



**Jenna Rickus, PhD**

**A hybrid cell-silicon neural prosthesis  
for the treatment of epilepsy**

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*I do not have significant financial interests related to this conference*



## Critical Problems

- 30% of patients are pharmacoresistant
- Effective drugs can have intolerable side effects
- Traditional surgery is not always an option

## Need Alternative Solutions

### 2000 Curing Epilepsy Specific Benchmark III.E.

**“Successfully use a device (e.g., a very small detector and/or drug pump that can be placed in the brain) that, in at least one type of epilepsy, will detect an oncoming seizure and apply treatment to stop the seizure before it begins.”**

## Existing Approaches

### **Transplanted cells**

provide spatial delivery  
ongoing drug supply  
lack temporal control

### **Electrical / Mechanical Pumps**

provide spatial delivery  
provide temporal delivery  
lack long term drug reservoir

# A new type of neural implant

**A closed loop hybrid cell-silicon device to provide seizure-induced GABA release from exogenous cells.**

## Goal

## Approach

## Solution

**Stop Seizures**



**Local administration of GABA agonists at the right place and time can stop many types of seizure**



**Temporal**

**&**

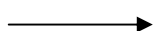
**Spatial**

**Control**

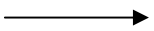
**of**

**GABA**

**No Side Effects**



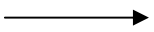
**Eliminate global action of treatment throughout entire brain**



**Avoid Problems of Drug Resistance**

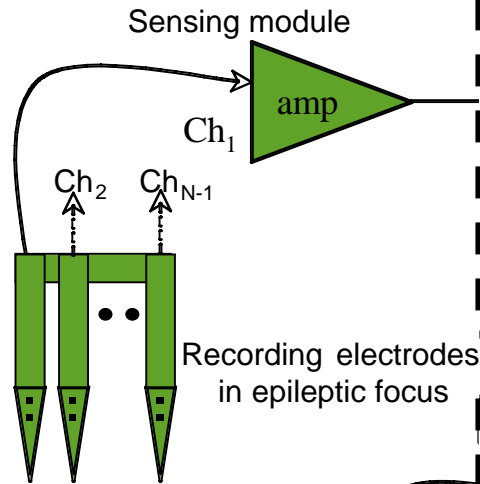


**Bypass systemic delivery  
Deliver only at time of seizure**



# Implanted Device Concept

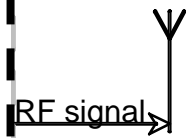
## 1. continuous recording



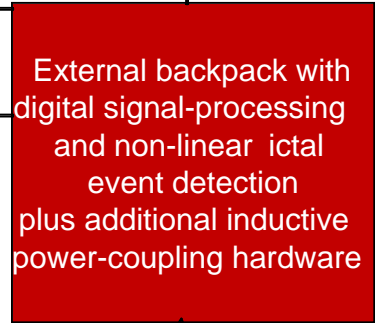
Recording electrodes in epileptic focus

## 2. output of recorded signal

wireless data module



## 3. seizure prediction



## 4. stimulation of device cells

stimulation module

Excitation of engineered neurons

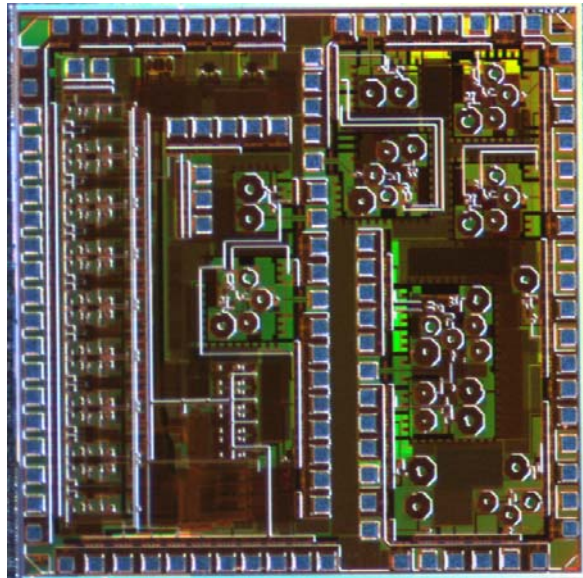


5. Release GABA from "living electrodes"

- 1) Sensing module
- 2) Wireless data transmission module
- 3) Signal-processing and inductive power module
- 4) Stimulating module
- 5) Engineered-cell module



## Existing Prototype 1

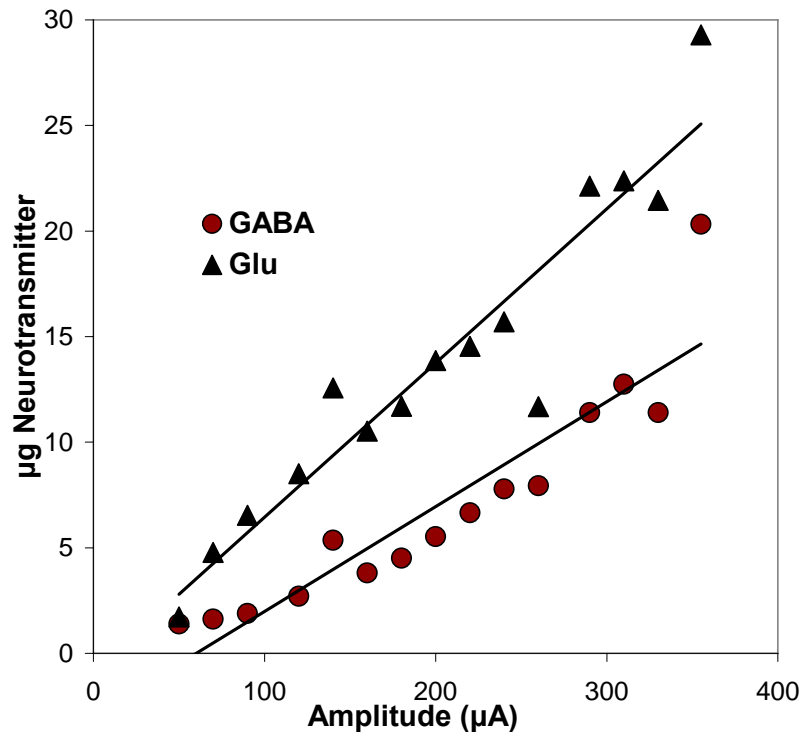


connects to both recording electrodes and stimulating “living electrodes”

- Wireless: up to 64 electrodes simultaneously
- 30 kHz sampling with 12 bit resolution
- Low Power < 10mW
- Power Management & Inductive Powering Circuitry  
***patient can recharge each night  
no battery changes***
- Real-time telemetry of recorded data  
***for external seizure detection  
patient can log data  
physician can review data***
- Programmable stimulus from on-chip function generator  
***physician can fully reprogram any time***

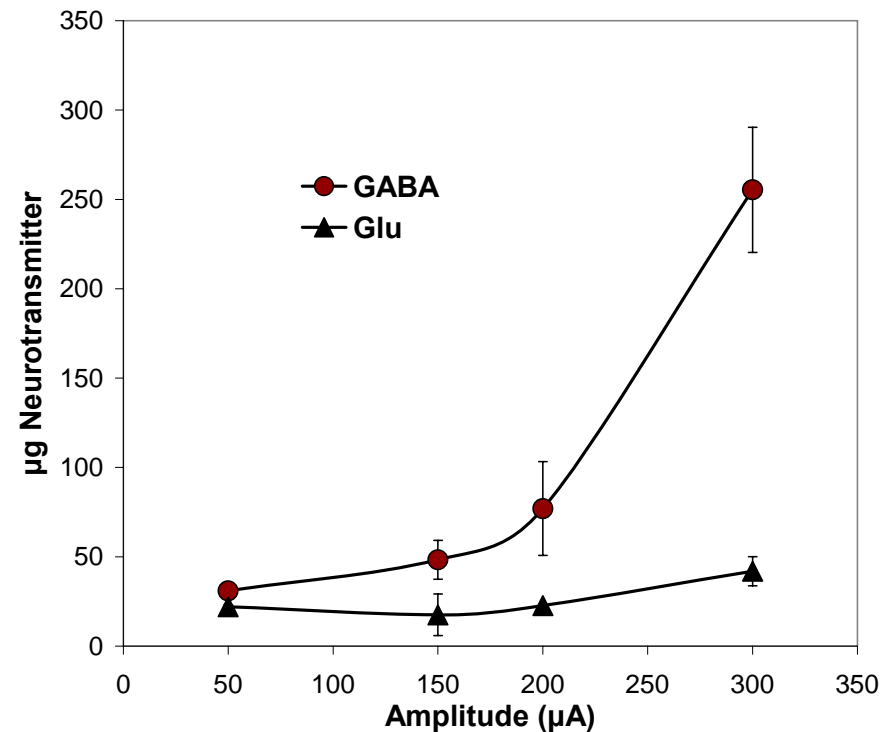
# In Vitro Demonstration of Calibrated GABA Release by the Device

## Cell Line 1



**Fairly Mature, Heterogeneous  
Population of  
Excitatory and Inhibitory Neurons**

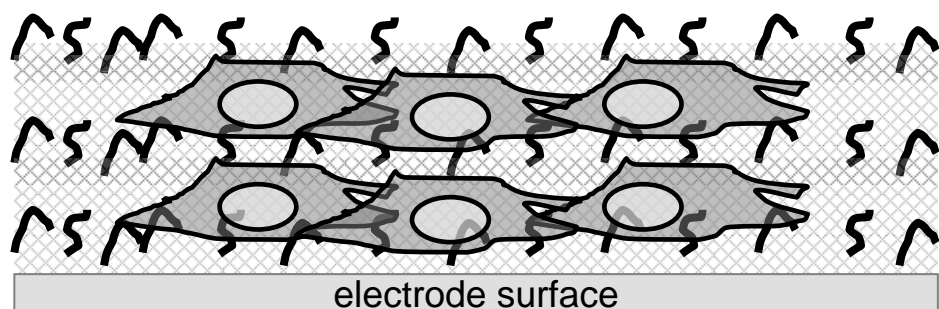
## Cell Line 2



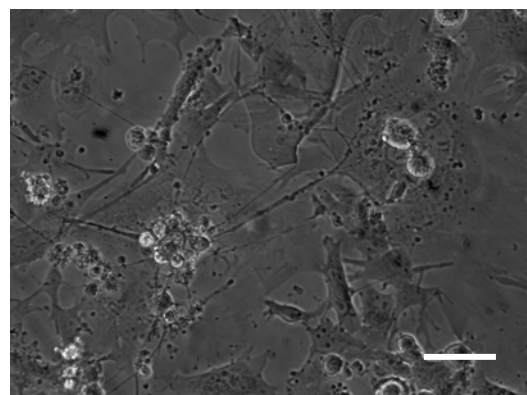
**Immature Immortalized  
Neurons, Expressing  
GABA producing enzyme (GAD)**



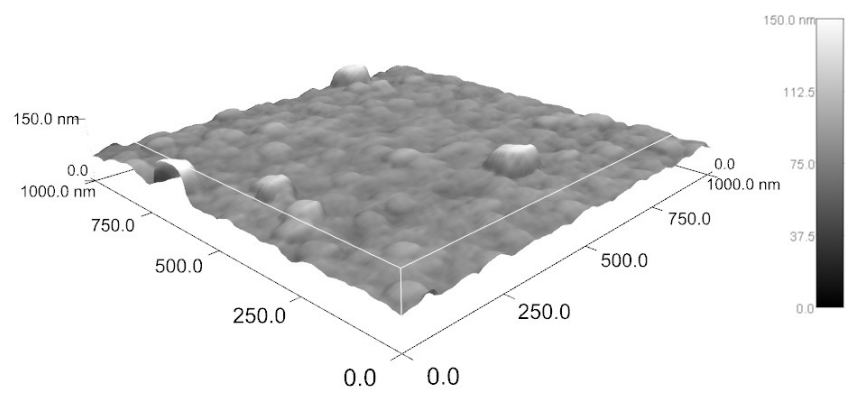
# Novel Peptide Porous Silica Materials To Create “Living Electrodes”



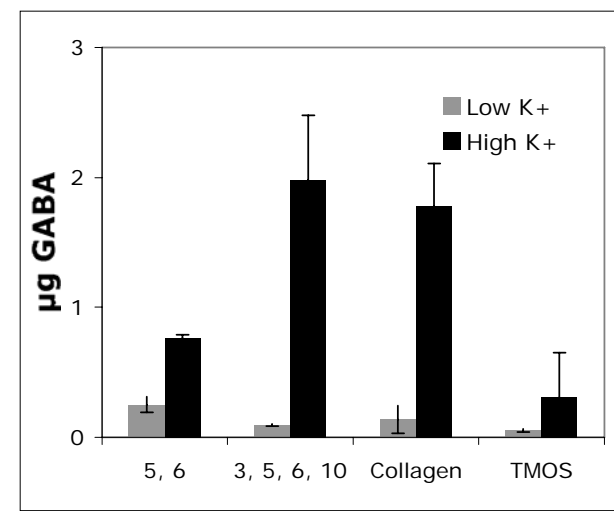
Cells are Integrated into the Device



Cells Survive & Function on Materials



AFM Image of Peptide Materials



Materials modulate GABA release potential

## Current and Future Work

### In vivo development and testing



**rat epilepsy models**

**living electrode design**

**long term cell survival and function**





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## Cell Lines

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