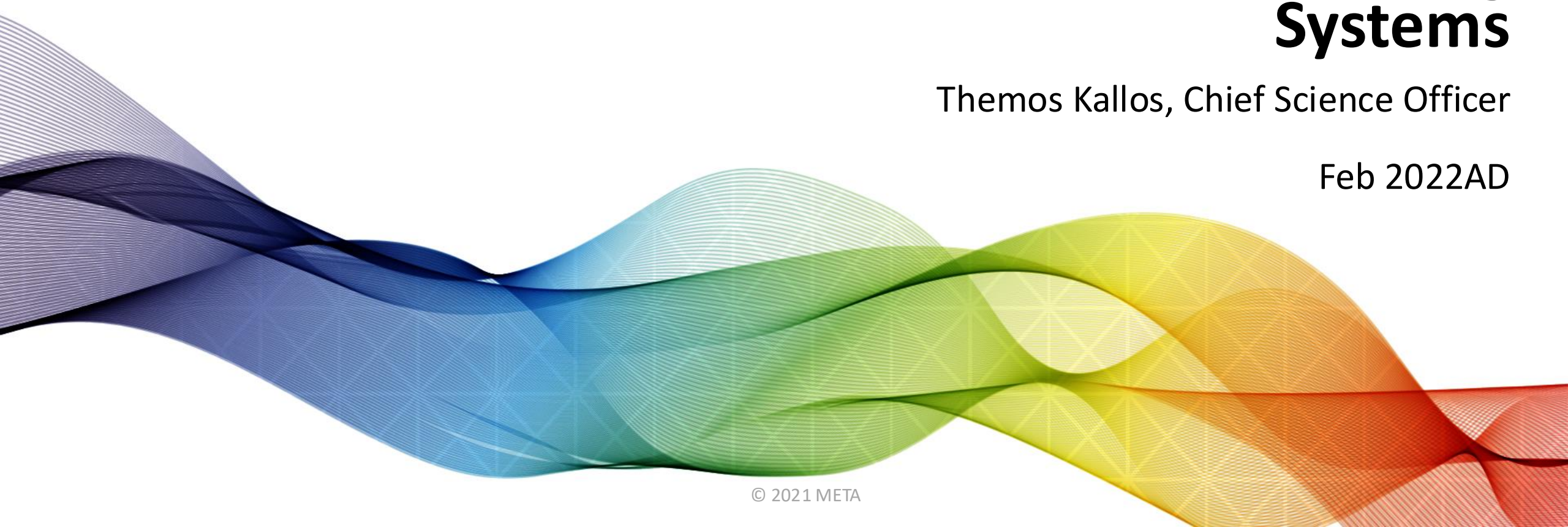
META®

Go Beyond.

Applications of Metamaterials in Next Generation Healthcare and Biosensing Systems

Themos Kallos, Chief Science Officer

Feb 2022AD



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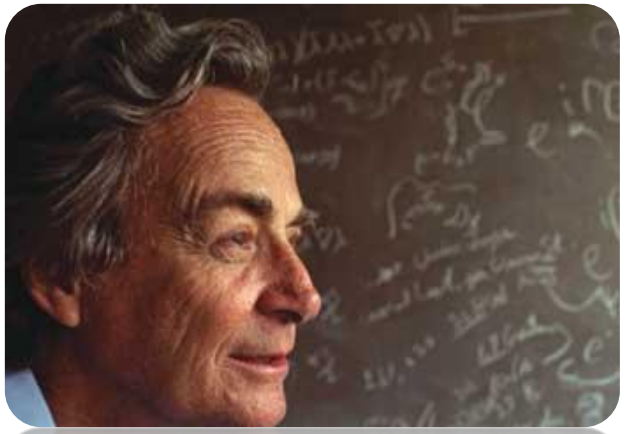
Outline

- About META
- META Applications
- META Medical Sensing Applications
- Focus Application 1 : SNR Enhancement in MRI Scans
- Focus Application 2 : Non-Invasive Glucose Sensing
- The Path to Market



"I can't see what exactly would happen,

but when we have some control of the arrangement of things in the small scale,

we will get an enormously greater range of possible properties that substances can have."

1959

About META

The META Timeline

2021	1st Metamaterial Company on NASDAQ
2011	META Founded (London, UK)
2000	Negative Refraction Demonstrated
1968	Veselago's Paper
1865	Maxwell's Equations
1492 AD	America Discovered
55 BCE	Romans invade Britain
776 BCE	First Olympiad
3000 BCE	Great Pyramid Built
10,000 BCE	Farming
200,000 BCE	Early Humans

META's Global Presence

Halifax, Nova Scotia, Canada
Head Office
R&D and Integrated Applications
Manufacturing facility

London, United Kingdom
EU Sales office
Research and Development

Pleasanton, California, United States
U.S.A. sales office
R&D - Design Office

Burnaby, BC, Canada
Security product R&D

Thurso, PQ, Canada
Secure manufacturing volume facility

Steinhausen, Switzerland
EU R&D & Sales

META Applications

Functional Films for the People

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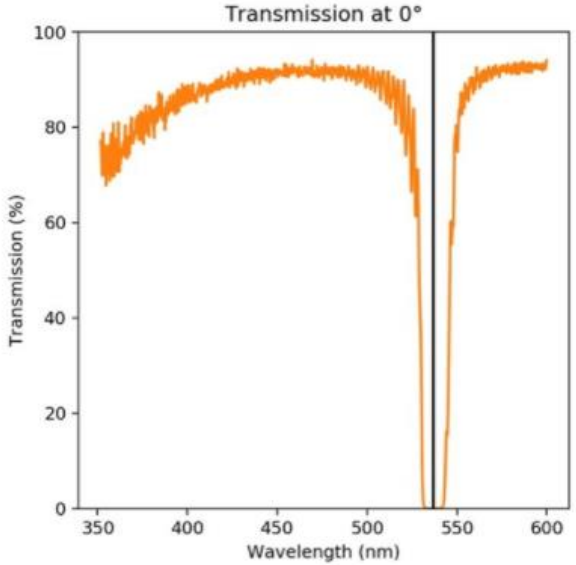
metaAIR® Laser Glare Protection Eyewear

	Notch Center (nm)		
	447	532	635
SBW (nm)	7	13	11
OD (log)	>2	>4	>2



Secure Currency & Brand Protection

- Produce motion, depth and color without inks or dyes.
- Full color, nearly impossible to reproduce.
- Engaging security features with RGB color, 3D images, and movement.
- Developing new security feature for a confidential top-10 central bank.

UEFA Euro Cup Tickets

Medical Sensing Applications

Seeing through the skin

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Application Roadmap

Image Enhancement

radiwise

MRI Medical Imaging

MRI Imaging with metamaterial film

MARKET POTENTIAL*

$2.0+B

mammowise

Early-Stage Breast Cancer Screening

Radio-wave Imaging for breast screening with metamaterial film

MARKET POTENTIAL*

$4.0+B

Sensor enhancement

glucowise

Non-invasive Glucometer

Dual Sensor mm-wave technology with metamaterial film (www.gluco-wise.com)

MARKET POTENTIAL*

$15.0+B

Consumer Molecular Biosensor

Daily use Bio-photonic sensor with sensitivity and performance enhanced using nanomaterial to meet rising demand for point of care testing.

MARKET POTENTIAL*

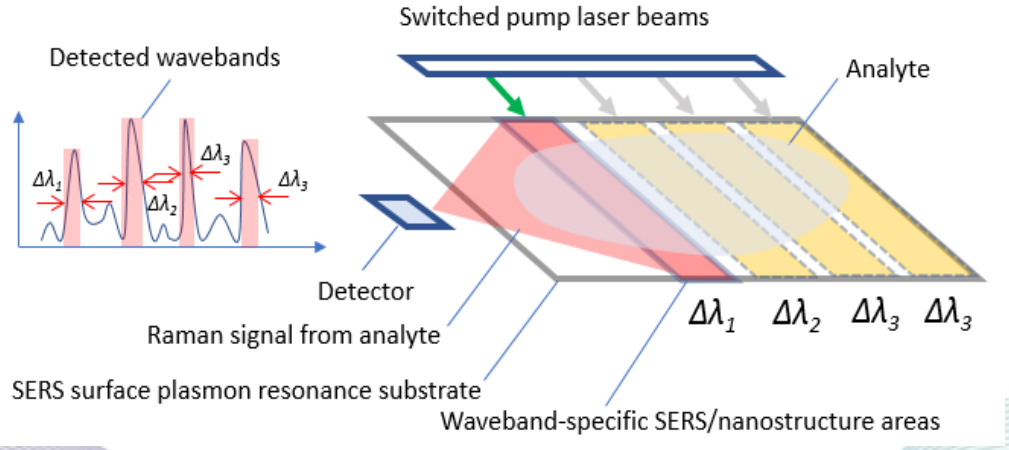
$10.0+B

Supported by UKRI Innovate UK | Technology Strategy Board Driving Innovation | NHS

*Source: Internal META estimates

Raman Spectroscopy for Infectious Diseases

PROBLEM: Current gold standard equipment is very expensive, and too bulky to be brought to the patient, let alone scalable to a personal device. Current equipment is unsuitable for deployment in GP surgeries, pharmacies or care homes or for the large-scale testing.

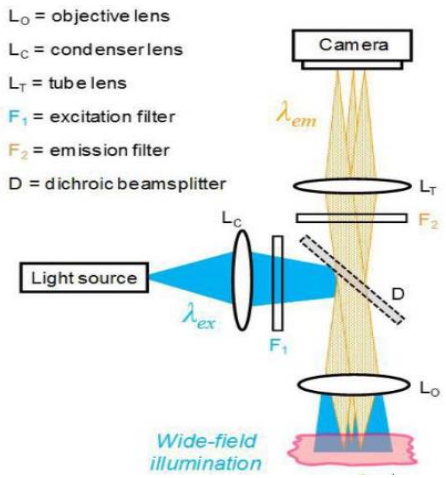


SOLUTION:

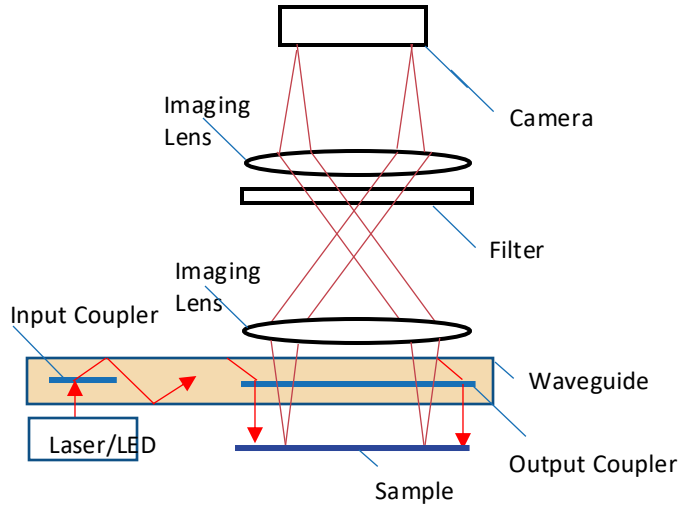
- Compact low cost solutions for consumer applications, e.g. Covid-19 detection
- Optical function compression and thin form factor for smartphone integration
- Efficient integration of SERS and nanostructures
- Laser beam delivery using switching gratings
- Compact application-customized nanostructure-based spectrometer solutions

Microscopy (Fluorescence and Colour Imaging)

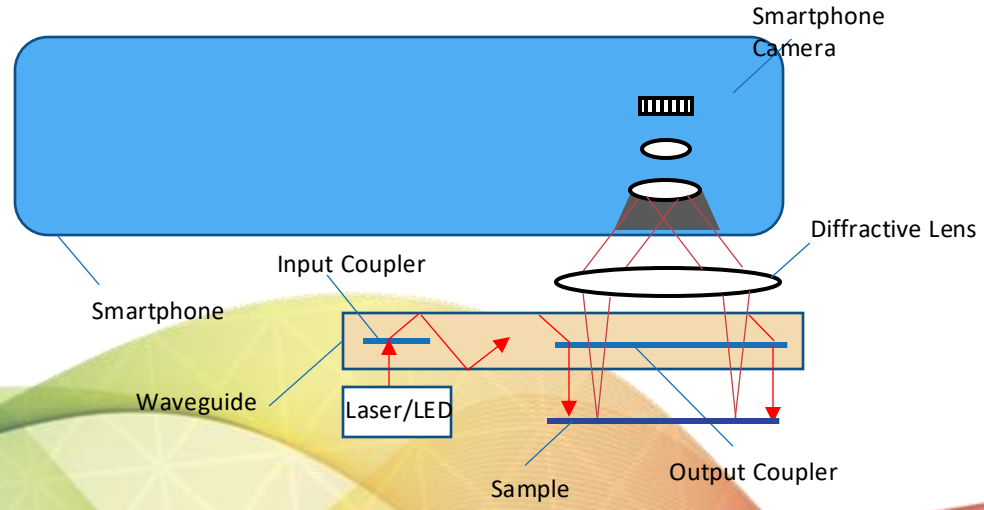
Thermo Fisher Scientific EVOS XL Core Imaging System



Integrated illuminator solutions



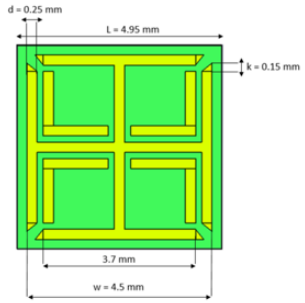
Smartphone integrated solutions

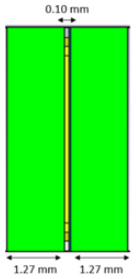


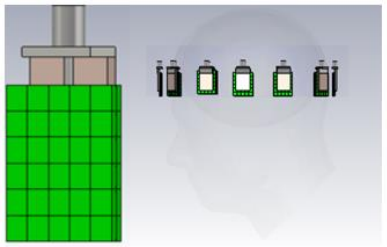
Improvements to fluorescence and color imaging system:

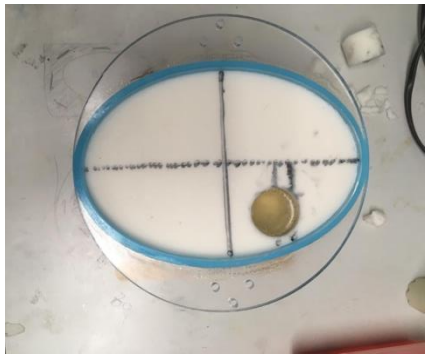
- Lasers – *form factor, image brightness, wavelength diversity, DOE-enablement*
- Homogenization – *phase randomization for uniform illumination*
- Diffractive condensers – *precise beam shaping, precise beam-shaping solutions*
- Dichroic beam splitters – *separated of source and fluorescent wavelengths*
- Thin imaging optics – *more advanced nanostructures can replace imaging lenses*
- Compact form factors – *smartphone application enablement*

Radio-Wave Imaging

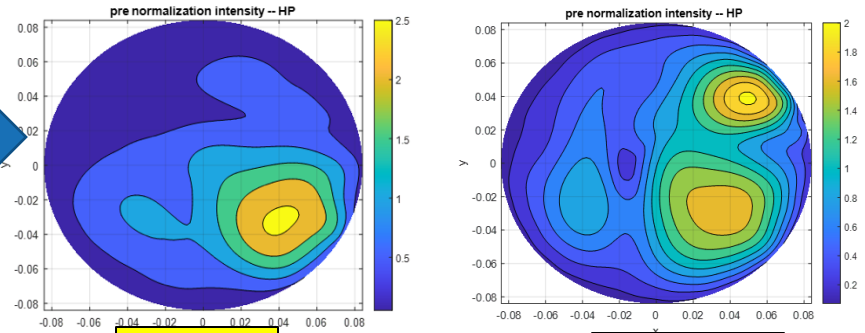








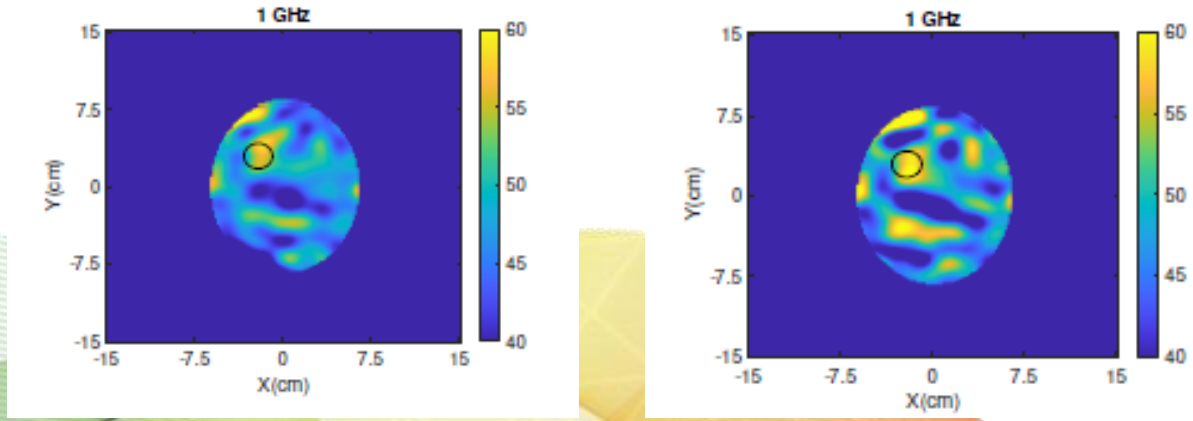
Radar Imaging



MTS **No MTS**

Skin
Bone
CSF
Grey matter
White matter
Blood target/Ischemic target

MTS **Tomography** **No MTS**



Focus Application 1

SNR Enhancement in MRI Scans

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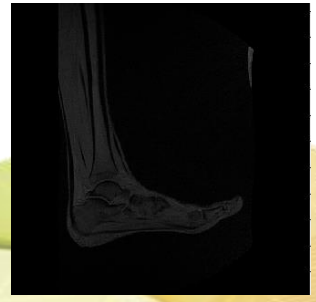
Overview

- Goal
  - Accessory that doubles the signal to noise ratio in 1.5T scans (works in conjunction with existing coils)
  - Accessory that improves SNR and homogenization in 3T scans
- Value Proposition
  - Improved image quality, especially in difficult, long scans (e.g. spine)
- Market
  - Total Addressable Market: 50,000 MRI machines worldwide
  - Serviceable Obtainable Market (initial): 10% of 1.5T/3T machines

Current Prototype inside MRI machine

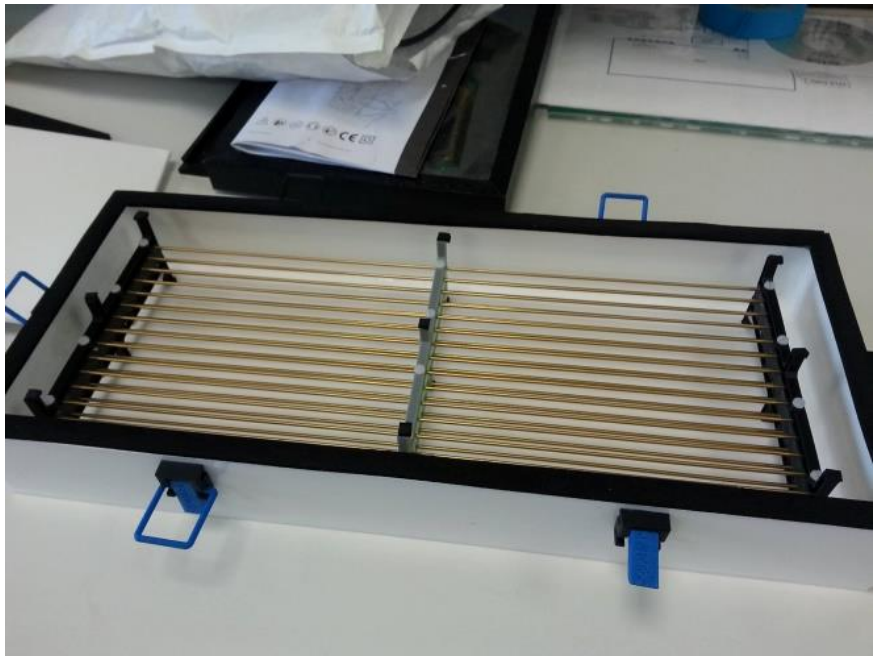
Scan without metamaterial device



Scan with metamaterial device

How it Works

- A surface consisting of multiple parallel non-magnetic metallic wires enhances the RF magnetic field in its vicinity (frequency 64 MHz for 1.5T)
- To achieve tuning at 64 MHz, the wires need to have precise length
- To also achieve a compact device, the wires need to be embedded in a high-dielectric material (e.g., water, ceramic, or powder)

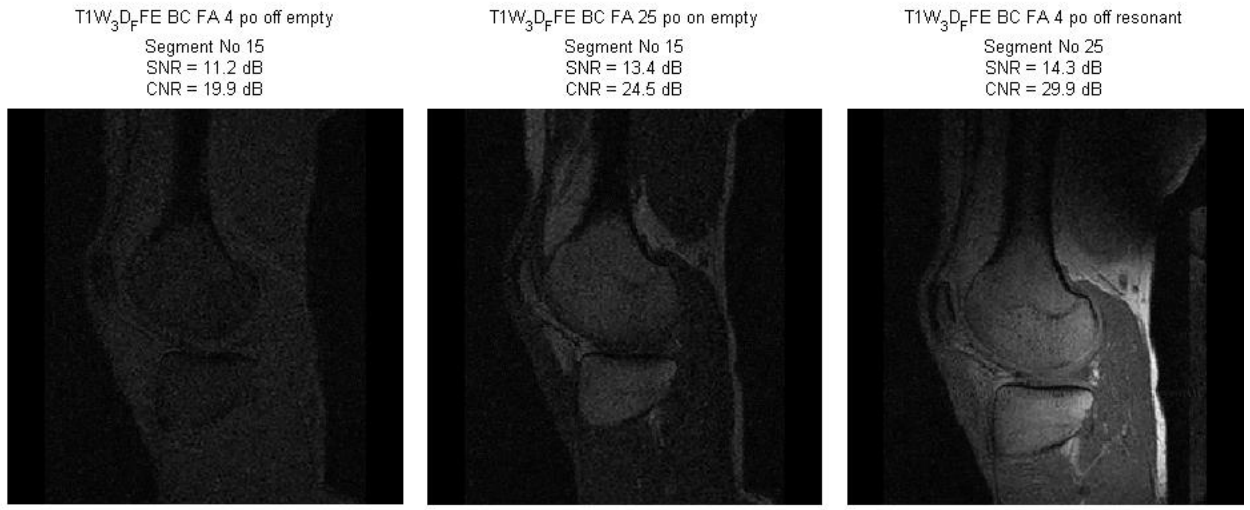


Human Studies Results

- 4 prototypes were designed, built and tested in the lab and MRI machines in humans
- The results demonstrate capability for:
  - Enhancing the SNR using non-water materials (x6 locally)
  - Achieving improved enhancement uniformity (at some expense of SNR boost)
  - Enhancing the SNR with minimal additional heating (by operating only in receive mode)

Single-Layer Water Prototype – MRI Scans

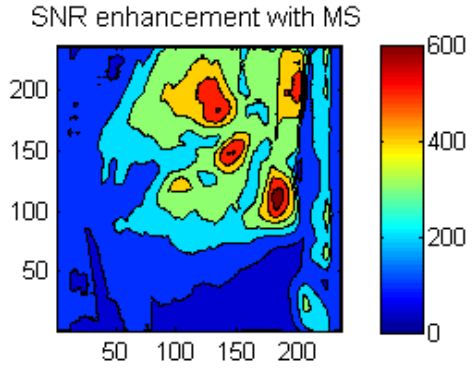
Raw data



Metasurface OFF Power Optimized Metasurface ON

Bmp images

- Low power (FA) scans
- Top row: images normalized to common maximum
- Bottom row: images filtered and normalized to individual maxima
- SNR enhancement is up to 5 times over relevant area
- Noise reduced dramatically



Focus Application 2

Non-Invasive Glucose Sensing

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Monitoring Glucose as a Type 1

Recommended: 8-10 readings per day

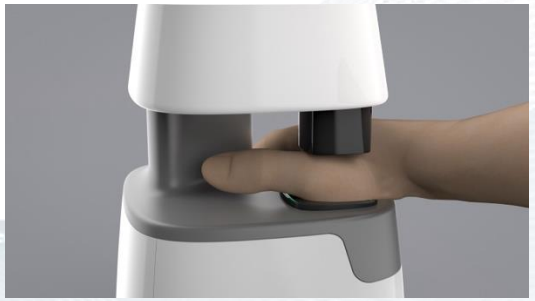
Average: 5 readings per day

Mediwise survey of diabetes patients (600) October 2013

GlucoWise® Platform Vision

META®

1 Point of Care (single point)



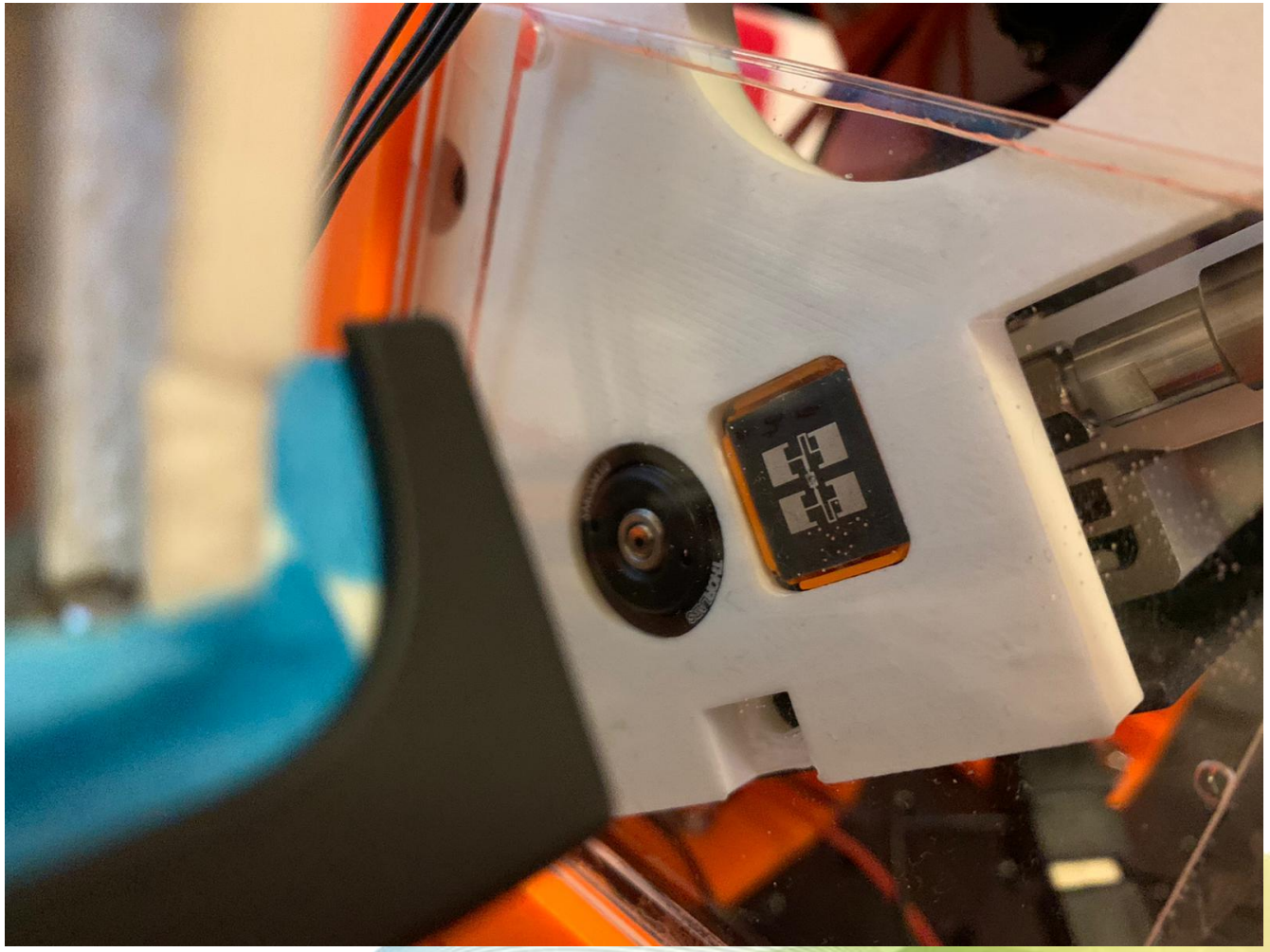
2 Portable (semi-continuous)

3 Wearable (CGM and other vitals)

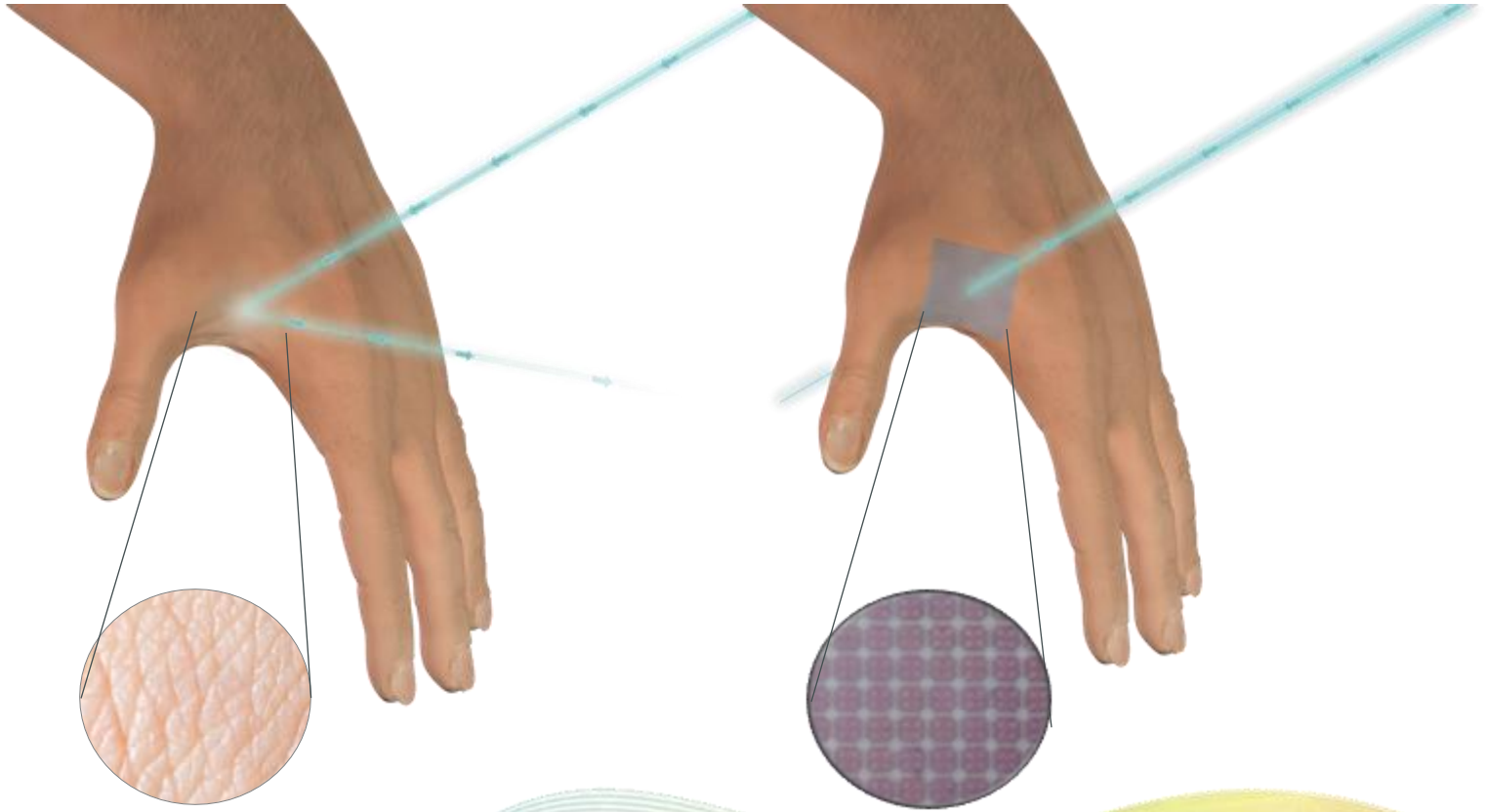
Frequency of Use

1-5 times /day	5-15 times /day	24/7 usage
>55yr, Families and Clinics	T2D, T1D, pre-diabetes, max discretion	T1D, T2D, Quantified Self, wellness

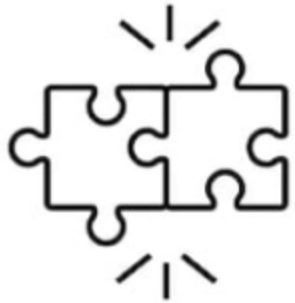
Novelty 1: Optical and RF Sensors



Novelty 2: Biosensing w/ Impedance Matching



Benefits



Thin, wearable, biocompatible film

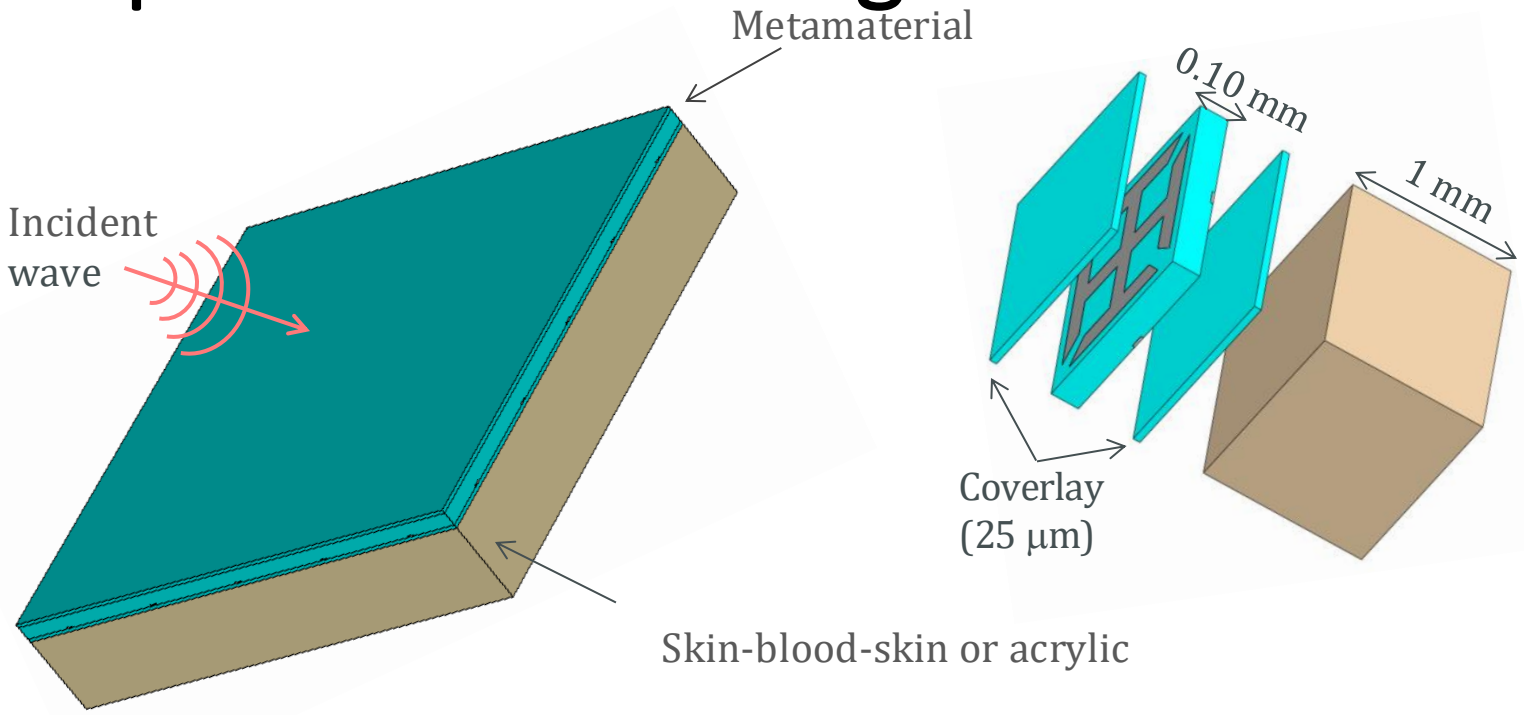
Can be integrated on the surface or inner case of smart devices and wearables

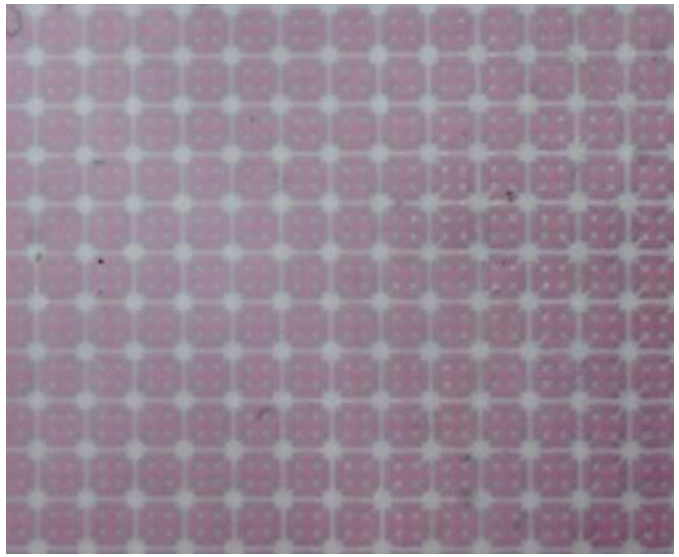
Designs for optical or radio wave signals

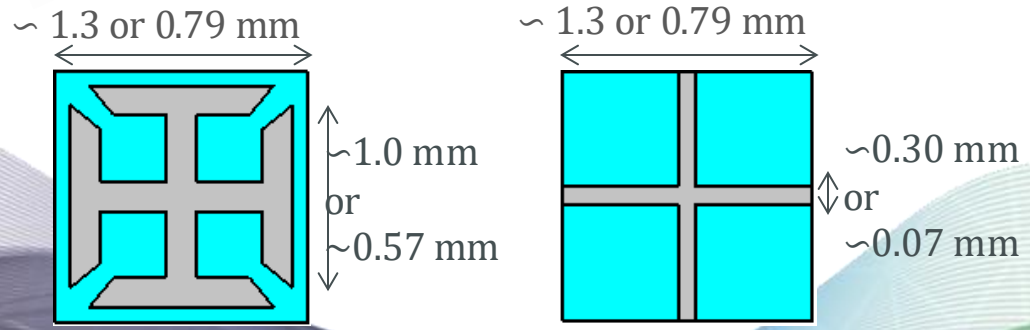
2x

Can enhance up to 250% signal transmission and reception to/from tissue

Impedance Matching Metamaterial Design

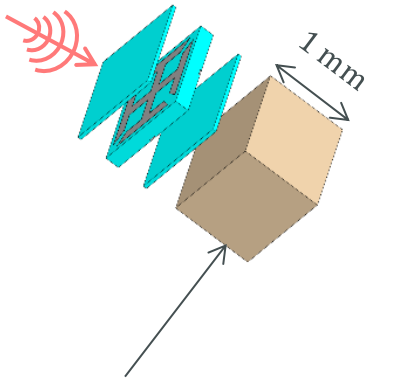




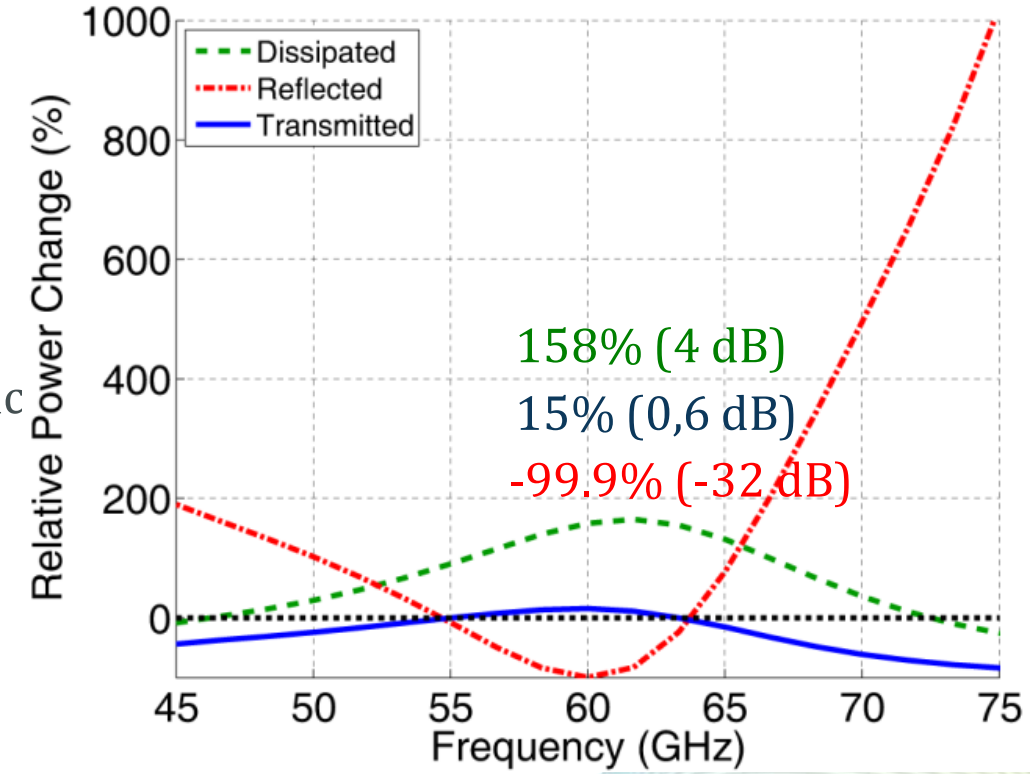


Simulation Results

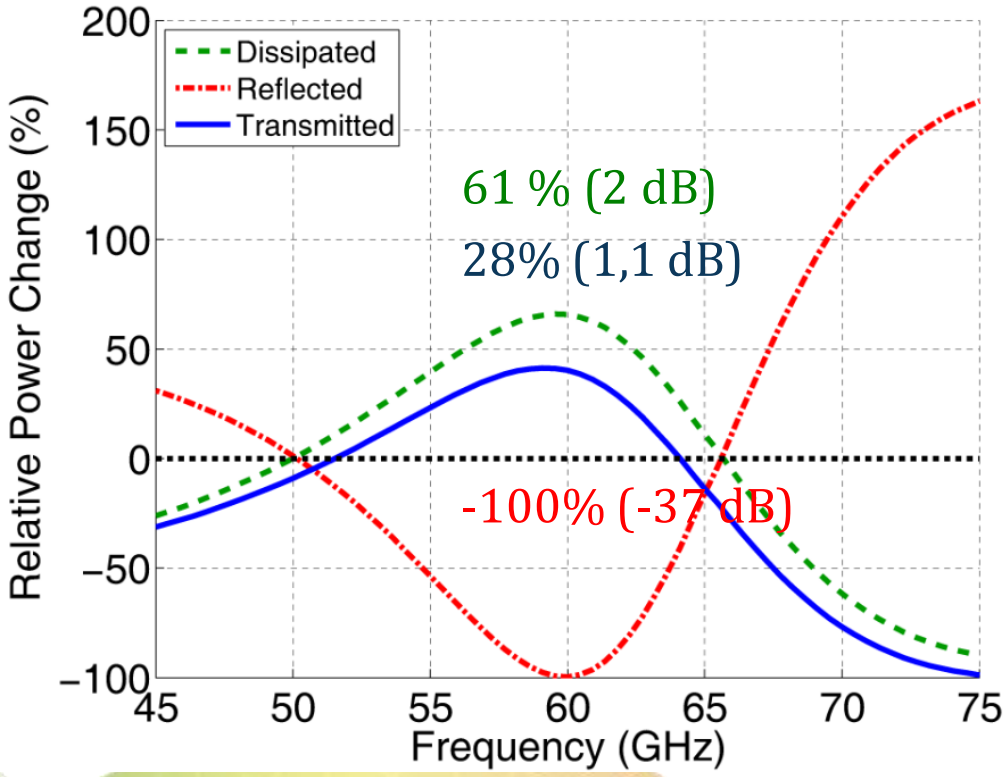
Relative power changes in the dissipated, reflected and transmitted power



Acrylic Design

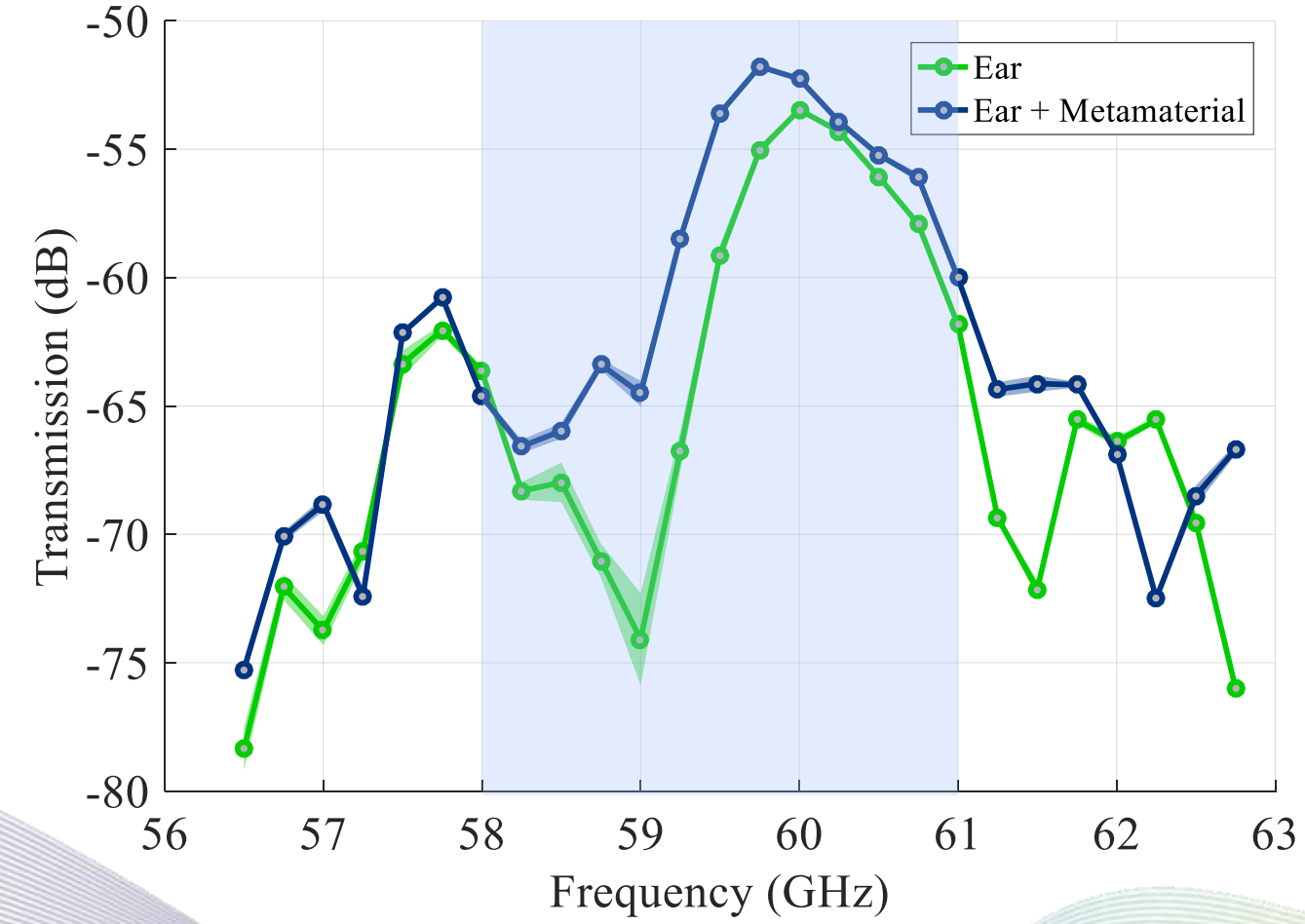


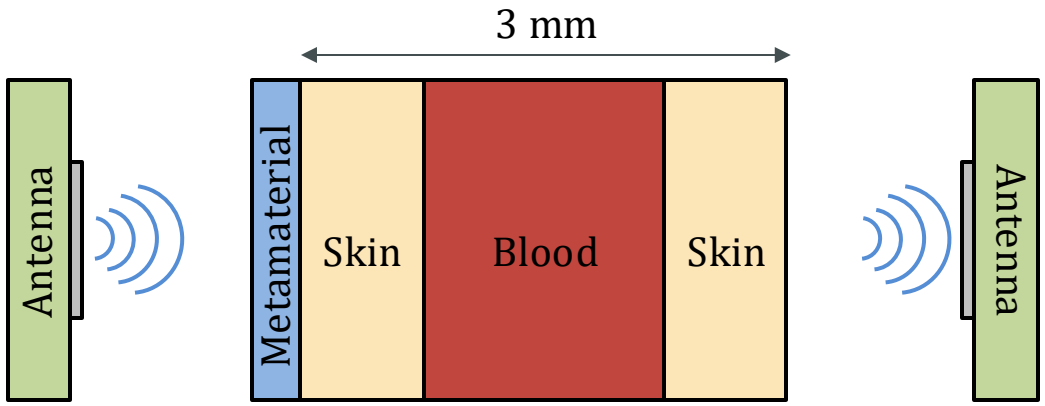
Skin Design



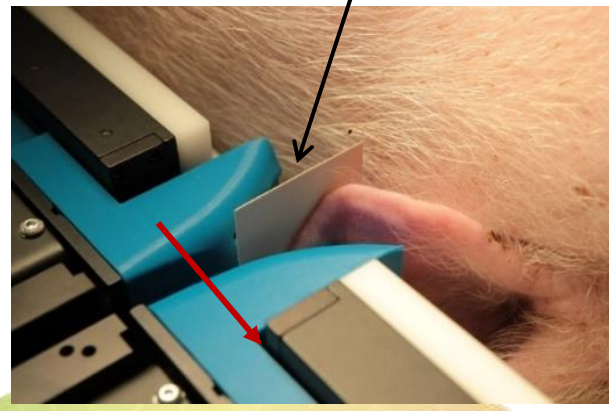
H. Cano-García, P. Kosmas, E. Kallos, "Metamaterial Antireflection Coating for Biological Tissues at Millimeter Waves"," *6th International Conference on Metamaterials, Photonic Crystals and Plasmonics (META'15)*, 2015. (Chapter 5)

Transmission Through a Pig Ear



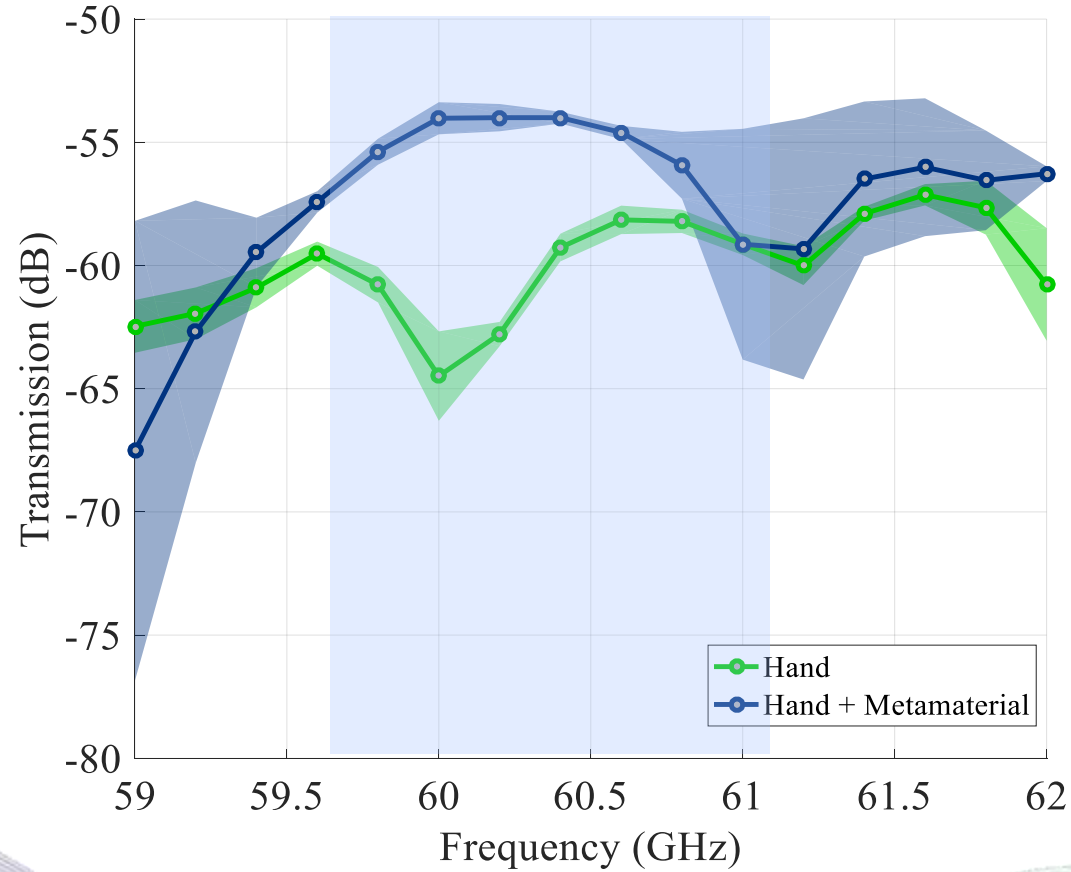


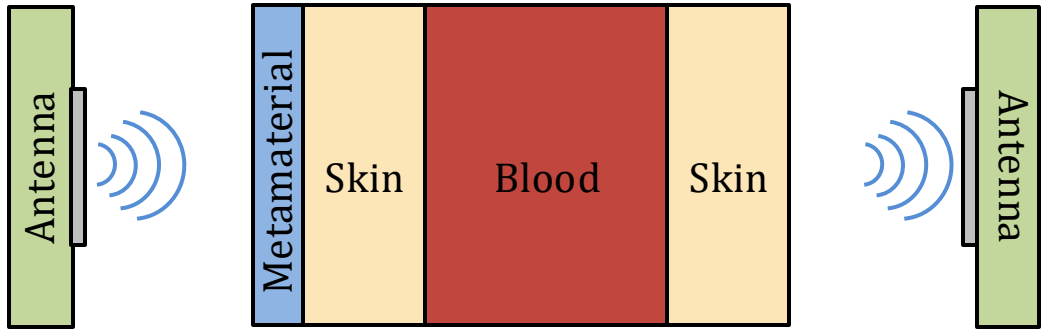
Metamaterial

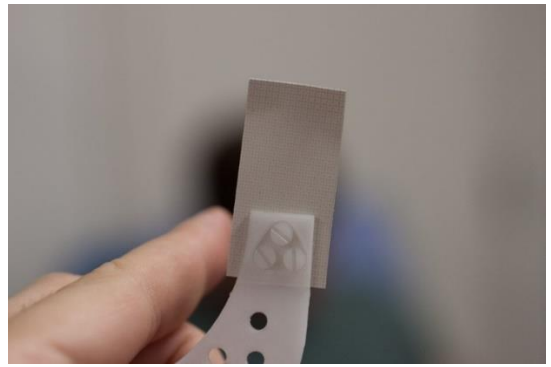


H. Cano-Garcia, P. Kosmas, and E. Kallos, "Demonstration of enhancing the transmission of 60 GHz waves through biological tissue using thin metamaterial antireflection coatings," in *2016 10th International Congress on Advanced Electromagnetic Materials in Microwaves and Optics (METAMATERIALS)*, 2016.

Transmission through Human Tissue







H. Cano-García, S. Saha, I. Sotiriou, P. Kosmas, E. Kallos, "Thin Metamaterial Antireflection Coating In-vivo Measurements to Test the Transmission Enhancement through Human Tissue", in 8*th International Conference on Metamaterials, Photonic Crystals and Plasmonics (META'17)*, 2017

GlucoWise Wearable Biosensor Vision

The Path to Market

FDA Pathways

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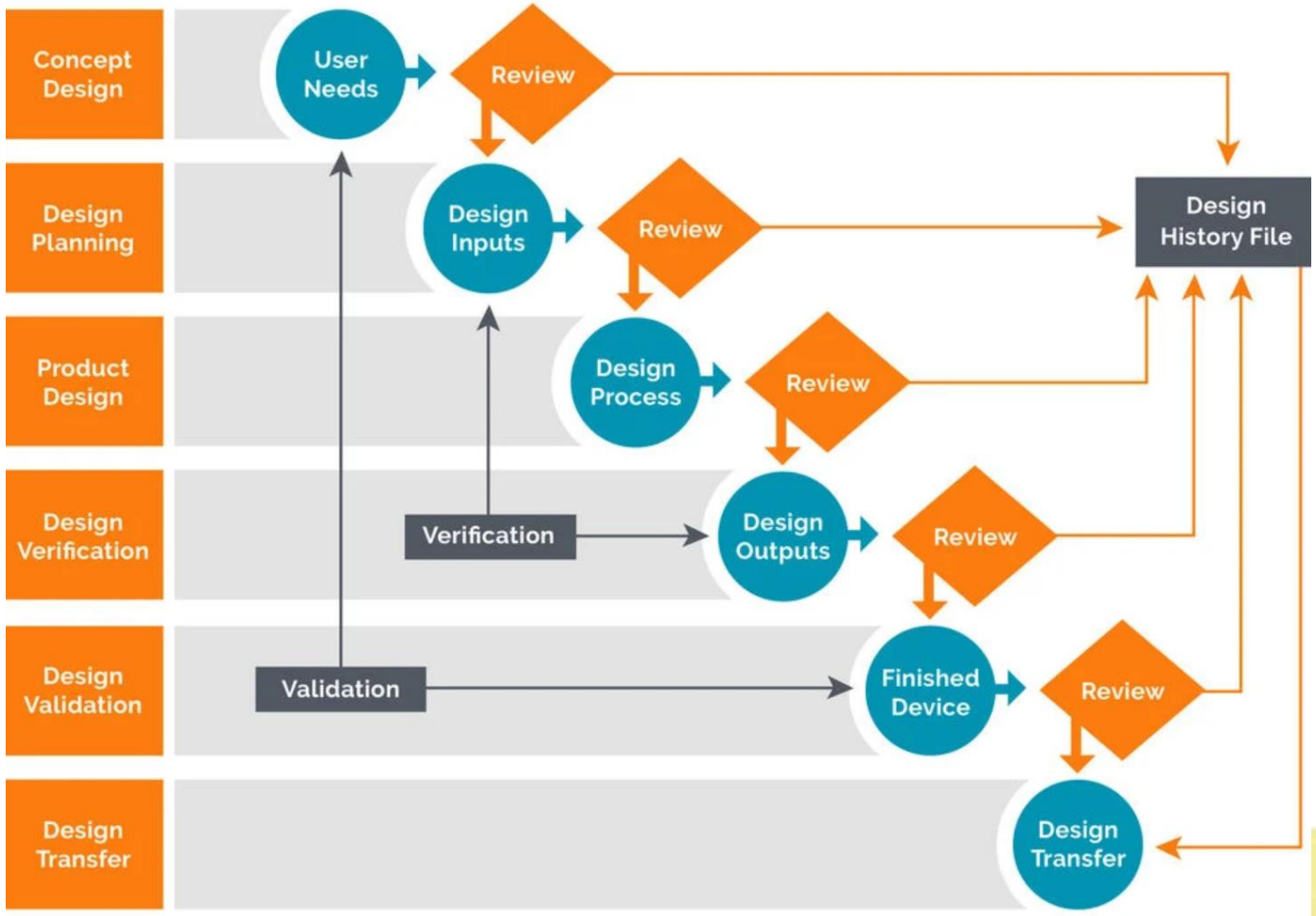
Paths for a New Medical Device

Device Class	Main FDA Regulatory Pathways	
Class I – Low Risk	510K	4,000 per year $30M
Class II – Moderate Risk	Pre-Market Approval	100 per year $100M
Class III – High Risk or no predicate	Exempt	

Medical Device Design Control Cycle



Source: www.cognidox.com

Thank You

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