Development of Alternative Magnetic Stimulation Design for Cochlear Arrays

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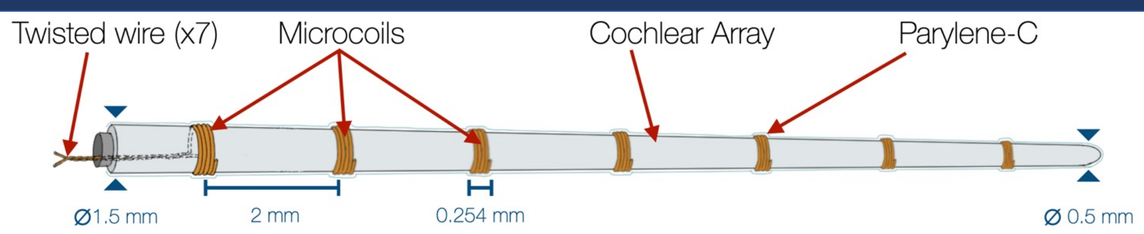
Motivation

- 736,900 people worldwide are cochlear implant (CI) users according to the NIDCD 2019 report[1].
- The cochlea exhibits a tonotopic geometry where acoustic waves are filtered spatially according to frequency where hair cells transduce acoustic waves into an electrical signal carried by the auditory nerve to the auditory cortex of the brain[2].
- Without functioning hair cells, hearing is imperfect or impossible; furthermore, a cochlear implant bypasses non-functional hair cells by stimulating nearby neurons.
- CIs inject electrical current into surrounding tissue; however, since the cochlea is filled with a conductive fluid, perilymph, a spread of excitation may occur[3].

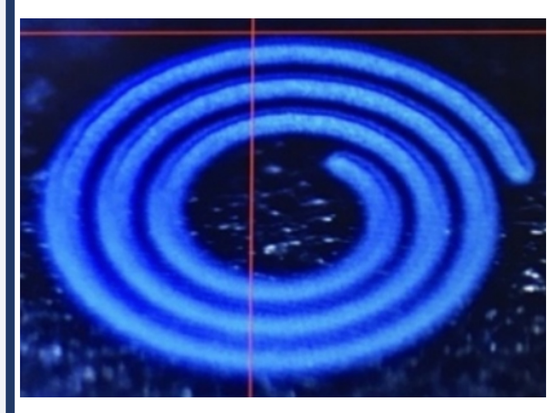
Hypothesis: Magnetic stimulation will prevent a spread of excitation because magnetic fields are not affected by material properties of the cochlea.

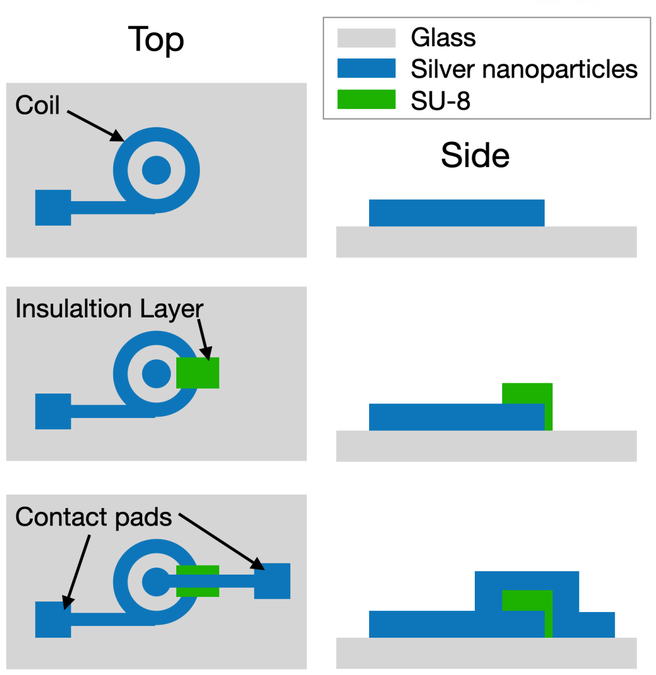
Fabrication



Aerosol Jet Printing

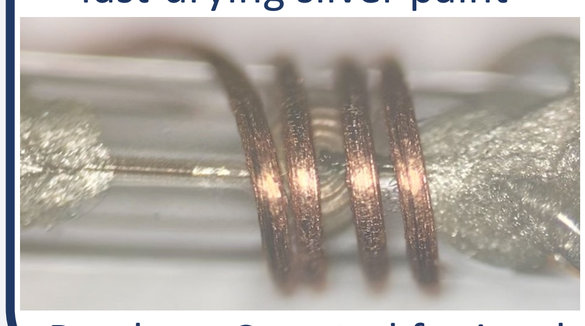
- Non-planar substrate
- 600-µm outer diameter
- 37.5-µm trace width

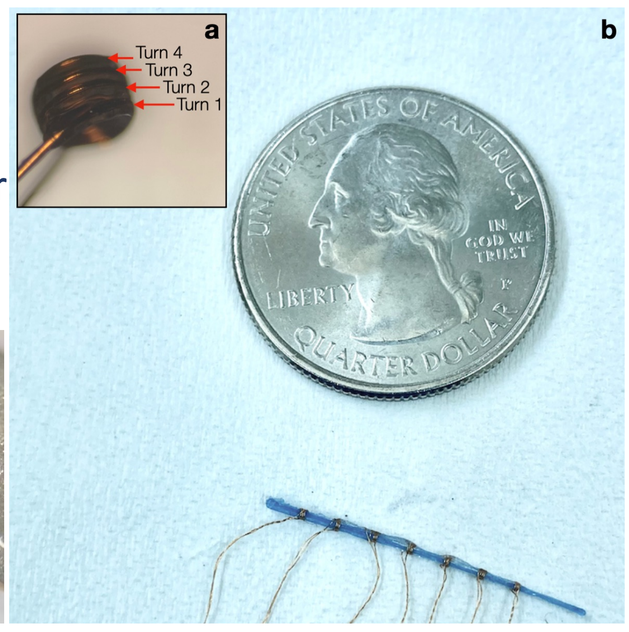




Solenoid and planar microcoil combination

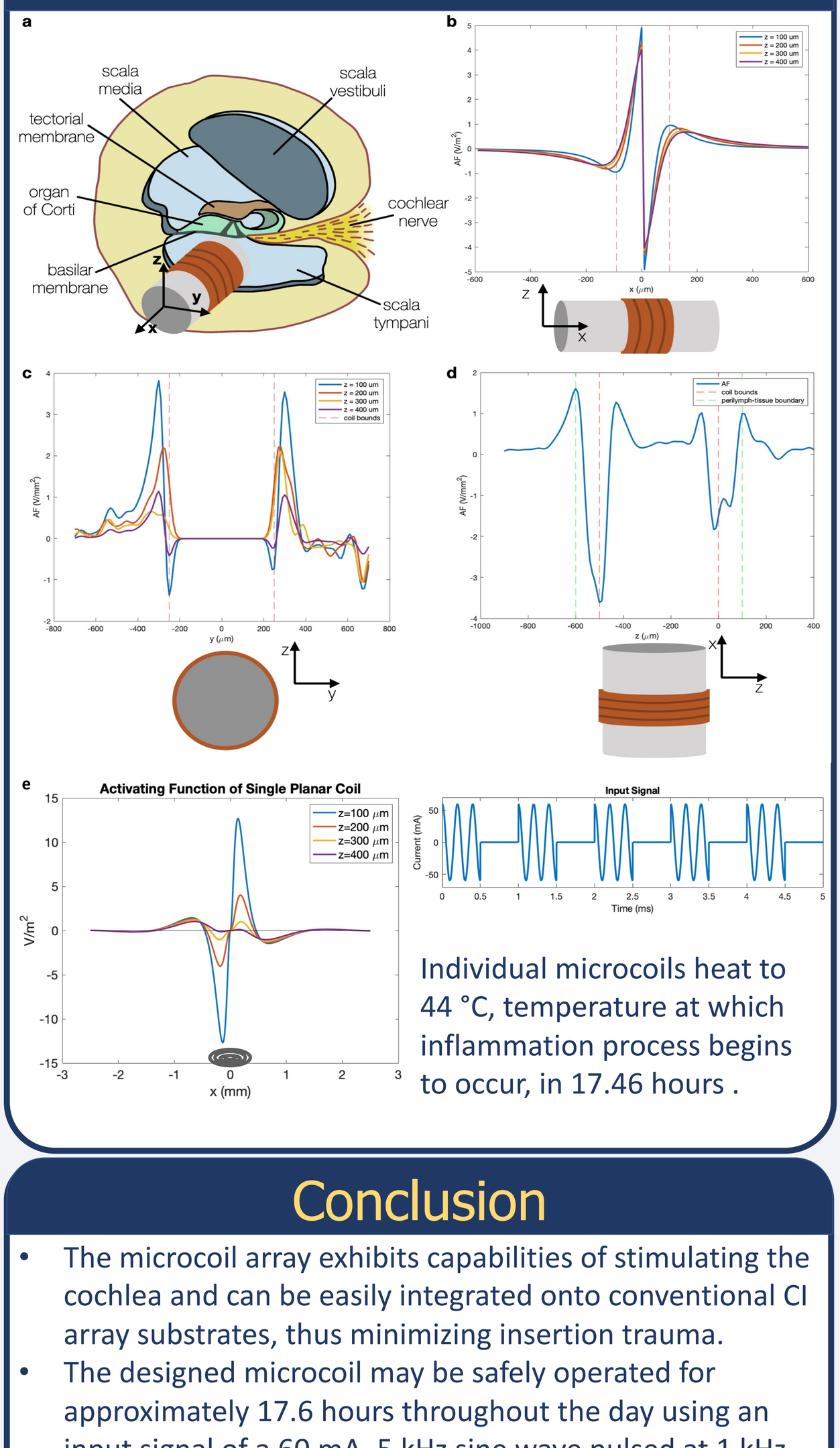
- 42 AWG, insulated copper
- Secured with epoxy and fast-drying silver paint





Parylene-C coated for insulation and biocompatibility.

Results



Individual microcoils heat to 44 °C, temperature at which inflammation process begins to occur, in 17.46 hours .

Conclusion

- The microcoil array exhibits capabilities of stimulating the cochlea and can be easily integrated onto conventional CI array substrates, thus minimizing insertion trauma.
- The designed microcoil may be safely operated for approximately 17.6 hours throughout the day using an input signal of a 60 mA, 5 kHz sine wave pulsed at 1 kHz with a 50% duty cycle.
- The combined depolarization and hyperpolarization regions are restricted to the width of the microcoil; therefore, a spread of excitation does not occur.

Future Directions:

- Upgrade materials to create an implantable prototype.
- Ex vivo and in vivo testing to observe micromagnetic stimulation capabilities

References

[1] The national institute on deafness and other communication disorders statistics,

[2] J. Hawkins, “Human Ear”, *Encyclopedia Britannica, inc.*

[3] J. A. Bierer, “Probing the Electrode–Neuron Interface With Focused Cochlear Implant Stimulation”, *Trends in Amplification,* vol. 14, no. 2, pp. 84-95, 2010.

Acknowledgements

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