Oliver Duncan
Manchester Metropolitan University

Tom Allen
Manchester Metropolitan University

Calum Williams
University of Cambridge

UK META MATERIALS NETWORK

Health Challenge

Dr Tom Allen

Healthy living

Dr Olly Duncan

Healthcare

Dr Calum Williams

Exercise

Dr Olga Kravchenko

- Facilitating sport, exercise & physical activity
- Monitoring exercise & physical activity
- Active travel
- Injury risk reduction (PPE, footwear, equipment etc)
- Disabled sport

Wellbeing

Prof. Emma Hodson-Tole

- Work life balance
- Sleep
- Healthy eating / lifestyles
- Transcranial magnetic stimulation
- Mental health
- Pollution

Ageing

Prof. Georges Limbert

- Falls / fall monitoring
- Exoskeletons
- Implants
- Facilitating independence
- Care in the community

Monitoring & diagnosis

Mr Martin Leigh

- Patient monitoring
- Sensors and point-of-care testing
- Implantable bioelectronics and wearables
- Biomedical imaging and diagnostics
- Digital Health

Therapeutics

Dr Rupam Das

- Physical disability (prosthetics, orthotics & wheelchairs)
- Dentistry
- Trauma & first aid (wound healing, smart dressings / bandages, braces & splints)
- Tissue engineering and scaffolds
- Target drug delivery and treatments
- Theranostics
- Photothermal therapy

Prevention → Treatment

Let's kick off on a jolly note!
Why should you care?

World Health Organization

- Worldwide **obesity has tripled** since 1975
- **Cardiovascular diseases are the leading cause of deaths globally**, ~18 million per year (approx. the population of the Netherlands)

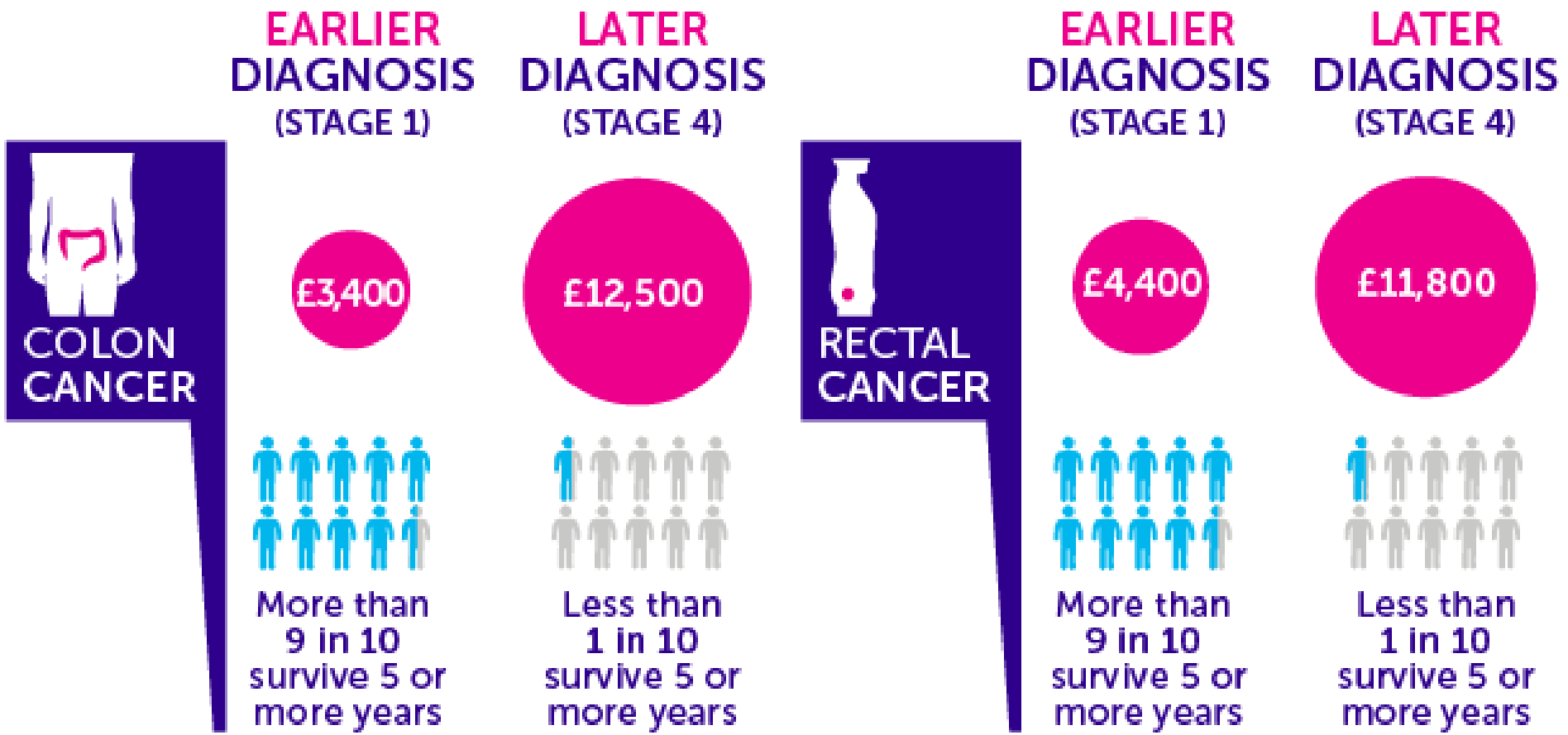
CANCER RESEARCH UK

- **1 in 2** UK people will be **diagnosed with cancer** in their lifetime
- There were **10 million deaths from cancer worldwide in 2020** (approx. the population of Sweden)

BMJ Quality & Safety

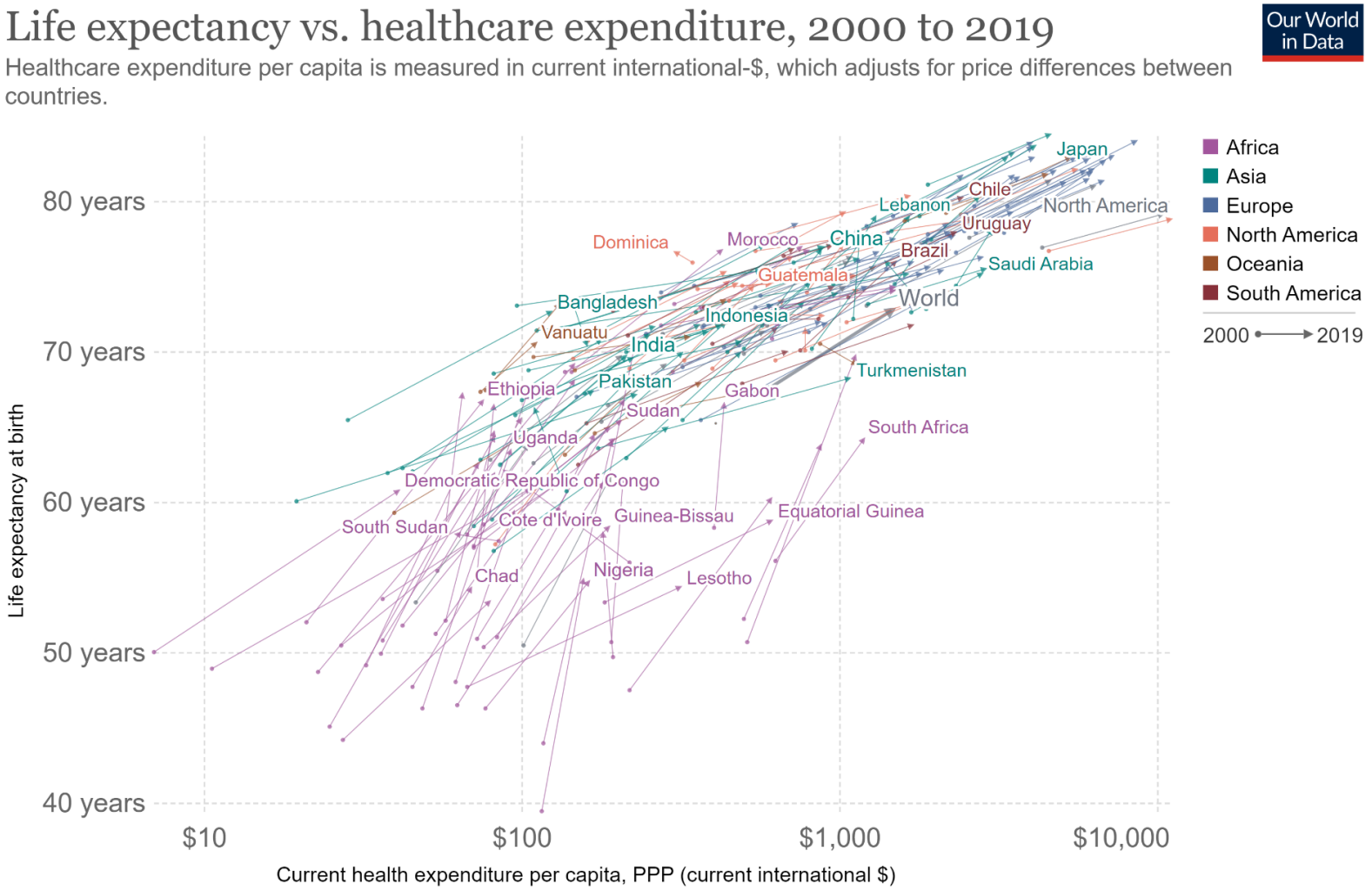
- Ever year in the US, there are: **12 million diagnostic errors, costing $750 billion and >100,000 lost lives** (most common: missing early cancers and heart disease)

WHEN THE NHS DIAGNOSES PATIENTS EARLIER, TREATMENT COSTS MUCH LESS



CANCER RESEARCH UK

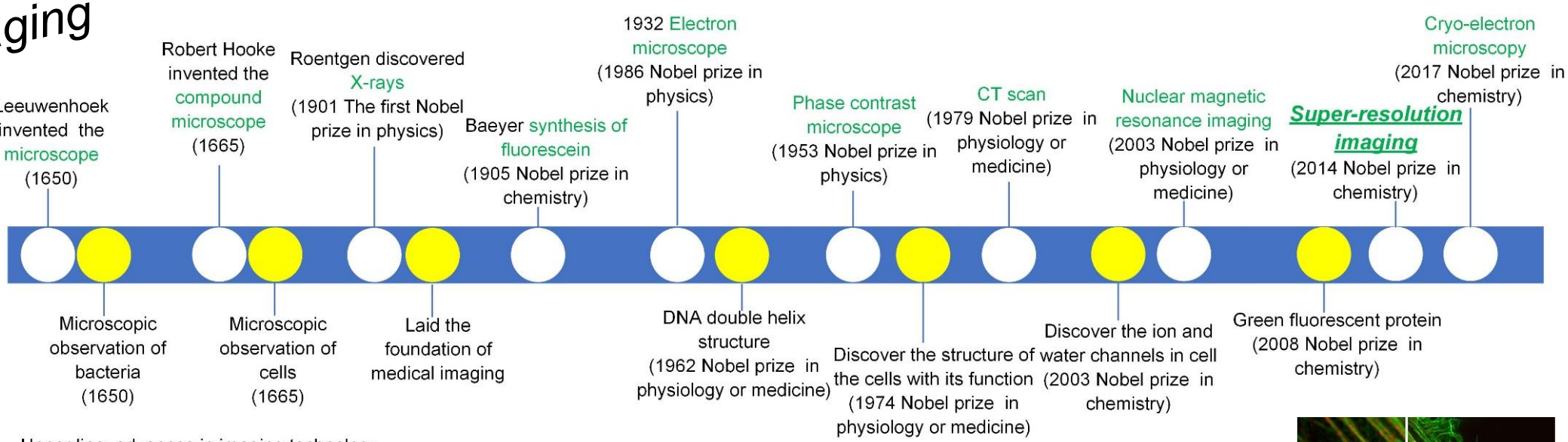
Healthcare expenditure per capita improves life expectancy: **How do we make healthcare affordable for all?**



Well … what can **WE** do?

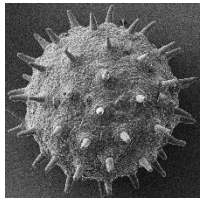
Developments in technology underpin breakthroughs in the life sciences healthcare

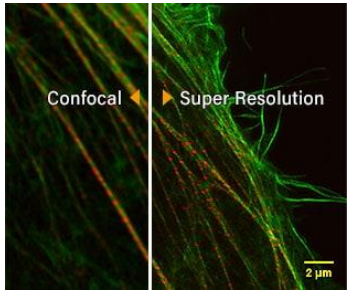
e.g. Imaging



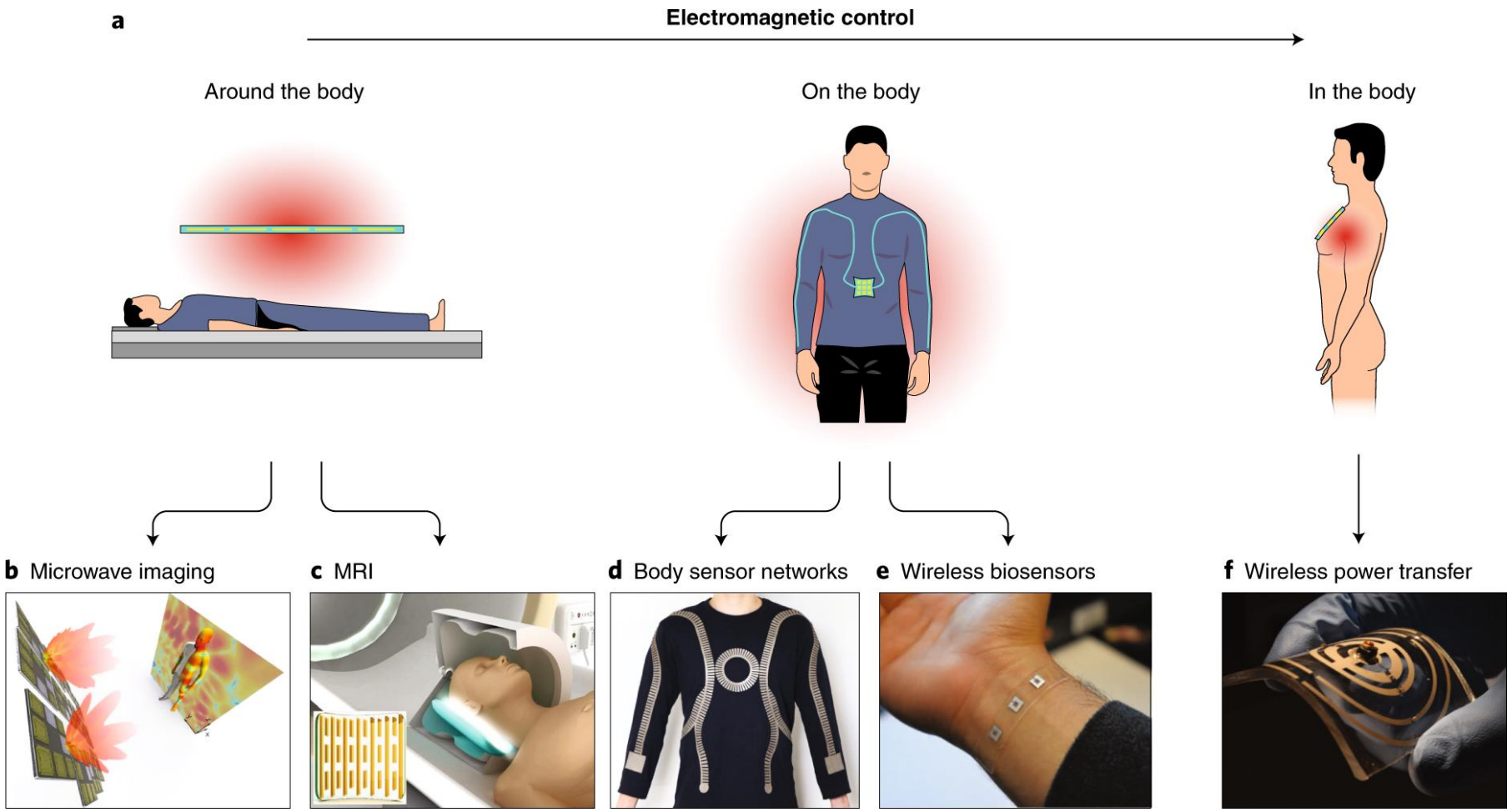
Upper line: advances in imaging technology

Below line: advances in life sciences





How can *metamaterials* help?



Metasurfaces for bioelectronics and healthcare

Zhipeng Li[1], Xi Tian[1], Cheng-Wei Qiu[1]✉ and John S. Ho[1,2,3]✉

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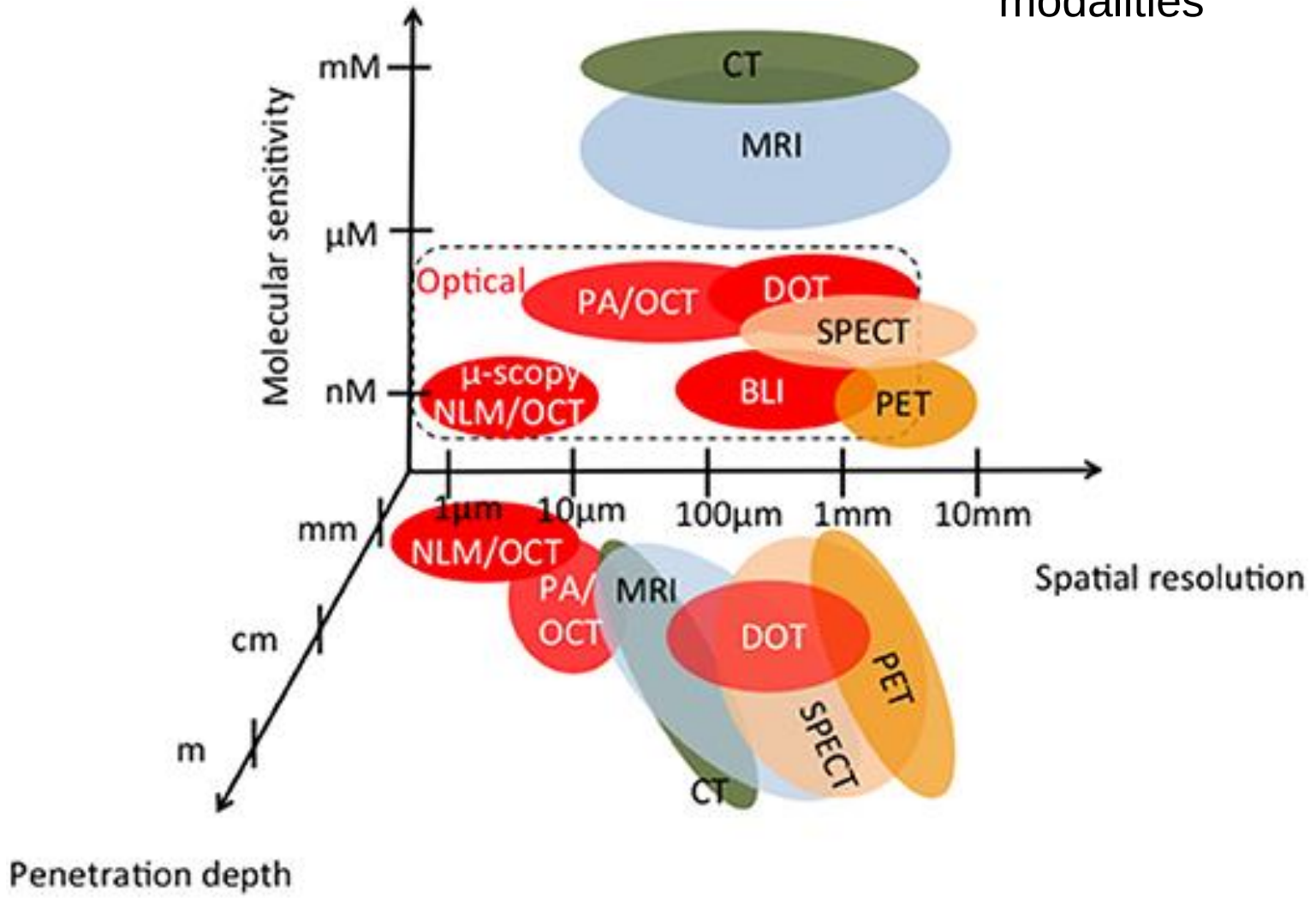
Prevention → Treatment

Imaging and diagnostics: outside / inside the body

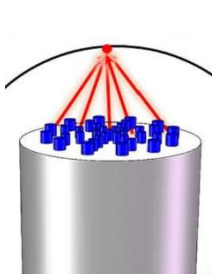
- penetration depth
- spatial resolution
  - sensitivity

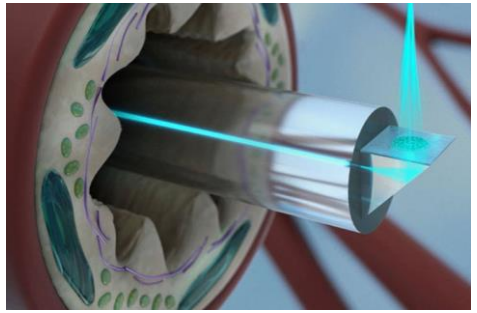
- finding contrast
- minimise radiation

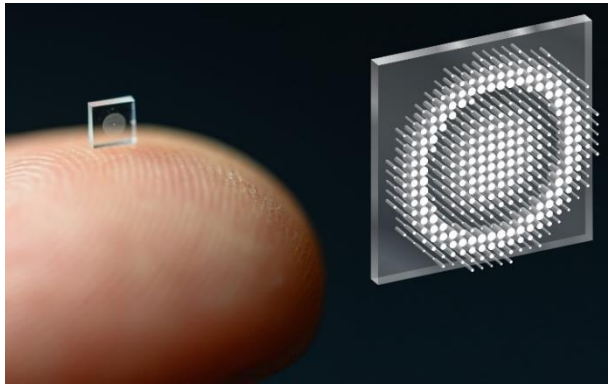


Imaging and diagnostics: outside / inside the body

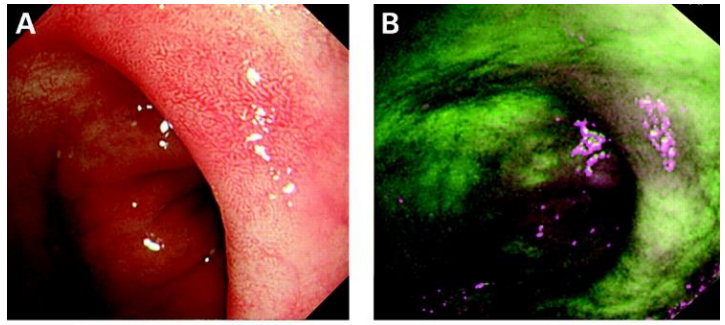
Endoscopy

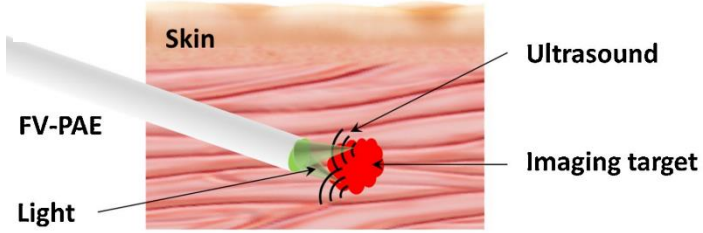


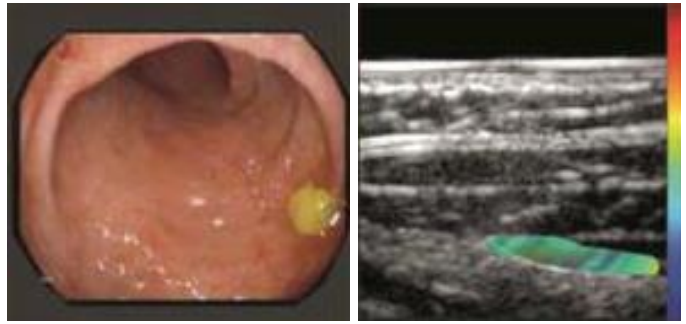




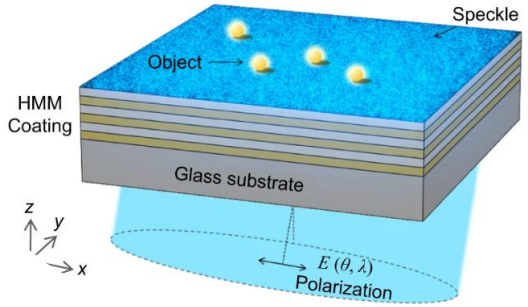
Multi-modal endoscopic imaging

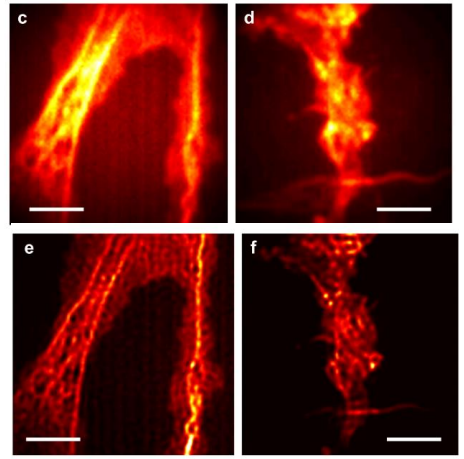






Super-resolution biomedical imaging



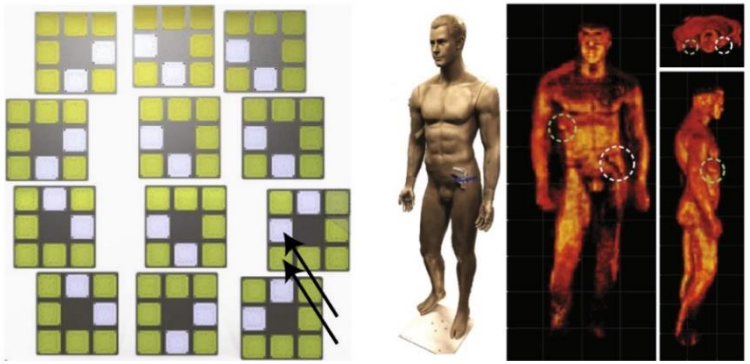


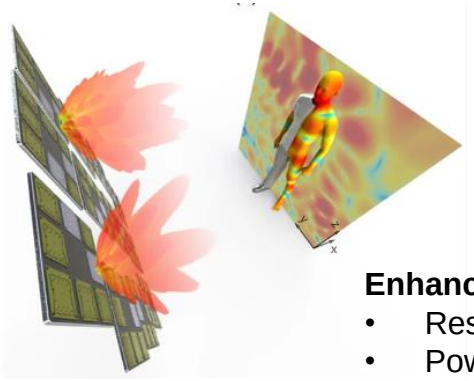
Metamaterial assisted illumination nanoscopy via random super-resolution speckles

Yeon Ui Lee, Junxiang Zhao, Qian Ma, Larousse Khosravi Khorashad, Clara Posner, Guangru Li, G. Bimananda M. Wisna, Zachary Burns, Jin Zhang & Zhaowei Liu ✉

Imaging and diagnostics: outside / inside the body

A human-scale microwave imager (coded aperture metasurfaces)





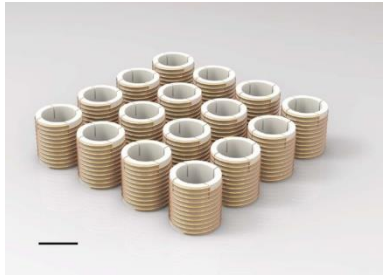
Enhancement

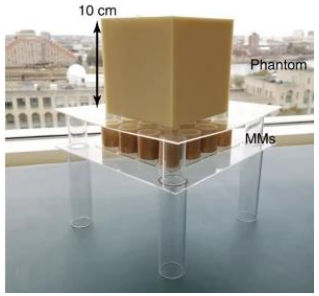
- Resolution and speed
- Power consumption
- Compactness

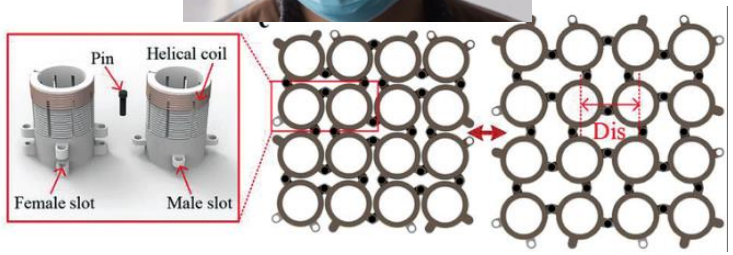
Large Metasurface Aperture for Millimeter Wave Computational Imaging at the Human-Scale

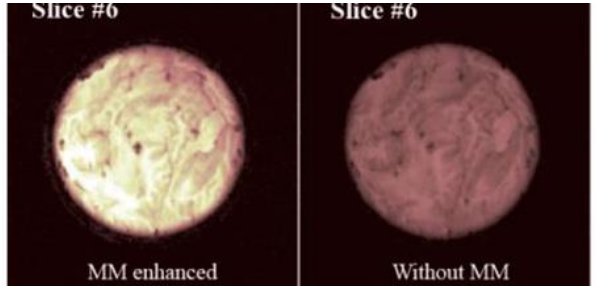
J. N. Gollub, O. Yurduseven, K. P. Trofatter, D. Arnitz, M. F. Imani, T. Sleasman, M. Boyarsky, A. Rose, A. Pedross-Engel, H. Odabasi, T. Zvolensky, G. Lipworth, D. Brady, D. L. Marks, M. S. Reynolds & D. R. Smith

A magnetic metamaterials for enhancing magnetic resonance imaging (MRI).









Enhancement

- SNR and Speed

Boosting magnetic resonance imaging signal-to-noise ratio using magnetic metamaterials

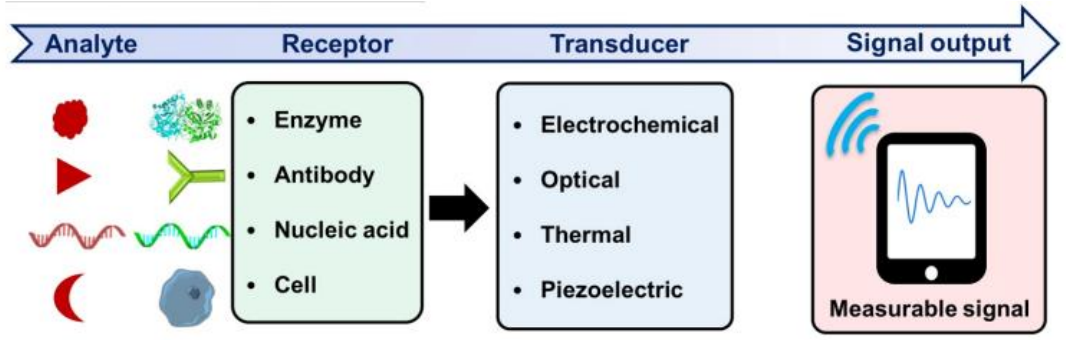
Guangwu Duan, Xiaoguang Zhao, Stephan William Anderson & Xin Zhang

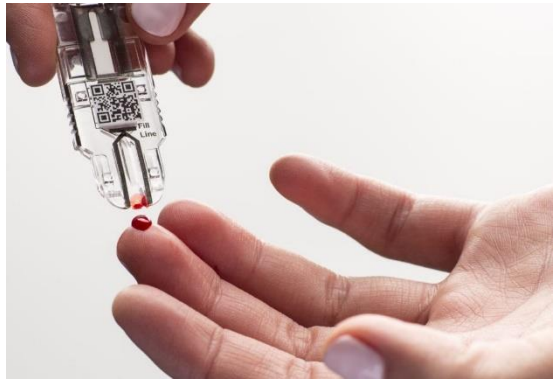
Auxetics-Inspired Tunable Metamaterials for Magnetic Resonance Imaging

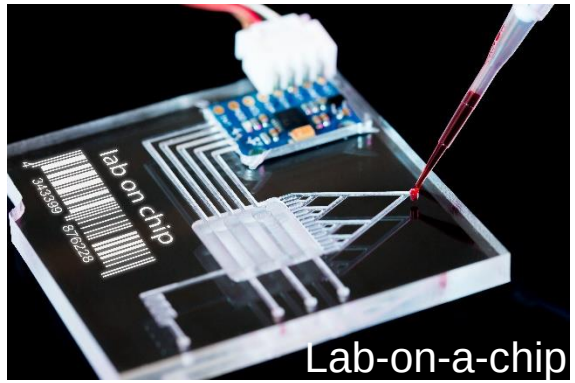
Ke Wu, Xiaoguang Zhao, Thomas G. Bifano, Stephan W. Anderson, Xin Zhang

Monitoring:
Biosensors, wearables and point-of-care (POC) diagnostics

What is a biosensor?

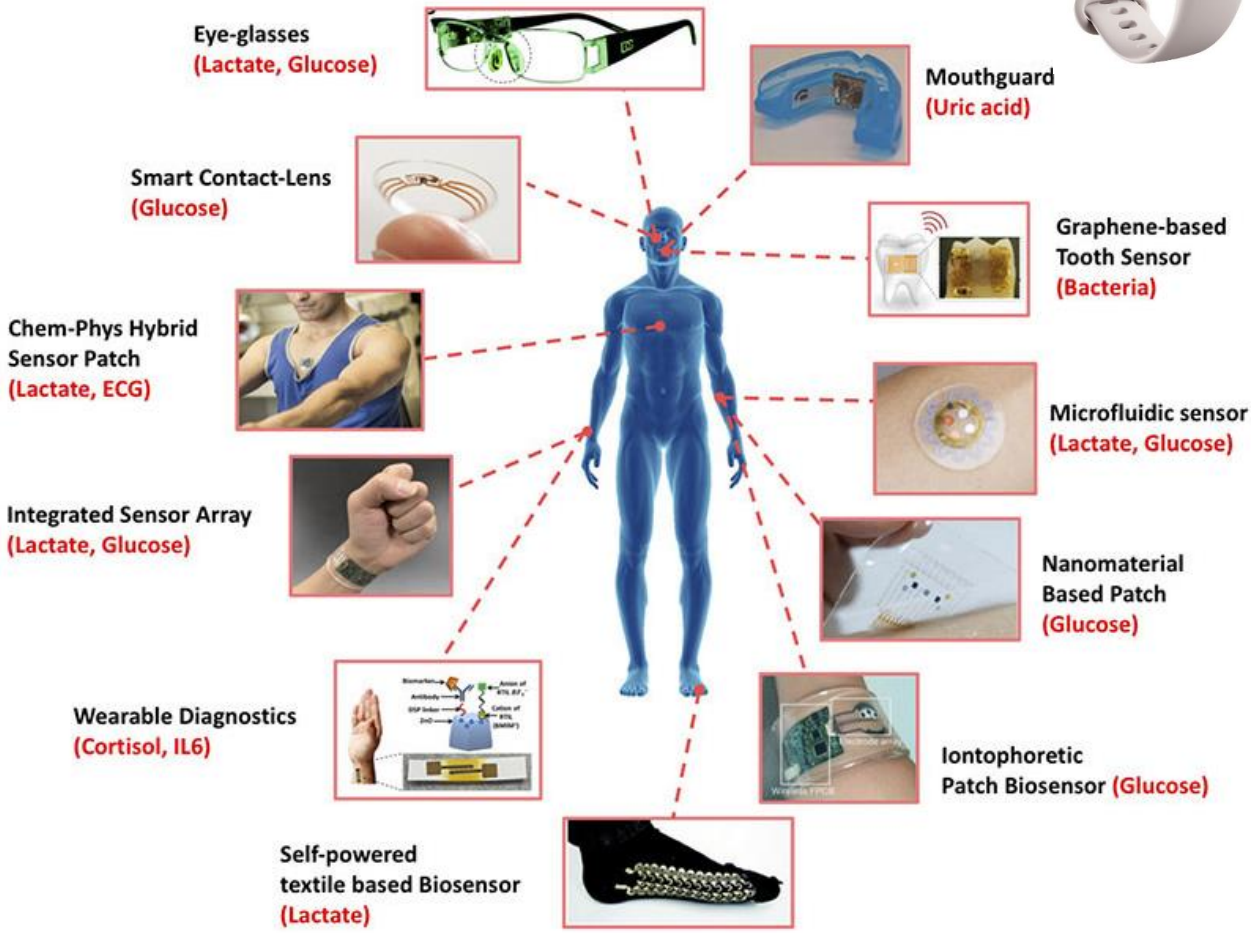






Organ-on-a-chip

Wearable biosensors



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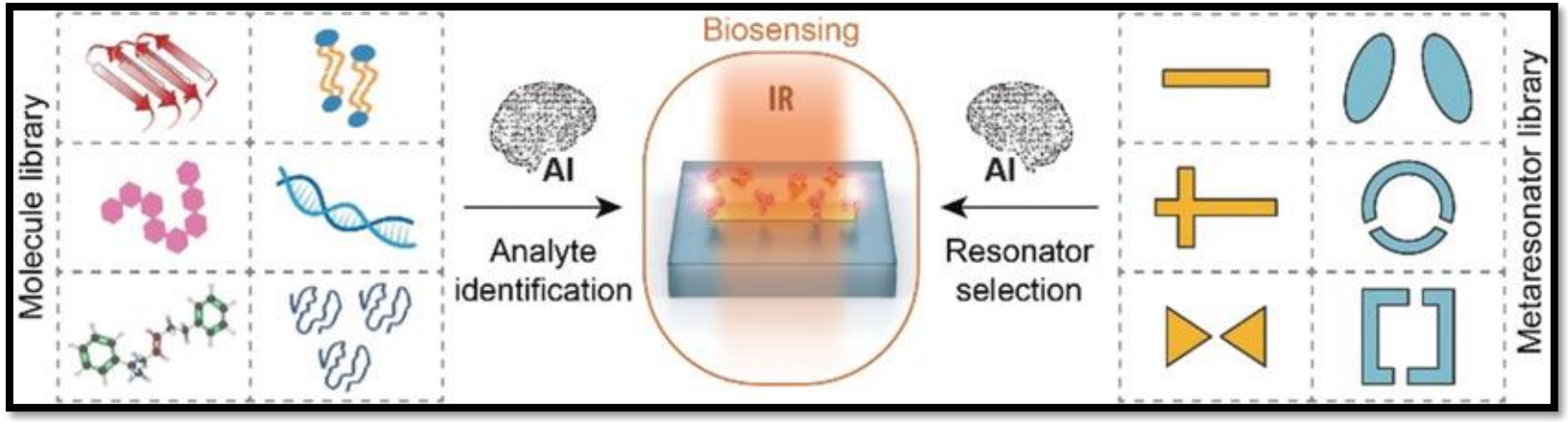
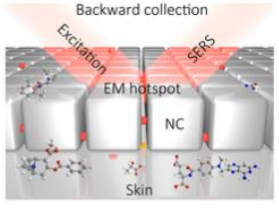
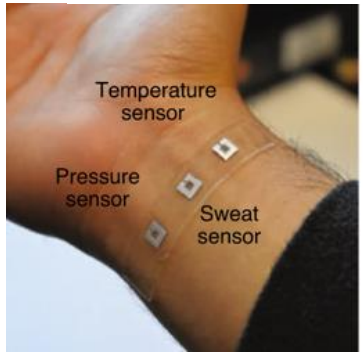
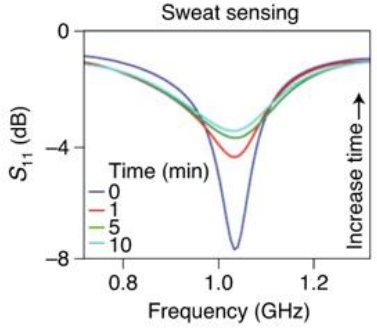


convert changes in presence of molecules, sweat, pressure etc. into resonant frequency shifts

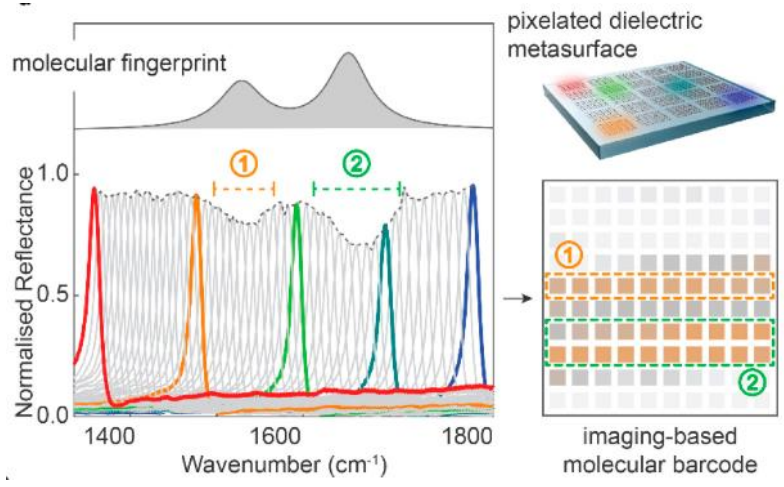
Wearable biosensors



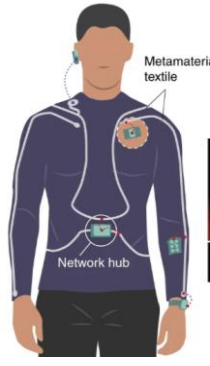


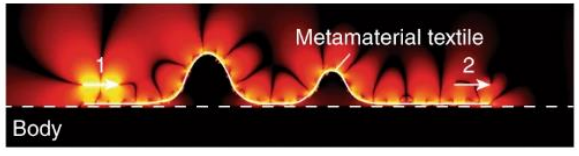


Molecular barcoding



Smart Textiles





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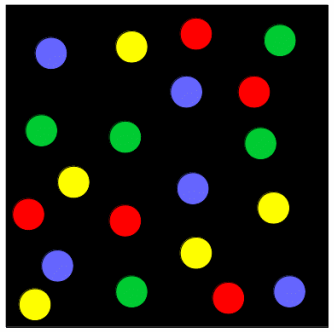
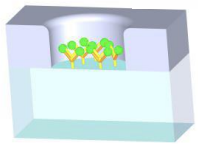
Biosensors, wearables and point-of-care (POC) diagnostics

illumina

DNA sequencing

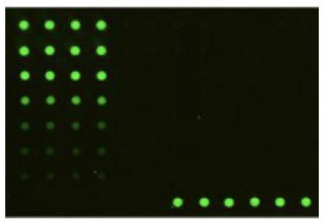


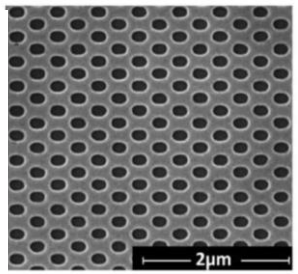
MOXTEK



Moxtek

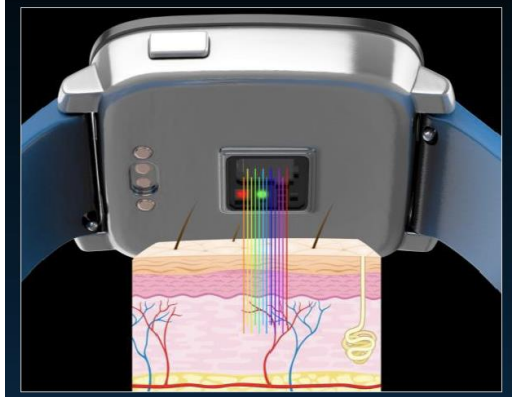
Streptavidin





Rockley® PHOTONICS

Clinic-on-the-wrist™ module



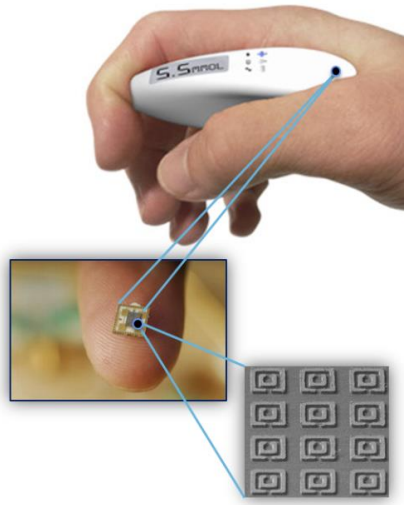
Multiple laser wavelengths probe non-invasively into the skin

- Blood pressure
- *Hydration*
- *Alcohol*
- *Glucose*

META® Go Beyond.

glucoWISE®

Key Differentiators:



Measures **glucose at the capillary level** by passing radio wave and optical signals through a thin part of the hand and receiving the signals via a sensor on the opposite side.

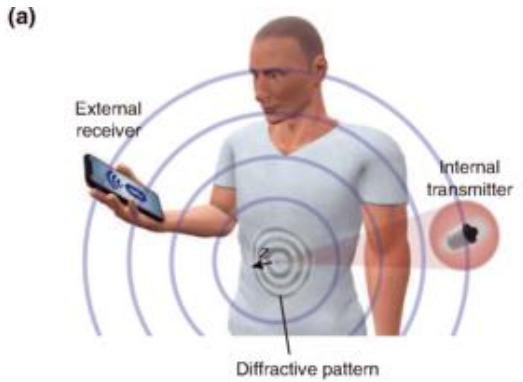
The sensors have integrated micro-composite films, which help make the skin transparent to the signals.

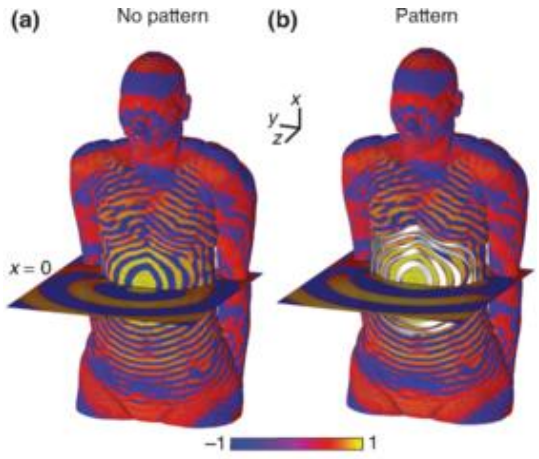
Credit: Themos Kallos

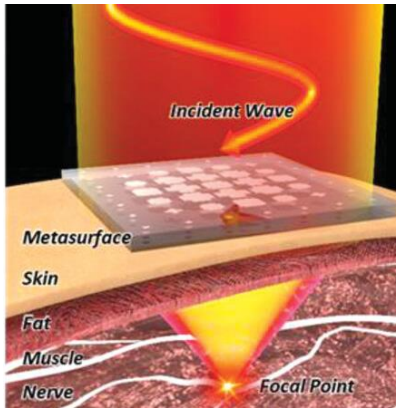
Implantable devices and impedance matching

Enhanced wireless power transfer and communications

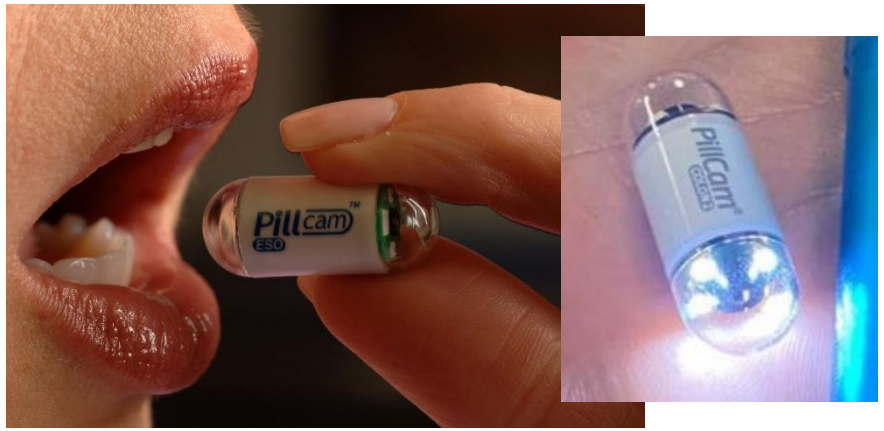
Transmission enhancement



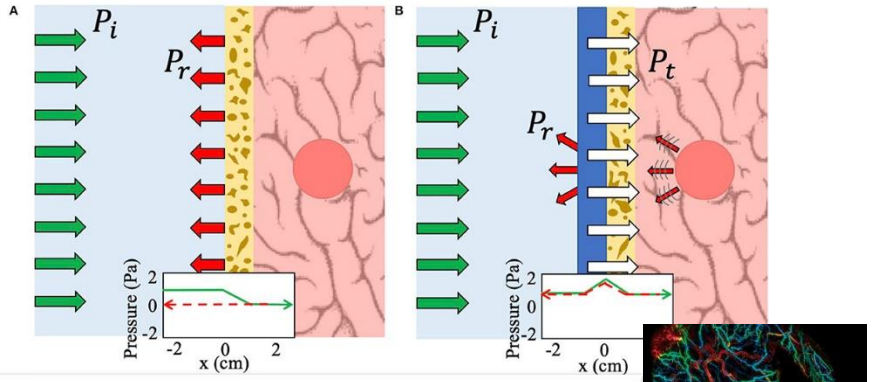


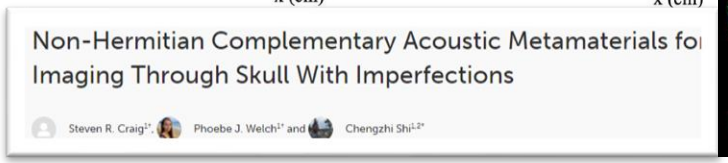


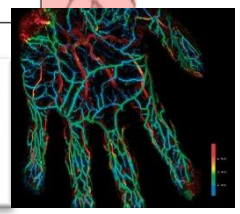
Medtronic



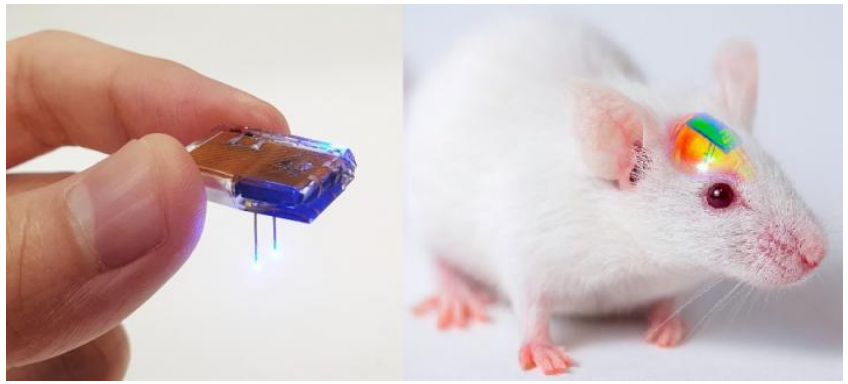
Impedance matching: air-to-body







Neural implants



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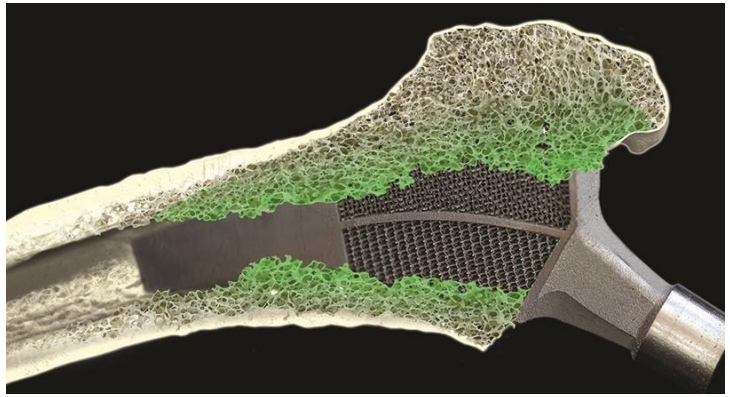
Prevention → Treatment

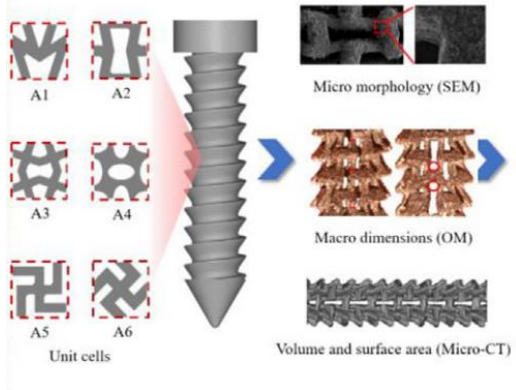
Therapeutics: Medical implants and biomaterials

Meta-implants



Rationally designed meta-implants: a combination of auxetic and conventional meta-biomaterials†

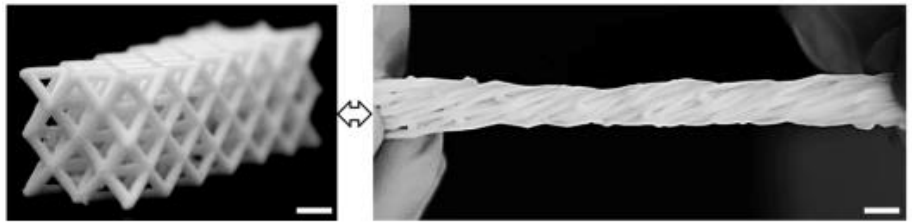
Helena M. A. Kolken, *[a] Shahram Janbaz,[a] Sander M. A. Leeflang,[a] Karel Lietaert,[b] Harrie H. Weinans[ac] and Amir A. Zadpoor[a]



A novel auxetic structure based bone screw design: Tensile mechanical characterization and pullout fixation strength evaluation

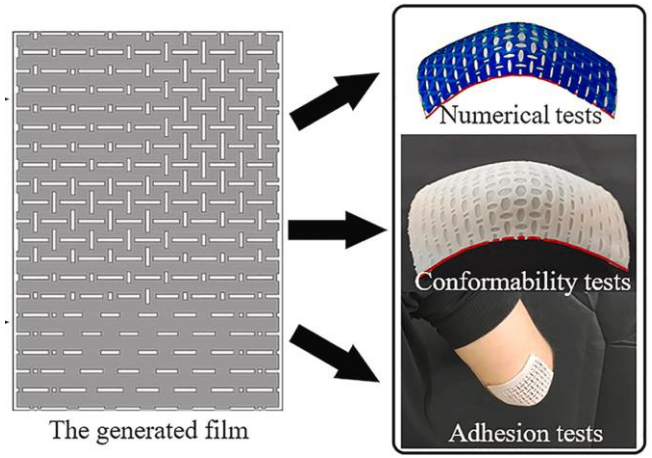
Yan Yao [a,b,c], Lizhen Wang [a,b,*], Jian Li [b,d], Shan Tian [a,b], Ming Zhang [c], Yubo Fan [a,b,d,**]

Tissue and bandages



Highly-stretchable 3D-architected Mechanical Metamaterials

Yanhui Jiang & Qiming Wang

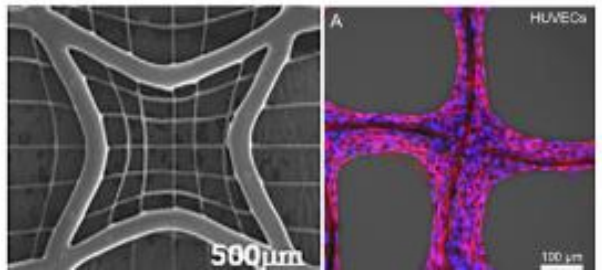


Design of a metamaterial film with excellent conformability and adhesion for bandage substrates

Haotian Wang, Chen Pan, Haiyuan Zhao, Tingyu Wang, Yafeng Han

Exoskeletons

Cell and tissue scaffolds

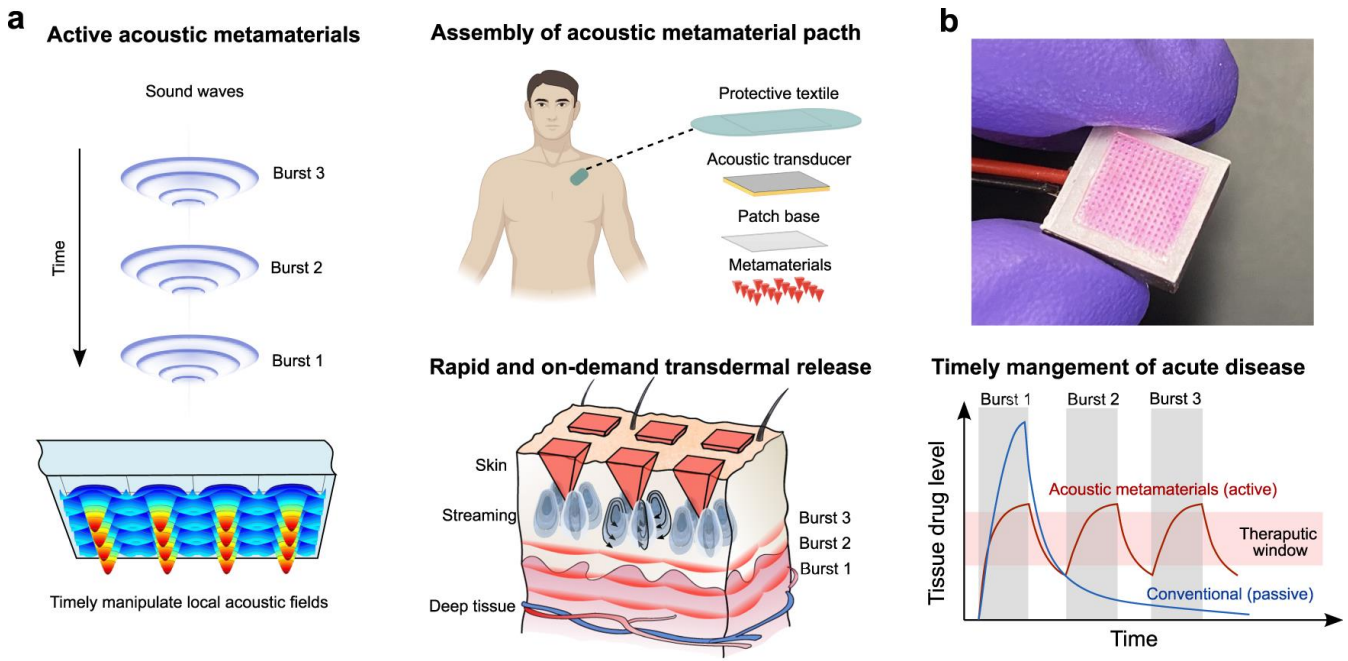


Fabrication of multi-scale and tunable auxetic scaffolds for tissue engineering

Yuan Jin [a,b,*,1], Chaoqi Xia [b,1], Qing Cao [b], Xueyong Zhou [a], Guangyong Li [a], Jianke Du [a], Yong He [b,

Therapeutics: Drug delivery treatments

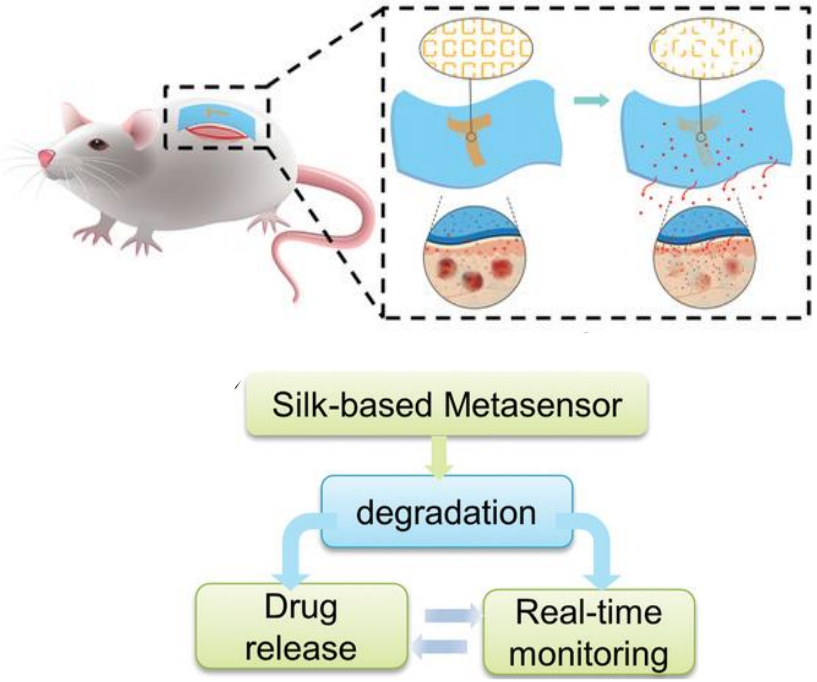
Transdermal drug delivery with active acoustic metamaterials



Acoustic metamaterials-driven transdermal drug delivery for rapid and on-demand management of acute disease

Junhua Xu, Hongwei Cai, Zhuhao Wu, Xiang Li, Chunhui Tian, Zheng Ao, Vivian C. Niu, Xiao Xiao, Lei Jiang, Marat Khodoun, Marc Rothenberg, Ken Mackie, Jun Chen, Luke P. Lee & Feng Guo

Monitoring: degradable antibiotic-loaded metamaterials



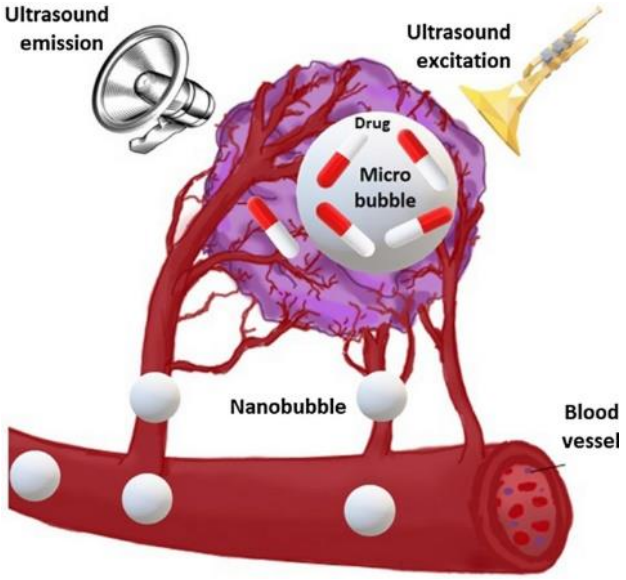
Implantable, Degradable, Therapeutic Terahertz Metamaterial Devices

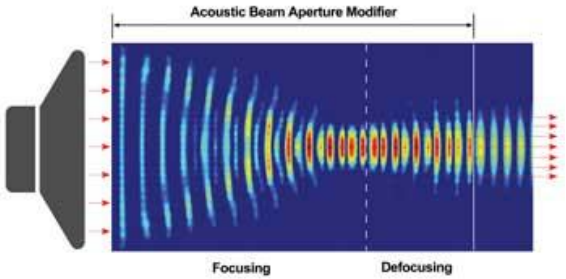
Long Sun, Zhitao Zhou, Junjie Zhong, Zhifeng Shi, Ying Mao, Hua Li, Juncheng Cao, Tiger H. Tao

…and a few more things (out of the box)

Ultrasound and nanomaterial: an efficient pair to fight cancer

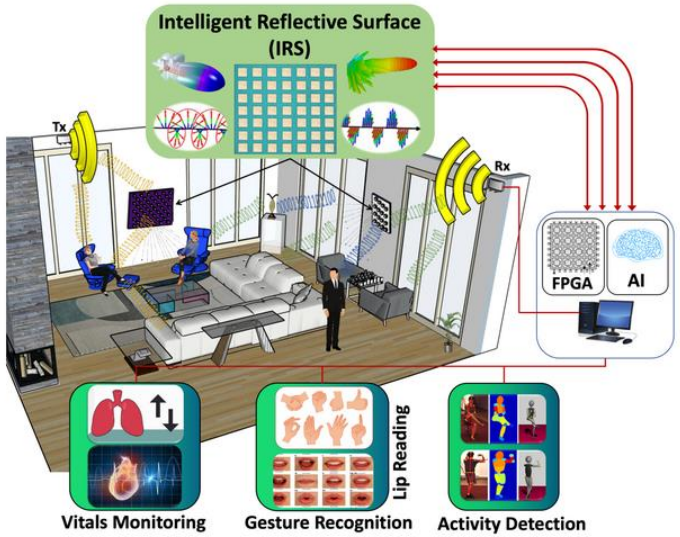
Edouard Alphandéry

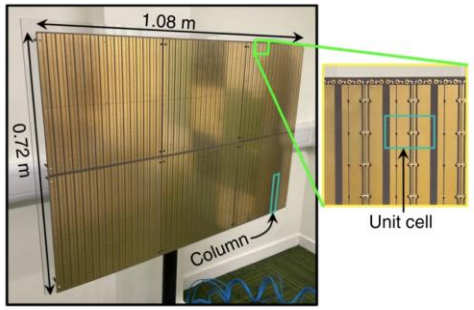




Intelligent wireless walls for contactless in-home monitoring

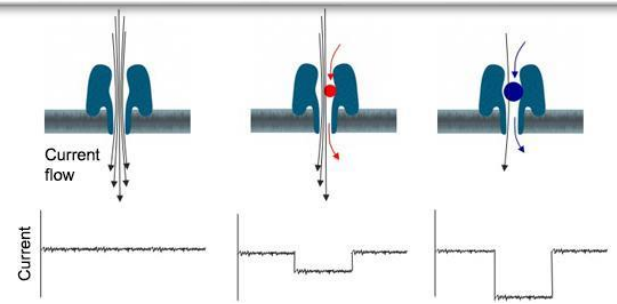
Muhammad Usman, James Rains, Tie Jun Cui, Muhammad Zakir Khan, Jalil ur Rehman Kazim, Muhammad Ali Imran & Qammer H. Abbasi

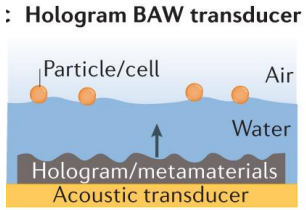


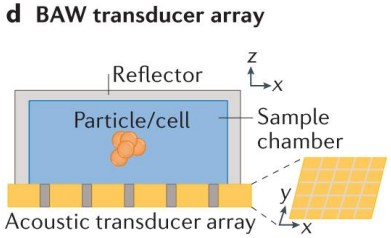


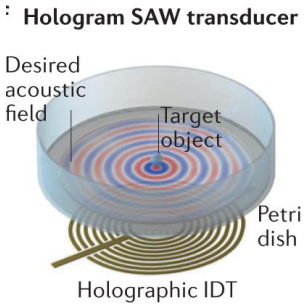
Acoustofluidics for biomedical applications

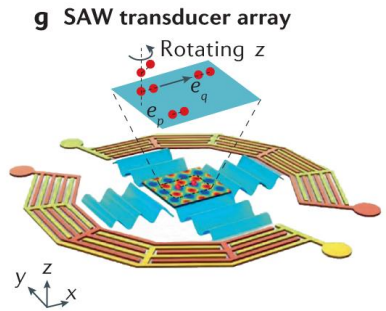
Joseph Rufo, Feiyan Cai, James Friend, Martin Wiklund & Tony Jun Huang







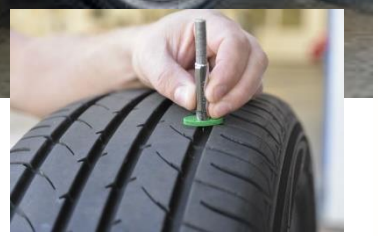




Key takeaways

+ Monitoring + Prevention + Minimally invasive
+ Diagnostic accuracy + Personalised + Cost effective

An analogy: a preventative model more sustainable



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Metamaterials for Health

HEALTHY LIVING

HEALTHCARE

EXERCISE

WELLBEING

AGEING

MONITORING & DIAGNOSIS

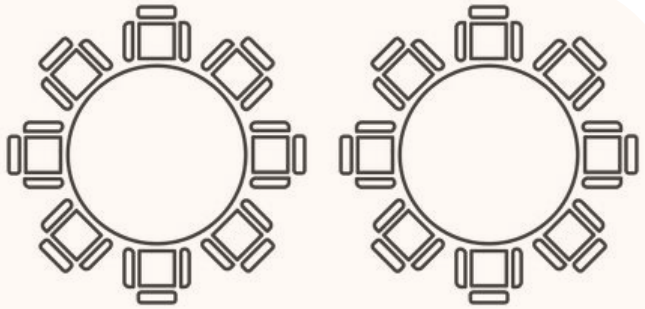
THERAPEUTICS

UK META MATERIALS NETWORK

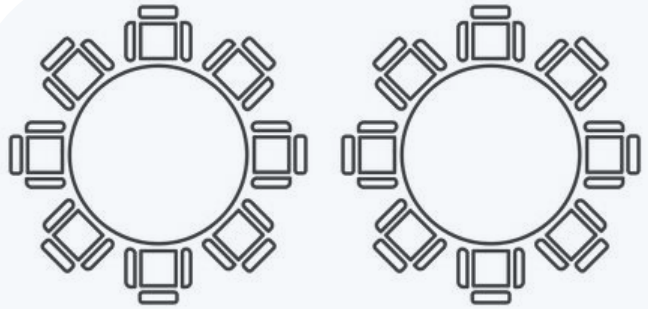
Roundtable Discussions

Opportunities for metamaterials in healthcare: questions, ideas, projects

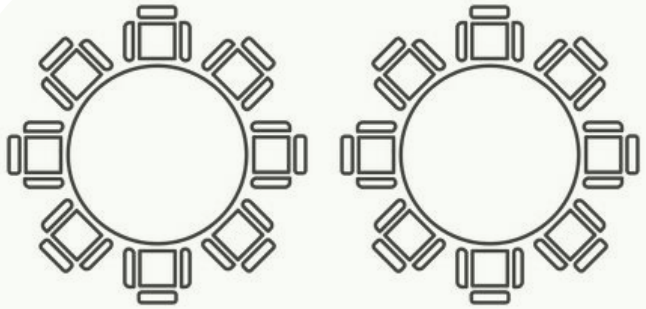
Ageing



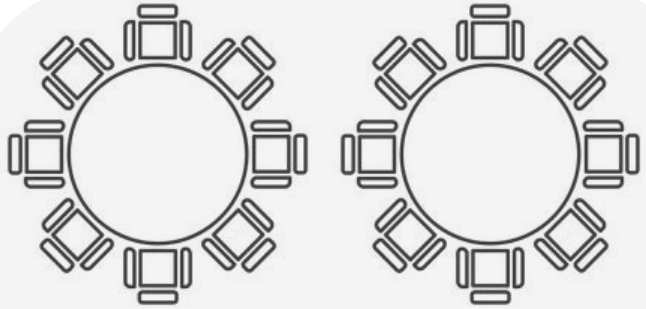
Monitoring & Diagnosis



Therapeutics



Keynote: Healthcare



Wildcard

Round table discussions: *Suggested* Layout

Opportunities for metamaterials in healthcare: questions, ideas, projects

TOPIC

Big research questions

Challenges

How could metamaterials help?

Proof of concept / demonstrators

Longer research projects