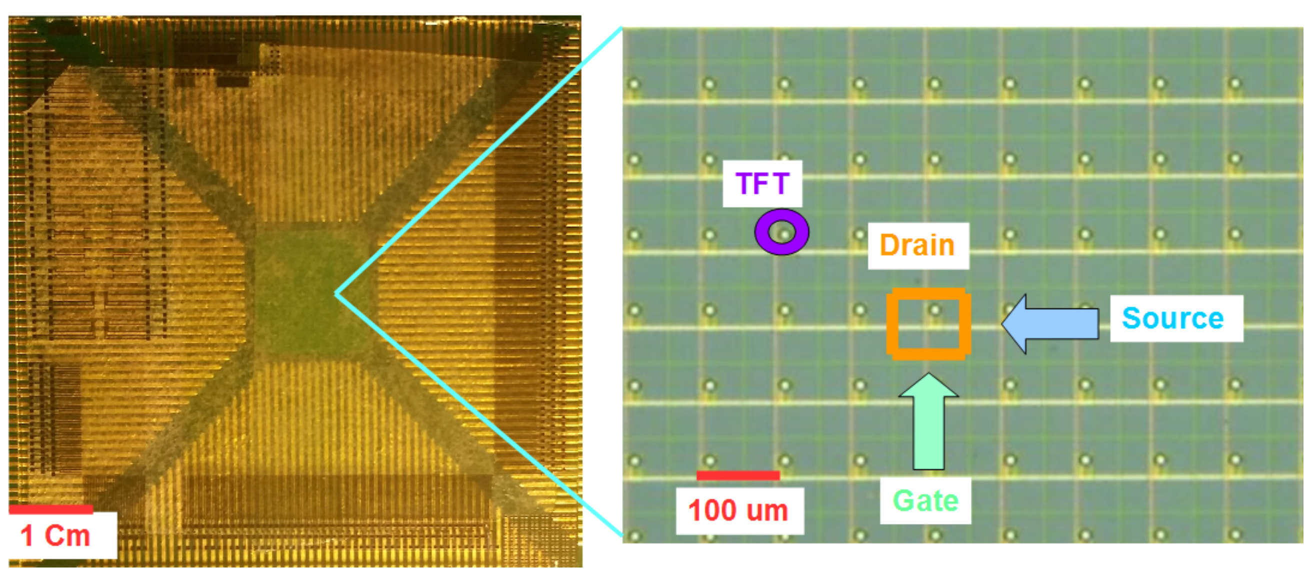

Figure 2. The Thin Film Transistor(TFT) array device

- Impedance spectroscopy works by sending an AC input voltage of varying frequency and analyzing the output current signal using the complex version of ohms law.
- $V=IZ=I|Z|e^{j\varphi}$

Experimental setup

- A yeast suspension was placed in a PDMS chamber on the device.
- A gate line was driven at 10V DC and a source line was driven at 1Vpp at various frequencies.
- The current from an adjacent source line was read and the phase difference was measured using a lock-in amplifier.
- This was done at several locations to give a stochastic aggregate result.
- Then, the yeast was killed by heat shock @ 90C for 30 minutes
- The experiment was then repeated with the dead cell suspension.

Results

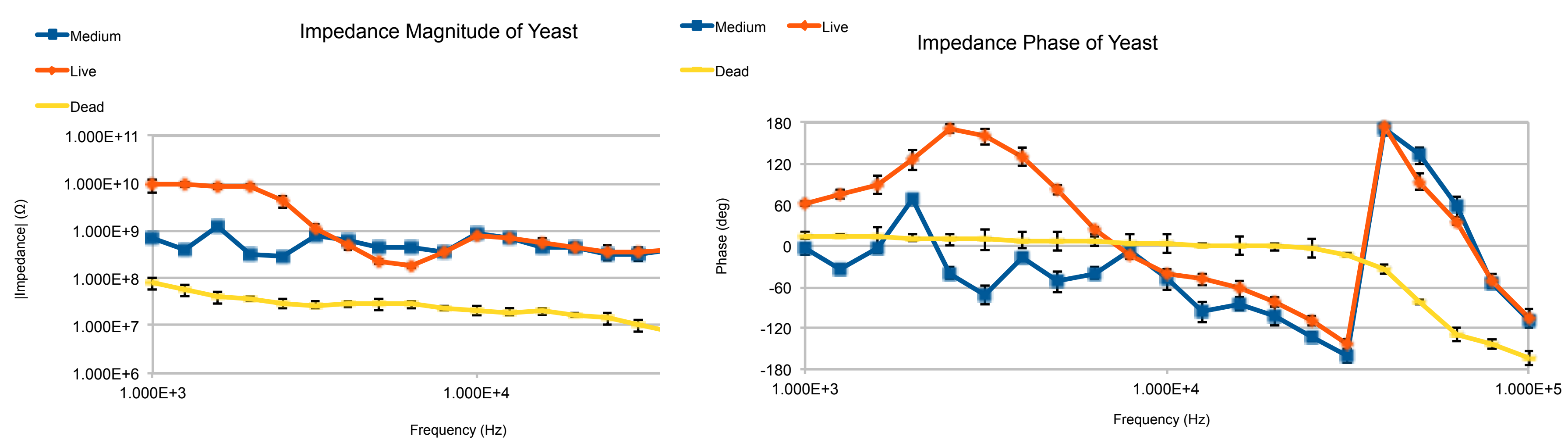

Figure 3. Electrical Impedance Spectroscopy(EIS) results for yeast
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- There are frequency ranges for both living and dead cells where they are independently differentiable from an empty medium with respect to both phase and impedance magnitude.
- The reason why the dead cells have significantly lower impedance than living cells, and near zero phase is due to the membrane rupture as shown in Fig. 4.

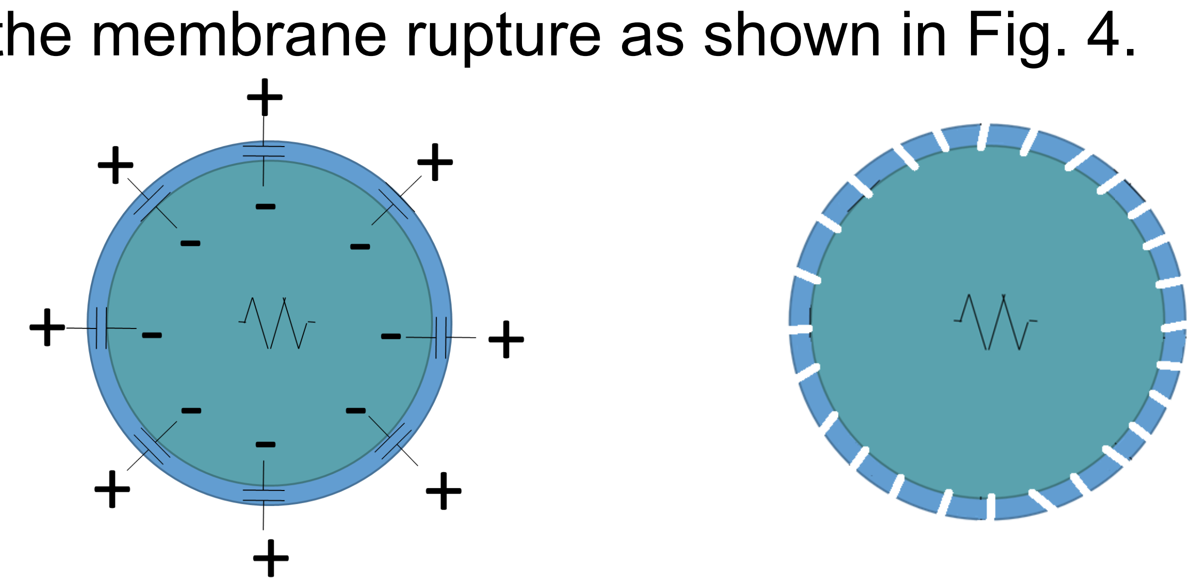

Figure 4. Electrical mockups of living and dead yeast cells respectively.

Conclusion

- We demonstrated the application of an optically transparent TFT array to provide real time differentiation of living and dead cells.
- By combining this with initial cell concentration data it is thus theoretically possible to analyze the state of cultures in real time with high spatial resolution.
- When combined with other proven uses of electrode arrays with biological cultures such as dielectrophoresis, electroporation, and electrofusion, this puts us one step closer to a true monolithic laboratory on a chip system.

Contact: cathcart@iis.u-tokyo.ac.jp