Neural Interfaces for Controlling Finger Movements

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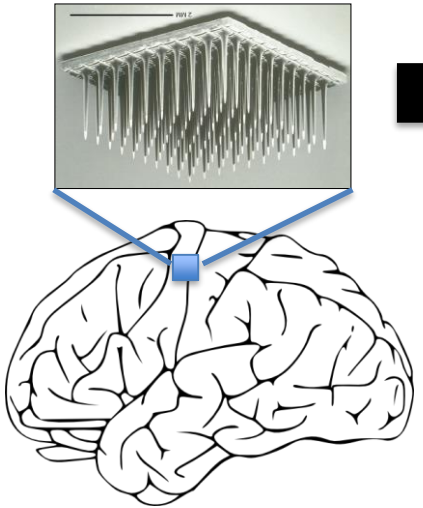

(Nuyujukian…Shenoy, 2014)

Supplementary Video 3

Typing Shakespeare

Monkey J

06/01/2016

Nuyujukian, Kao, Ryu, & Shenoy

Proceedings of the IEEE (2016)

What We Work On

- Peripheral nerve control of finger movement
- Brain control of finger movement
- Breaking barriers on electrode density

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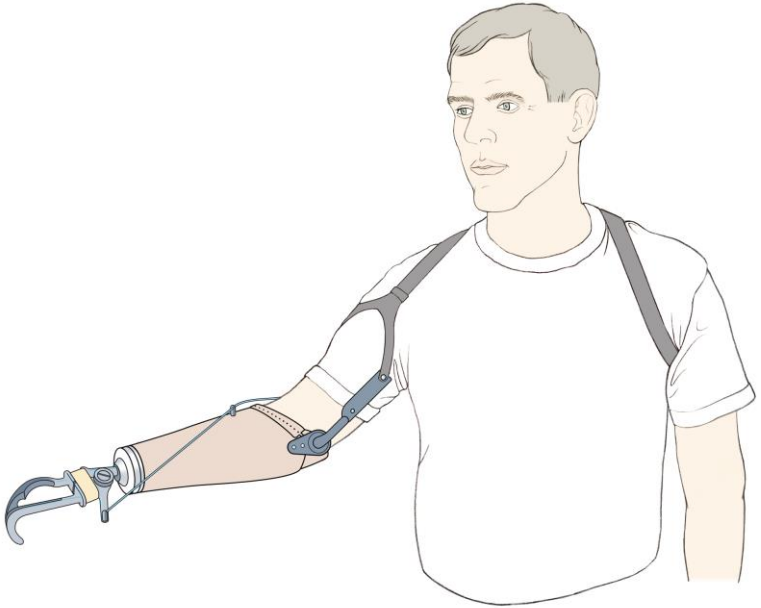
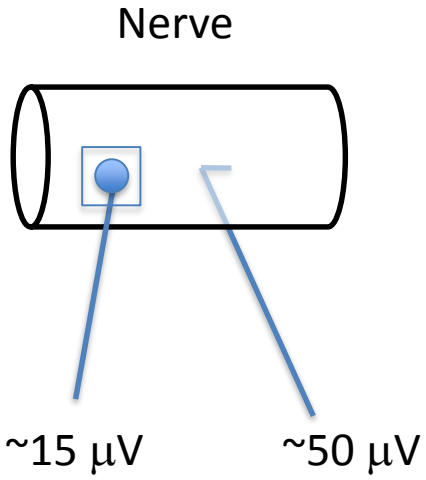
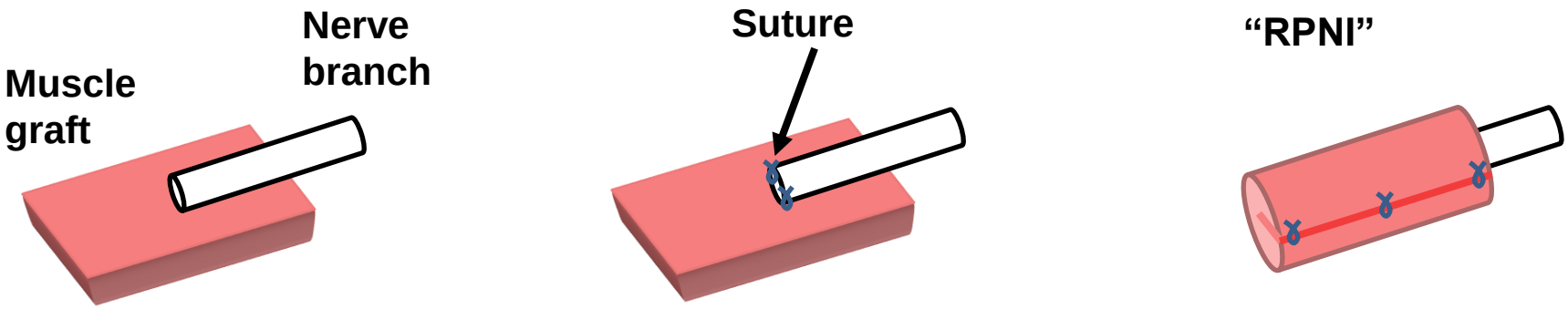


Empire Strikes Back, 1980

40,000 with complete hand amputations in US

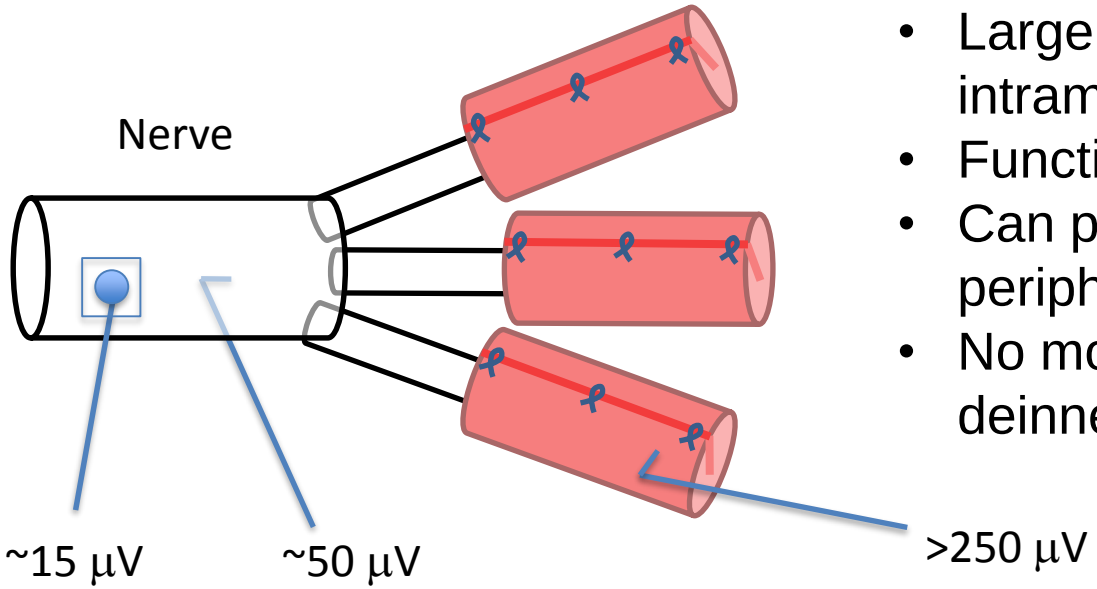

Nerve
~15 μV
~50 μV

Regenerative Peripheral Nerve Interface



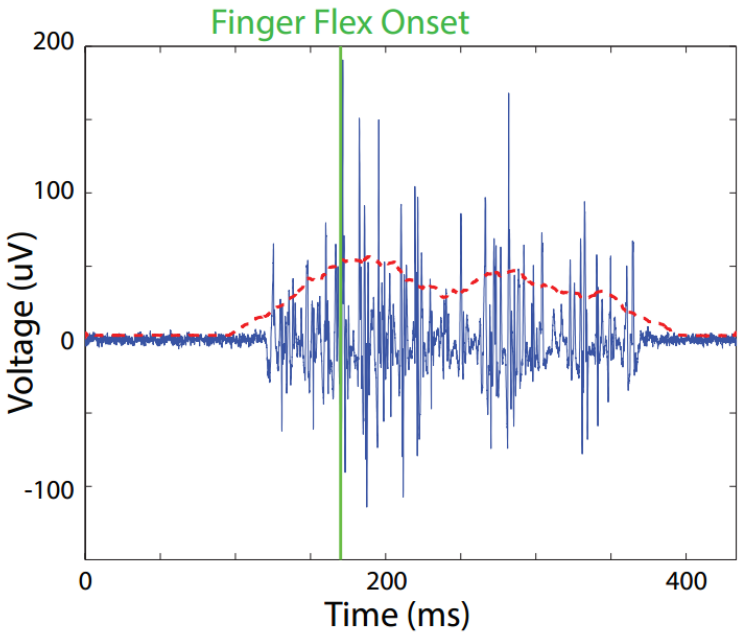
(Cederna, Urbanchek, Anderson)

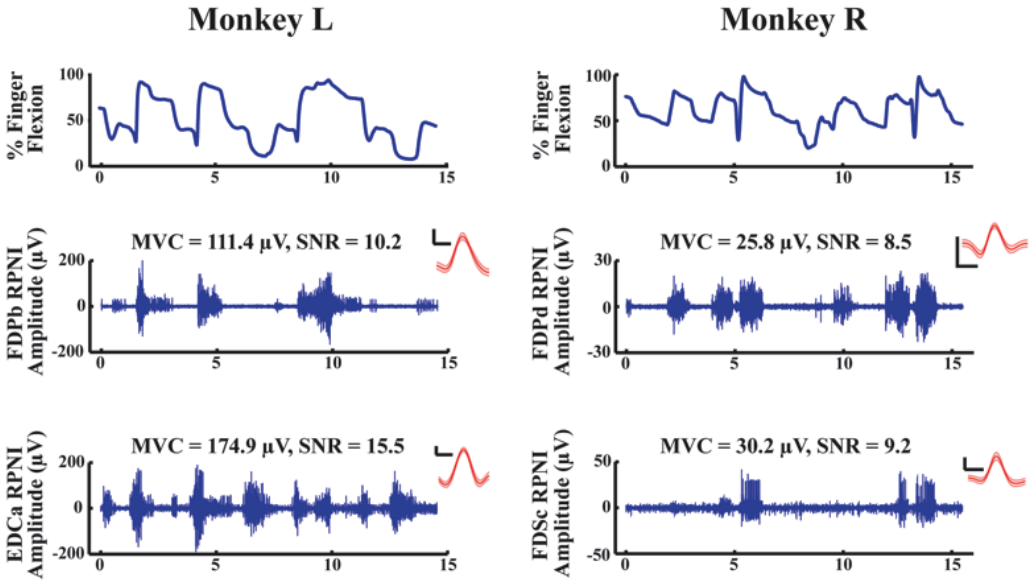
Regenerative Peripheral Nerve Interface



- Large, stable recordings with intramuscular electrodes
- Functionally selective
- Can prevent neuroma and peripheral phantom pain
- No moving of nerves, or deinnervation of existing muscles

Signal Amplitude





(Irwin…Chestek, *JNE*, 2016)

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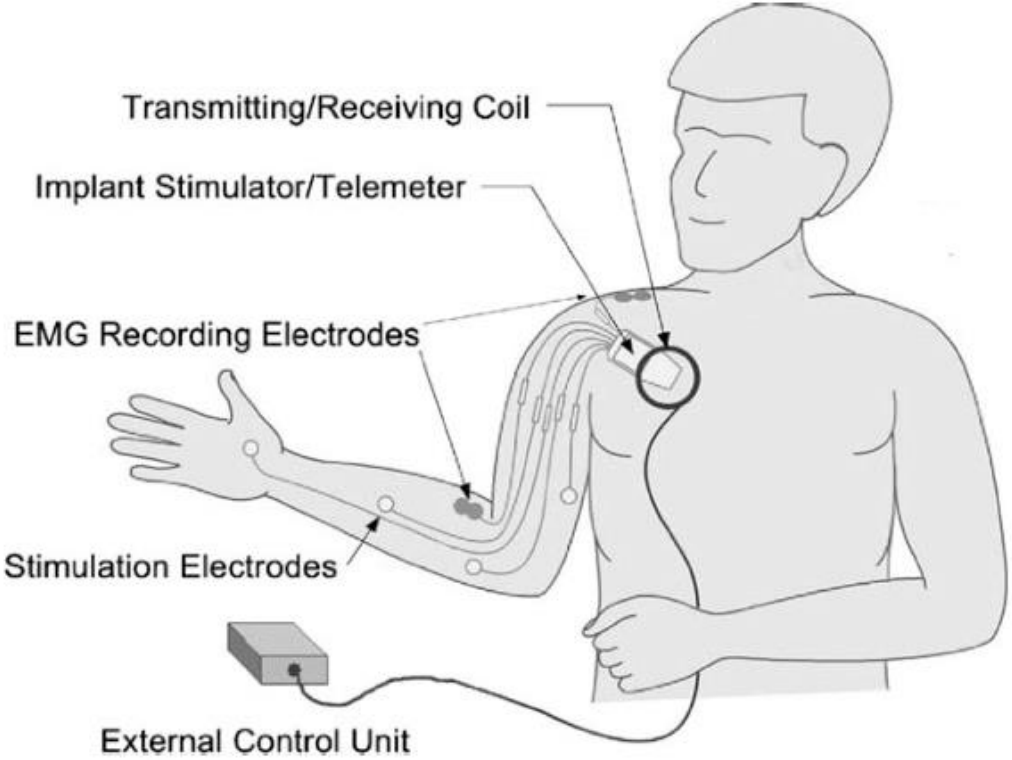
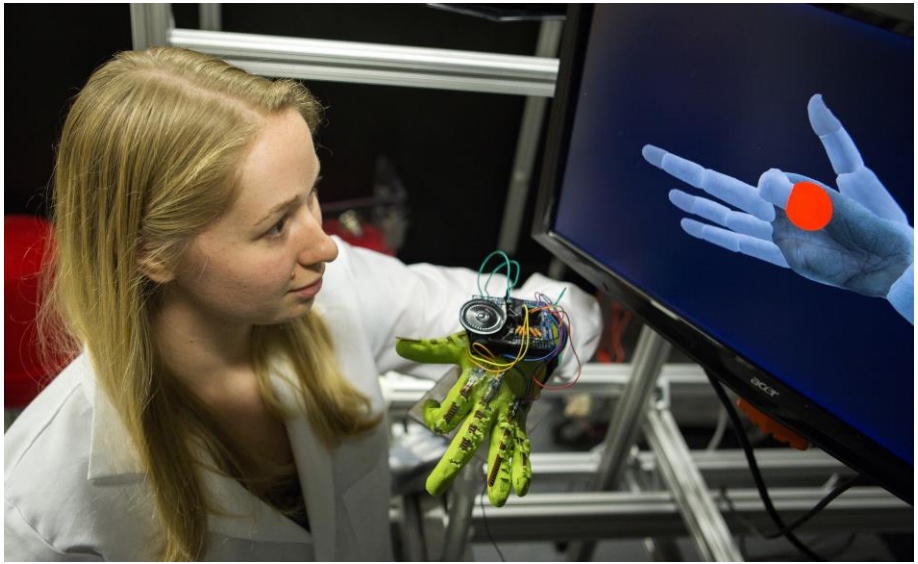
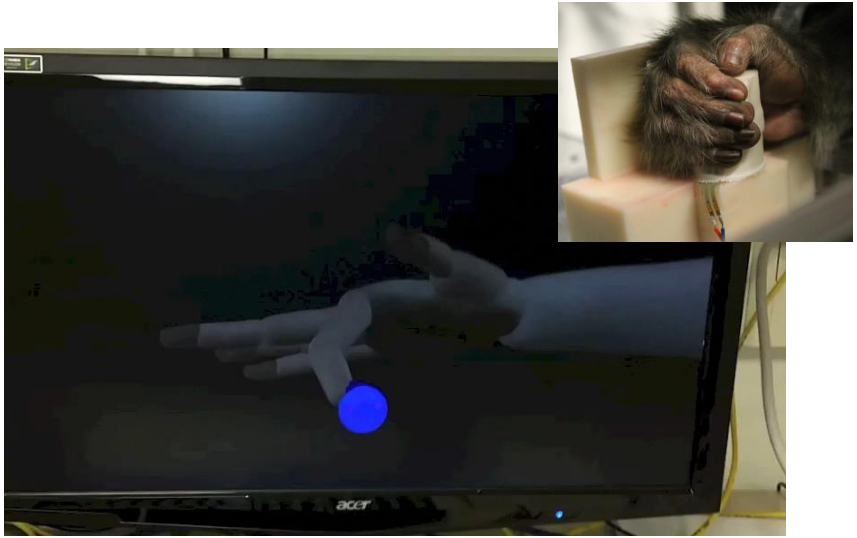
1.3 million with spinal cord injury



Kilgore and Peckham

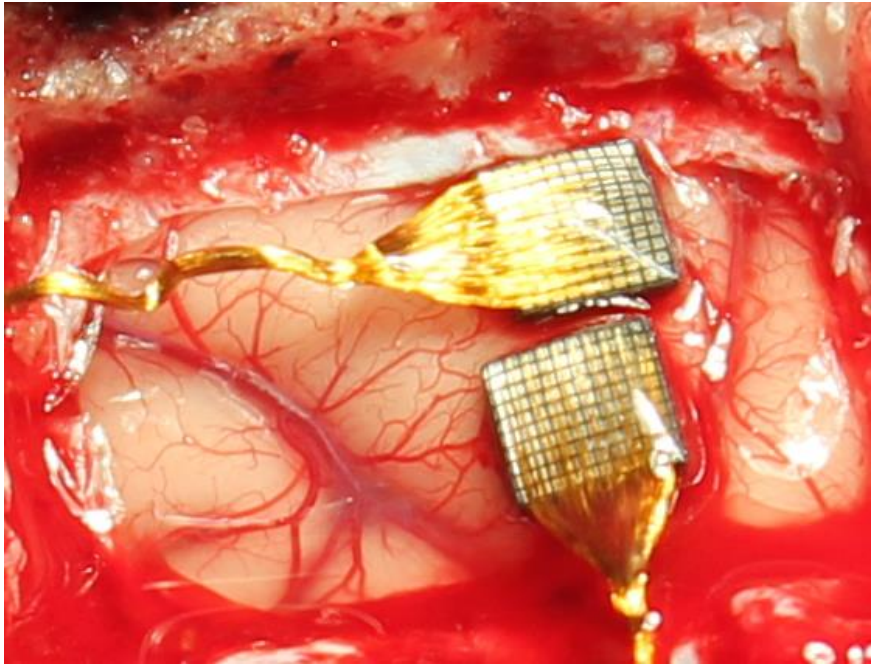




(Irwin…Chestek, *SFN*, 2015)

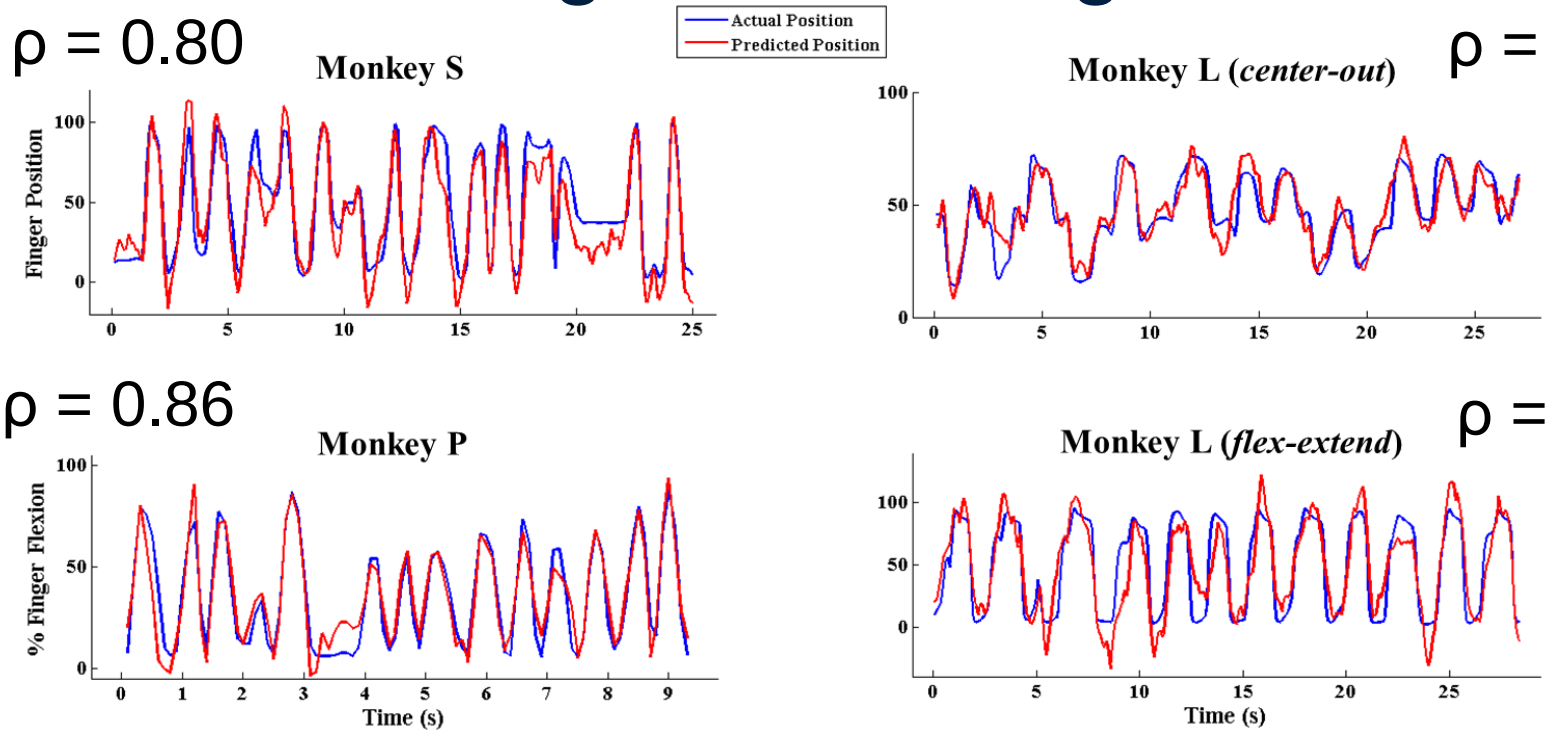
(Macaque hand by Davoodi, Loeb, MSMS)

Utah Array Implants



Parag Patil, MD, BME PhD, Neurosurgery

Finger Decoding

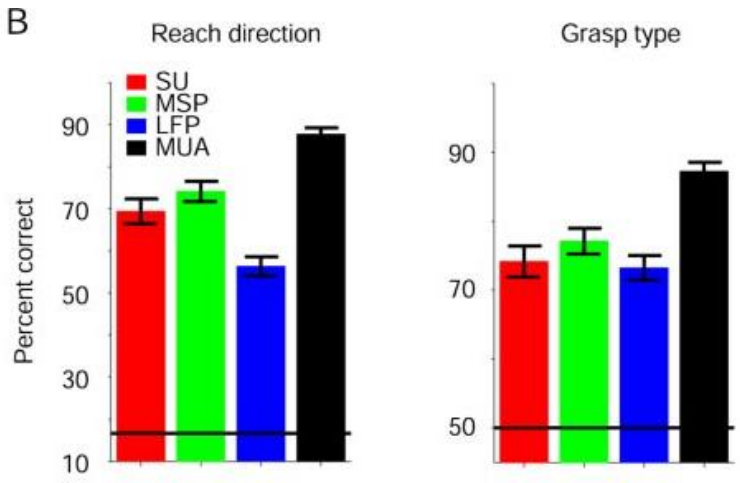


(Irwin…Chestek, unpublished)

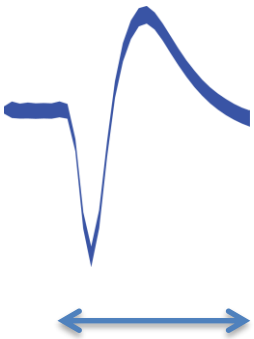
Why can't we add this to the existing system that stimulates paralyzed arms?

100 chan x 30 ksps x 16-bits = **48 Mbps**

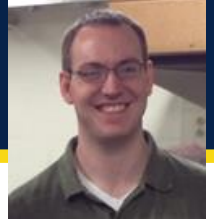
“Spiking Band” Power



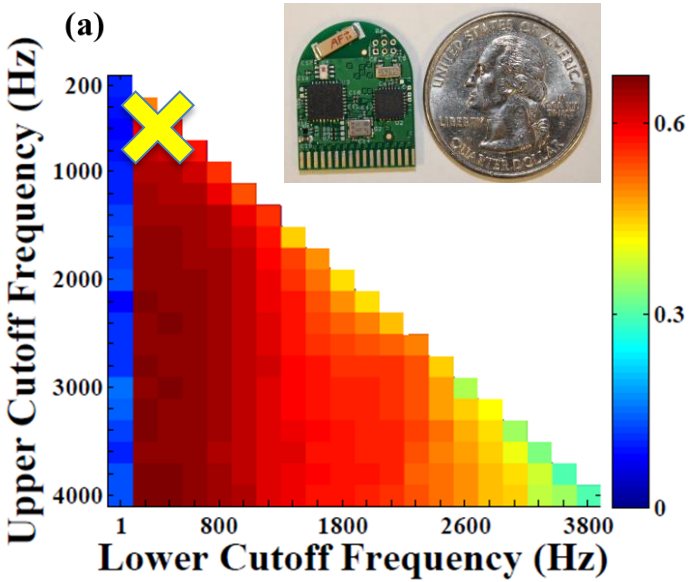
(Stark and Abeles, 2007)

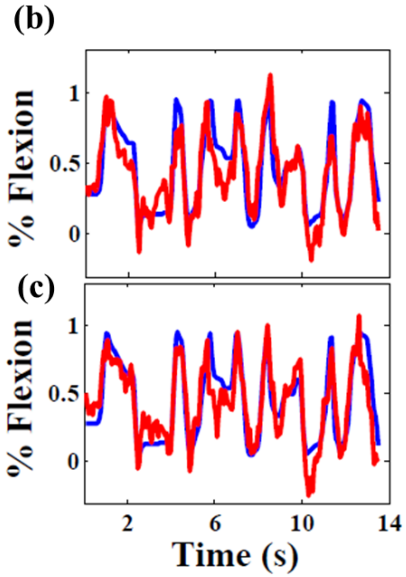


1 ms,
1 KHz



“Spiking Band” Power





High bandwidth spikes, 30 ksps:
ρ = 0.82

Low bandwidth, 300-1000 Hz
ρ = 0.78

89% Power Savings

(Irwin*, Thompson*, … Chestek, *IEEE TNSRE*, 2015)

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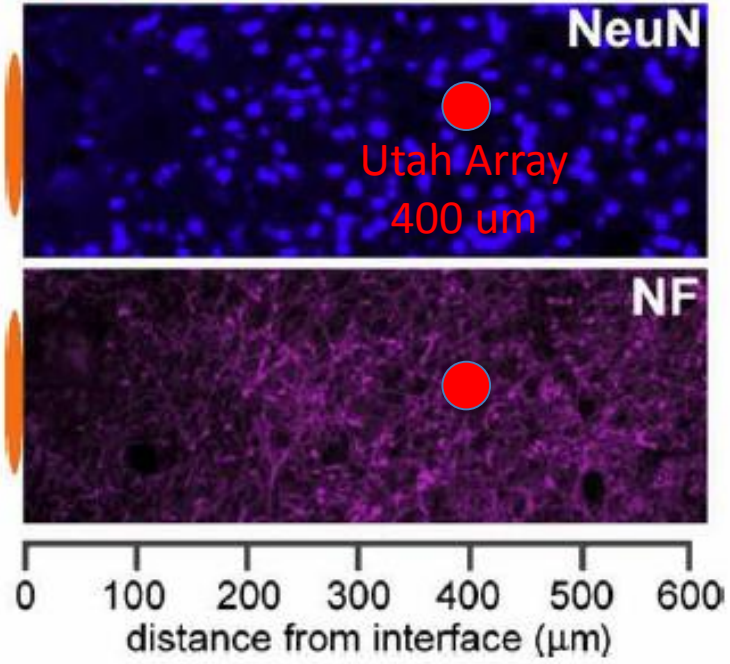
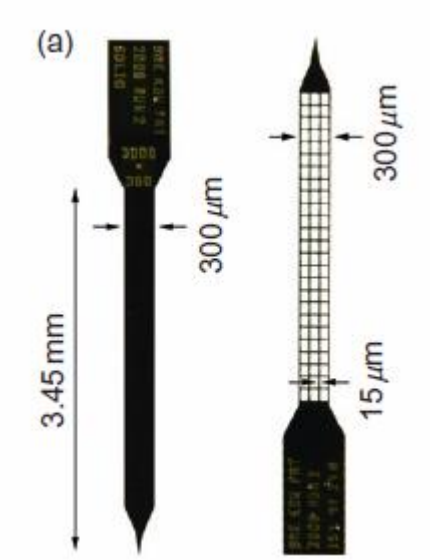
Conventional Electrodes Cause Scarring

- Limits electrode density



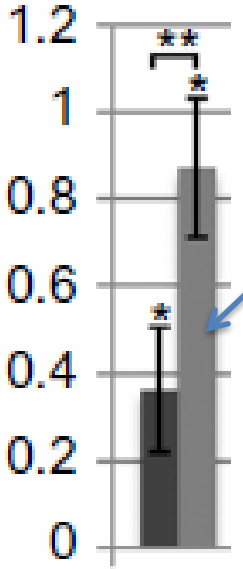
Biran et. al, *Exp. Neurol.*, 2005

Best Known Solution = Small

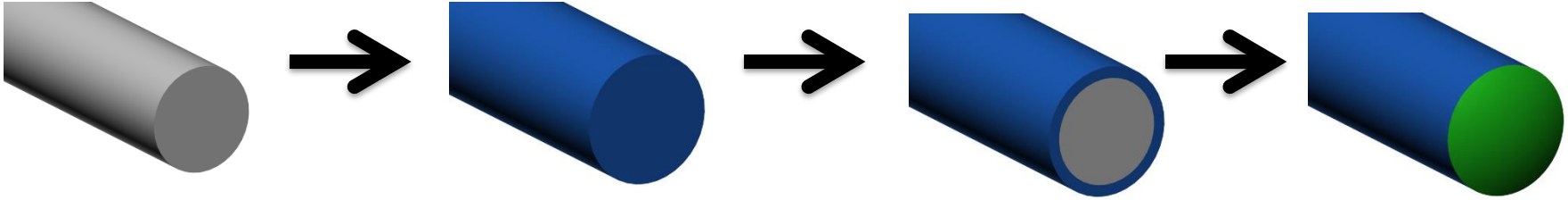


Skousen et. al, *Prog. Brain Res.*, 2011

Fraction of Normal Density 0-50 um from electrode



Grid Electrode

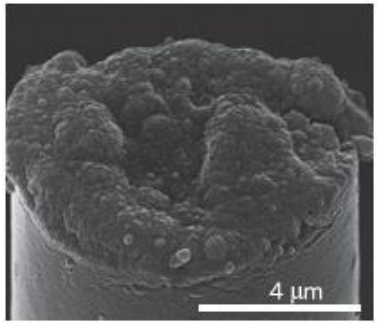


Bare Carbon Fiber (**d=7µm**)

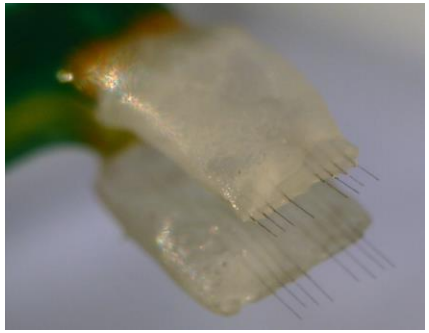
Parylene-c Coating (**t=800nm**)

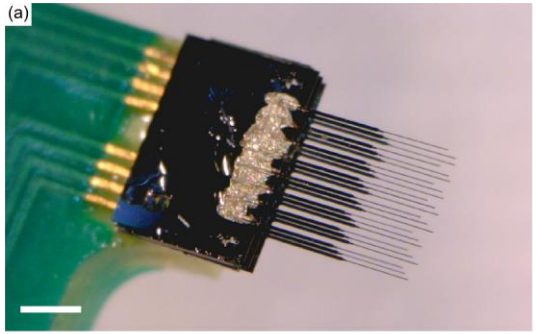
Cut tip

PEDOT Coating



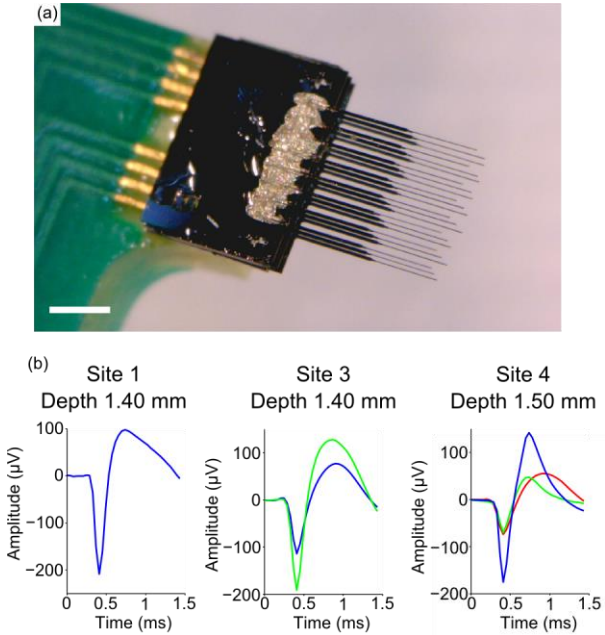
Kozai et. al, *Nature Mat.*, 2012





(Patel…Chestek, JNE 2015)

3x8 Arrays

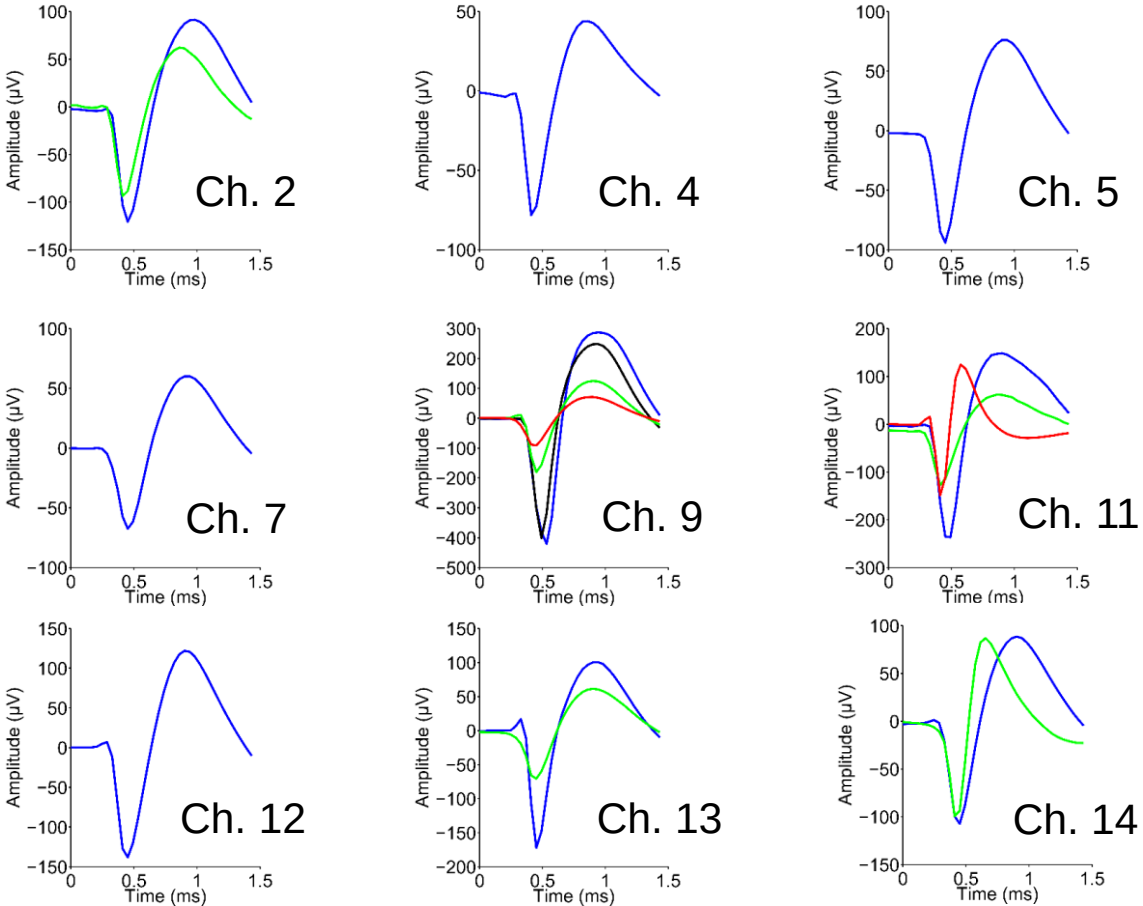


Insertion of 3D Silicon Support Structure
Trial #4

750 μm Silicon Shanks + 500 μm Carbon Fibers

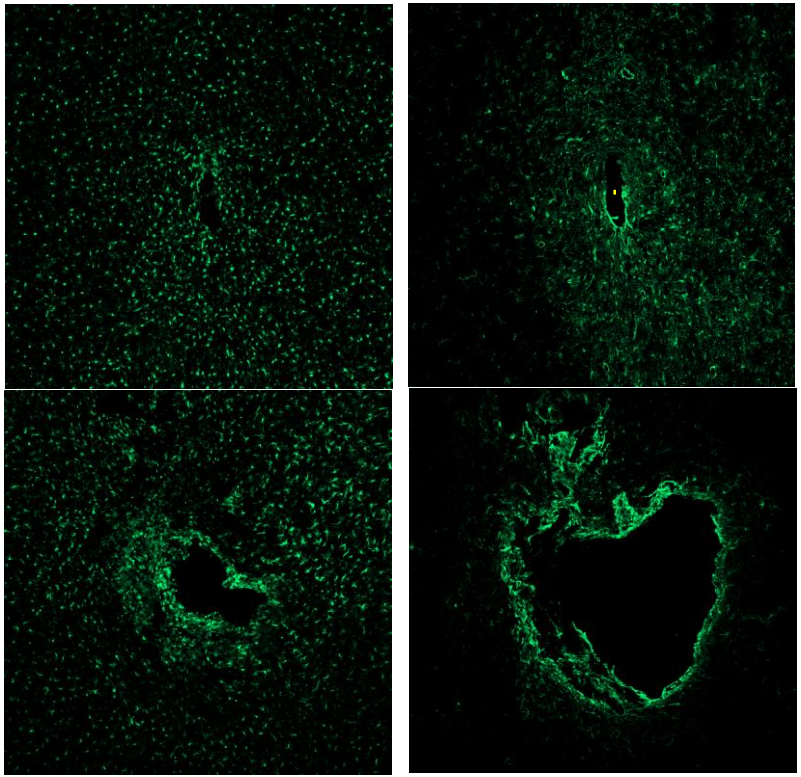
Date: 09-01-2014

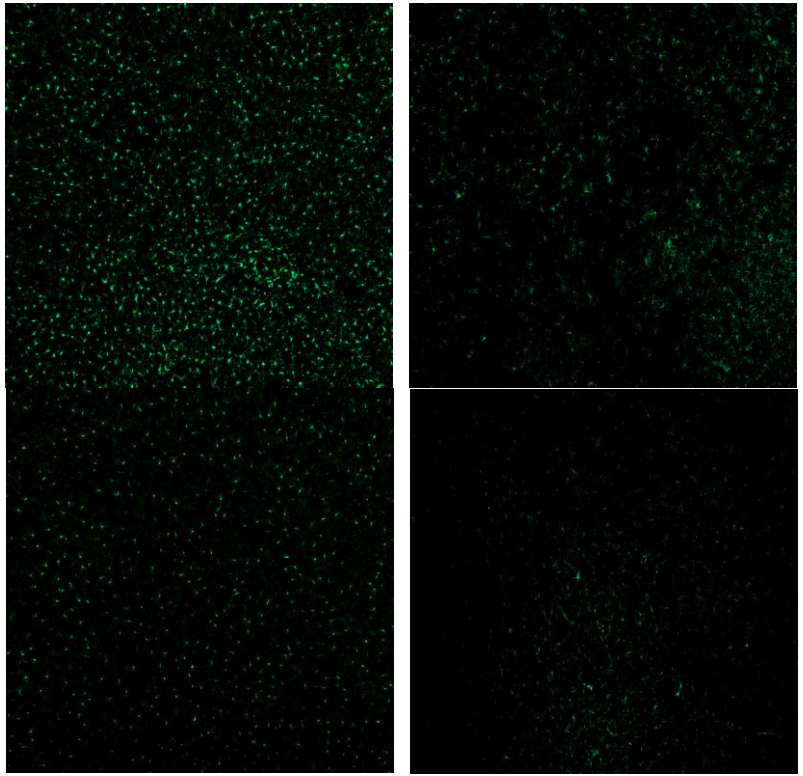
(Patel…Chestek, *JNE*, 2015)



Day 15 Recordings from one rat

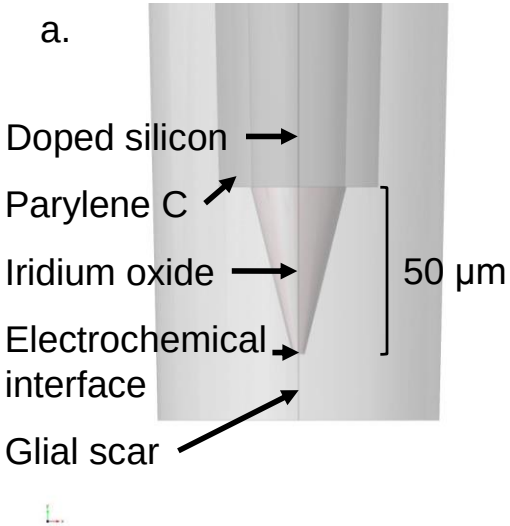
(Patel…Chestek, *JNE*, 2015)

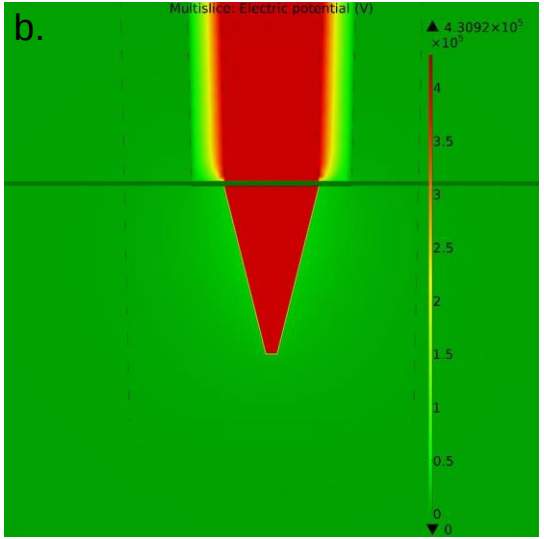


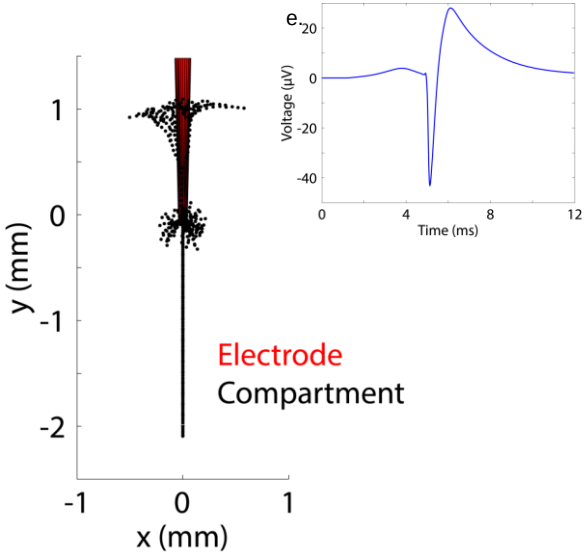


(Patel…Chestek, *JNE*, 2017)

Compartmental Model







(Malaga…Chestek*, Patil*, *JNE*, 2015, Moffitt and McIntyre, 2005, Lempka et al., 2011)

Funding Sources

WALLACE H. COULTER Foundation

DARPA

CRAIG H. NEILSEN FOUNDATION

THE McKNIGHT FOUNDATION

NATIONAL INSTITUTES OF HEALTH

- Muscle graft work
- Brain control of finger movement
- Carbon arrays

- Lab members
  - Paras Patel, PhD
  - Autumn Bullard, Philip Vu, Chrono Nu
  - Ciara Caldwell, Sam Nason, Elissa Welle
  - Alex Vaskov, Pavlo Popov
- Alumni
  - Karen Schroeder (Postdoc Columbia)
  - Zachary Irwin (Started Myonic Systems)
  - David Thompson (Asst. Prof. Kansas State)
  - Jessica Nicole Bentley (Soon at Emory)
  - Breanne Christie (PhD student, CWRU)
- Lab Staff
  - Eric Kennedy, Kaile Bennett
- Collaborators
  - Parag Patil, Kevin Chen, Karlo Malaga Neurosurgery
  - Euisik Yoon, Kyounghwan Na, EECS
  - Khalil Najafi, Daniel Egert, EECS
  - Paul Cederna, Melanie Urbanchek, Nick Langhals, Shoshana Woo, Plastic Surgery
  - Nick Kotov, Huanan, Zhang, ChemE
  - William Stacey, Steve Gliske, Neurology
  - George Mashour, Anesthesiology
  - Eva Feldman, Neurology
  - Deanna Gates, Kinesiology
  - Brent Gillespie, Mech Eng

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