Washington University in St. Louis
Office of Technology Management

# MICROFLUIDIC DEVICE FOR HIGH-THROUGHPUT, MULTIPLEXED ELECTROCHEMICAL ANALYSIS WITH LIVE-CELL IMAGING AND SPECTROMETRY

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## Technology Description

An interdisciplinary team of Washington University researchers has developed a high-throughput microfluidic bioelectrochemical cell (μBEC) that collects electrochemical data and is compatible with live-cell microscopy and spectrometry. This device transcends the capabilities of standard bioelectrochemical analyses (low-throughput bulk reactors), which can only perform analyses serially rather than in parallel. Using an array of microscale chambers, the μBEC is high-throughput and can analyze up to 96 biological or experimental samples at a time. The μBEC is also compatible with optical imaging (such as confocal, fluorescence, and super-resolution microscopy) and secondary-ion mass spectrometry (SIMS) instruments. The versatility of this invention makes it a powerful tool for studying the bioelectrochemistry of living cells and for developing advanced nanomaterials.

## Stage of Research

**Prototype** – The inventors have used a four-chamber configuration of this device to simultaneously acquire publication-quality electrochemical data and fluorescence confocal images of microbial cells. They have also built a prototype compatible with plate readers and common laboratory equipment using the standard 96-well plate format and demonstrated that they can use ultrasonic standing waves to manipulate cells in the μBEC.

**Future work** – The inventors are now developing prototypes compatible with super-resolution imaging and SIMS, as well as devices that allow removal of chamber bottoms after experiments for further downstream analysis.

## Applications

- **Electrophysiological research** of excitable cells such as neurons or of ion channels and pumps
- **Bioelectrochemical research** of microbes using extracellular electron transfer (EET)
- **Advanced nanomaterials development** using the device as a substrate for charge-tunable assembly of DNA, biofilms, and other biomaterials or polymers

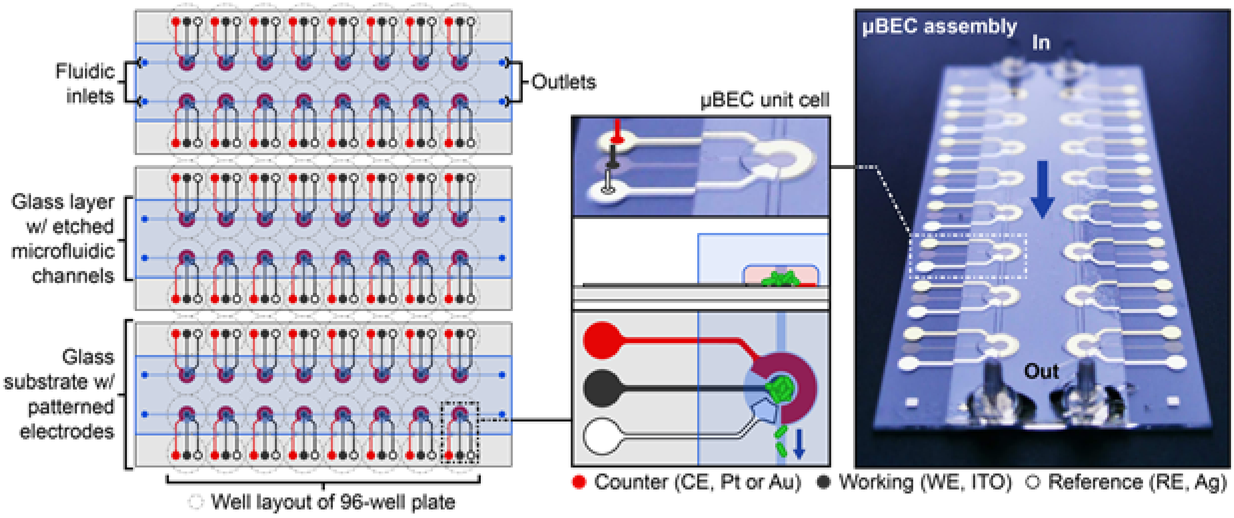
## Key Advantages

- **Compatible with other analytical instruments –** can acquire electrochemical data *while* also analyzing with:
  - Fluorescence microscopy
  - Confocal microscopy

  - Super-resolution microscopy
  - SIMS
- **High throughput –** arrayed, multi-chamber setup compatible with conventional 96-well plate format allows for bioelectrochemical analysis of over 10-fold more samples at once than with bulk reactors, facilitating strong statistical analysis and genetic library screens
- **Multiplexed analysis –** precise control over experimental conditions in each well facilitates greater complexity in measurements and experiments
- **Scalable manufacturing –** designed for cost-effective and high-volume manufacturing

**Publications:** Guzman, M. S. et al. Phototrophic extracellular electron uptake is linked to carbon dioxide fixation in the bacterium Rhodopseudomonas palustris. *Nat. Commun*. 10, 1355 (2019).

**Technology Schematic**




*Schematic illustrating µBEC assembled with standard 96-well spacing.* ***Left.*** *Overhead view displaying arrayed chambers, microfluidic channels, and reference (white), working (black), and counter (red) electrodes. Chambers can be separate or interconnected with microfluidic lines and can be used to investigate one or more biological samples in one or more sets of experimental conditions. The device architecture shown here permits up to 6 different fluids/cell types and up to 48 different electrical conditions.* ***Middle.*** *Enlarged top and cross-sectional side views of single µBEC unit cell containing surface-attached cells.* ***Right.*** *Image of µBEC prototype.*

**Patents:** Micro-bioelectrochemical cell devices and methods of detecting electron flows (U.S. Patent Application Publication No. 20200282396)

**Websites:** Bose Lab; Scalable Integrated MicroSystems (SIMS) Lab