

Neural Engineering: Emerging Technology for Interfacing with the Nervous System

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Department of Biomedical Engineering

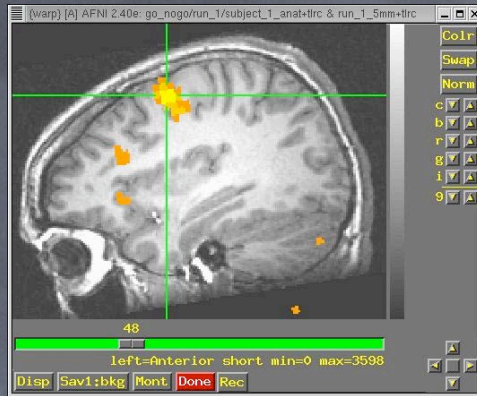
Department of Neurological Surgery

Clinical Neuroengineering Training Program

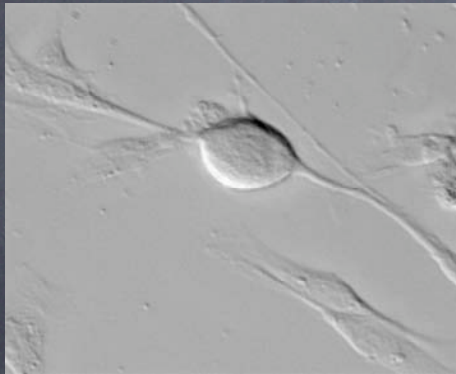
University of Wisconsin-Madison



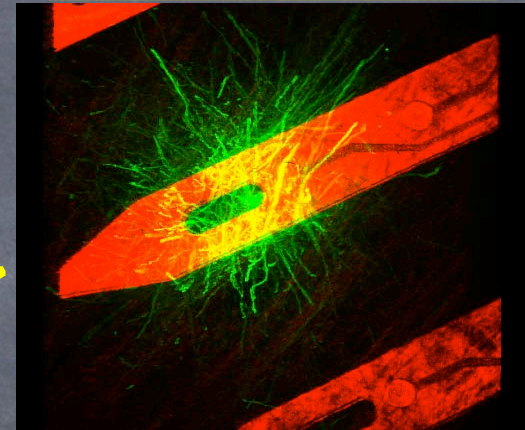
Neurosurgery



Neuroscience

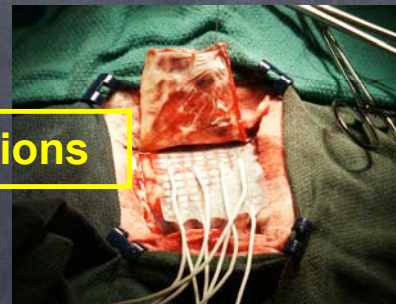
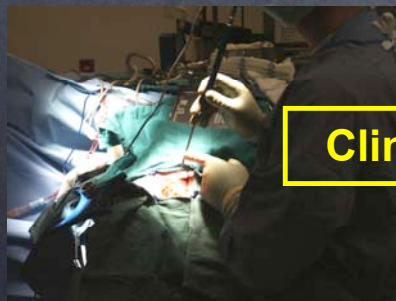


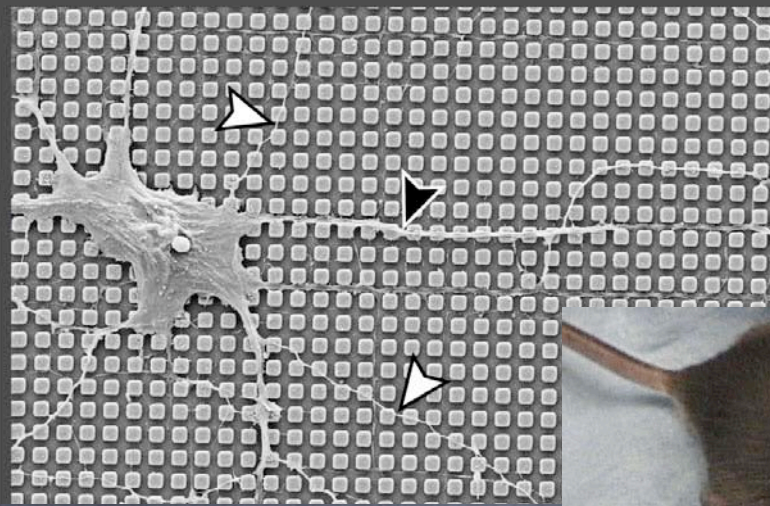
Engineering



Neuro Engineering

Clinical Applications

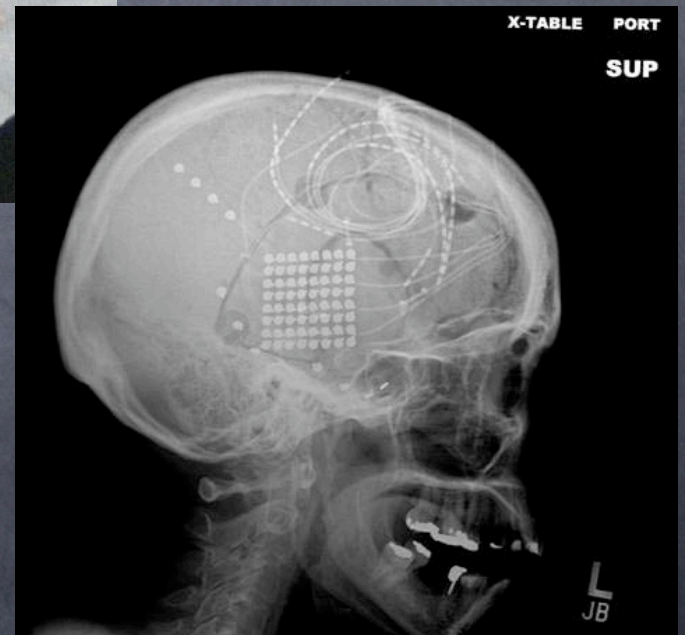




Cell Culture

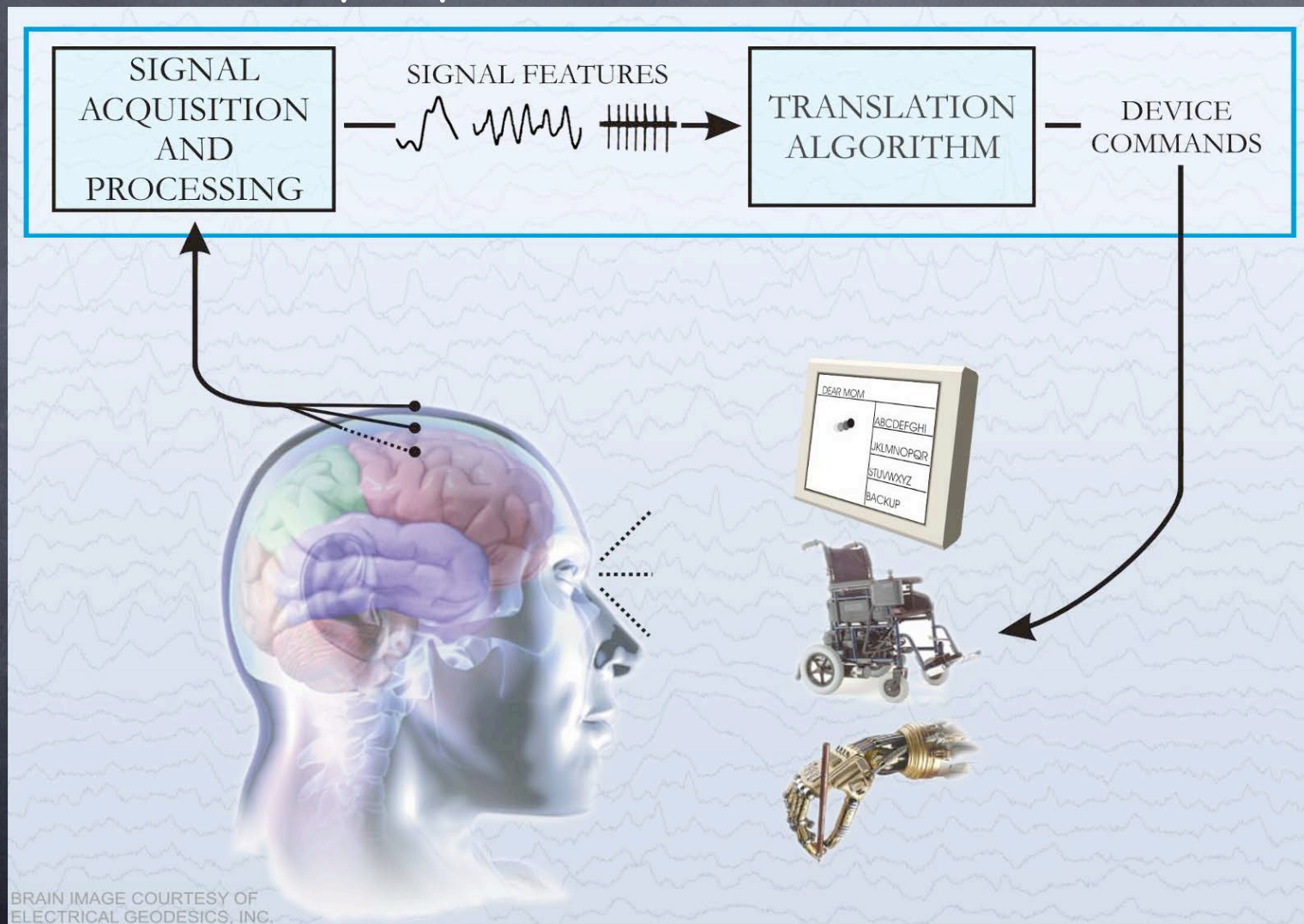


Animal Models



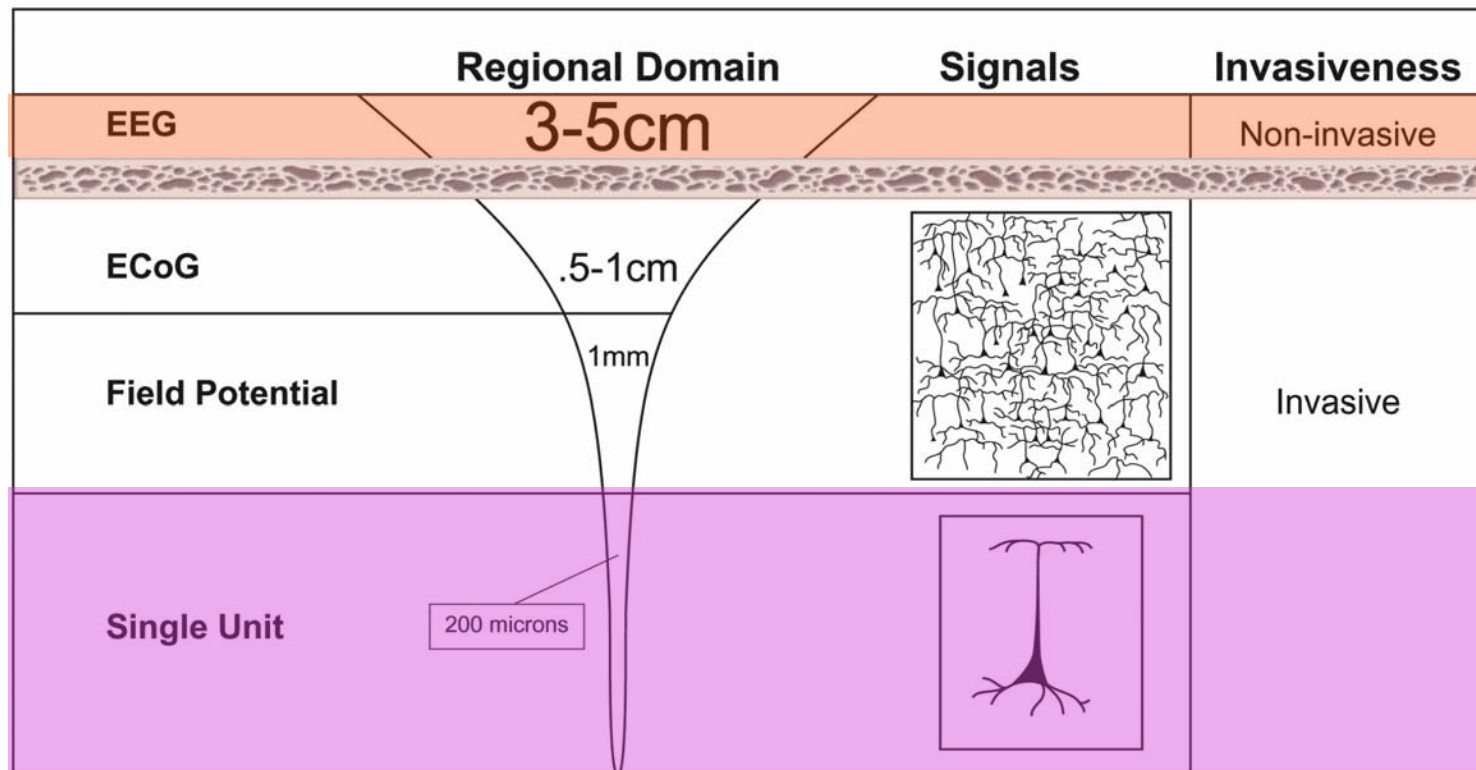
Clinical Applications

A brain-computer interface (BCI) is a communication system that does not depend on the brain's normal output pathways of peripheral nerves and muscles.

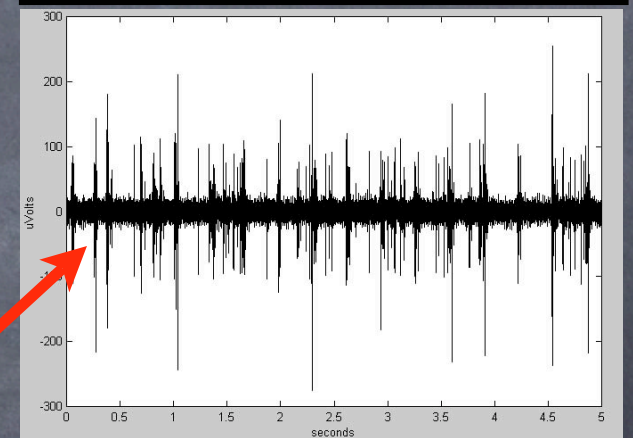
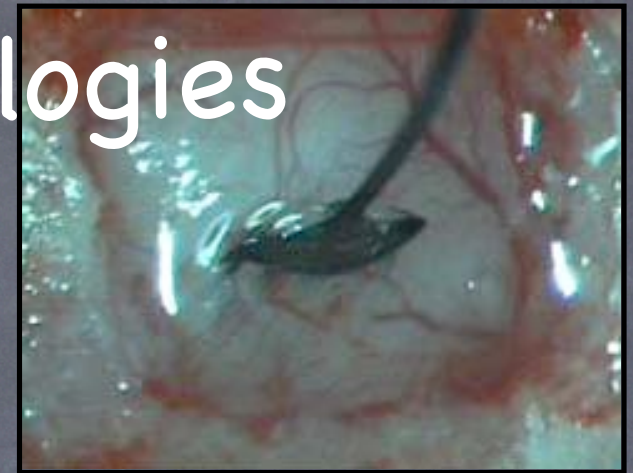
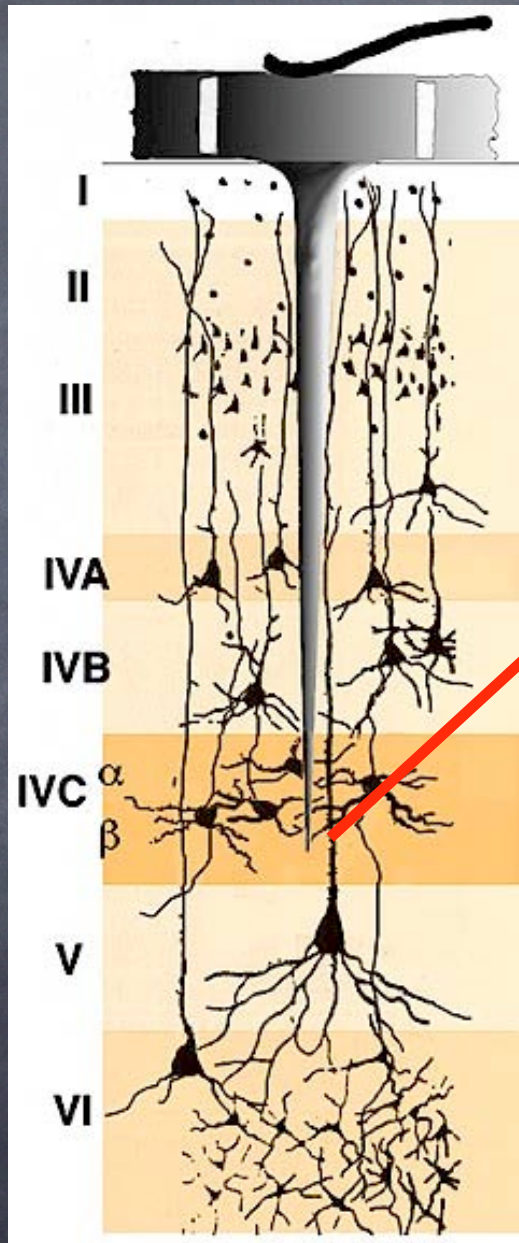
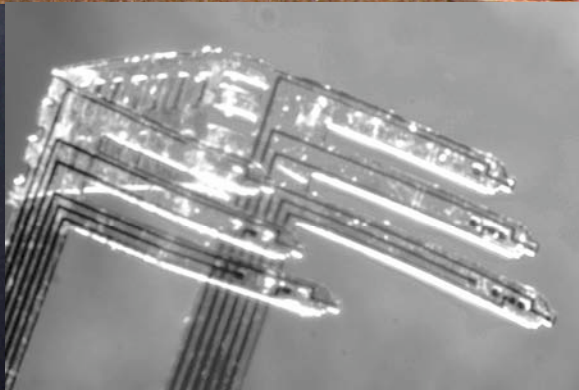
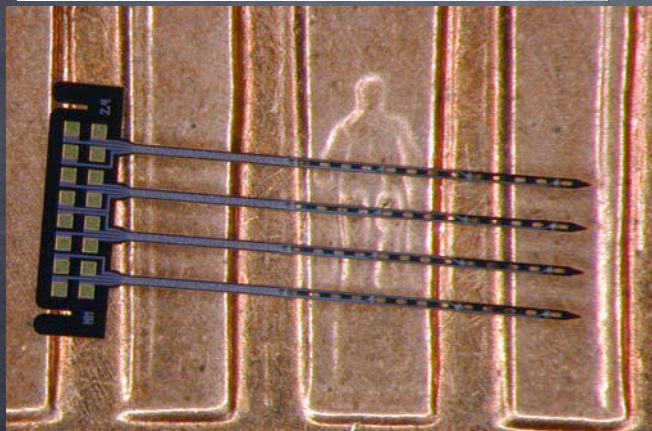
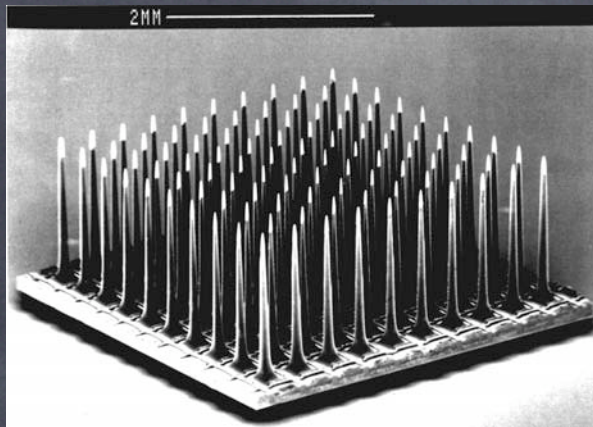


Courtesy Electrical Geodesics and Gerwin Shalk @ the Wadsworth Center

Possible Signal Sources for BCI's



Microelectrode Technologies

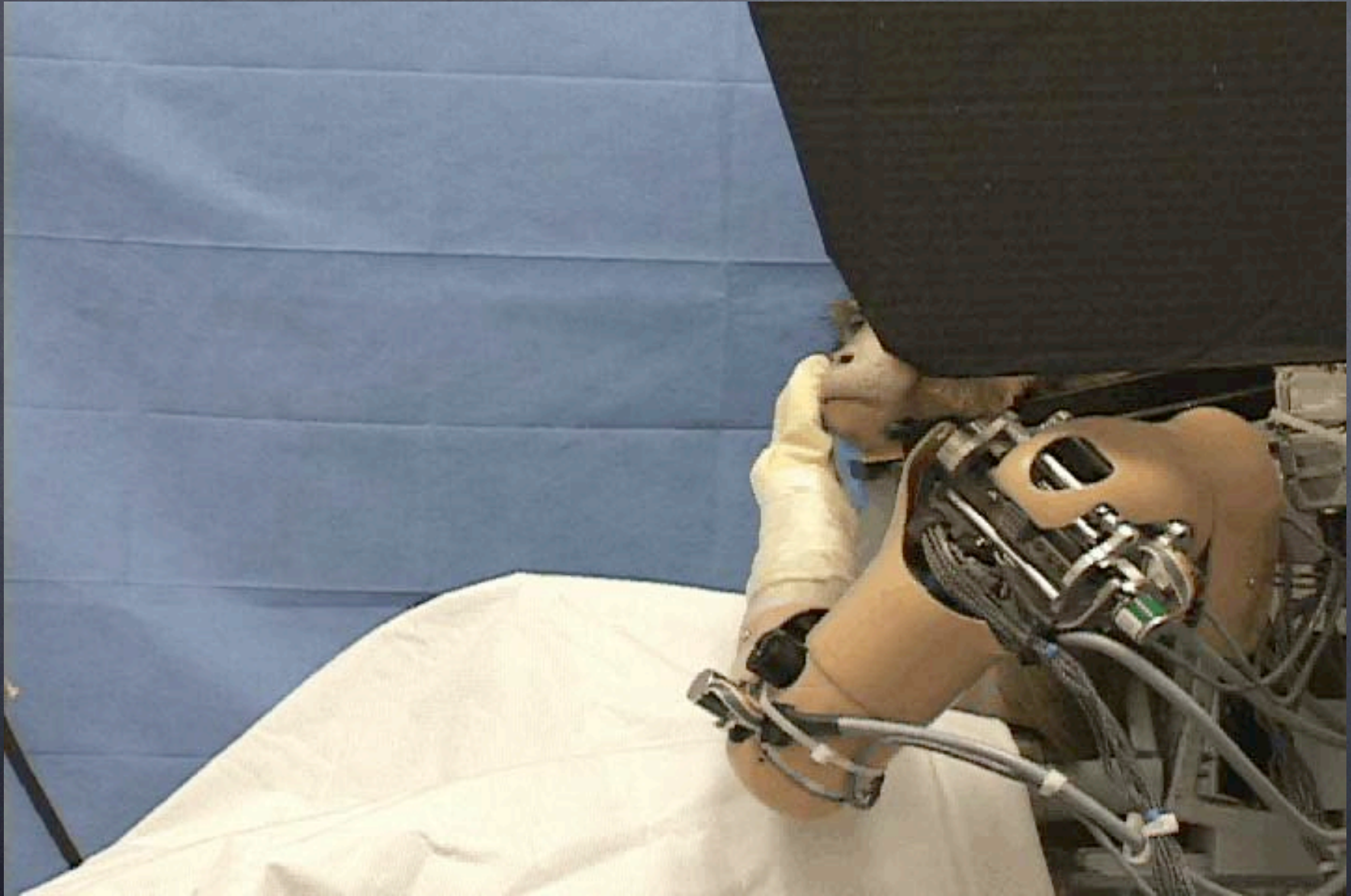


Chronic Microfabricated Silicon Based Implants in Monkey Motor Cortex

**96 Sites in
Monkey
Motor
Cortex**



Neural Control of Robotic Arm



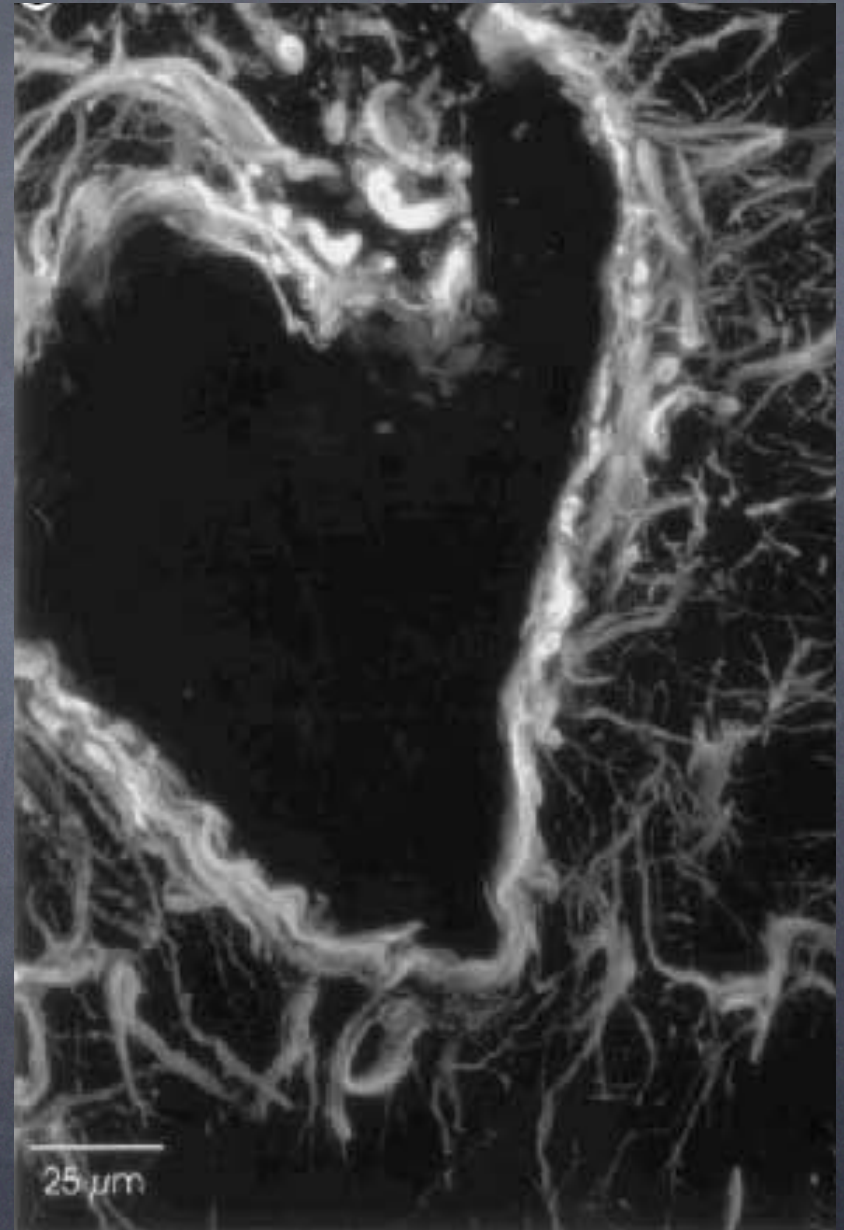
Video Courtesy of Andy Schwartz, University of Pittsburgh

Problem: Implant Functionality

Underlying mechanism

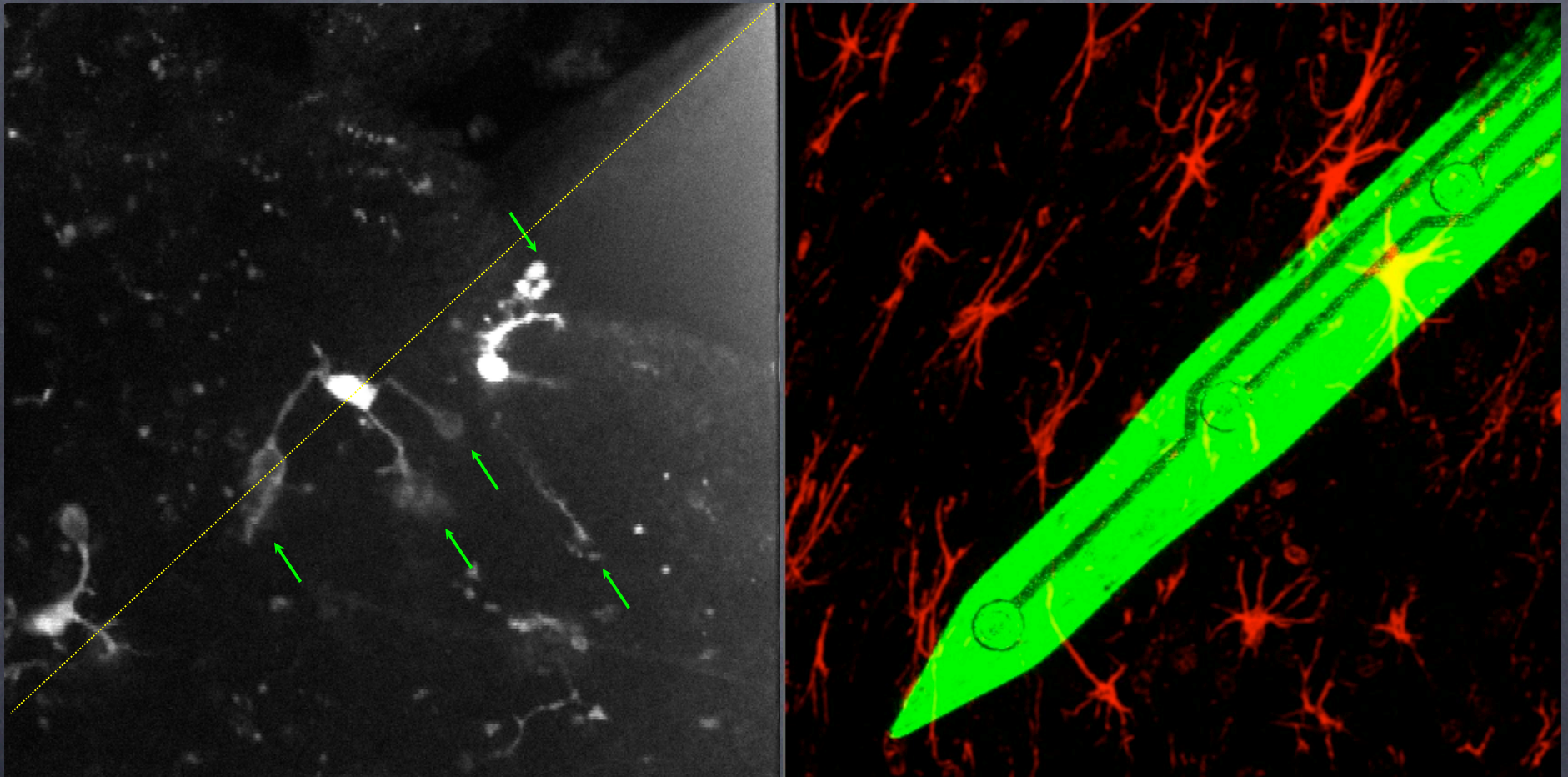
Tissue reaction to implant
causes changes in tissue
electrical properties
and/or neural death

**This motivates the need for
evaluating and controlling tissue
responses**



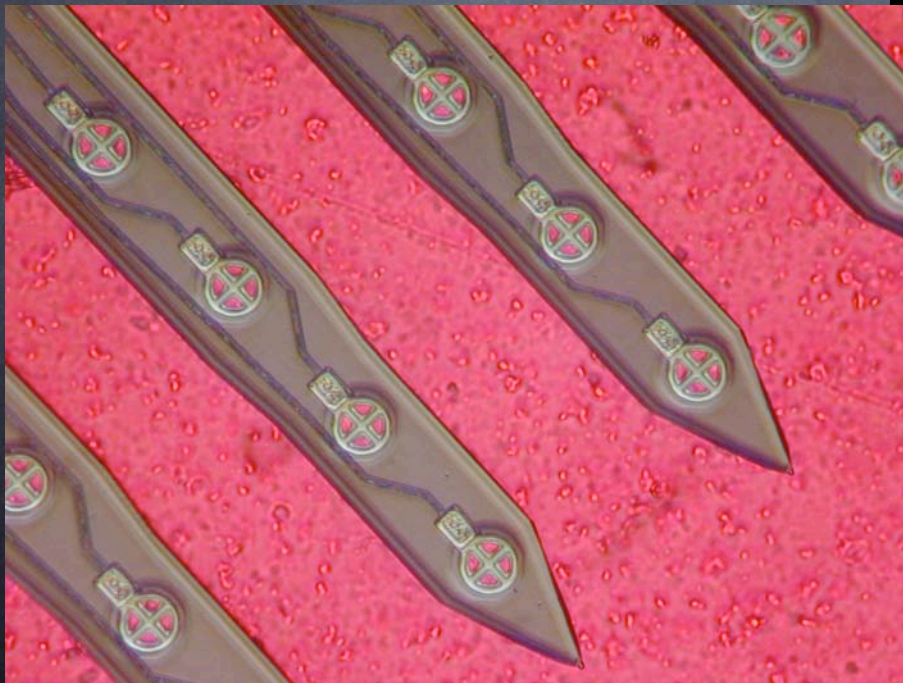
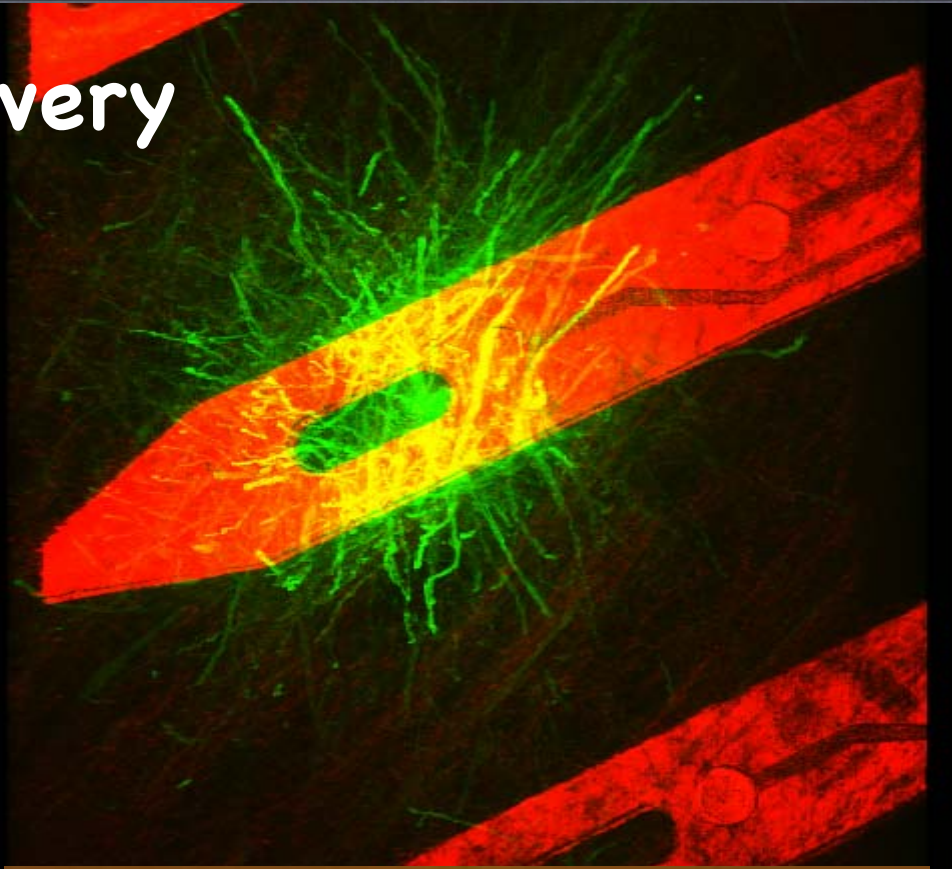
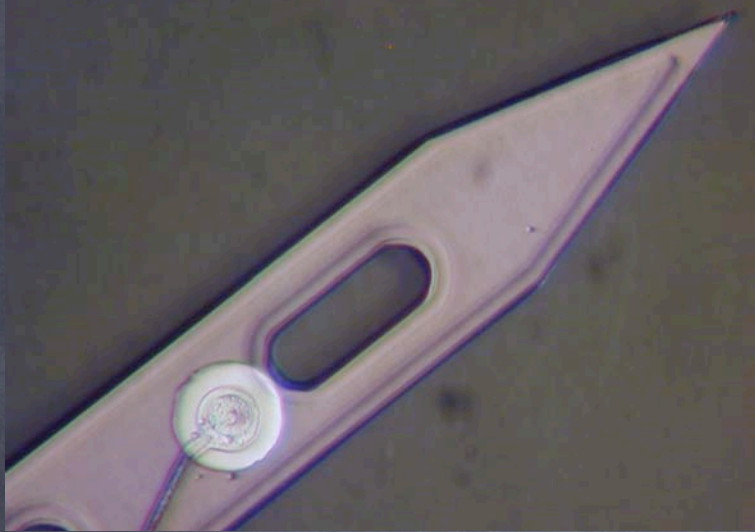
Turner et. al., Exp. Neurology 1999

Multiphoton In Situ Imaging in Labeled Transgenic Mice



Microglia filopodia endfeet can be seen attached to the electrode surface after only 2 hours.

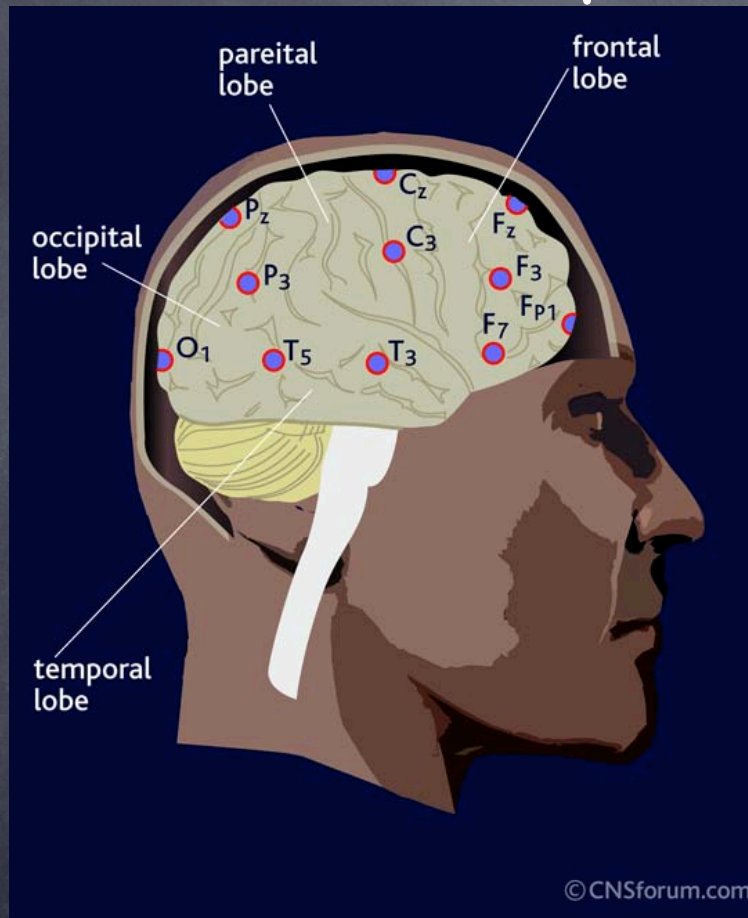
Microfluidic Drug Delivery



Williams et al, J Neural Engineering, 2005

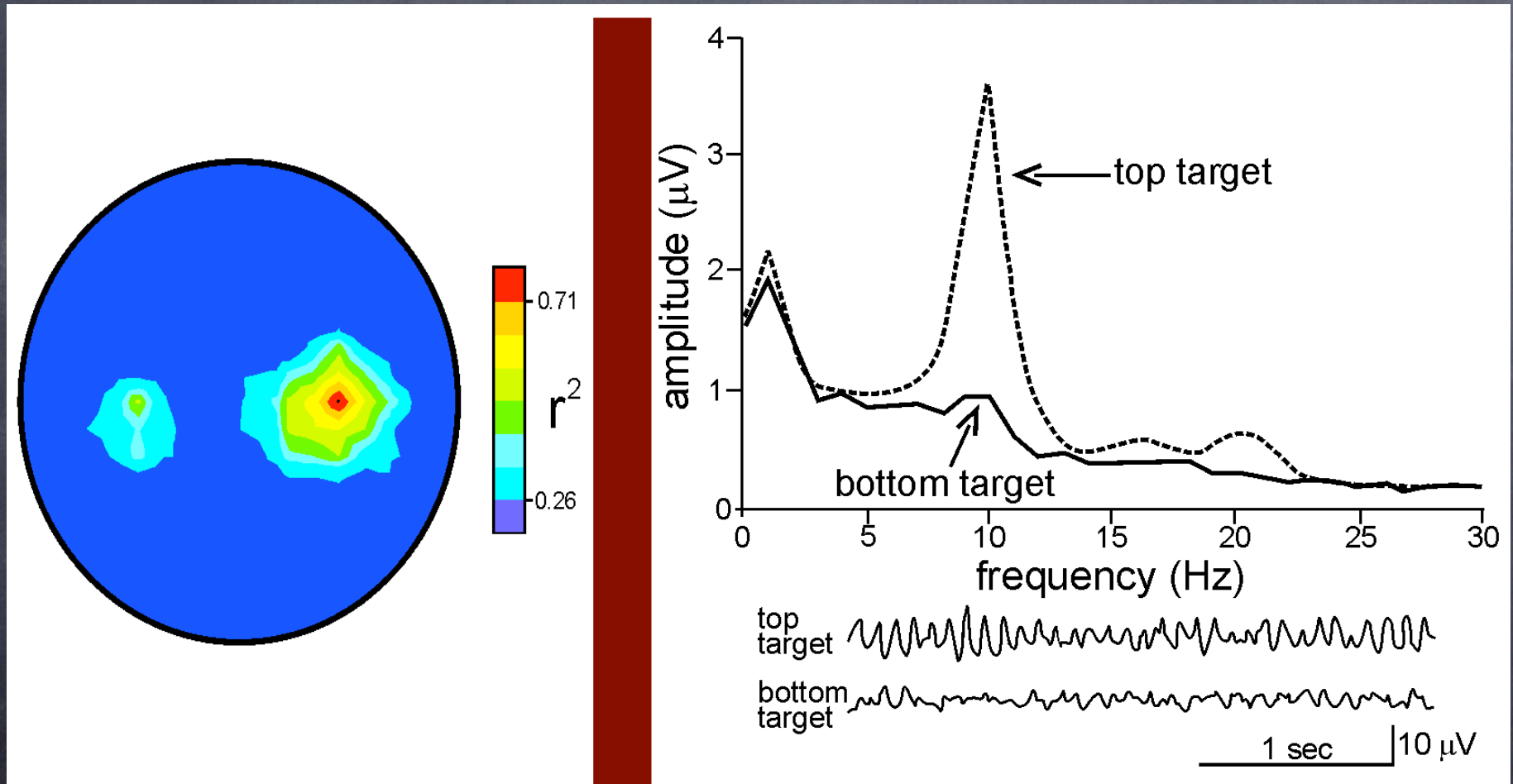
Electroencephalogram (EEG)

Scalp Electrodes



A single electrode provides estimates of synaptic action averaged over tissue masses containing between roughly 100 million and 1 billion neurons (Nunez, 2006)

Sensorimotor Rhythm During Imagined Movement

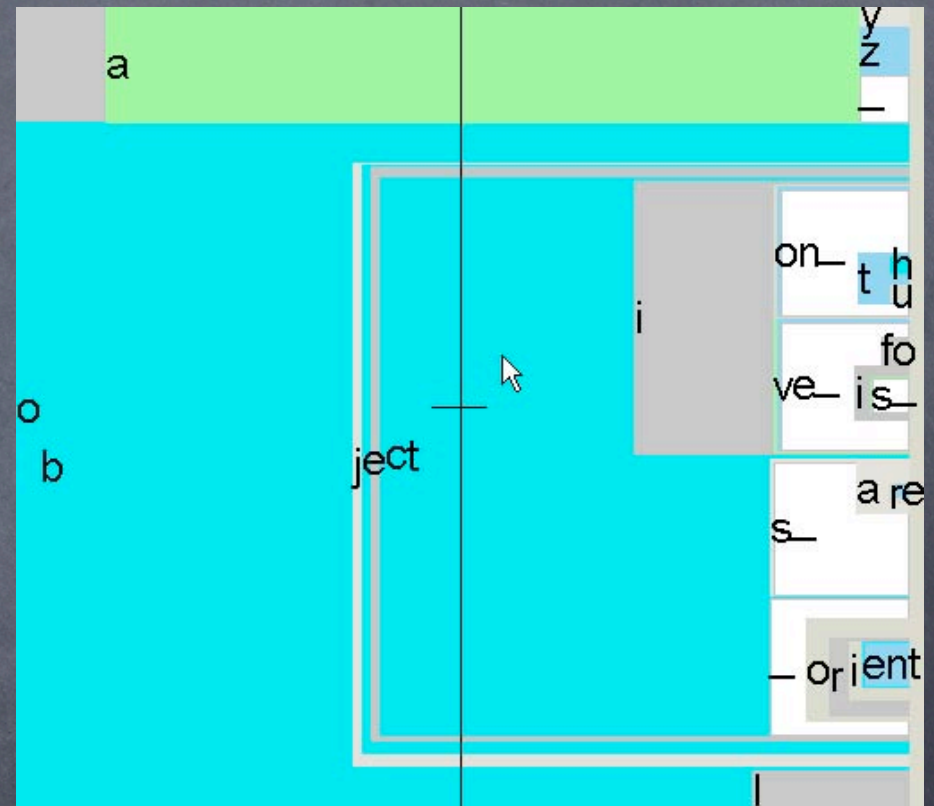
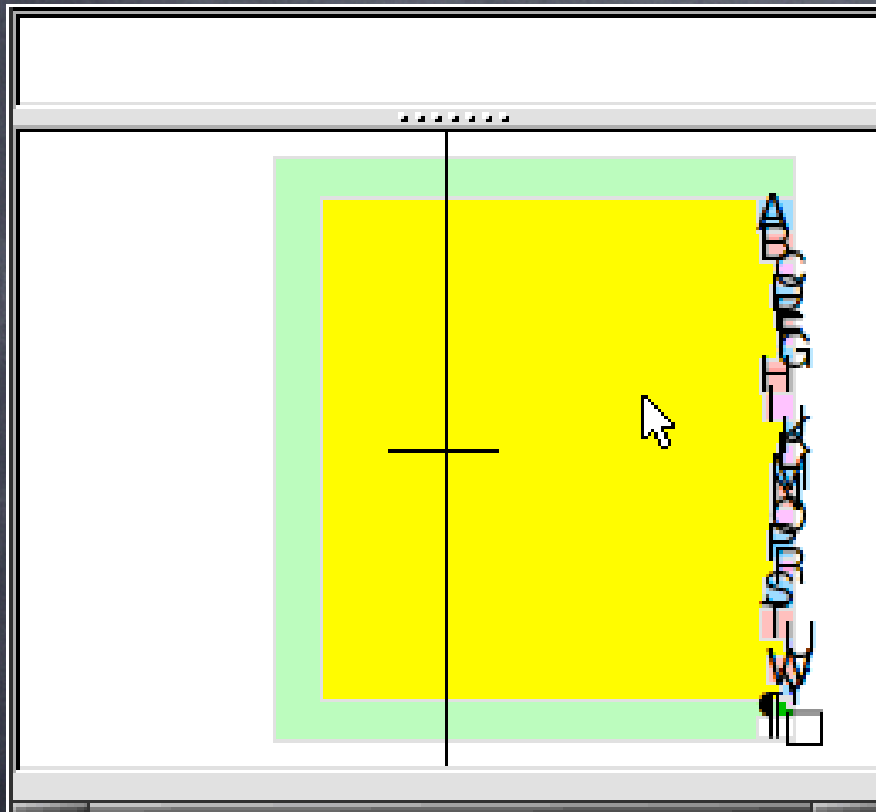


Wolpaw et al, 1991

2-D EEG Cursor Control



Brain Operated Spelling

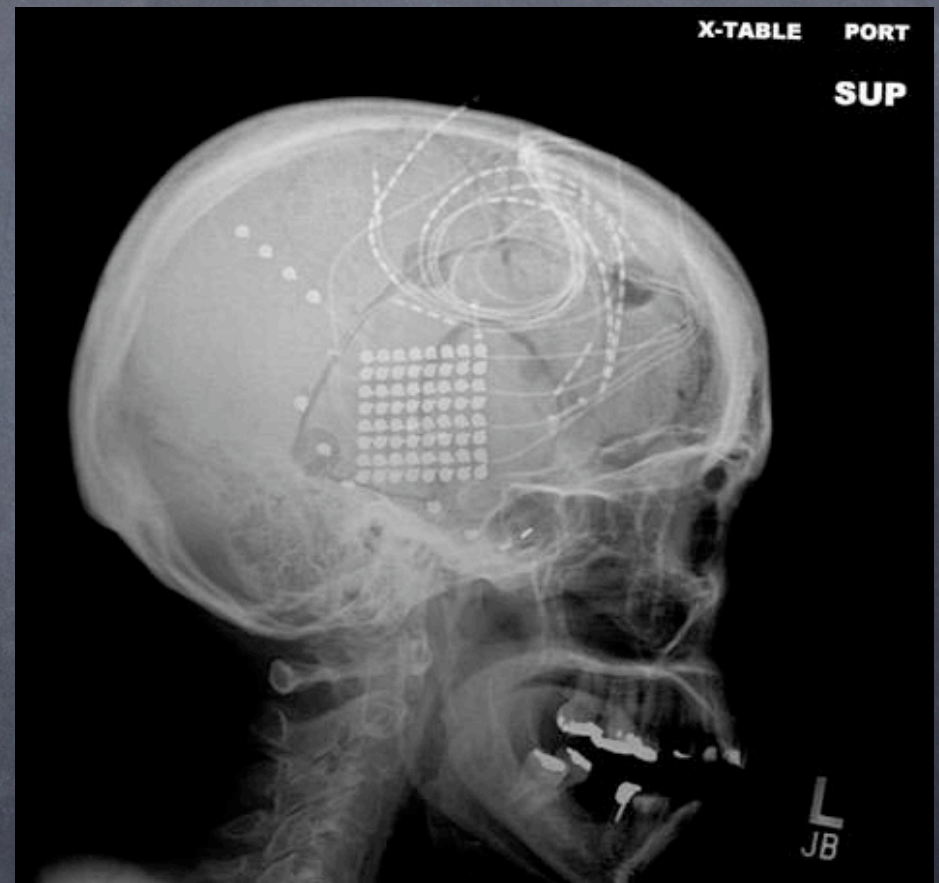
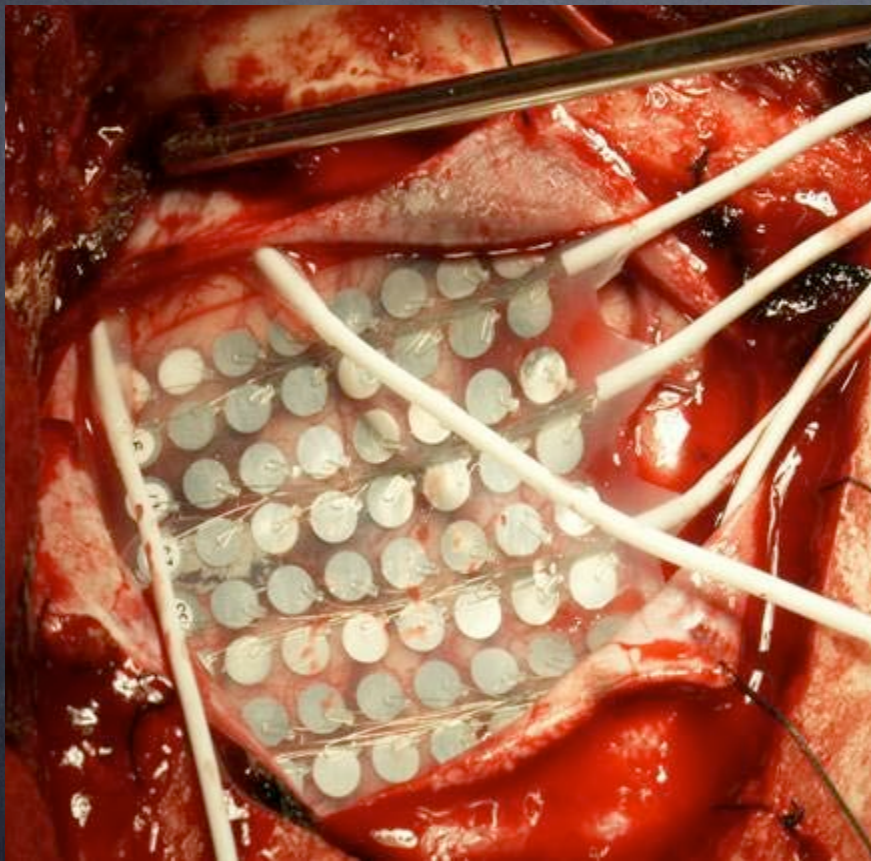


User navigates through a 'map' of the human language

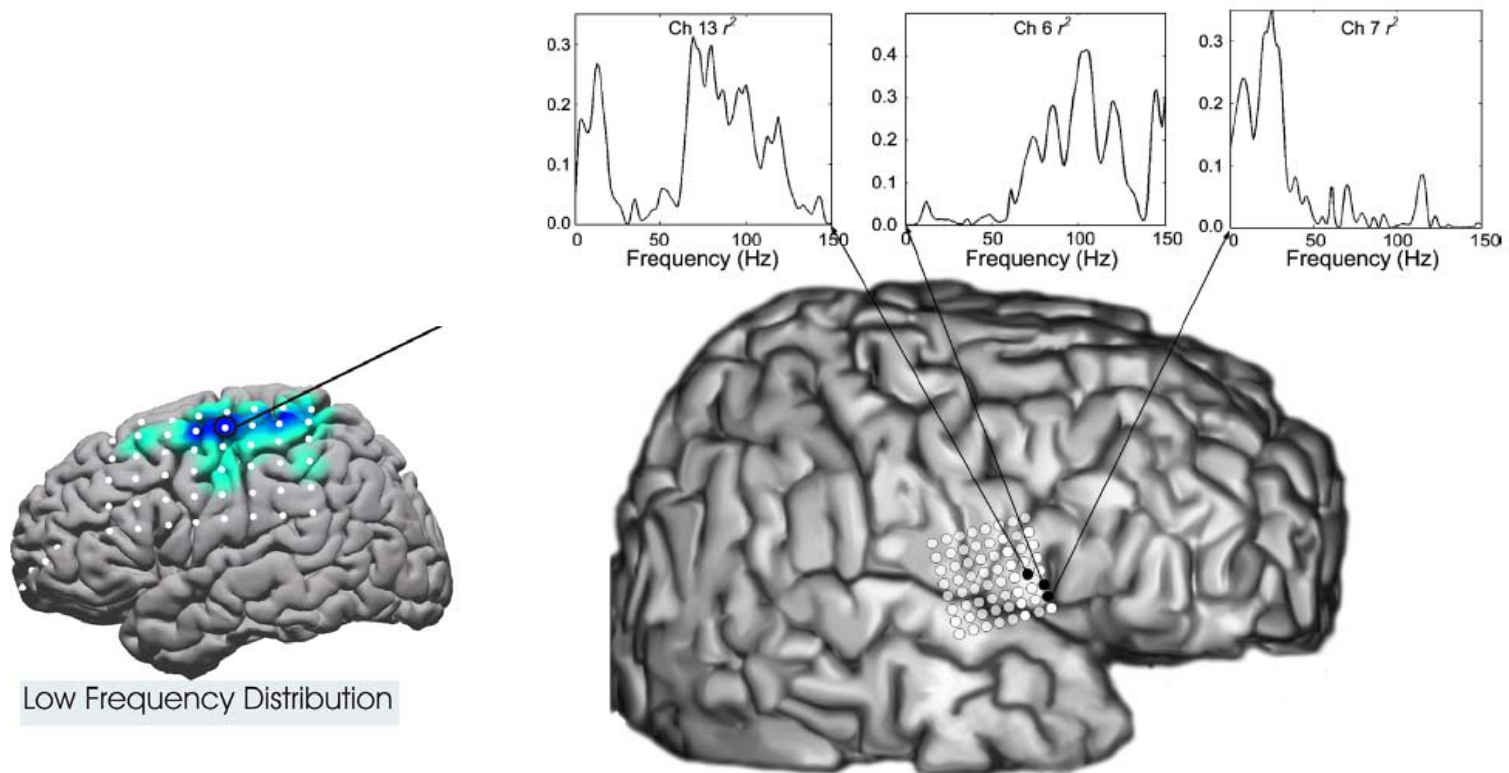
Saying 'Hello'



Clinical Opportunity: Epilepsy



Variable Frequency Distributions



Wilson, J.A., et al., IEEE Trans Neural Syst Rehabil Eng, 2006.

Leuthardt, Neurosurgery, 2006

Non-Motor ECoG BCI

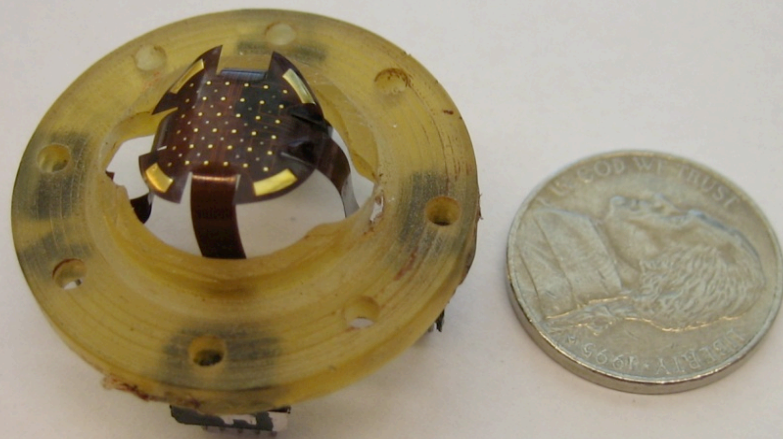
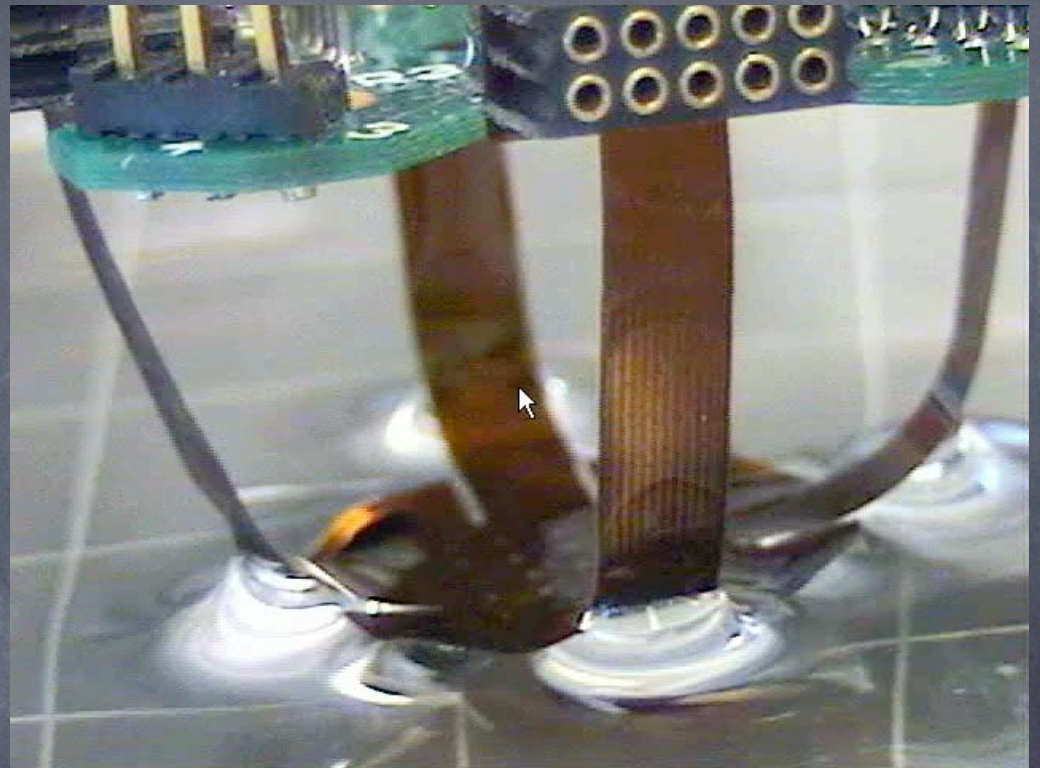
UW Hospital Brain-Computer Interface Project



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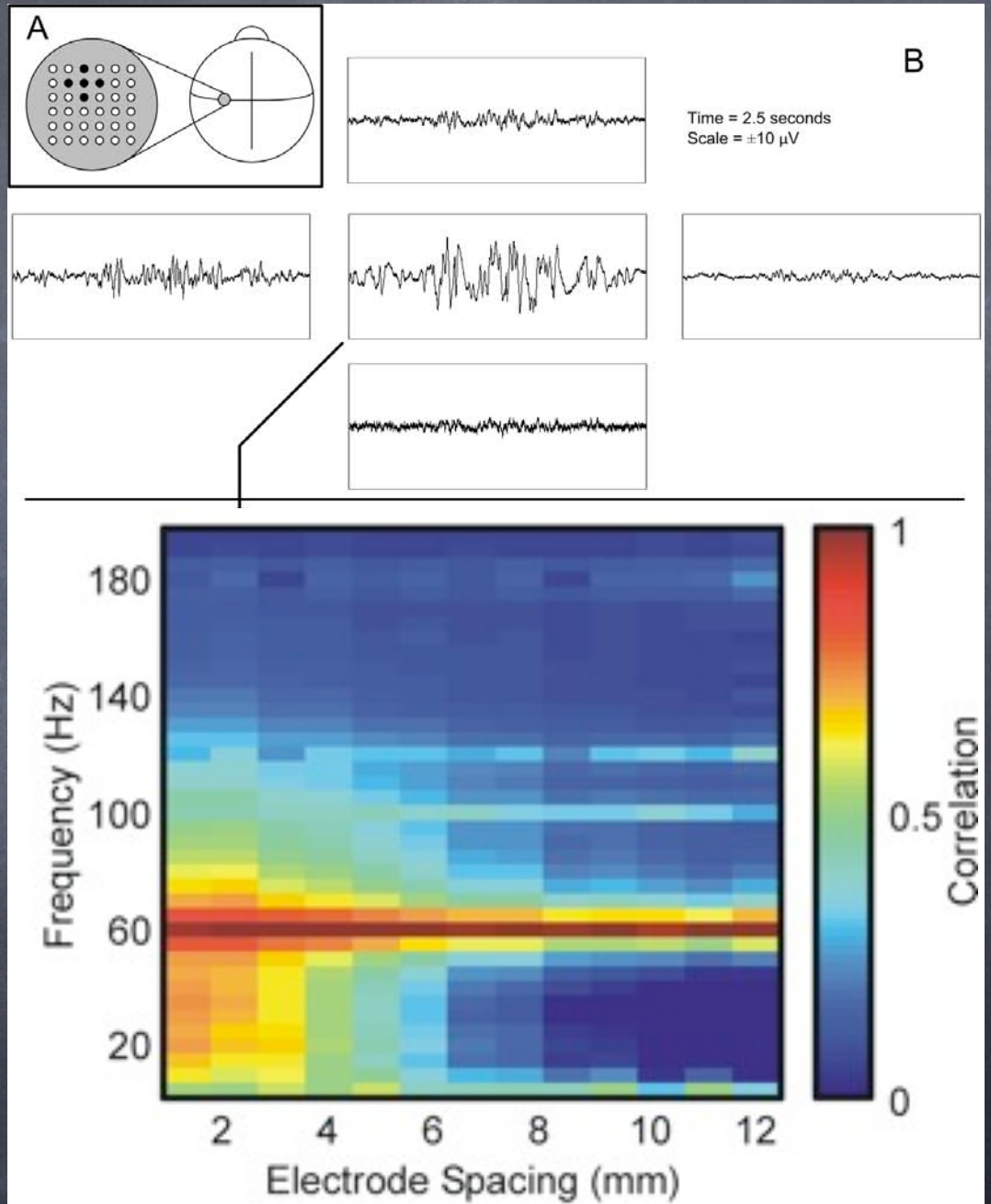
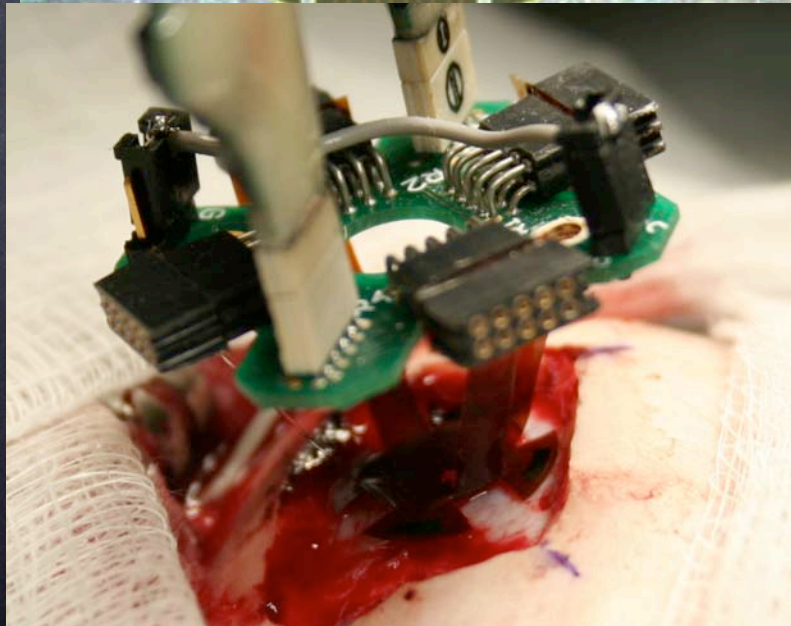
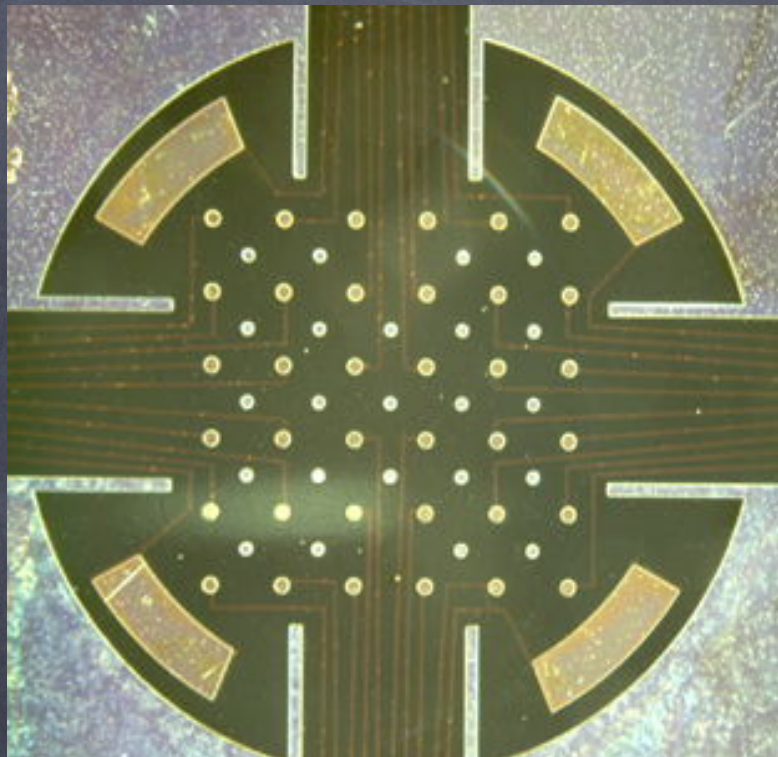
Felton et al, Neurosurgery, 2007

Flexible Thin Film Electronics



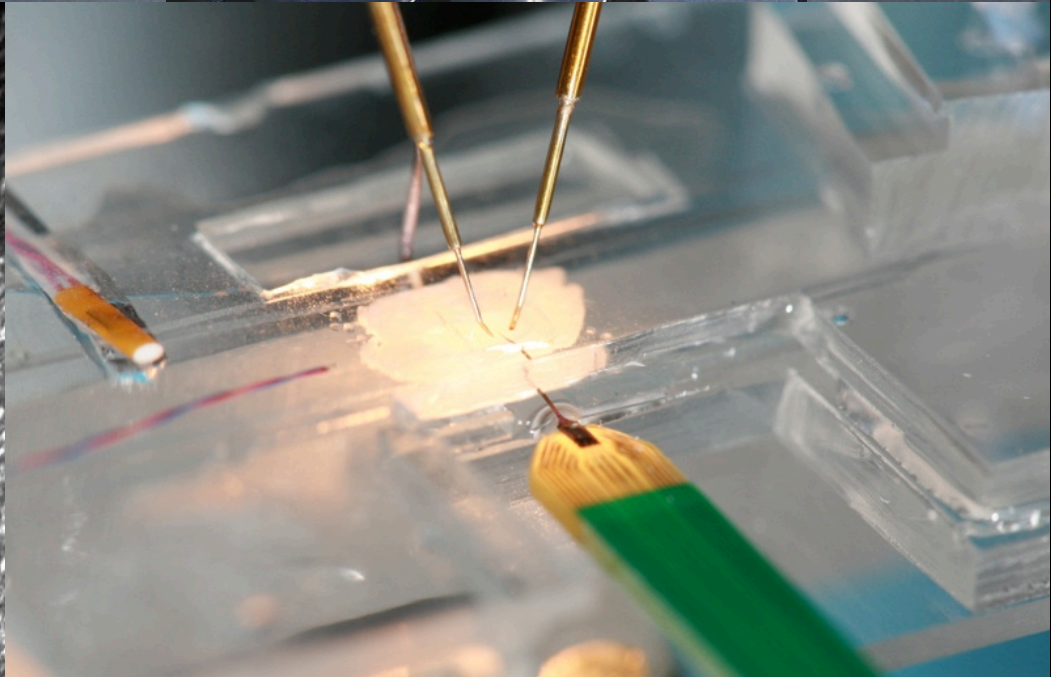
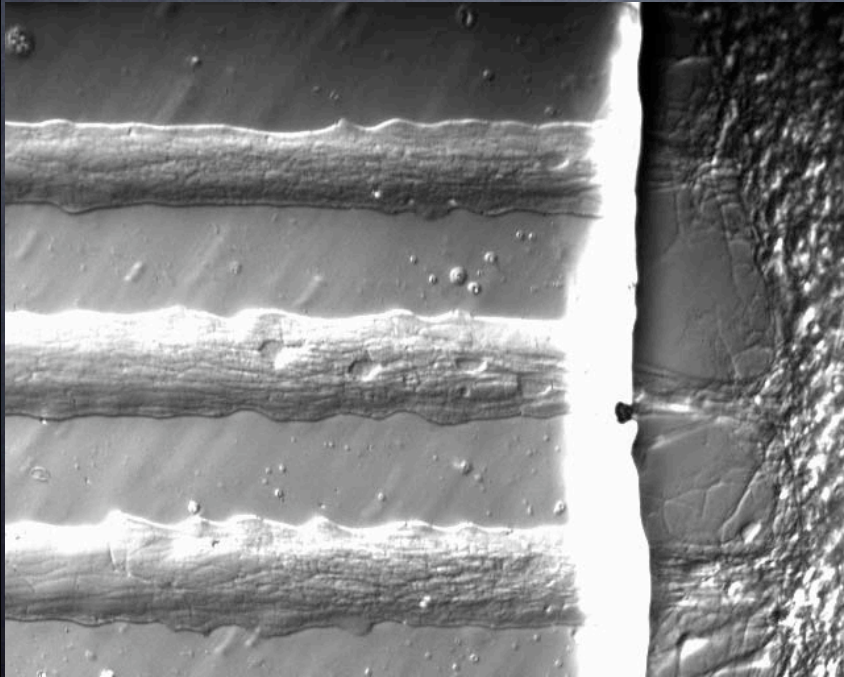
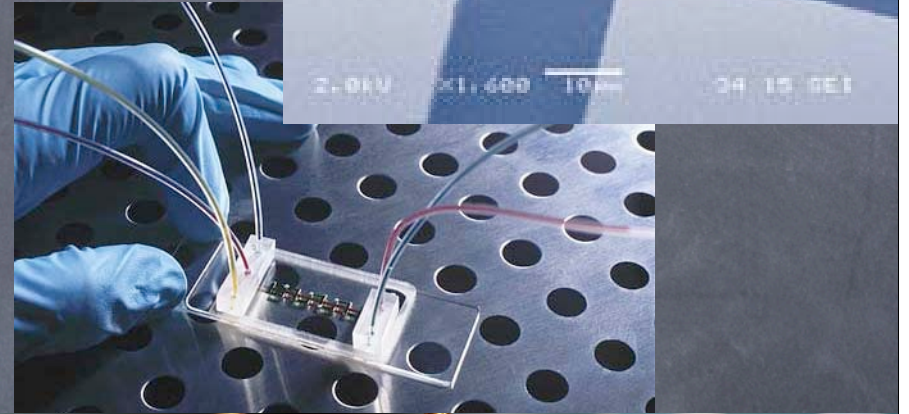
- Ultra-flexible
- Unique Surface Interactions
- High Resolution

Future Directions: microECoG Implants



Other Neuroengineering Activities at UW

- Micropatterning for Guiding neural development
- Microfluidics for controlled chemical delivery



Nanotechnology for Directed Neural Growth



Primary Cortical Neurons Growing on
Nano-Grafted Protein Patterns

Acknowledgements

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Dr. Robert Radwin, Dr. Lisa Krugner-Higby, Dr. Kevin Eliceri, Dr. Eric Dent
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- **UW Clinical Neuroengineering Training Program**



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