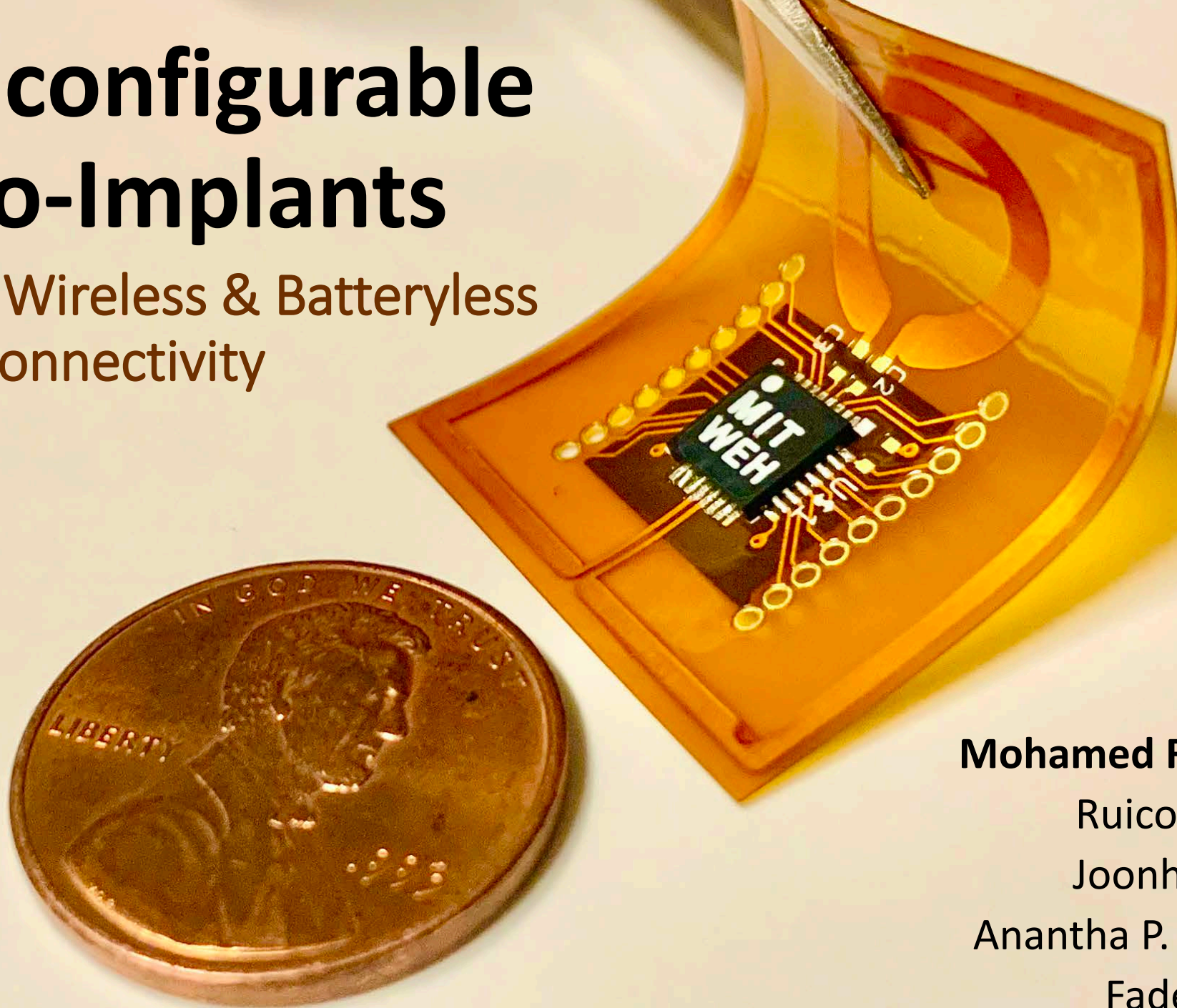


# Self-Reconfigurable Micro-Implants

Cross-Tissue Wireless & Batteryless  
Connectivity



**Mohamed R. Abdelhamid**

Ruicong Chen

Joonhyuk Cho

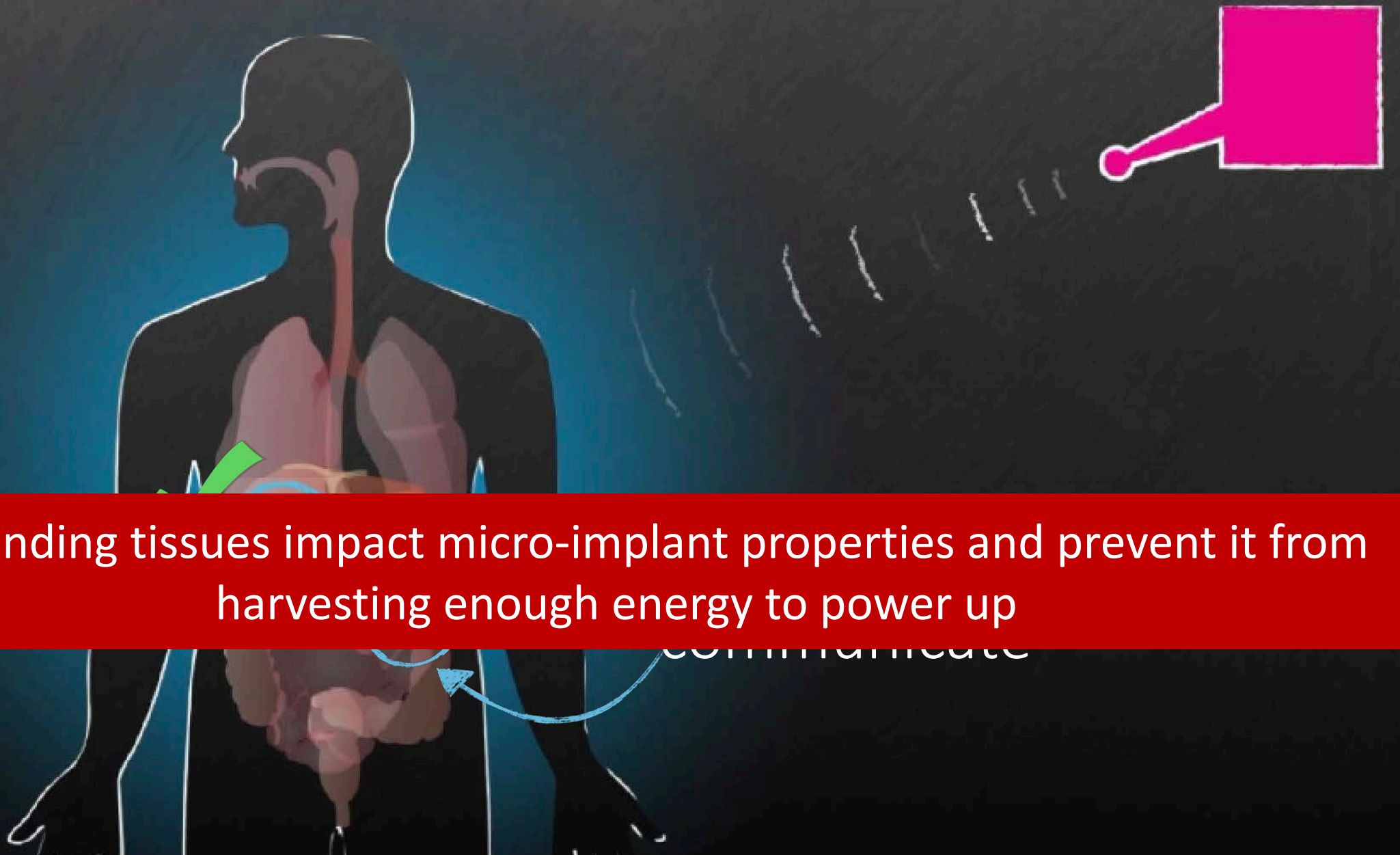
Anantha P. Chandrakasan

Fadel Adib





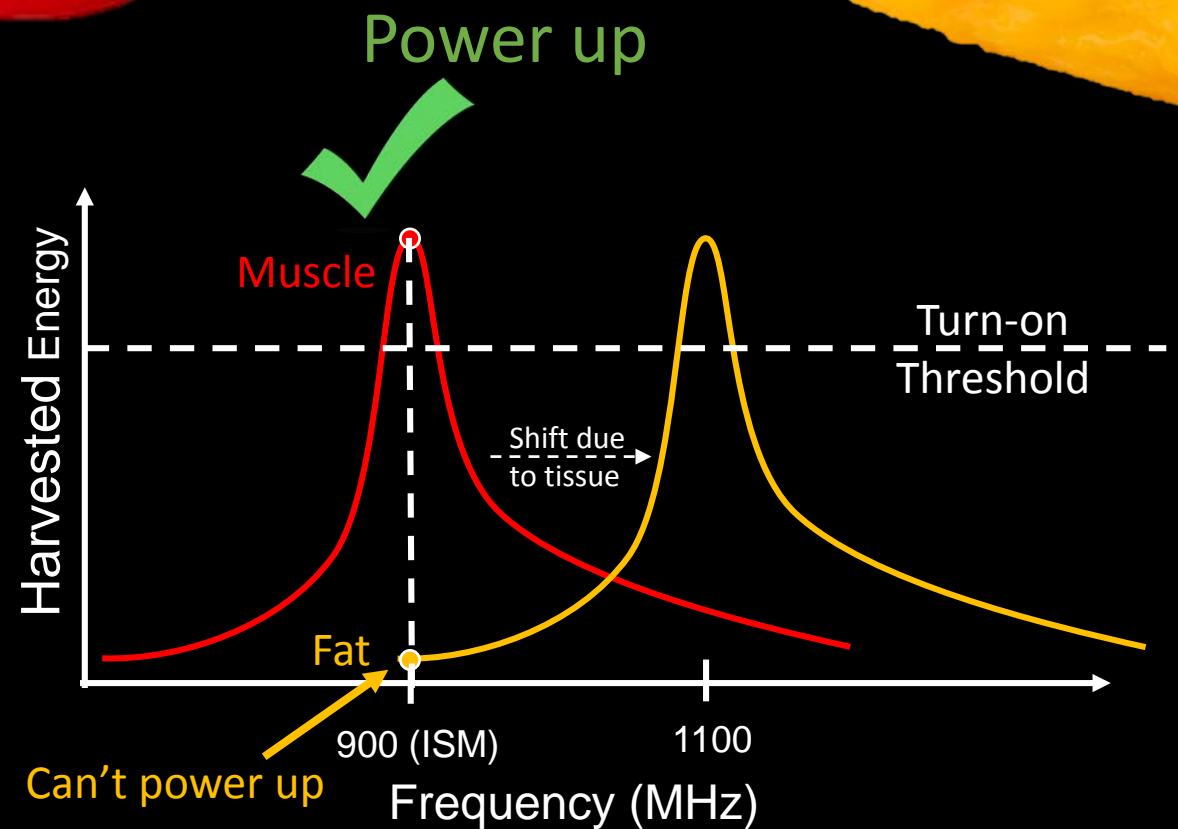
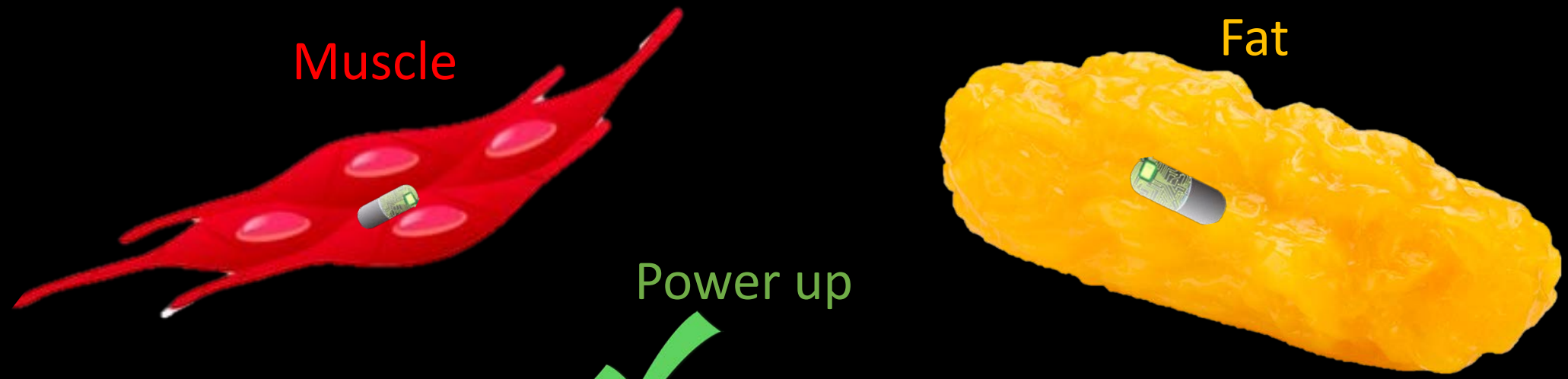




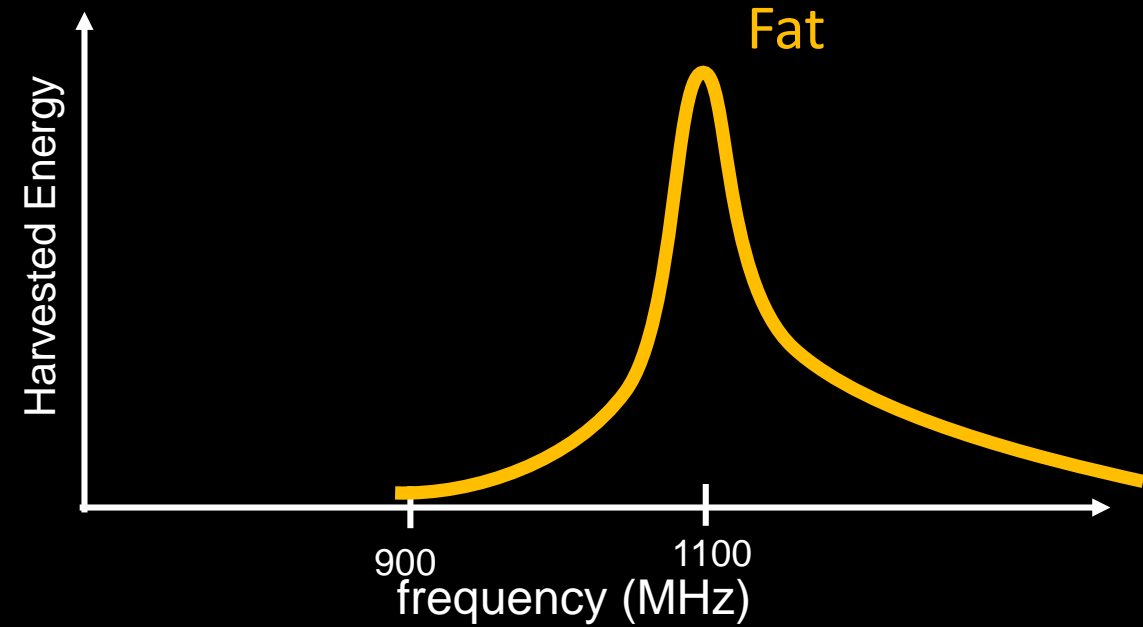
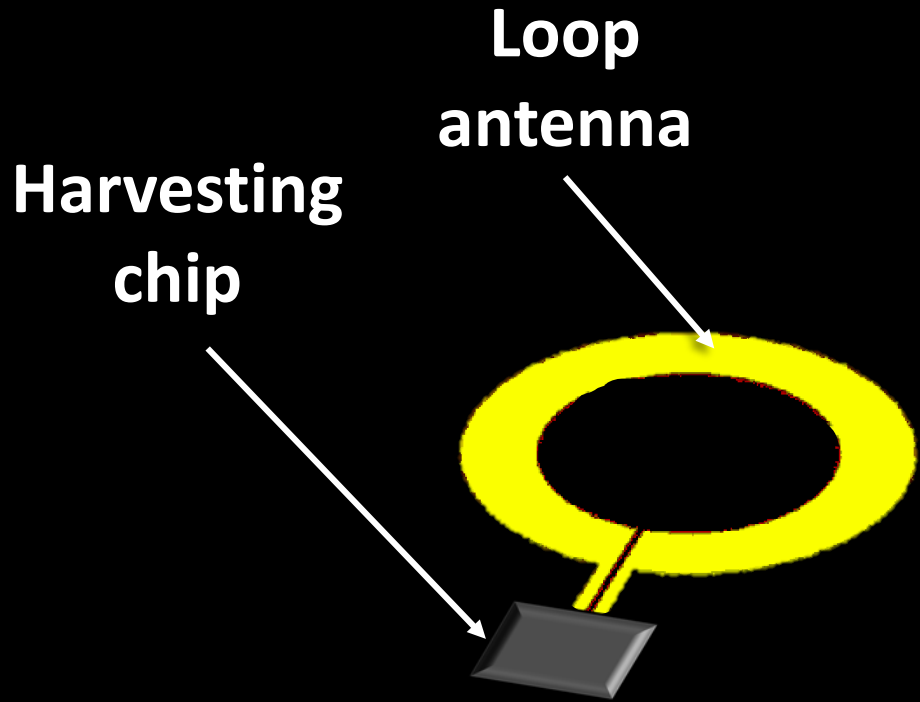
Surrounding tissues impact micro-implant properties and prevent it from harvesting enough energy to power up



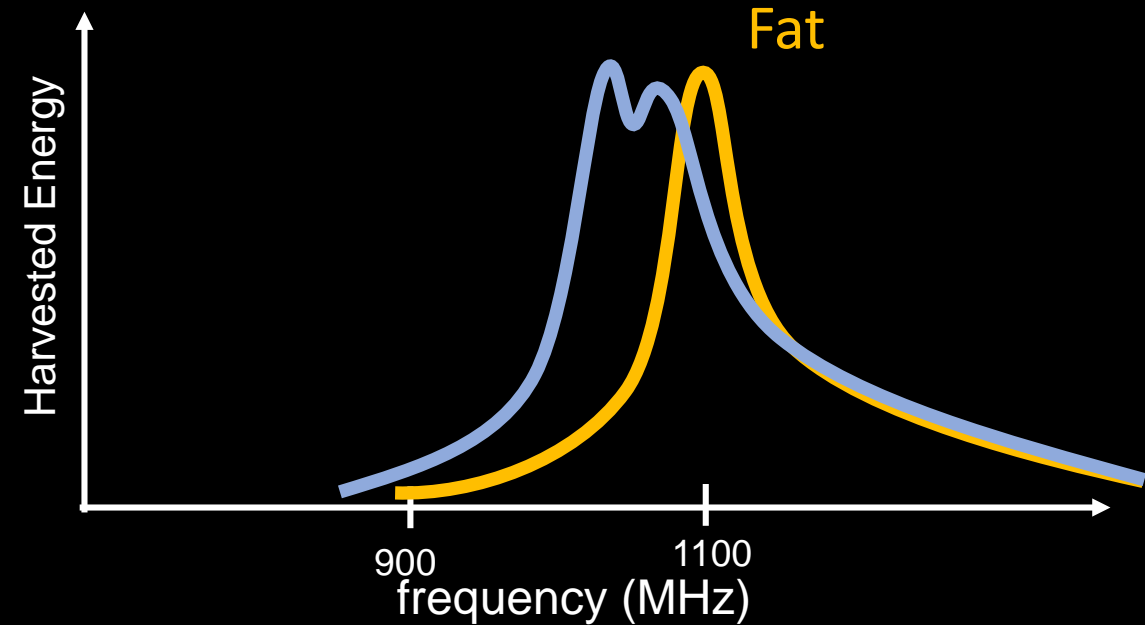
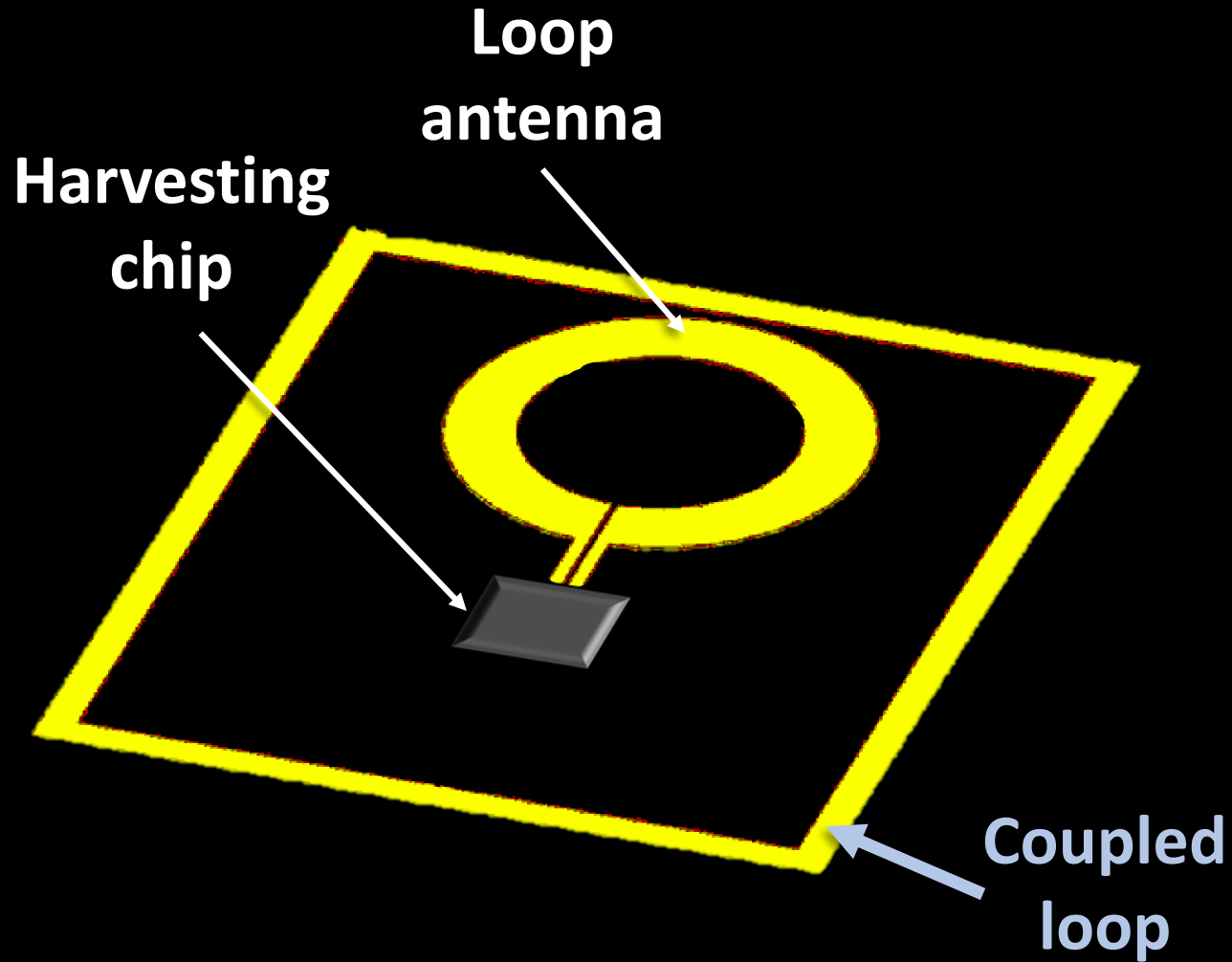
Problem: Antenna resonance is impacted by surrounding tissues



# In-Body Loop Antenna



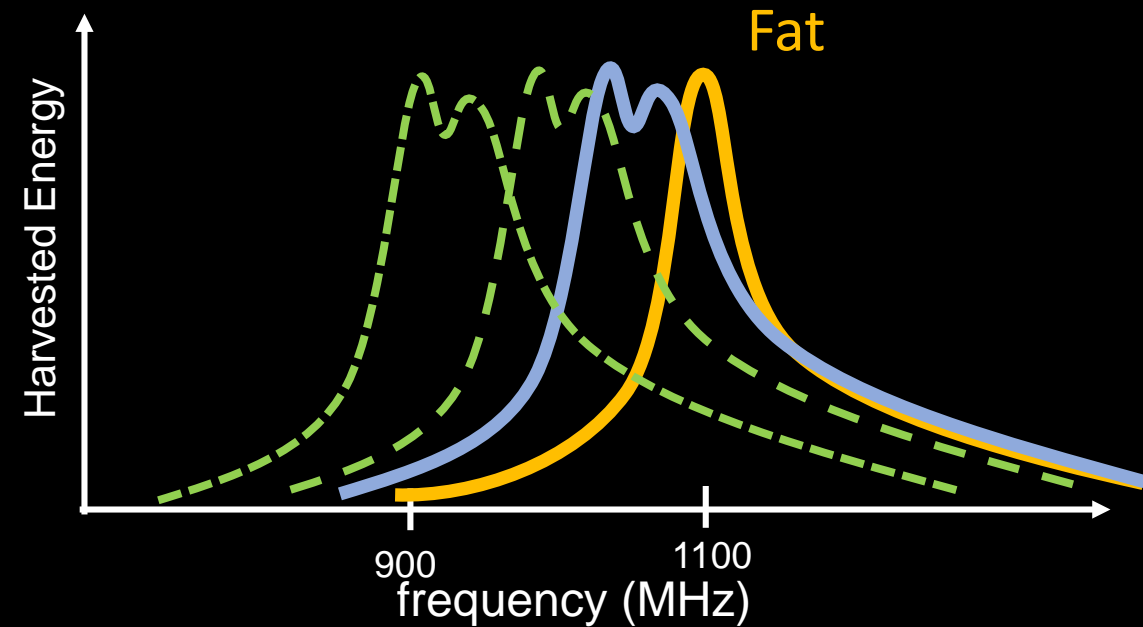
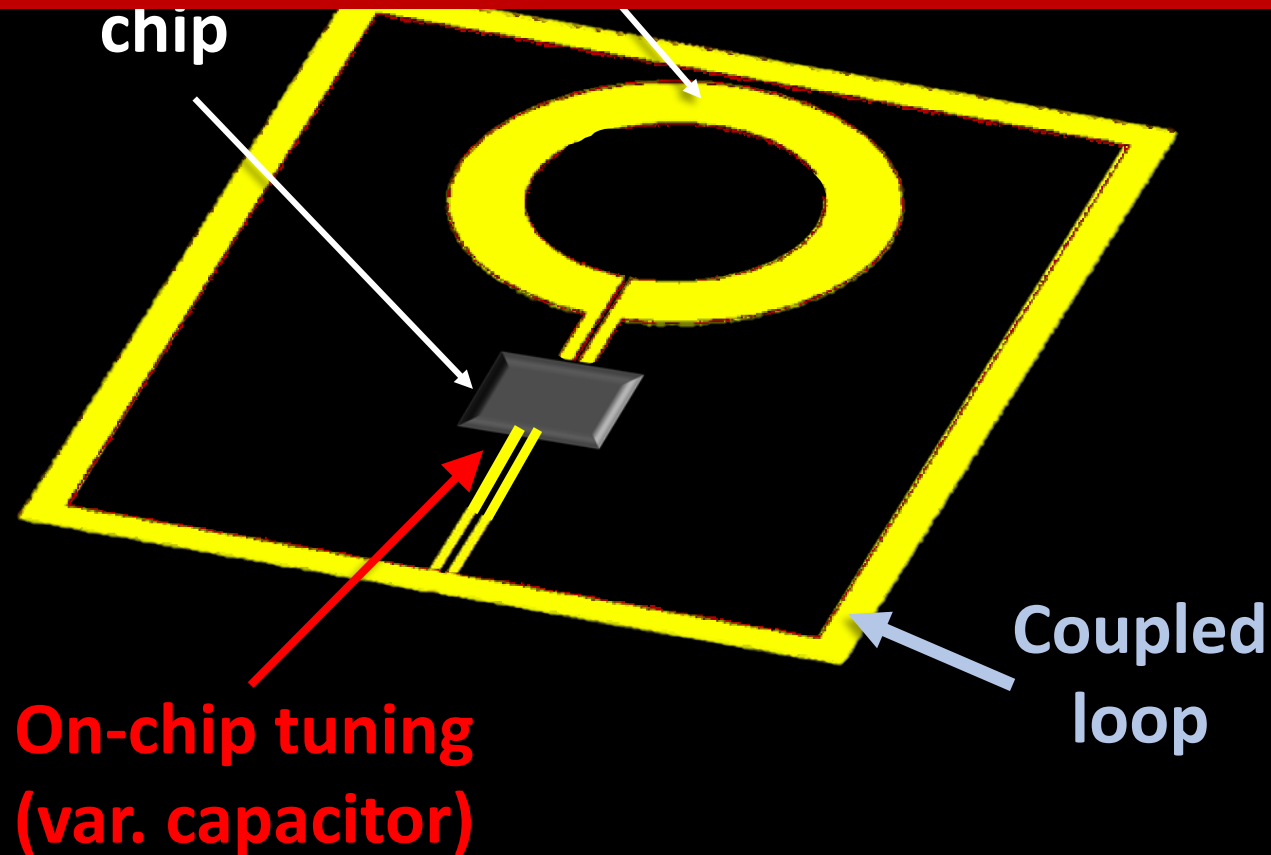
Idea: Introduce a coupled structure in order to control resonance



Idea: Introduce a coupled structure in order to control resonance

loop

$\mu$ medIC builds on this idea to enable full programmability of its antenna, harvesting circuits, and communication logic (and enable cross-tissue operation)



# Implementation & Fabrication

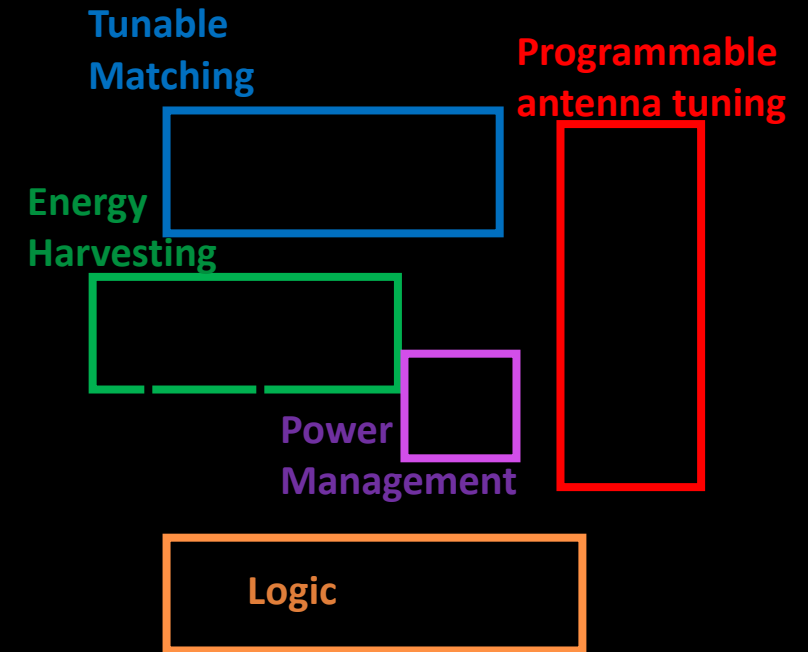
- Incorporates MAC layer + protocol
- Power consumption: **350 nanoWatts**

## Magnified Die Micrograph

Antenna on Flex  
PCB substrate



$1 \times 1 \text{ mm}^2$  chip fabricated  
using TSMC 65nm LP process.

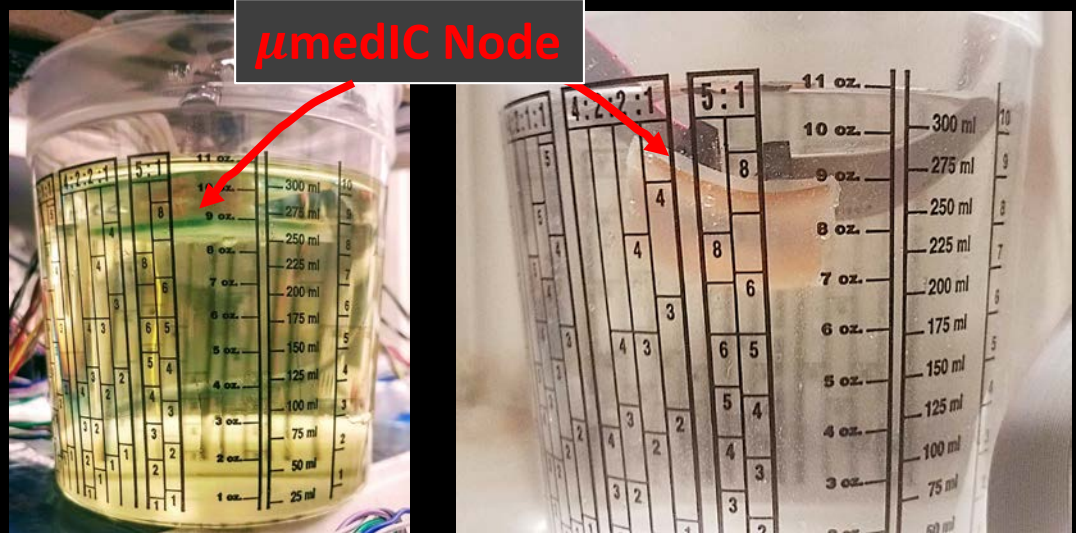


- Reader (power Up + downlink Tx + uplink Rx): on software radios (USRP N210 + SBX daughterboard)

# Evaluation in Different Environments

## In-vitro setup

Oil vs Water

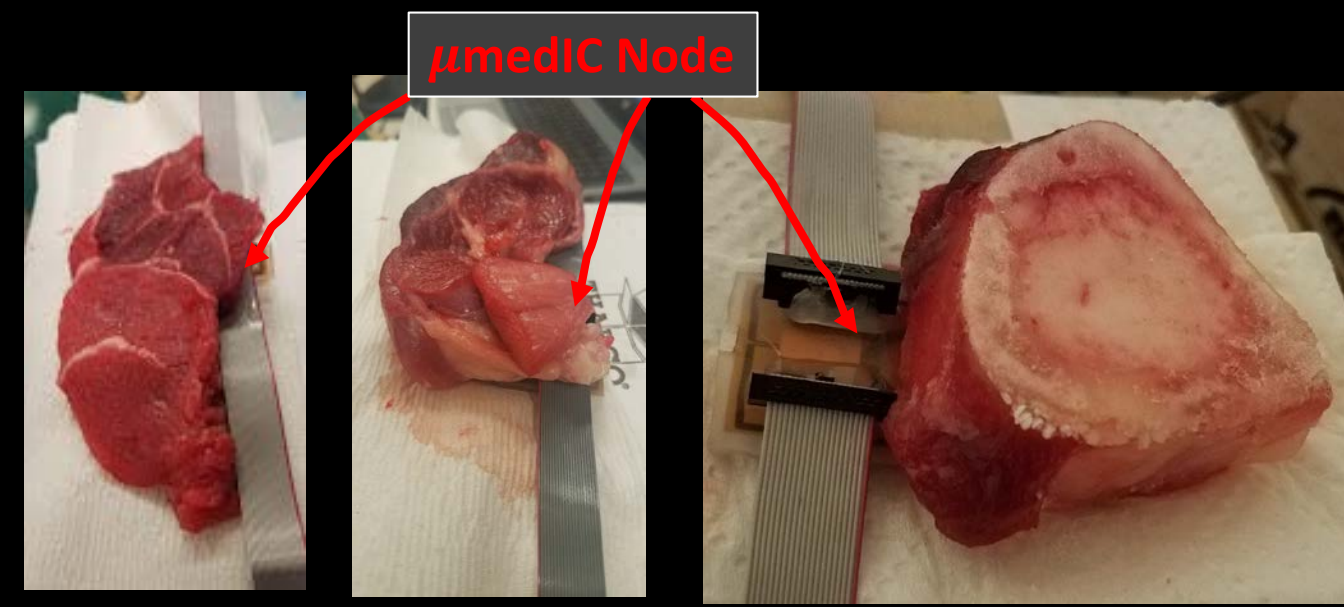


Oil-based setup

Saline solution setup

## Ex-vivo setup

Evaluation in different meat tissues



Lean tissue

Fatty tissue

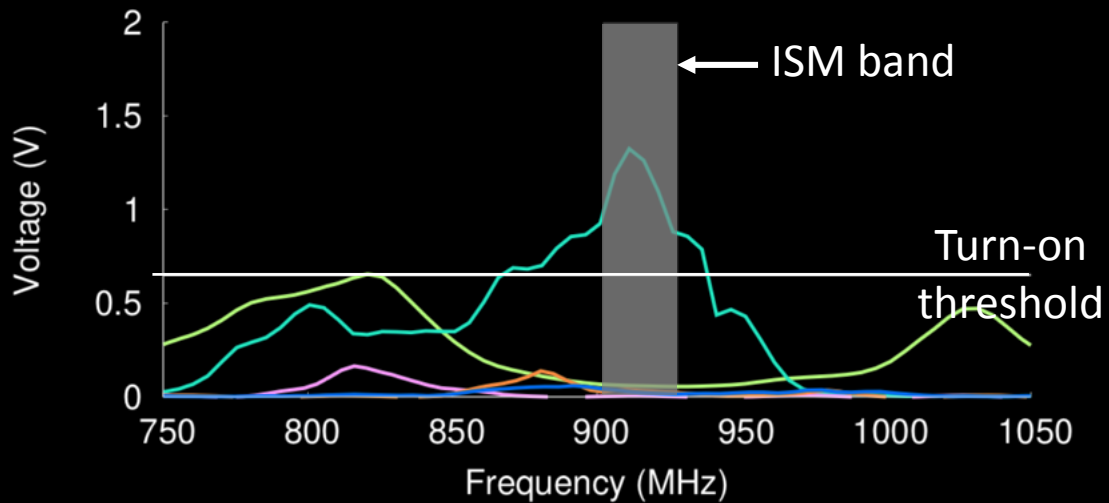
Mixed tissue



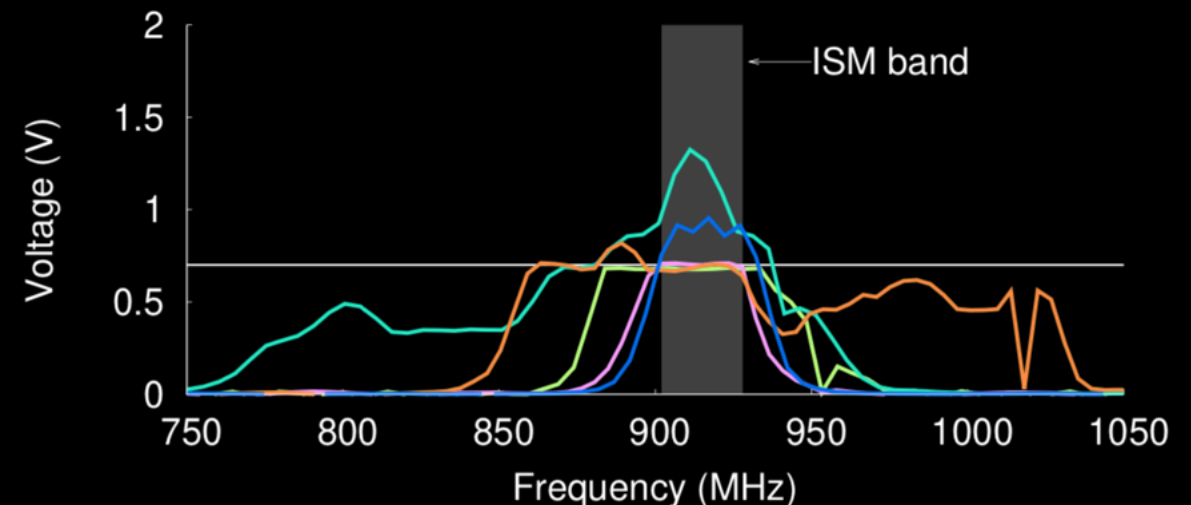
# Powering up Across Tissues

External reader transmits a continuous signal at fixed power and distance

Fixed (non-reconfigurable) design



$\mu$ medIC's reconfigurable design



$\mu$ medIC's reconfigurable design (for changing the resonance) allows it to power up across all tissues

# $\mu$ medIC:

## Wireless, Batteryless, and Self-Reconfigurable Micro-Implant

- First system that enables **cross-tissue wireless & batteryless** connectivity
- First batteryless micro-implanted system capable of **self-reconfiguration** for energy harvesting & backscatter communication inside tissues
- Designed, fabricated, and evaluated in different **tissues (in-vitro & ex-vivo)**
- Fully-integrated system (IC+antenna) consumes **350 nanoWatts**, supports up to **6Mbps**

