2020
AUXDEFENSE
2ND WORLD CONFERENCE ON ADVANCED MATERIALS FOR DEFENSE

Epidermal Systems and Virtual Reality: Emerging Disruptive Technology for Military Applications

Opening Session, 8 July 2020, h. 10:20

Marco Marsili

Centro de Investigação, Inovação e Desenvolvimento da Academia Militar (CINAMIL)
Centro de Investigação e Desenvolvimento do Instituto Universitário Militar (CIDIUM)
Centro de Estudos Internacionais (CEI-IUL), Instituto Universitário de Lisboa (ISCTE-IUL)
Centro de investigação do Instituto de Estudos Políticos da Universidade Católica Portuguesa (CIEP-UCP)

Organizers: Universidade do Minho Fibrenamics SCIENCENTRIS From Knowledge to Market

2020 AUXDEFENSE
2ND WORLD CONFERENCE ON ADVANCED MATERIALS FOR DEFENSE

Introduction

This presentation focuses on skin as sensory interface, and explores the latest discoveries in bioelectronic science.

The presentation analyses at what extent invisibility is possible by emulating nature, and if military applications can really benefit from technology that combines epidermal systems and virtual reality.

2020 AUXDEFENSE
2ND WORLD CONFERENCE ON ADVANCED MATERIALS FOR DEFENSE

USS Freedom, 22 Feb., 2013 (U.S. Navy photo)

Military camouflage is the use of camouflage by an armed force to protect personnel and equipment from observation by enemy forces.

UF PRO Tactical Gear in CONCAMO

It means applying color and materials to military equipment of all kinds, including vehicles, ships, aircraft, gun positions and battledress, either to conceal it from observation (crypsis), or to make it appear as something else (mimicry).

"Dazzle" or "motion camouflage", that mimicks the optic flow of the background, has proved to have a limited effectiveness (Scott-Samuel et al., 2011).

Israeli F-16s inside the Ramon Crater in the Negev Desert (IDF photo)

Multi-scale or fractal camouflage

Multi-scale camouflage combines patterns at two or more scales, often (though not necessarily) with a digital camouflage pattern created with computer assistance.

The function is to provide camouflage over a range of distances, or equivalently over a range of scales (scale-invariant camouflage), in the manner of fractals, so some approaches are called "fractal camouflage" (Billock, 2010).

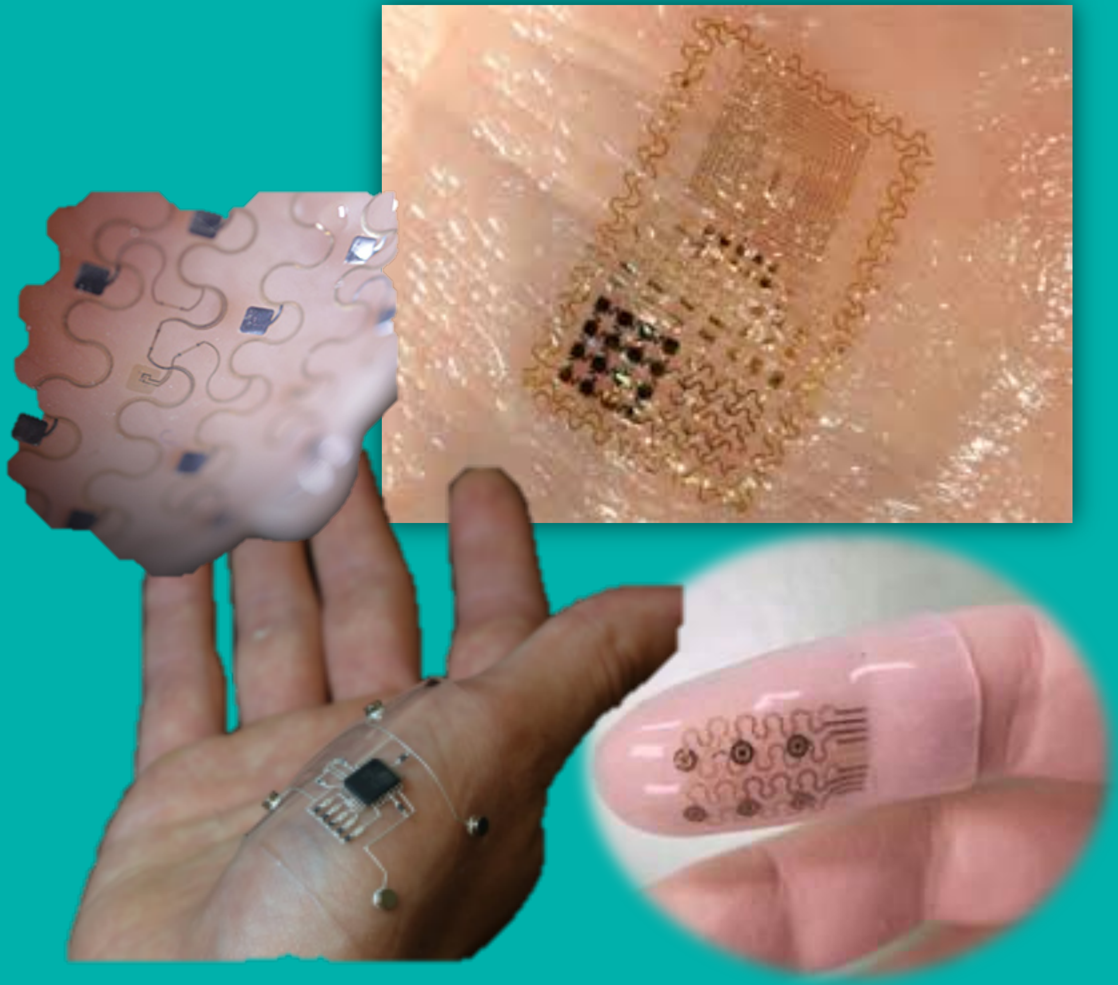
However, this technique does not guarantee improved performance.

Netherlands fractal pattern camouflage (2019)

Adaptive camouflage

The skin is a relatively underexplored sensory interface that could significantly enhance experiences.

The reseach (Rogers & Ahn, 2016) is focusing on silicon nanomembranes, ranging from synthesis and manipulation to manufacturing, device integration and system level applications, including uses in bio-integrated electronics, three-dimensional integrated photonics, solar cells, and transient electronics.



Bio-integrated electronics:
silicon nanomembranes and soft-skin-like-electronics

2020 AUXDEFENSE
2ND WORLD CONFERENCE ON ADVANCED MATERIALS FOR DEFENSE

Learning from Nature, the master of disguise

Material scientists have developed a color-changing sheet inspired by squid and octopus, whose skin can transform to blend with its surroundings.

The basic idea is that the creatures use light-sensitive molecules in the skin to register the light coming from the background against which they sit, and then use this information to alter the appearance of colour-changing cells.

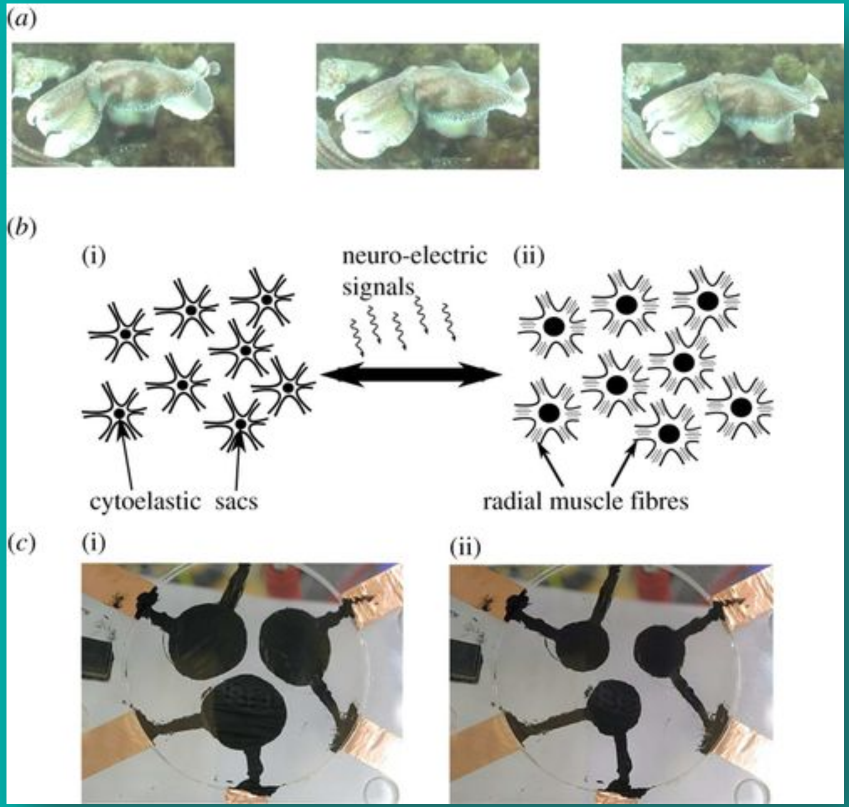
Octopus skin can in fact do more than match a background’s colour: it can even mimic its texture.



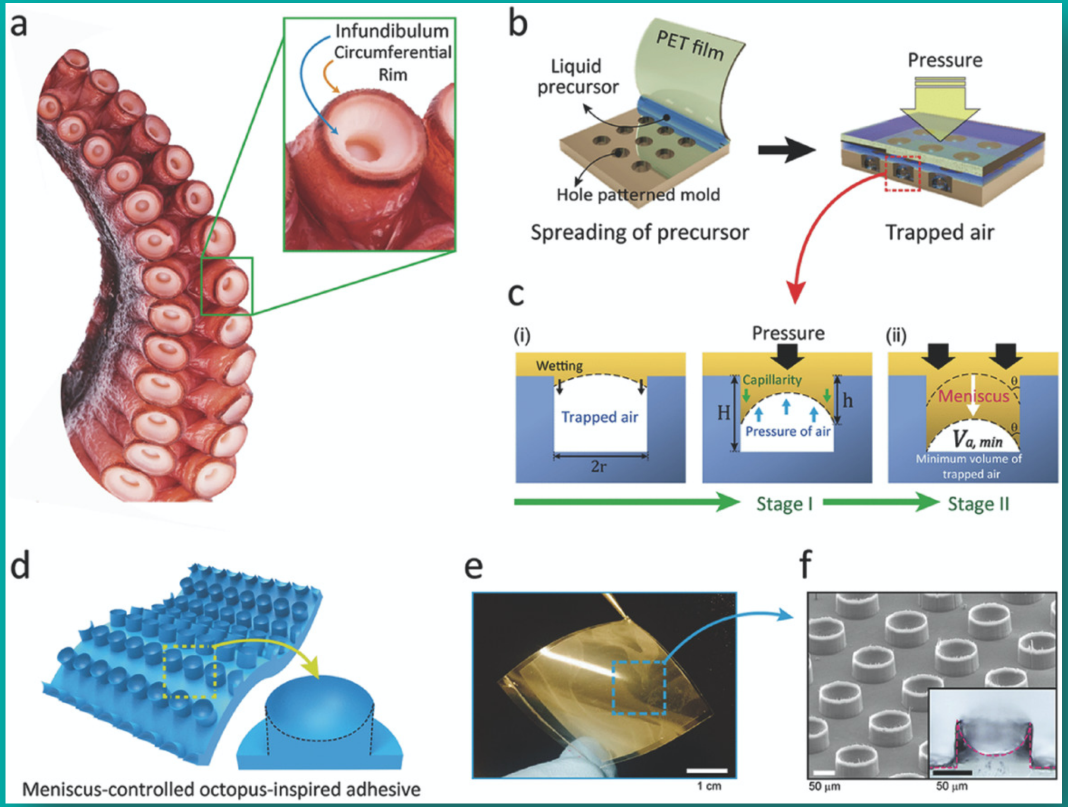



AUXDEFENSE 2020
2ND WORLD CONFERENCE ON ADVANCED MATERIALS FOR DEFENSE

Learning from Nature:
octopus and squid smart camouflage



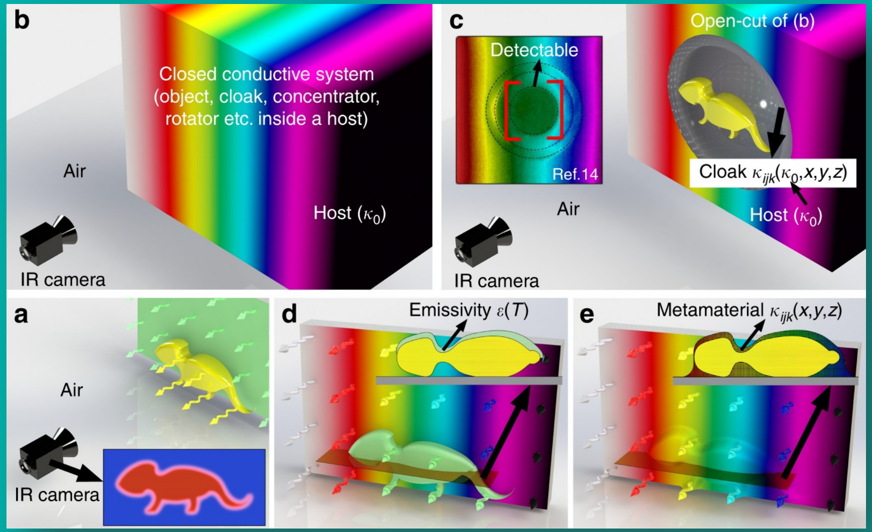
Fishman, Rossiter & Homer (2015), Hiding the squid: patterns in artificial cephalopod skin, Fig. 1



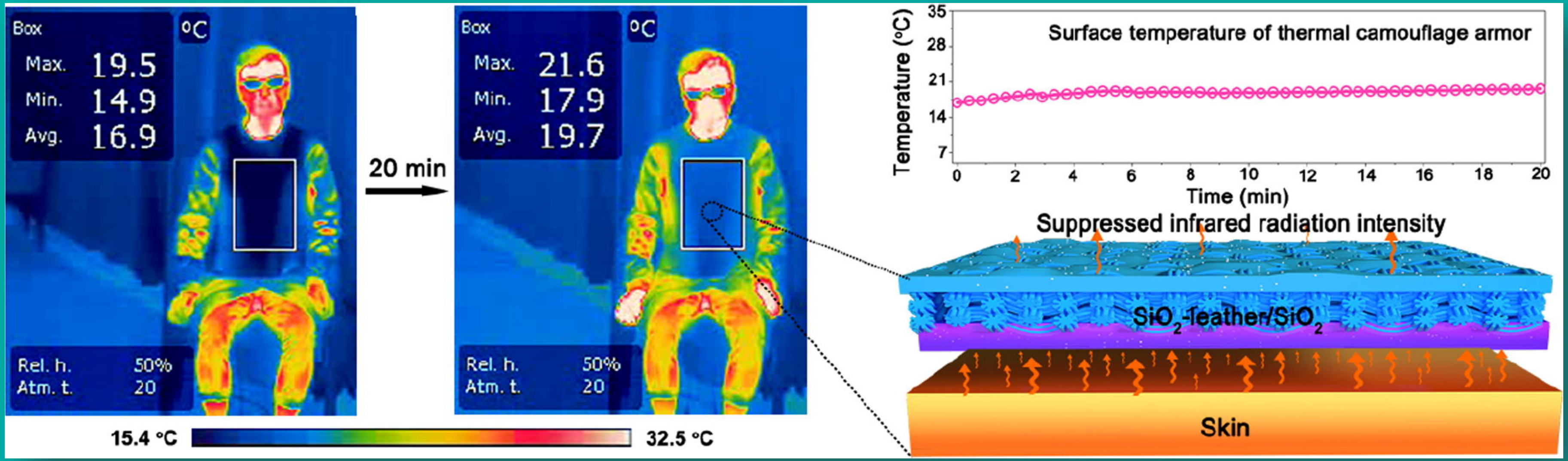
Baik, Kim, Lee et. al. (2018), Highly Adaptable and Biocompatible Octopus-Like Adhesive Patches with Meniscus-Controlled Unfoldable 3D Microtips for Underwater Surface and Hairy Skin, Fig. 1

2020 AUXDEFENSE
2ND WORLD CONFERENCE ON ADVANCED MATERIALS FOR DEFENSE

Thermal camouflage: Nature inspires us and provides solutions for camouflage systems



Li et al. (2018), Fig. 1: Schematic graph of different strategies of thermal camouflage



Wang et al. (2019), Fig 1: Surface temperature of thermal camouflage

AUXDEFENSE 2020
2ND WORLD CONFERENCE ON ADVANCED MATERIALS FOR DEFENSE

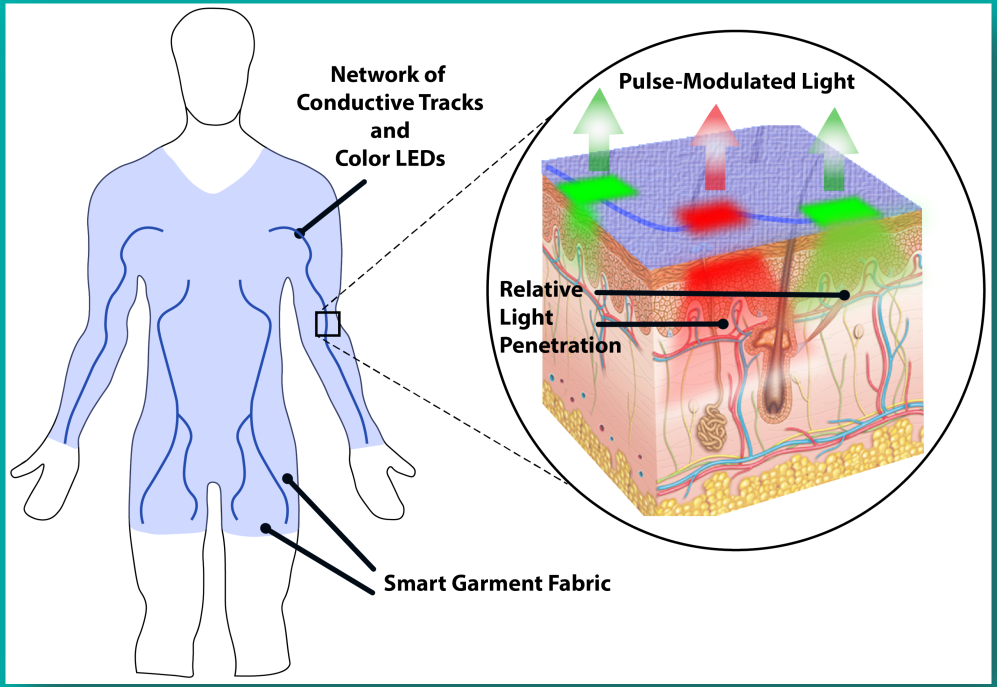
To make the adaptive displays, the researchers began by imprinting a 16x16 grid of cells on a soft plastic.

The cells, each about a millimetre across, contain a colour-changing dye embedded in a polymer.

The dye is black at room temperature, but when warmed to around 47°C (117°F) its chemical structure changes and it becomes transparent. Cool it, and it becomes black again.

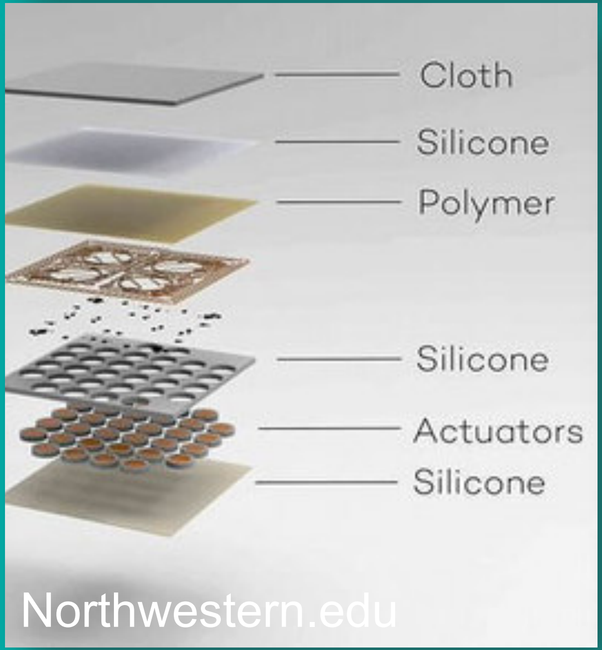
At the corners of each cell the researchers added tiny light sensors that record how much light falls on the cell, and this signal is used to control an electric current that helps warm up the dye.

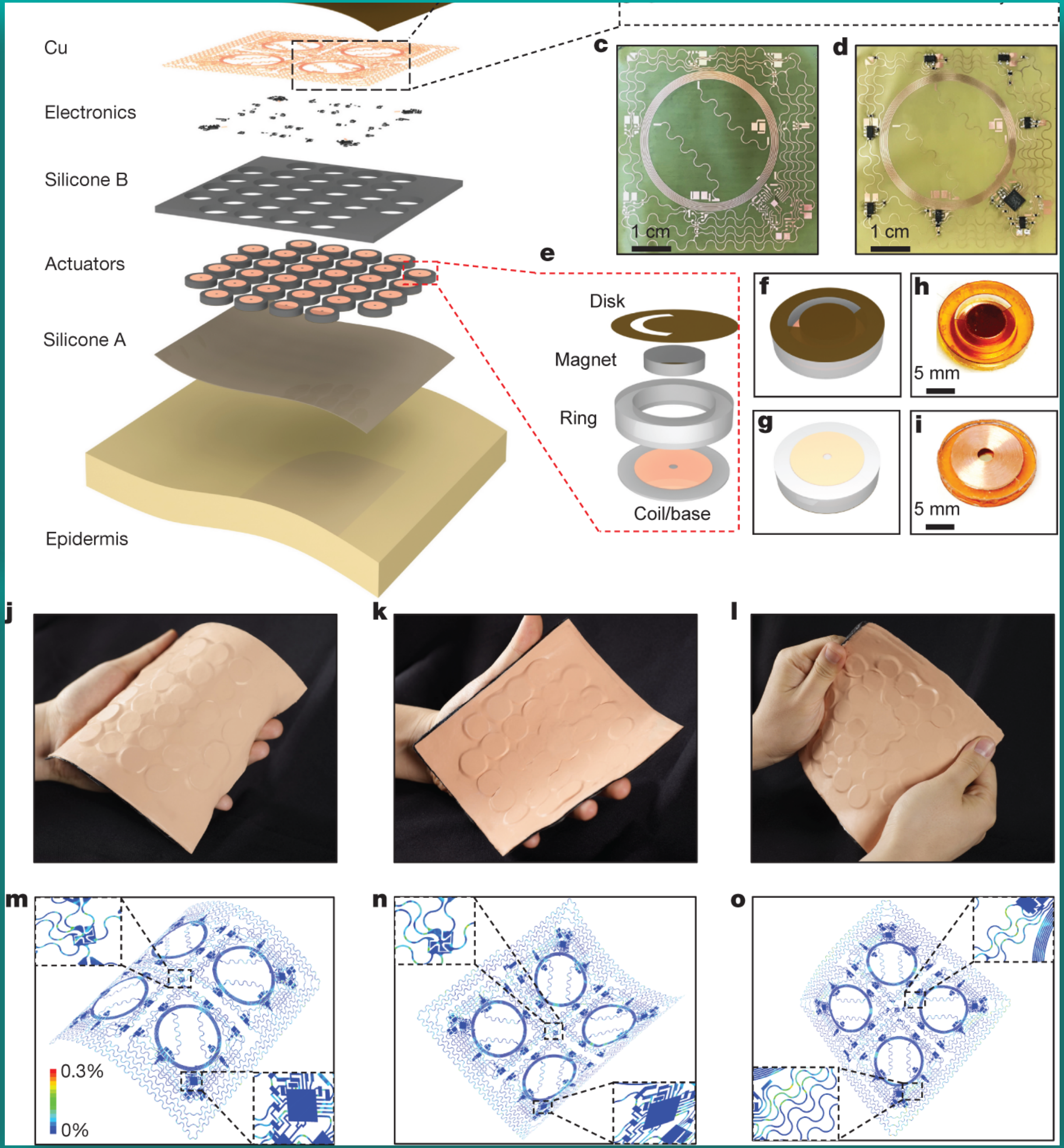
Shine a light on the material, and the black dye will turn transparent and expose a reflective silvery material beneath. The result is similar, at a crude level, to the way that octopus skin works.



Iakolev (2018), Fig. 1: Illustration of the experimental smart garment with conductive tracks and light emitting diodes (LEDs) facing the tissue surface. Generated illumination penetrates skin tissue and becomes modulated by pulsatile blood flow in the microvasculature. Backscattered light is then captured and analysed by the remote optical system (not shown)

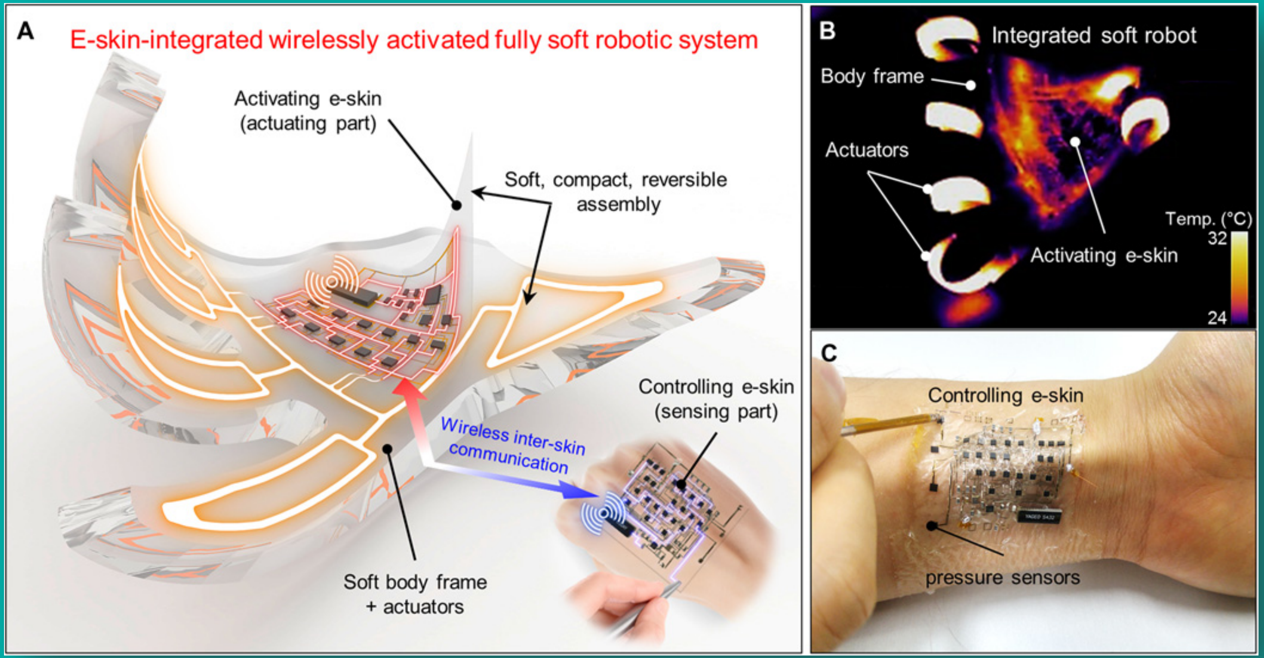
Skin-integrated wireless haptic interfaces for virtual and augmented reality





Yu, Xie, Yu et al. (2019), Fig. 1: Design and architecture of an epidermal VR system

Epidermal VR system



Byun, Lee, Yoon et al. (2018), Fig. 1: Skin-like soft driving system for wirelessly activated fully soft robots

A fabric coated with miniaturised LEDs and cameras that, by projecting the appropriate background image in all directions, could confer genuine invisibility, is the material the military has always wanted.

A new thin, wireless and battery-free system can adds a sense of touch to any virtual reality (VR) experience (Yu, Xie, Yu et al. 2019).

Electronic systems and haptic (that is, touch-based) interfaces capable of softly laminating onto the curved surfaces of the skin to communicate information via spatio-temporally programmable patterns of localized mechanical vibrations – the apparatus communicates through near-field communication (NFC) protocols.

Is a skin-interfaced wearable and scalable device where miniaturized actuators generate a discrete sense of touch at a corresponding location on the skin, with almost no encumbrances on the user.

REFERENCES

Baik S, Kim J, Lee HJ, et al. Highly Adaptable and Biocompatible Octopus-Like Adhesive Patches with Meniscus-Controlled Unfoldable 3D Microtips for Underwater Surface and Hairy Skin. Advanced Science, 2018, 5 (8). DOI: 10.1002/advs.201800100.

Billock VA, Cunningham DW, Tsou BH. In: Andrews DH, Herz RP, Wolf MB (eds.) Human Factors Issues in Combat Identification. What Visual Discrimination of Fractal Textures Can Tell Us about Discrimination of Camouflaged Targets. 2010, Ashgate, Farnham, p. 99-101.

Byun J, Lee Y, Yoon J et al., Electronic skins for soft, compact, reversible assembly of wirelessly activated fully soft robots. Sci. Robot, 2018, 3, eaas9020. DOI: 10.1126/scirobotics.aas9020.

Fishman A, Rossiter J, and Homer M. Hiding the squid: patterns in artificial cephalopod skin. Interface, 2015, 12 (108). DOI: 10.1098/rsif.2015.0281.

Forbes P. Dazzled and Deceived: Mimicry and Camouflage. 2009, Yale University Press, New Haven, CT.

Iakovlev D, et al. Smart Garment Fabrics to Enable Non-Contact Opto-Physiological Monitoring. Biosensors, 2018, 8(2), 33. DOI: https://doi.org/10.3390/bios8020033.

Li Y, Bai X, Yang T et al. Structured thermal surface for radiative camouflage. Nat Commun, 2018, 9, 273. DOI: https://doi.org/10.1038/s41467-017-02678-8.

Rogers JA, Ahn JH (eds.). Silicon Nanomembranes: Fundamental Science and Applications. John Wiley & Sons, Hoboken, NJ, 2016.

Scott-Samuel NE, Baddeley R, Palmer CE, Cuthill IC. Dazzle camouflage affects speed perception. PLoS One, 2011, 6(6), e20233. DOI: 10.1371/journal.pone.0020233.

Wang X, Tang Y, Wang Y, et al. Leather enabled multifunctional thermal camouflage armor. Chemical Engineering Science, 2019, 196, pp. 64-71.DOI: https://doi.org/10.1016/j.ces.2018.12.005.

Yu C, Li Y, Zhang X, Huang X, et al. Artificial adaptive camouflage skins. PNAS, 2014, 201410494. DOI: 10.1073/pnas.1410494111.

Yu X, Xie Z, Yu Y, et al. Skin-integrated wireless haptic interfaces for virtual and augmented reality. Nature, 2019, 575, p. 473–479. DOI: 10.1038/s41586-019-1687-0.

THANK YOU!

Extended abstract in the Book of Abstracts — Proceedings of AuxDefense 2020
edited by Raul Fangueiro, published by Sciencentris, Braga — ISBN 978-989-54808-4-5.
Full paper will be published in Key Engineering Materials.

E-MAIL
info@marcomarsili.it

WEBSITE
http://www.marcomarsili.it

TWITTER
https://twitter.com/MarcoMarsili1

https://doi.org/10.5281/zenodo.3902295

This work was supported by Fundação para a Ciência e a Tecnologia (FCT) through national funds under grant SFRH/BD/136170/2018.

2020 AUXDEFENSE
2ND WORLD CONFERENCE ON ADVANCED MATERIALS FOR DEFENSE

FCT Fundação para a Ciência e a Tecnologia

2020
AUXDEFENSE
2ND WORLD CONFERENCE ON ADVANCED MATERIALS FOR DEFENSE

Q&A

Organizers:

Universidade do Minho

Fibrenamics

SCIENCENTRIS
From Knowledge to Market