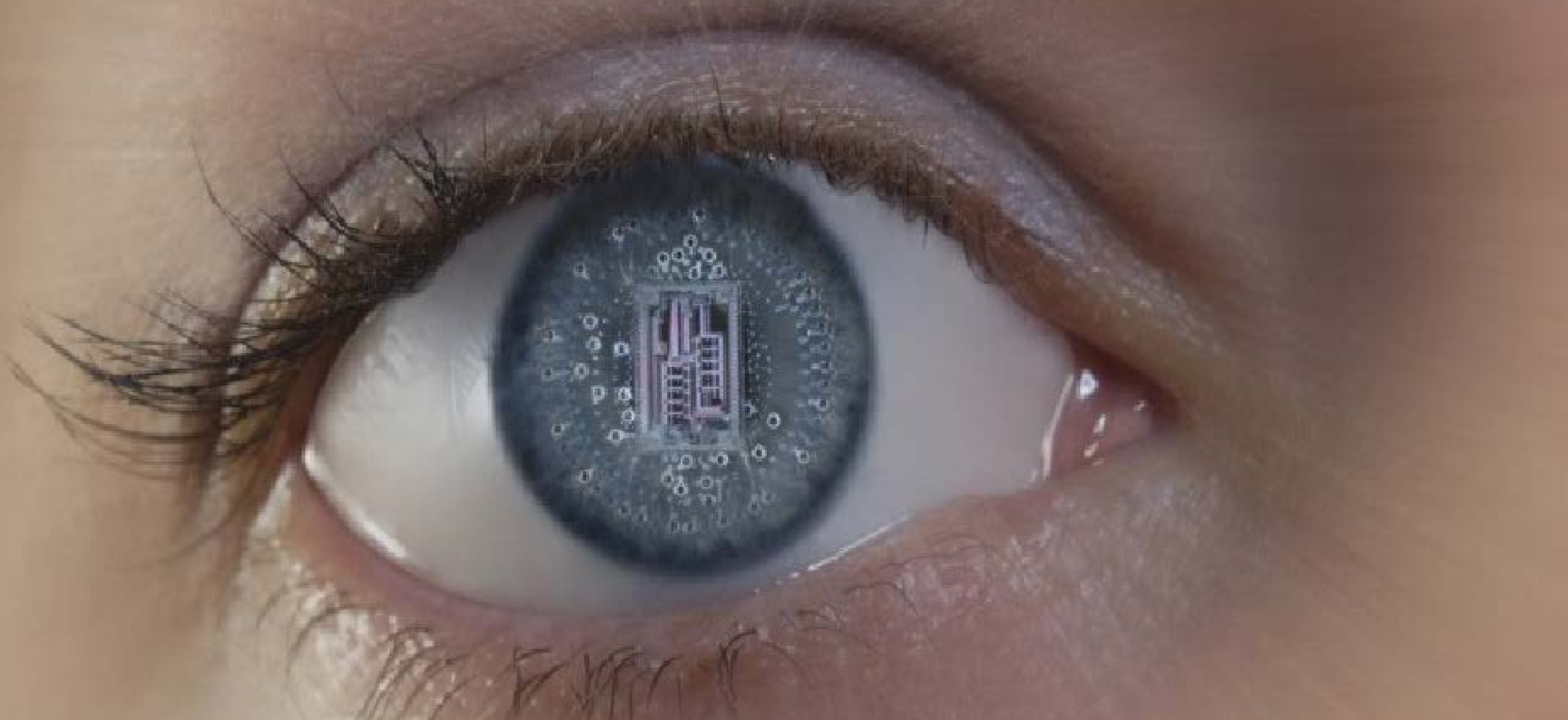
Strategic circuits for neuromodulation of the visual system



SUANING, Gregg J.

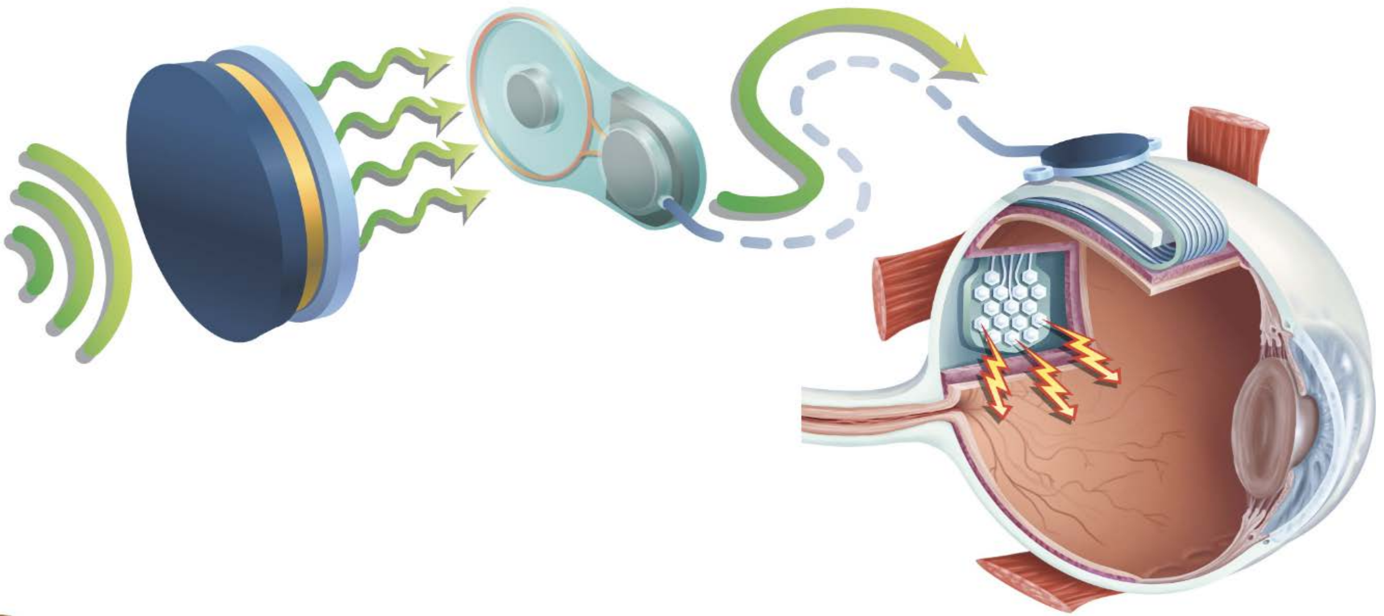
Graduate School of Biomedical Engineering,
University of New South Wales, Sydney, Australia

Australian Government Funding

Australian Research Council 2010-2015: A$14M

"The goal of the wide-view neurostimulator is to deliver vision that enables the recipient to gain mobility by providing sight for navigation and the avoidance of obstacles.

The neurostimulator contains 98 electrodes with power, data and vision processing…"



2017 – 2020 Australian National Health and Medical Research Council
A$1.1M for pilot clinical trial

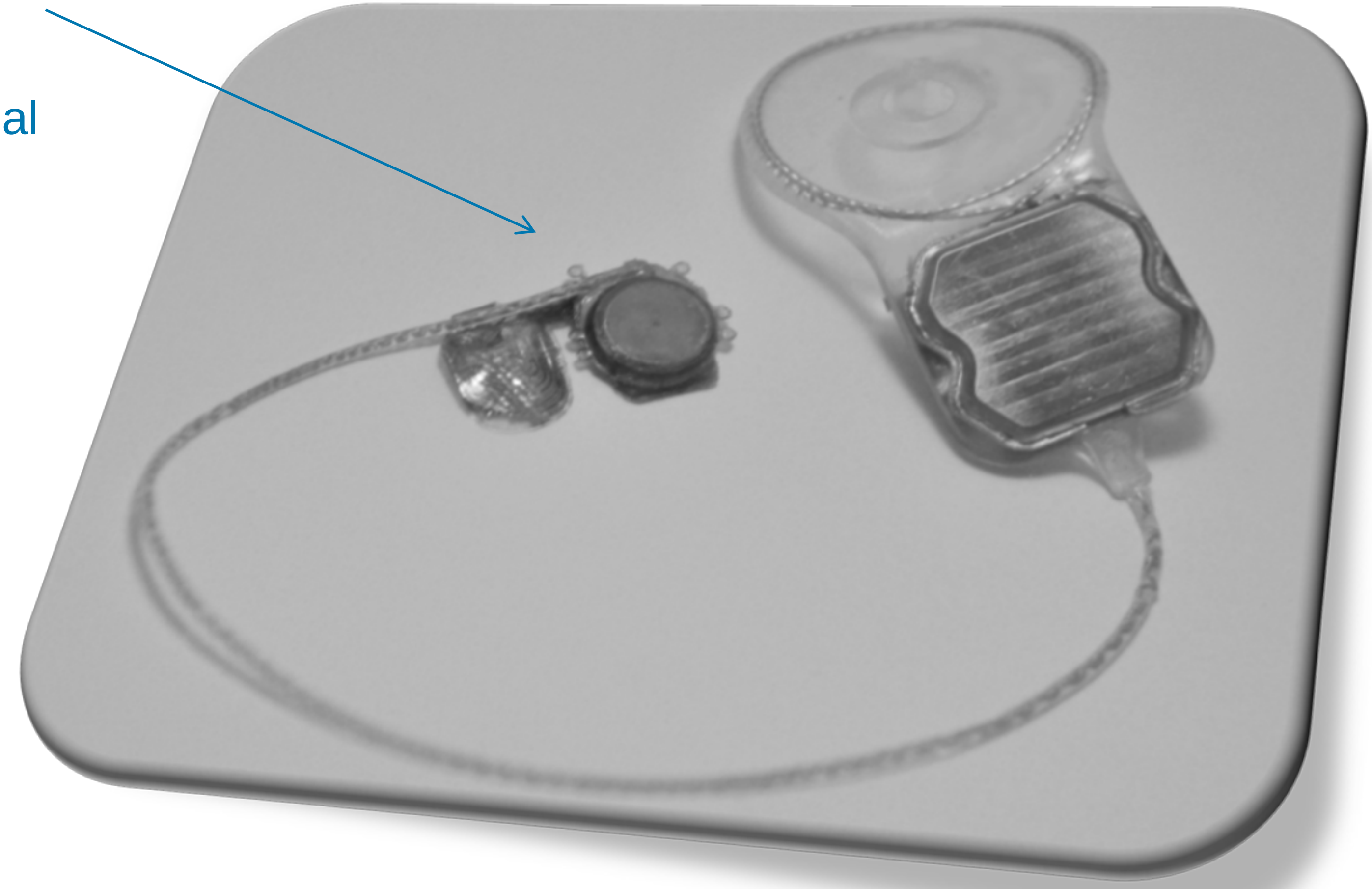
UNSW SYDNEY • AUSTRALIA

Phoenix^{99} Implant Architecture

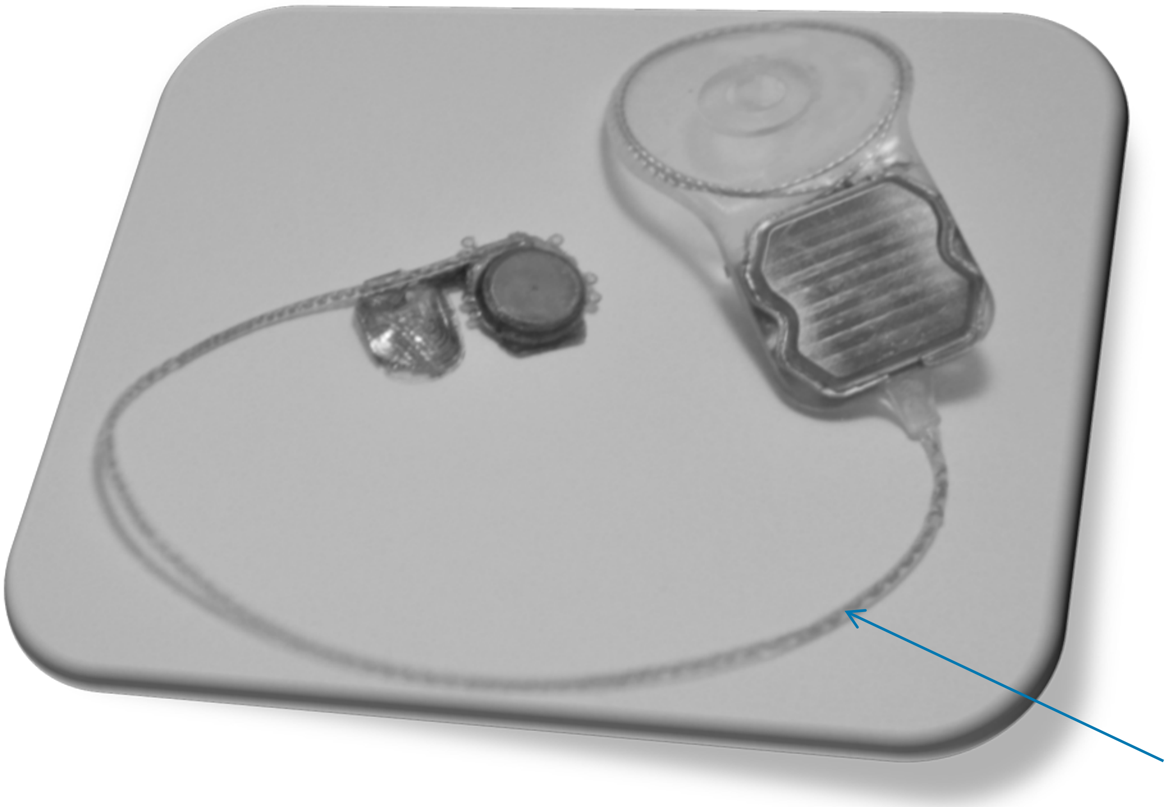
UNSW
THE UNIVERSITY OF NEW SOUTH WALES
SYDNEY · AUSTRALIA

Phoenix^{99} implantable system architecture

Visual Simulator:
98+1 stimulation channels, bi-directional telemetry,
HV-CMOS



Phoenix^{99} implantable system architecture



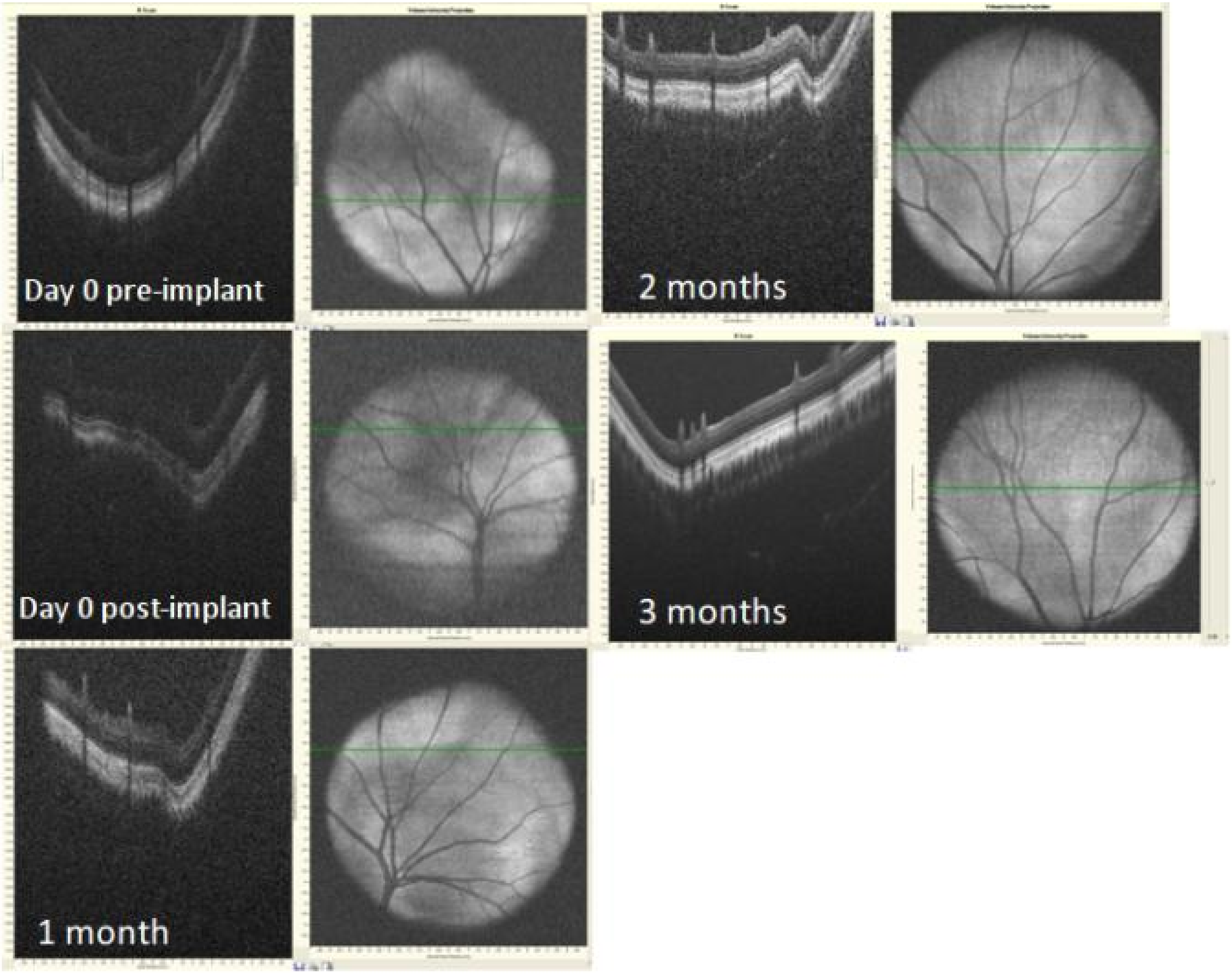
Two-signal interface: charge-neutral data and power transfer between devices. Data delivered between stimulations for efficiency

Phoenix[99] implantable system architecture

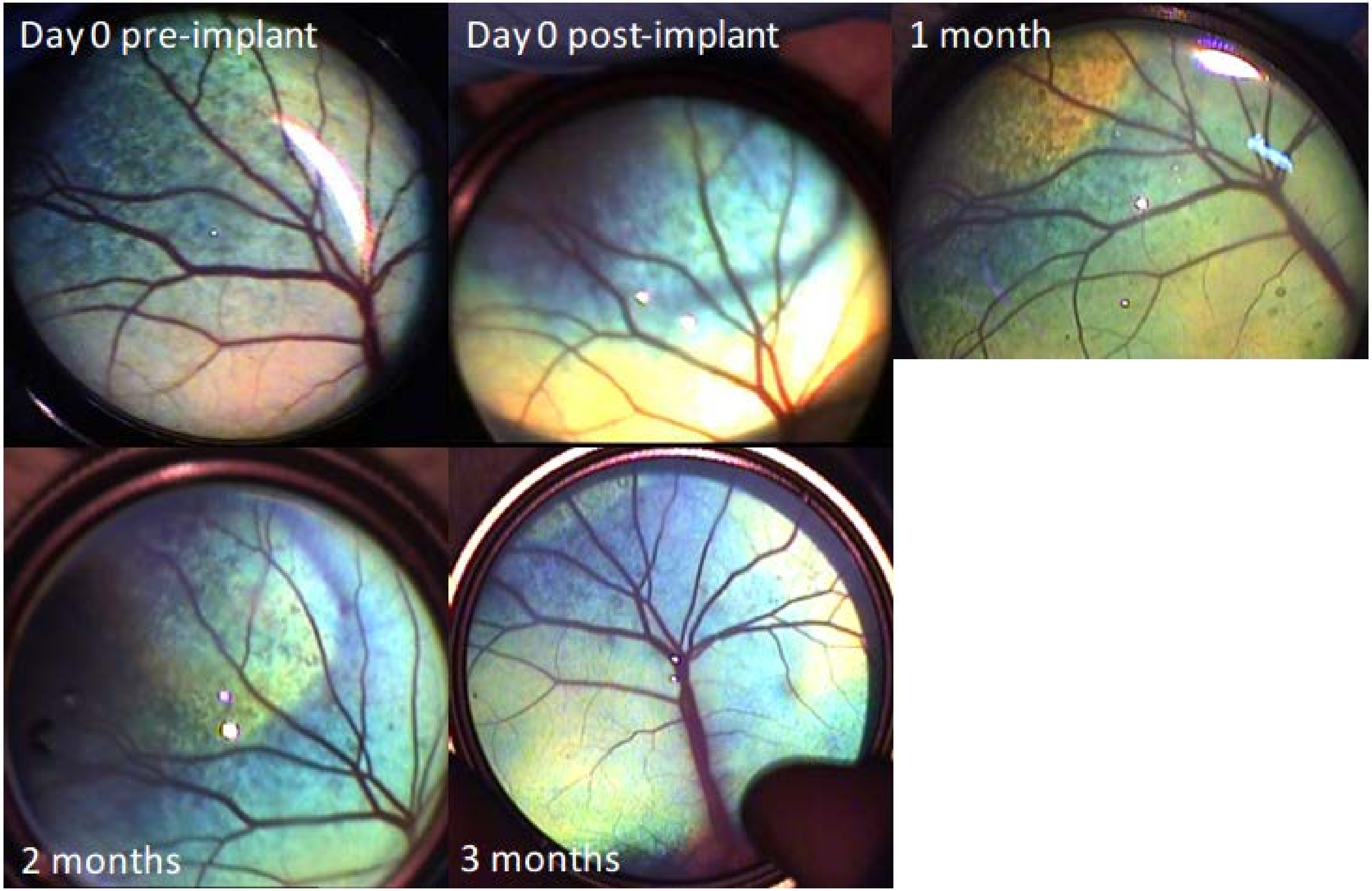
Telemetry implant: manages power and bidirectional data transfer via transcutaneous inductive coupling, meters-out visual stimulator requirements via two-signal interface.

Phoenix^{99} pre-loaded trocar

Phoenix^{99} implantation procedure - OCT



Phoenix[99] implantation procedure – Fundus Imaging



Study findings:

- Device is readily implanted
- Device is robust enough to withstand implantation process
- Device is stable in its position throughout the implantation period
- No adverse findings/significant changes in ophthalmoscopy, OCT or IR imaging
- Fibrotic encapsulation does not impede ocular movement
- Stable transition from orbit to orbital margin and beyond (as per human study)
- Stable trans-scleral opening for passage of electrode wires

Electrically active implant:

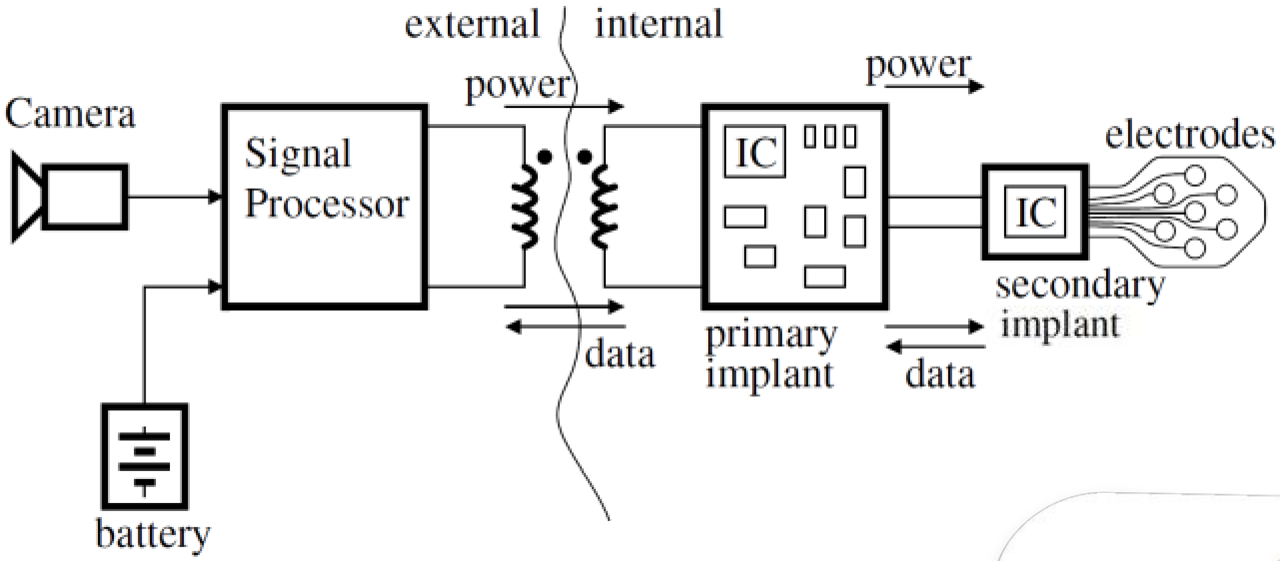
- 1x electrically active implant implanted
- “Switch on” confirmed delivery of concomitant stimuli
- Device maintained functionality over a 90 day implant period, but was not stimulated during that time.

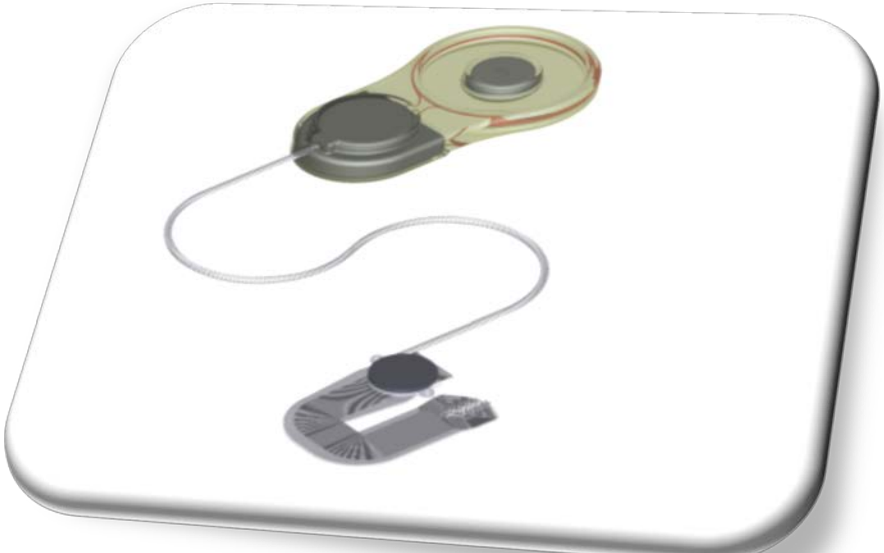
- New devices being manufactured now in order to continue the study.

How is this device different?

- Split system with novel data/energy transfer
- Hexapolar stimulation for cross-talk containment
- Quasi-monopolar stimulation for threshold reduction
- Concomitant stimulation for rapid refresh of the visual scene

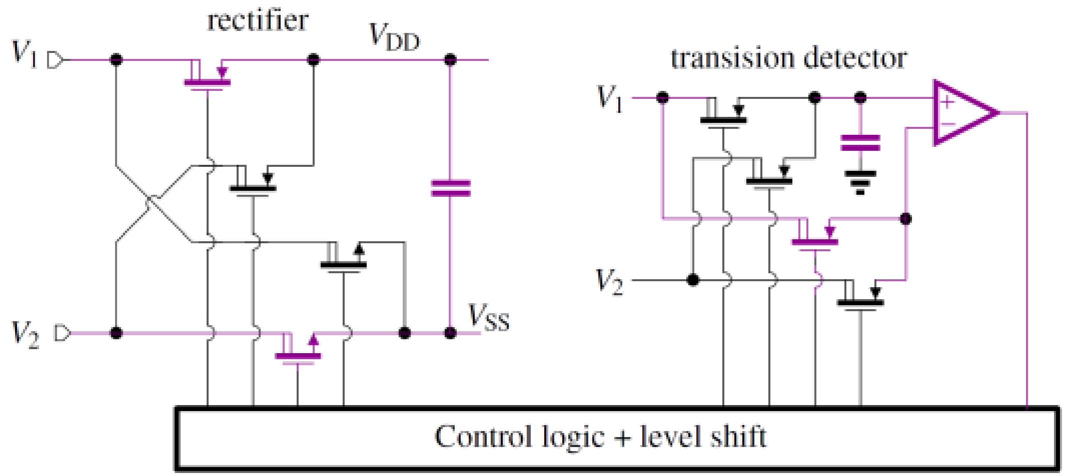
Power and data transfer

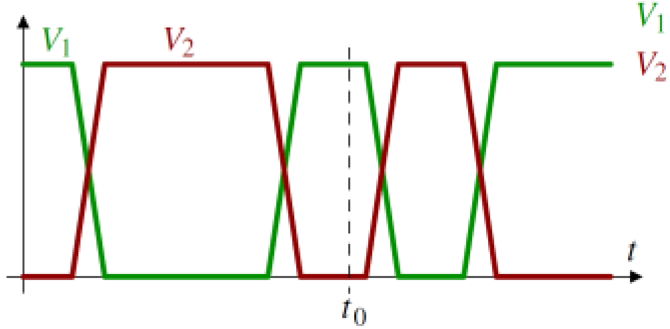


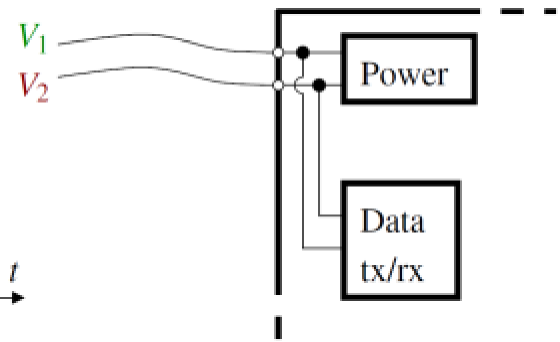


Power and data transfer

Charge-neutrality required to avoid galvanic corrosion



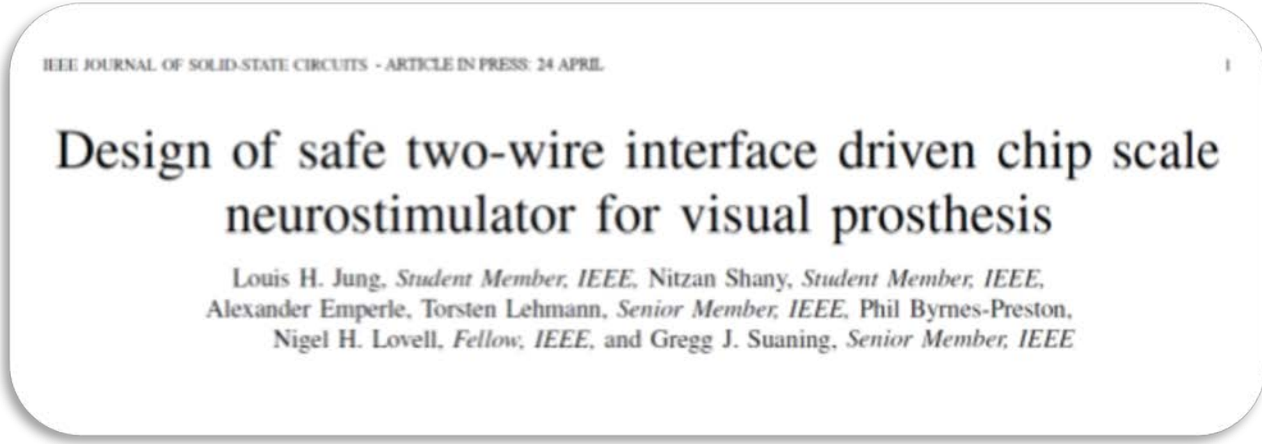




- Charge-neutral data/power
- Voltage-encoding for reverse telemetry
- requires high-speed and efficient rectification

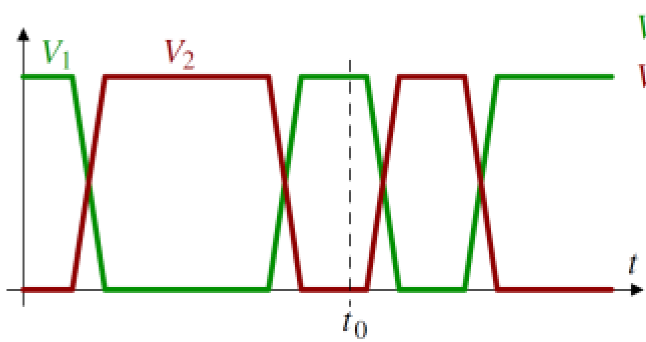
Power and data transfer

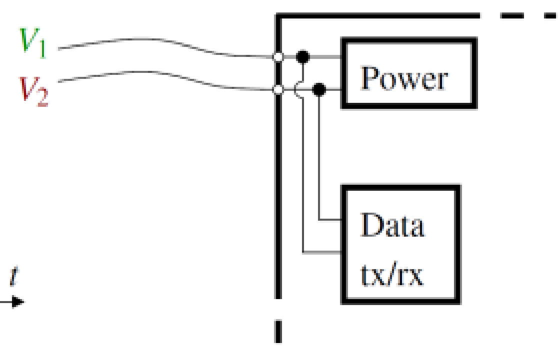
Charge-neutrality required to avoid galvanic corrosion


IEEE JOURNAL OF SOLID-STATE CIRCUITS - ARTICLE IN PRESS: 24 APRIL 1

Design of safe two-wire interface driven chip scale neurostimulator for visual prosthesis

Louis H. Jung, *Student Member, IEEE*, Nitzan Shany, *Student Member, IEEE*, Alexander Emperle, Torsten Lehmann, *Senior Member, IEEE*, Phil Byrnes-Preston, Nigel H. Lovell, *Fellow, IEEE*, and Gregg J. Suaning, *Senior Member, IEEE*





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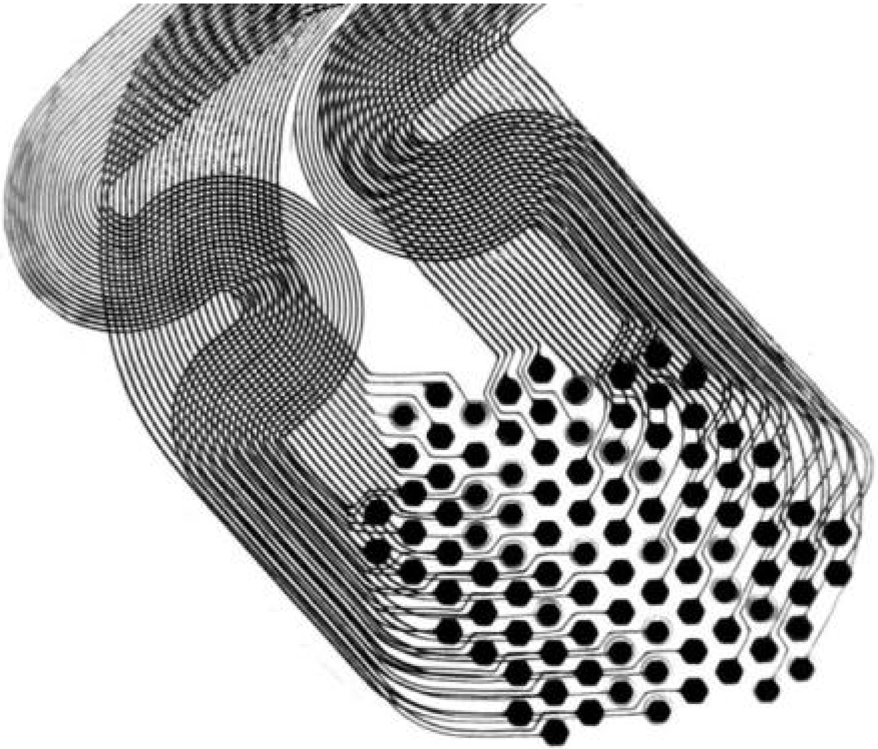
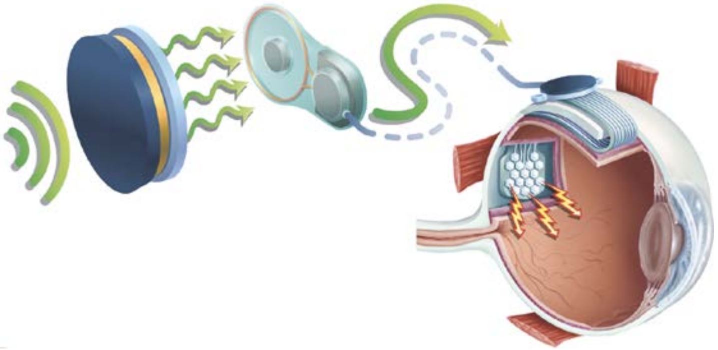
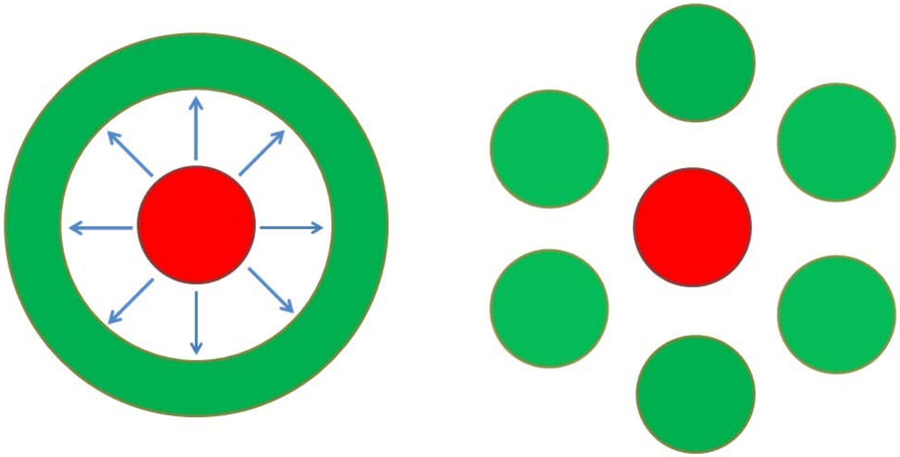
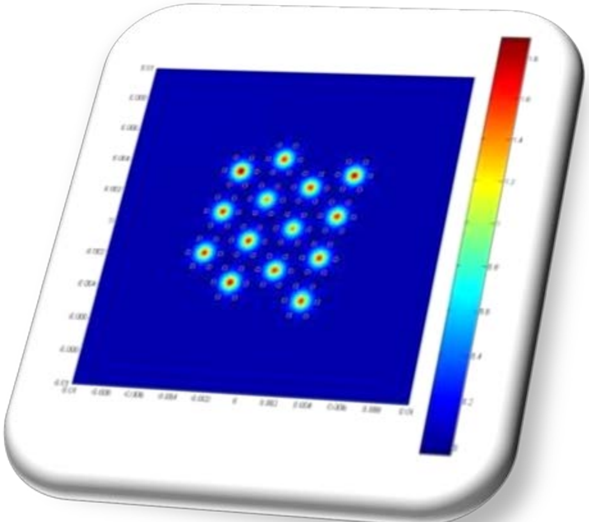
Hexapolar Stimulation

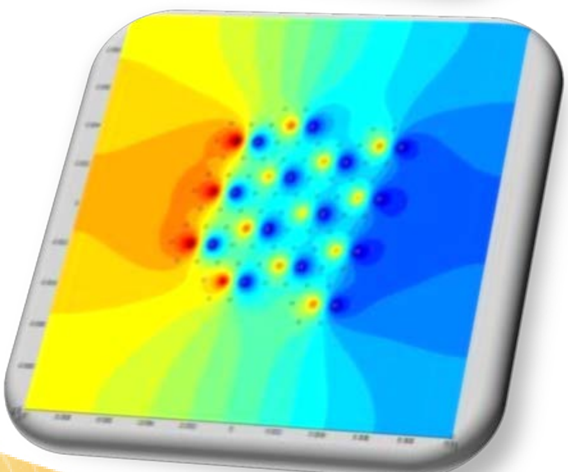


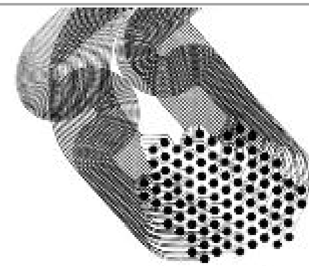


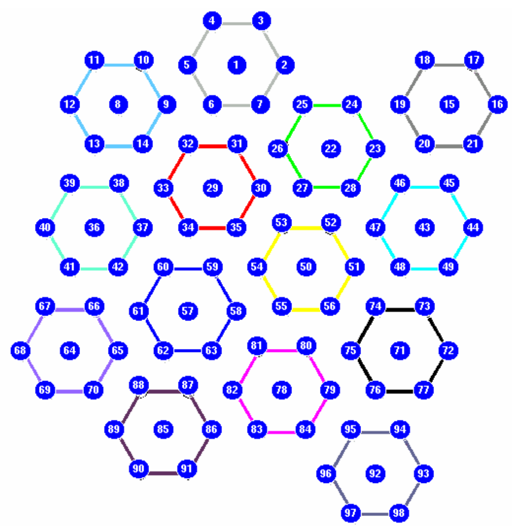


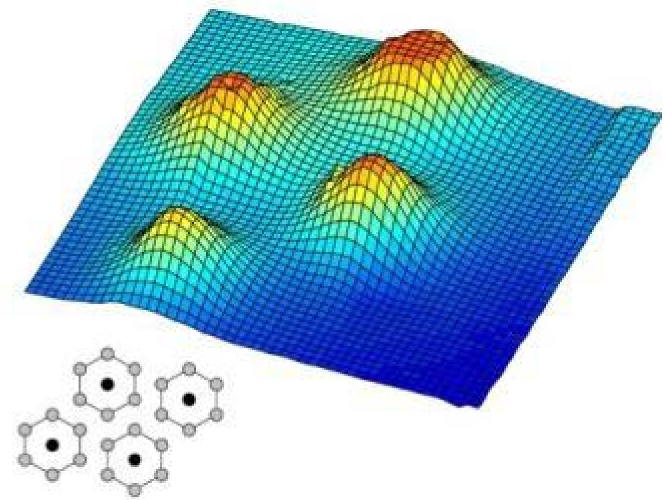
Hexapolar Stimulation

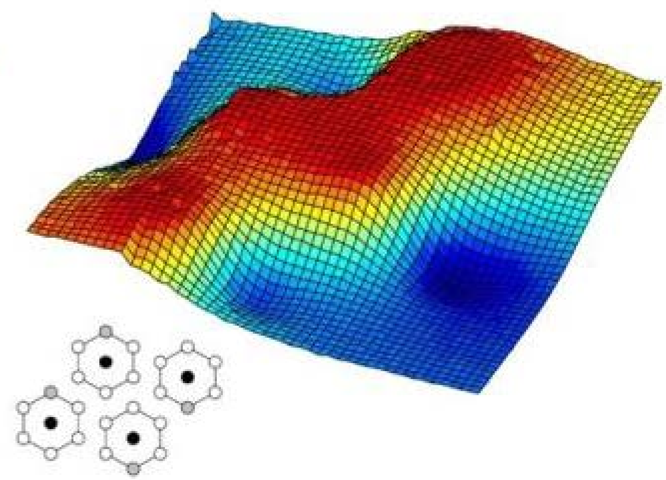




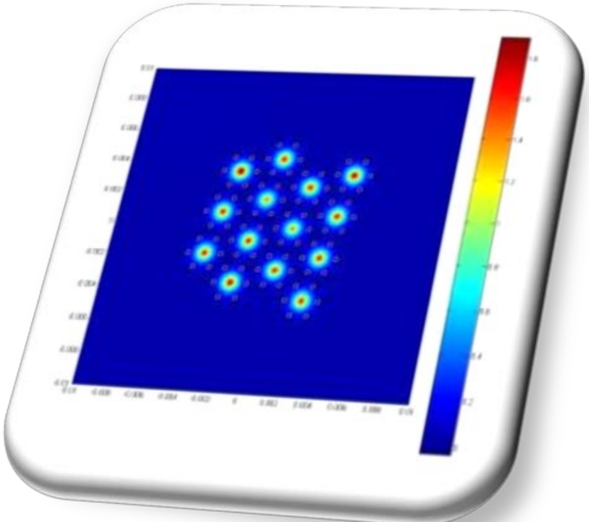


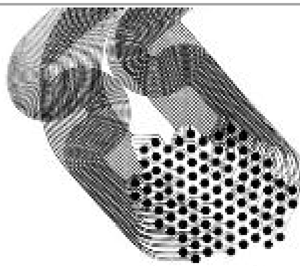


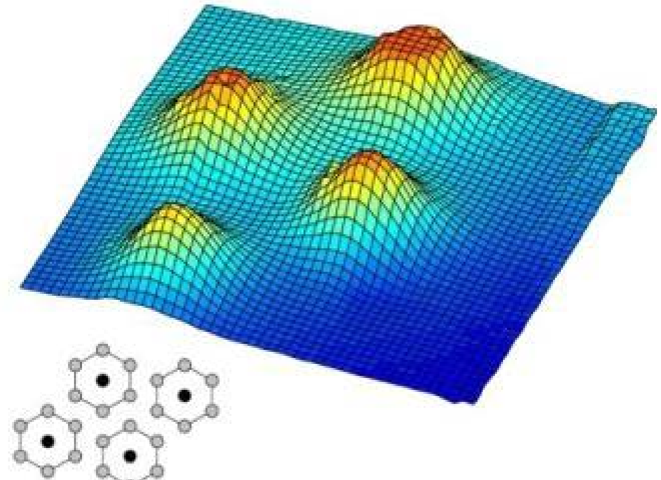


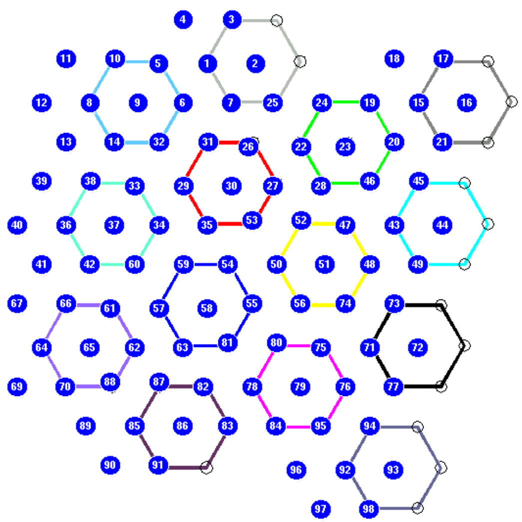


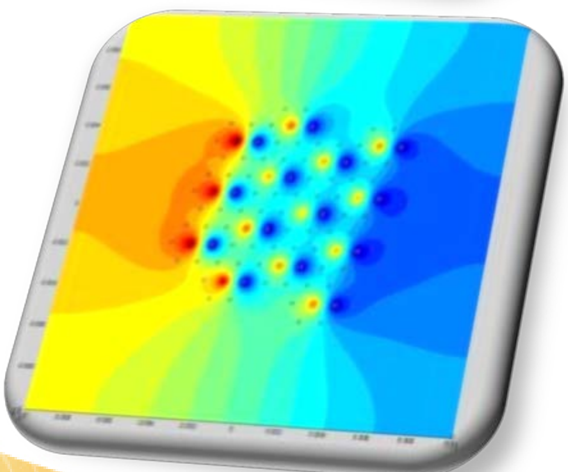
Hexapolar Stimulation

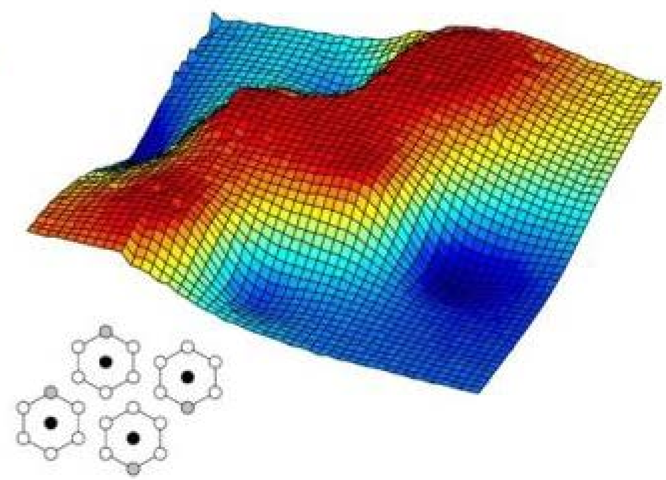




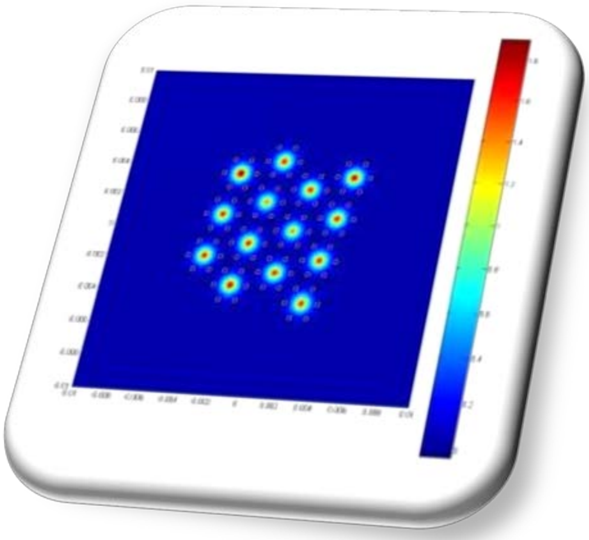


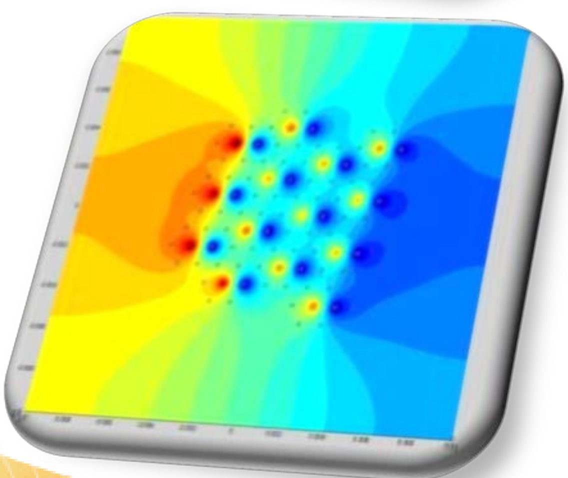


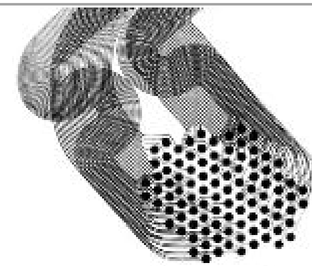


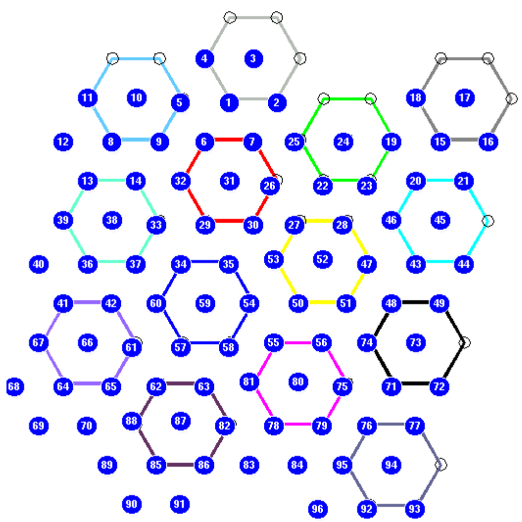


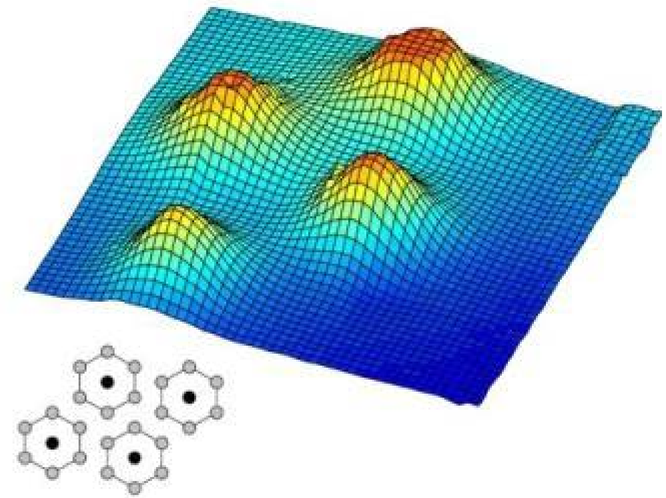
Hexapolar Stimulation

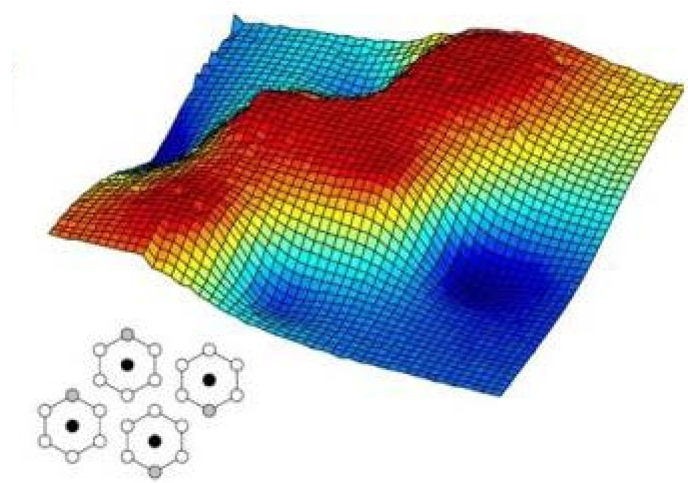












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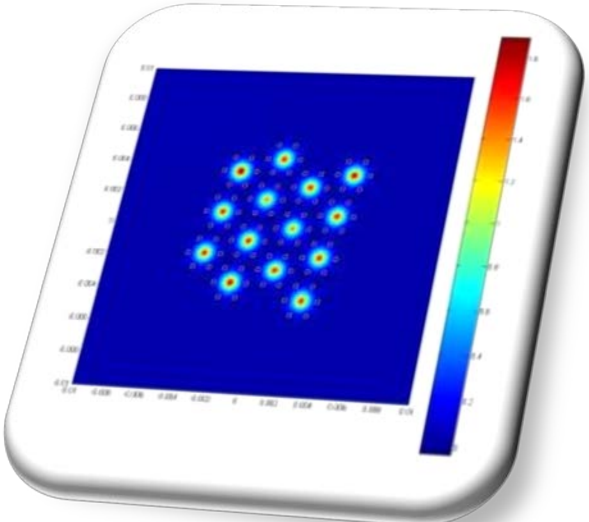

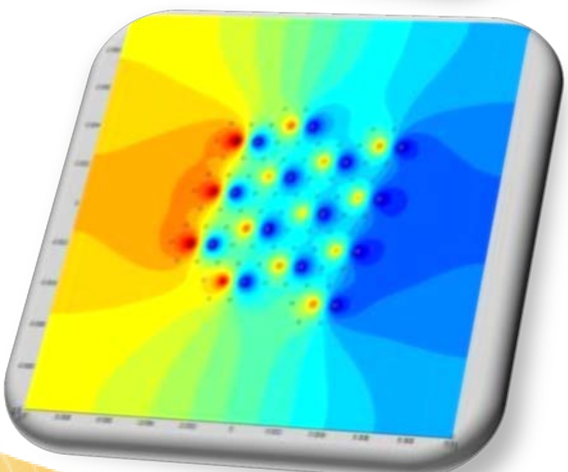

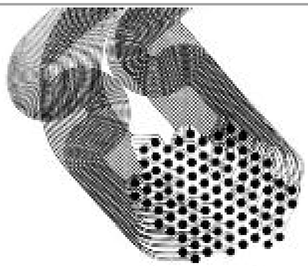

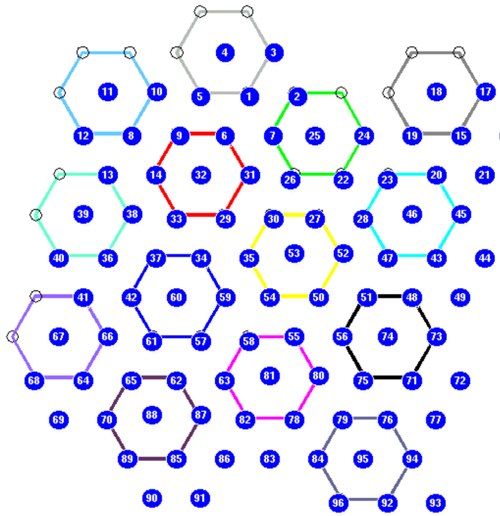

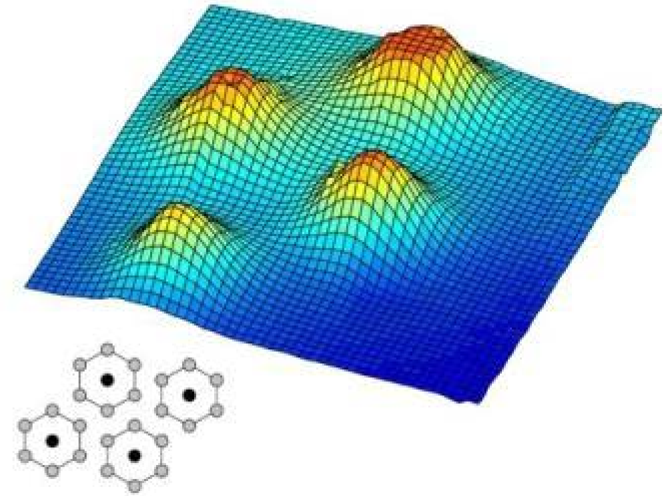

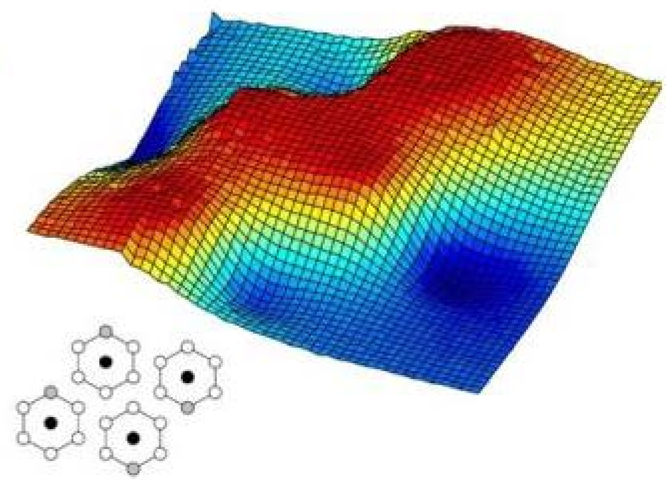

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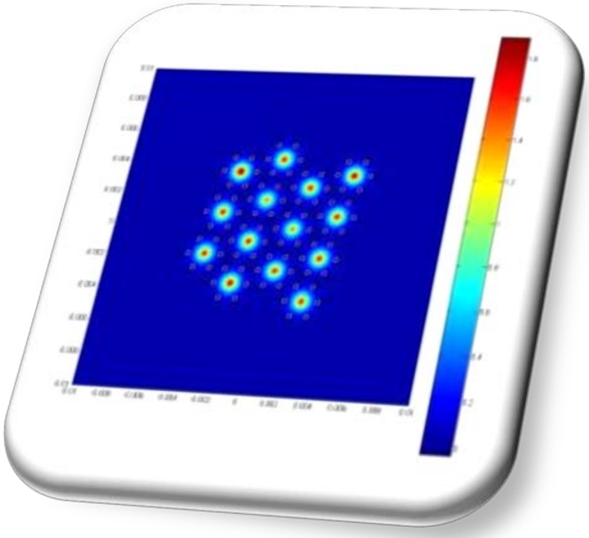

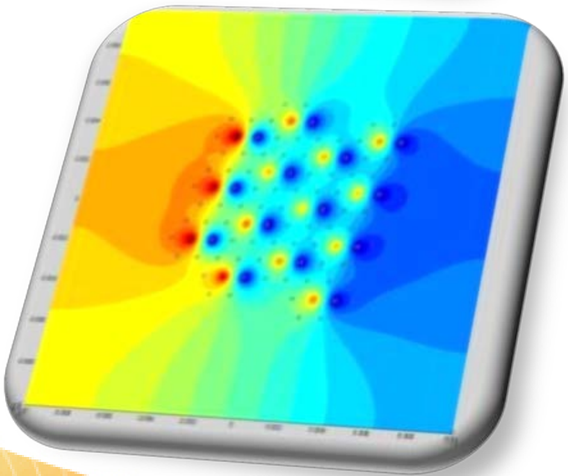

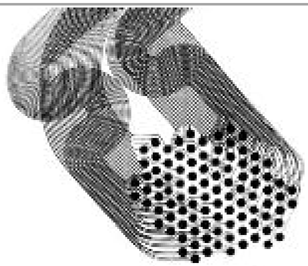

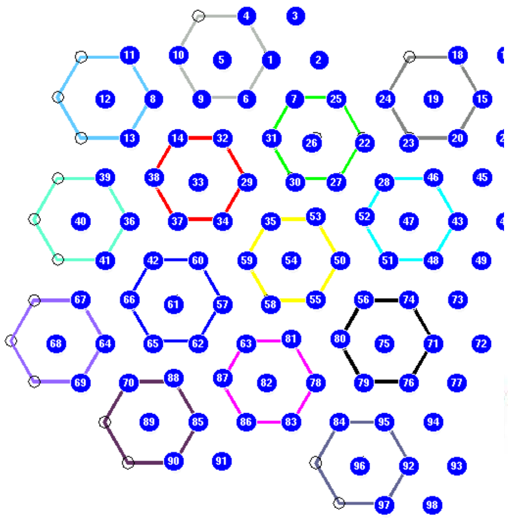

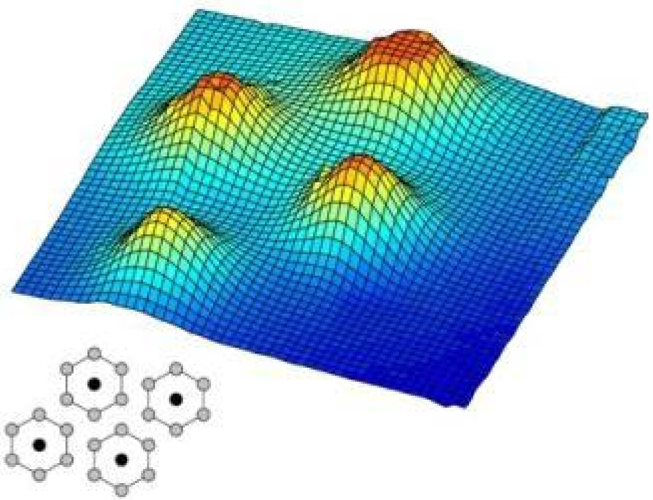

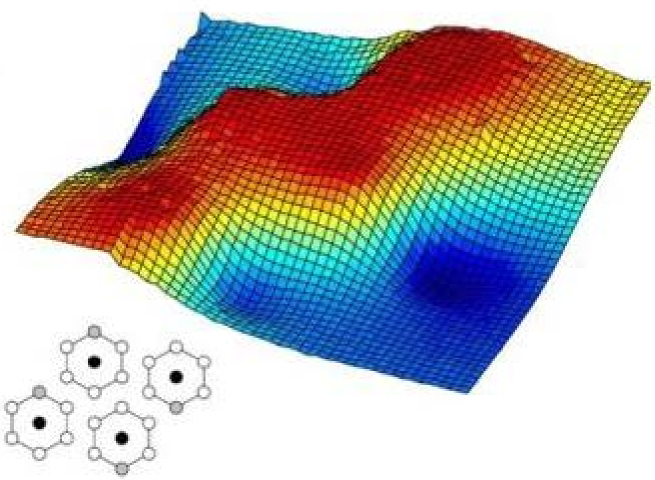

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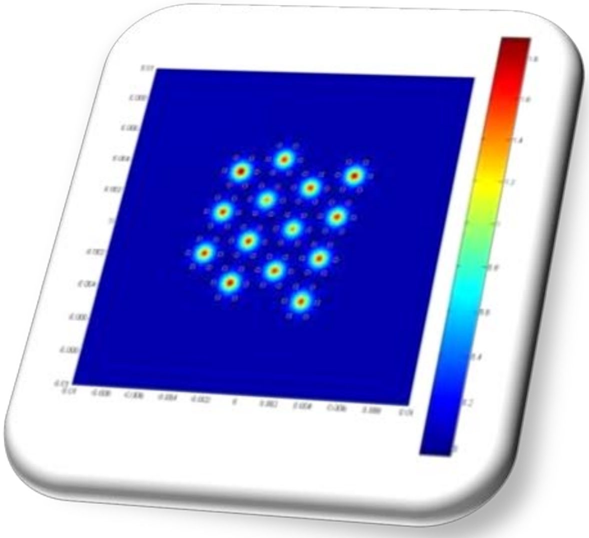
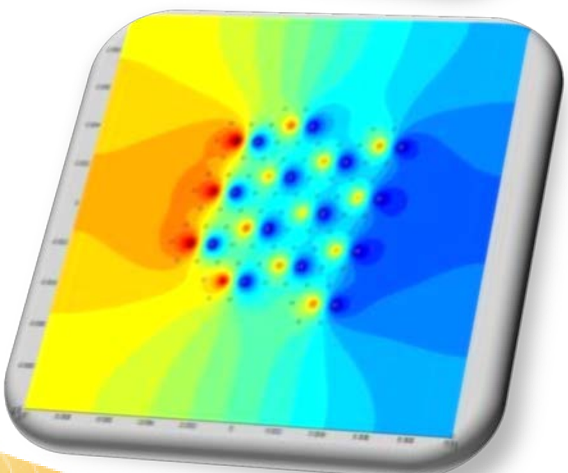
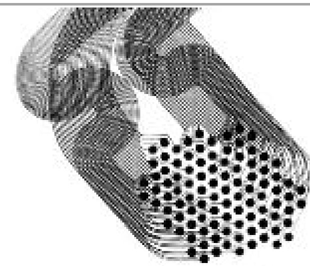
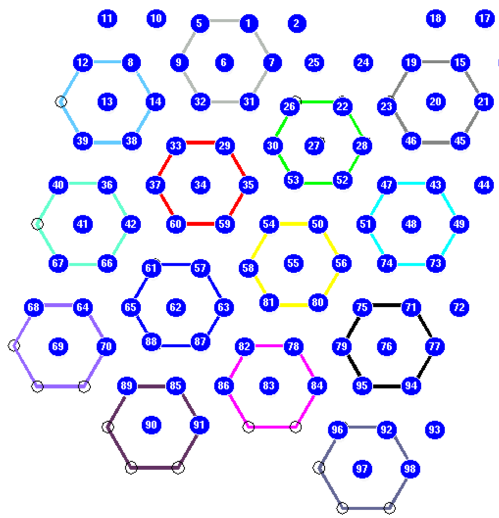
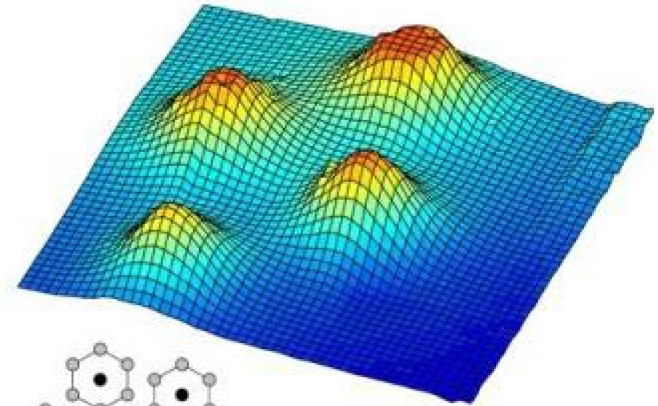
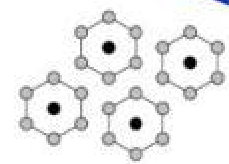


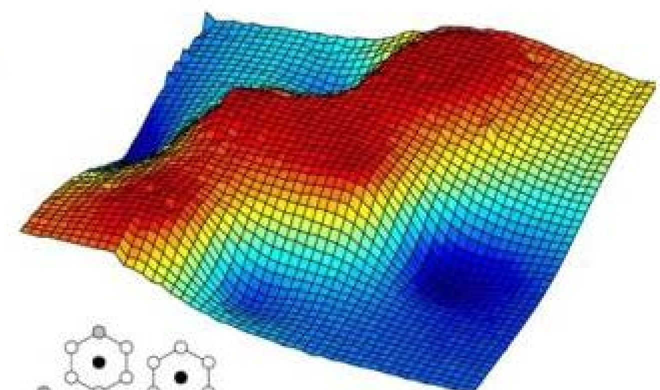


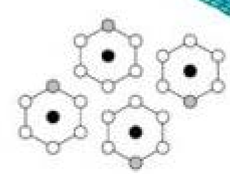




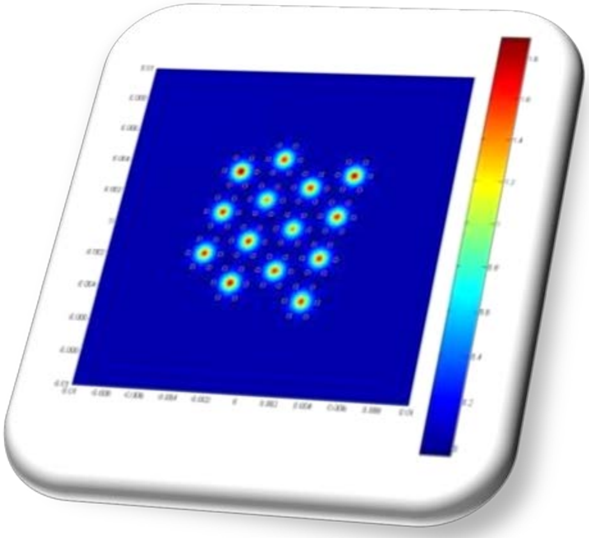


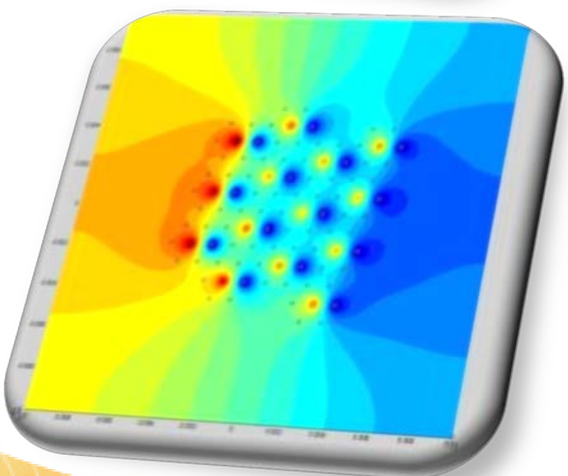


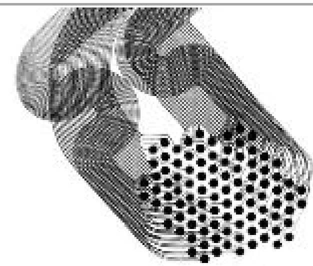


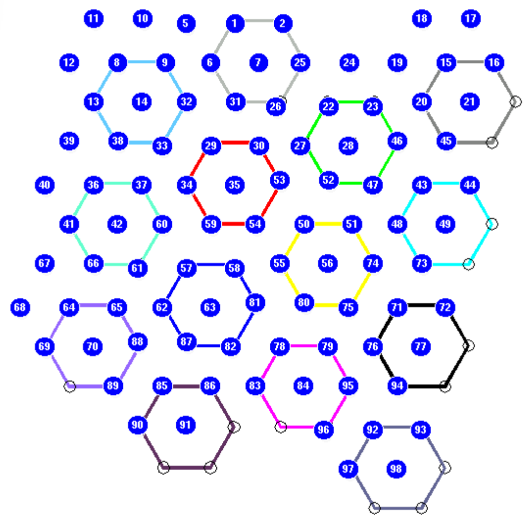


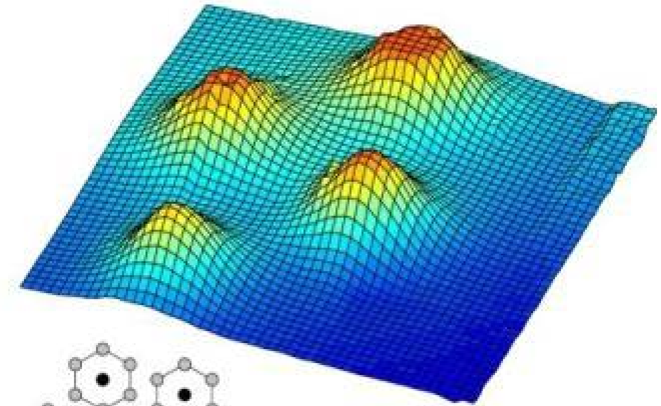
Hexapolar Stimulation

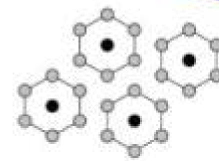


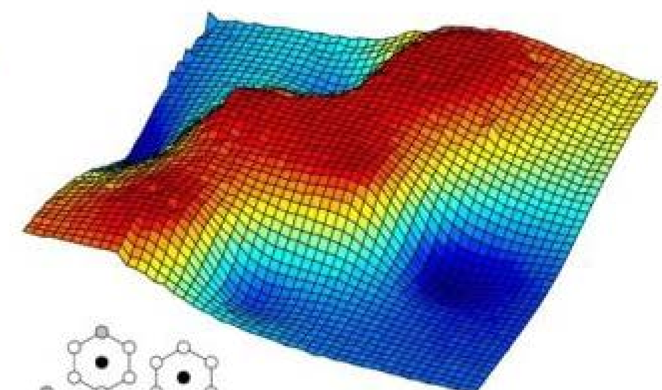


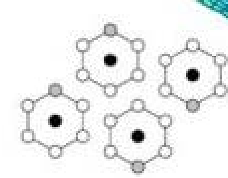




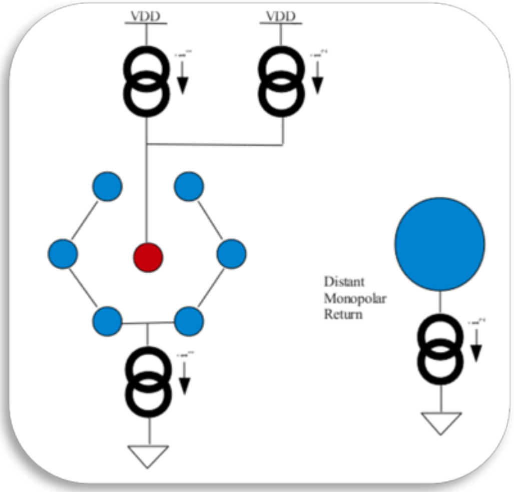


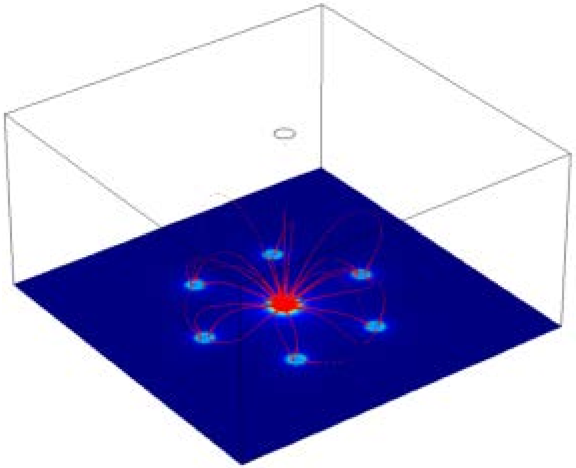




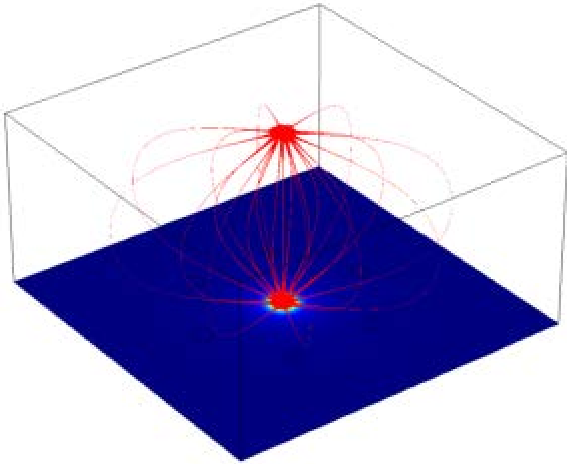


Quasi-Monopolar Stimulation

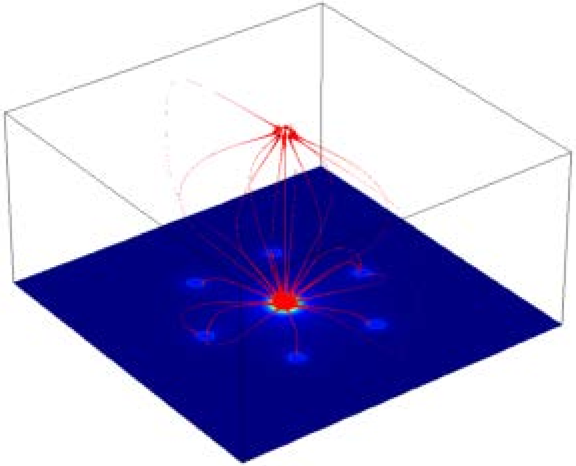




Hexpolar

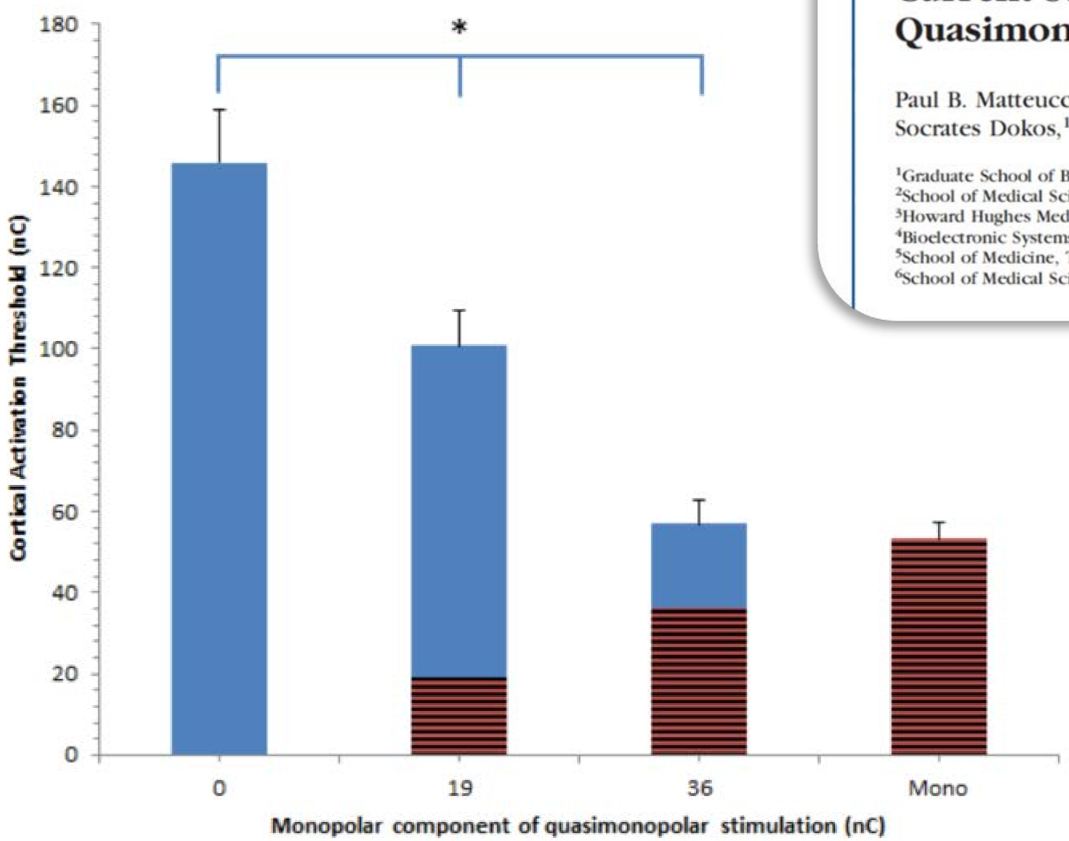


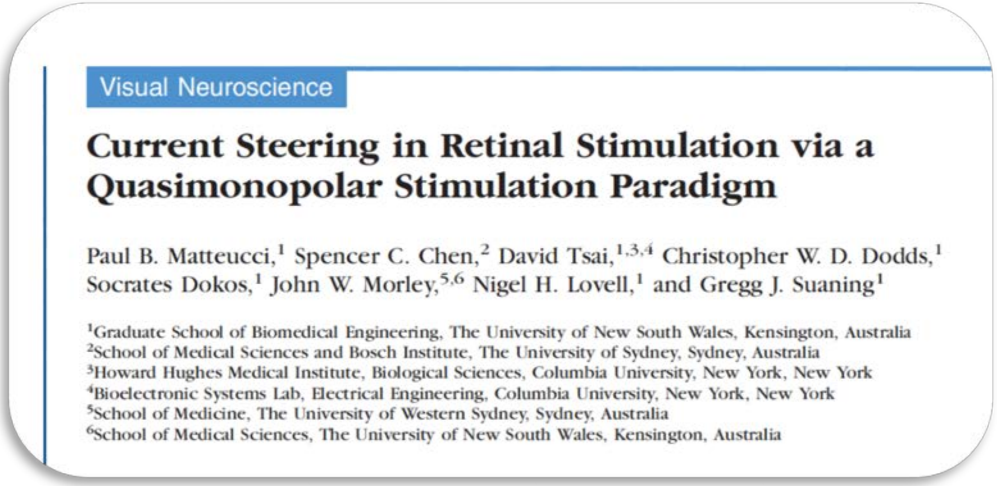
Monopolar



Quasi-monopolar

Quasi-Monopolar Stimulation





Visual Neuroscience

Current Steering in Retinal Stimulation via a Quasimonopolar Stimulation Paradigm

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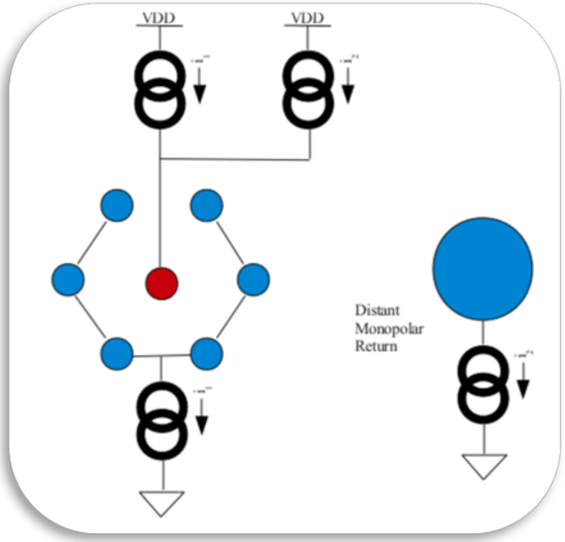
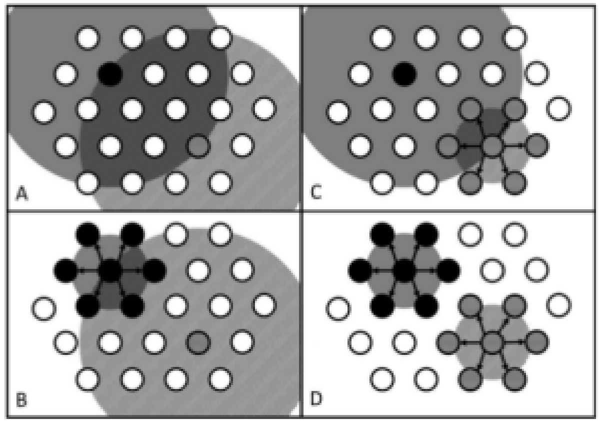
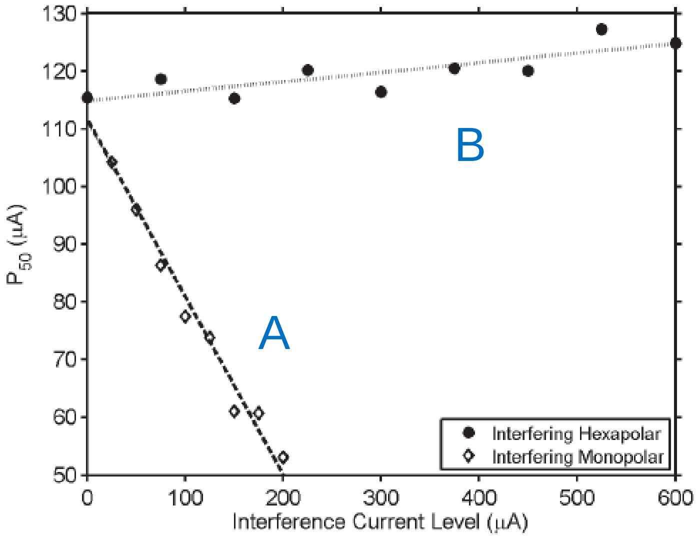


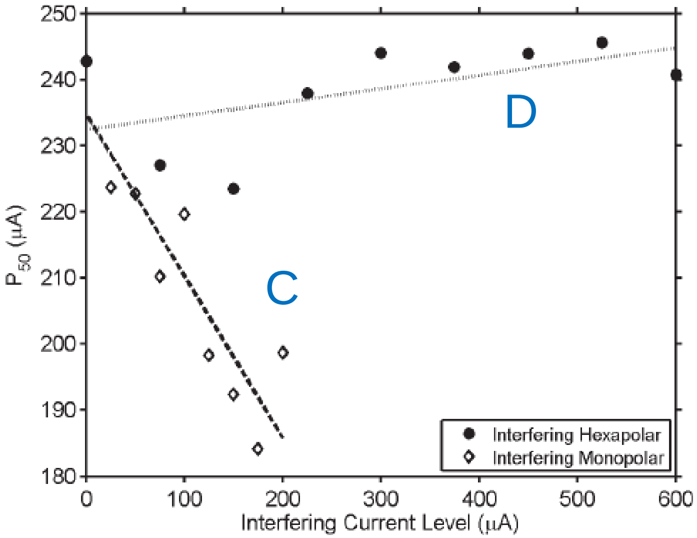
Concomitant Stimulation

Moving beyond the established benefits of hexapolar and quasi-monopolar stimulus.



P_{50} threshold reduction with a broad field 'interfering' simultaneous stimulus





From Matteucci et al. 2016, Invest. Ophthalmol. Vis. Sci. 57(3): 1031-7

Thank You!