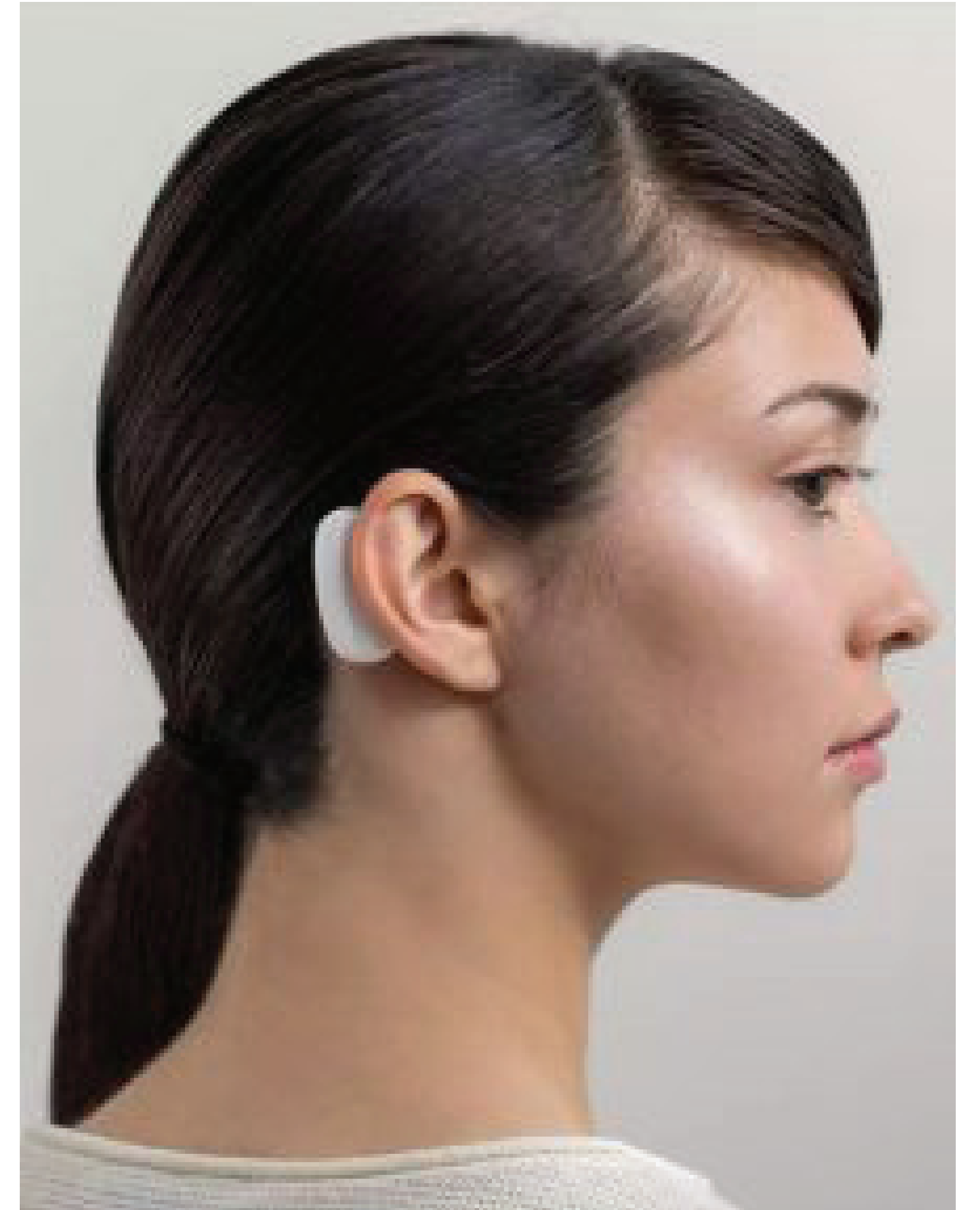
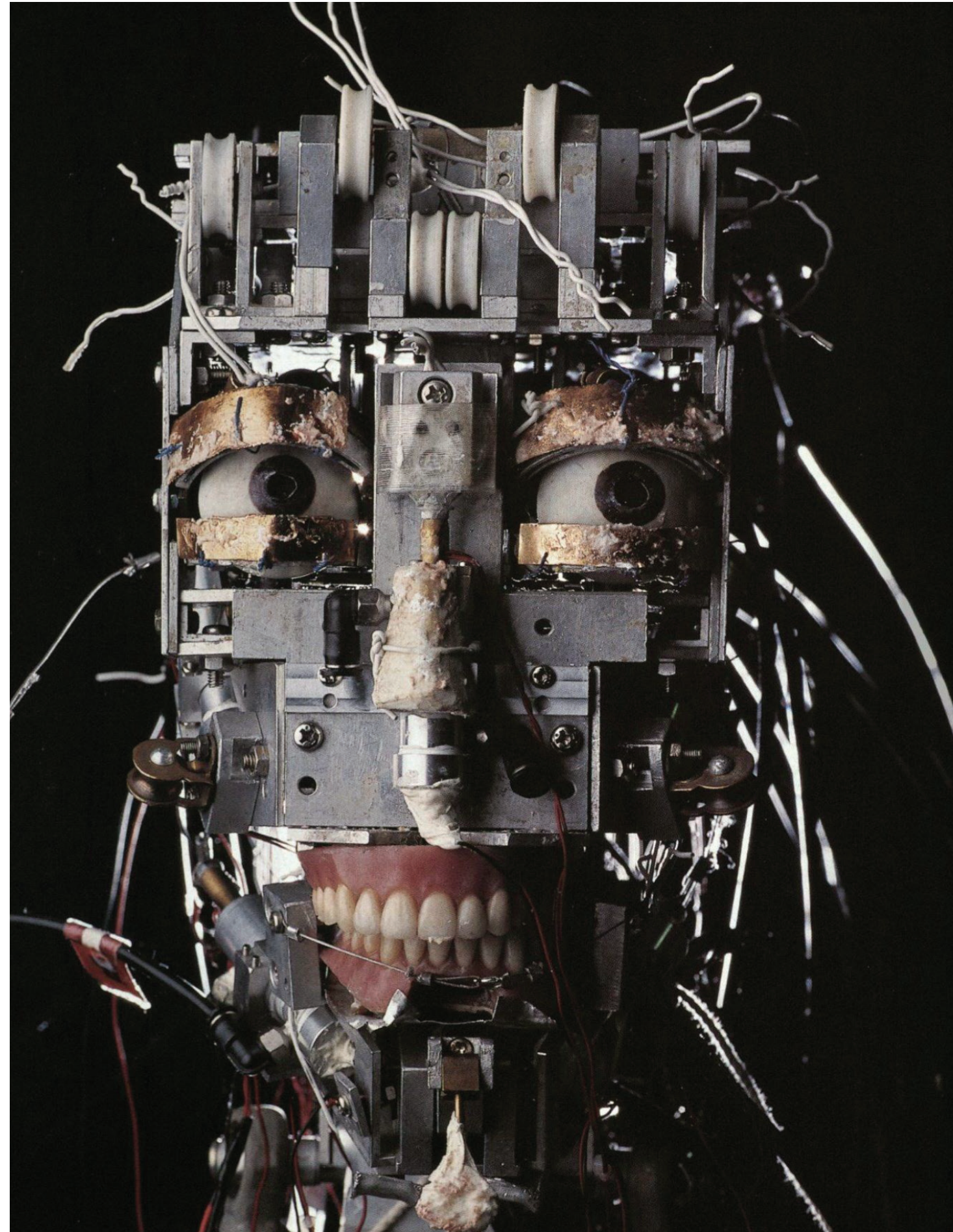


# SOFT TECH

Fabrics, Electronics  
and the Body



# Previous Grad-ID Studio





# Previous Grad-ID Studio

## Skin 2.0

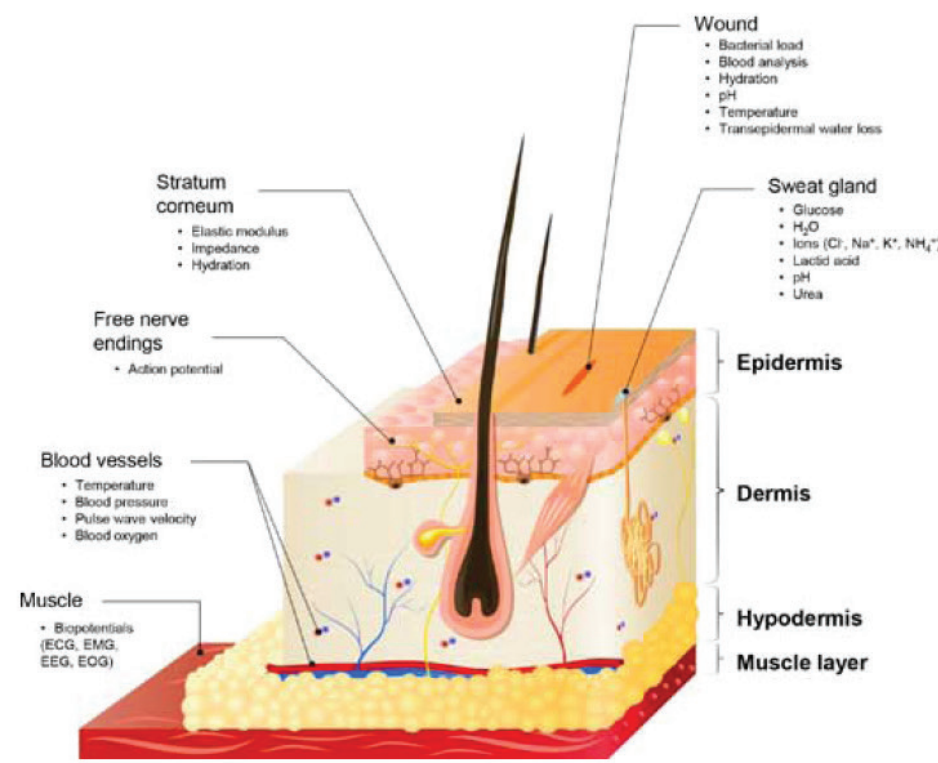
### WEARABLE SENSOR PROTOTYPES FOR NEW AWARENESS (2019)

This project is a continuation on the concept of technology as an extension of self. By unlocking the aesthetic of technology outside of its common cultural box forms (phone, computer, watch, tv) and introducing organic shapes and terms such as "skin," we can regain a connection with nature and world to propose new ideas of interacting with it.

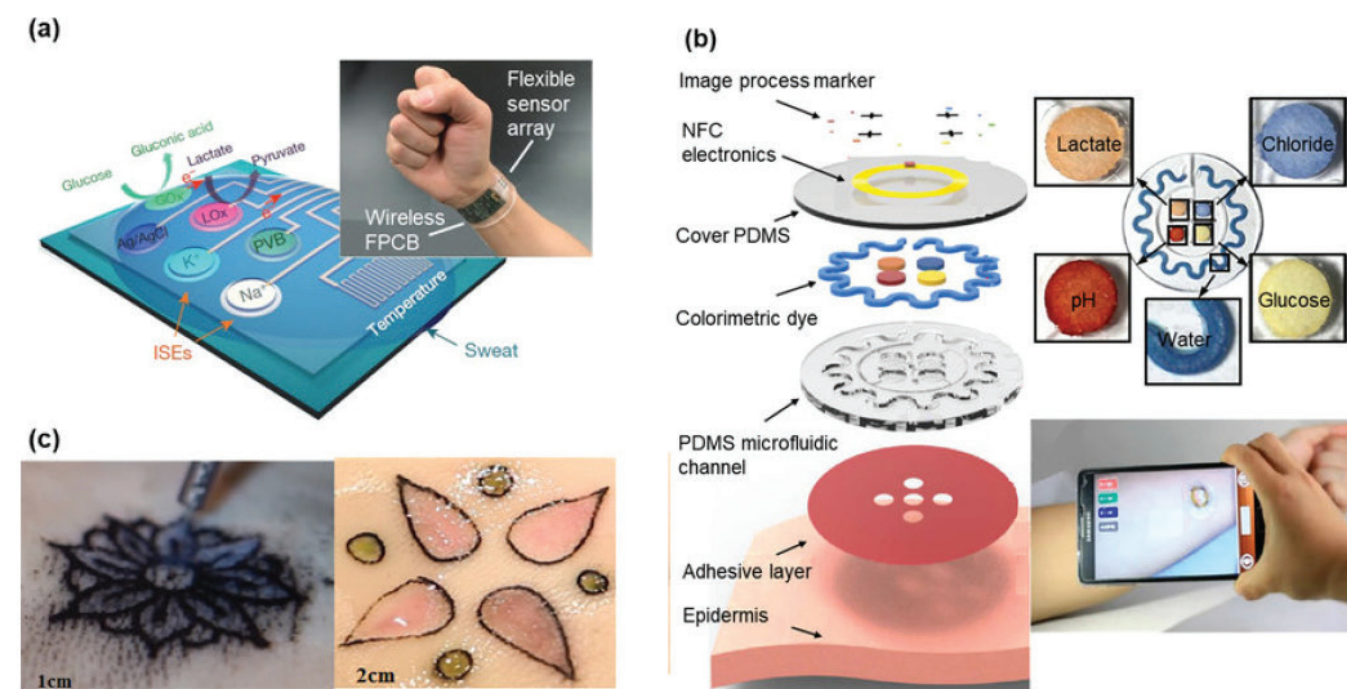
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Moon\_Tong-June, Portfolio

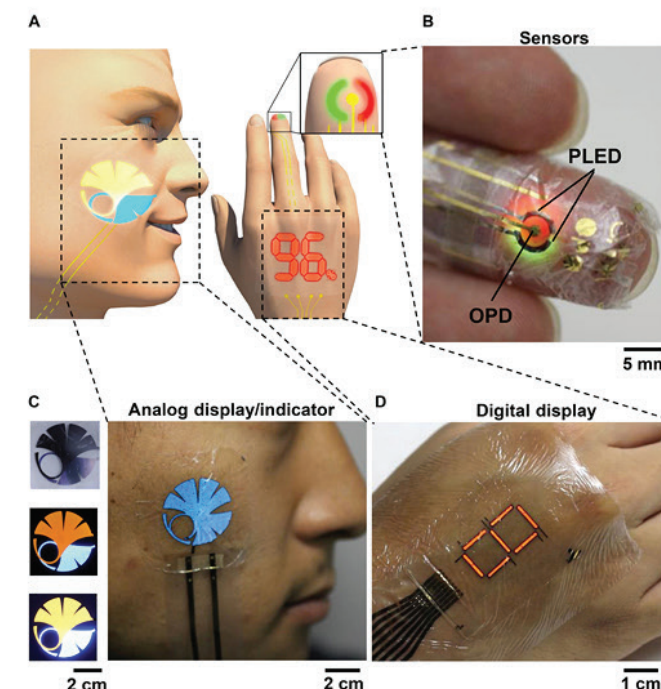
15



Lab-On-Skin, Nanowerk (2017)



Real Time Analysis of Bioanalytes in Healthcare, Food, Zoology and Botany, Researchgate.net (2017)

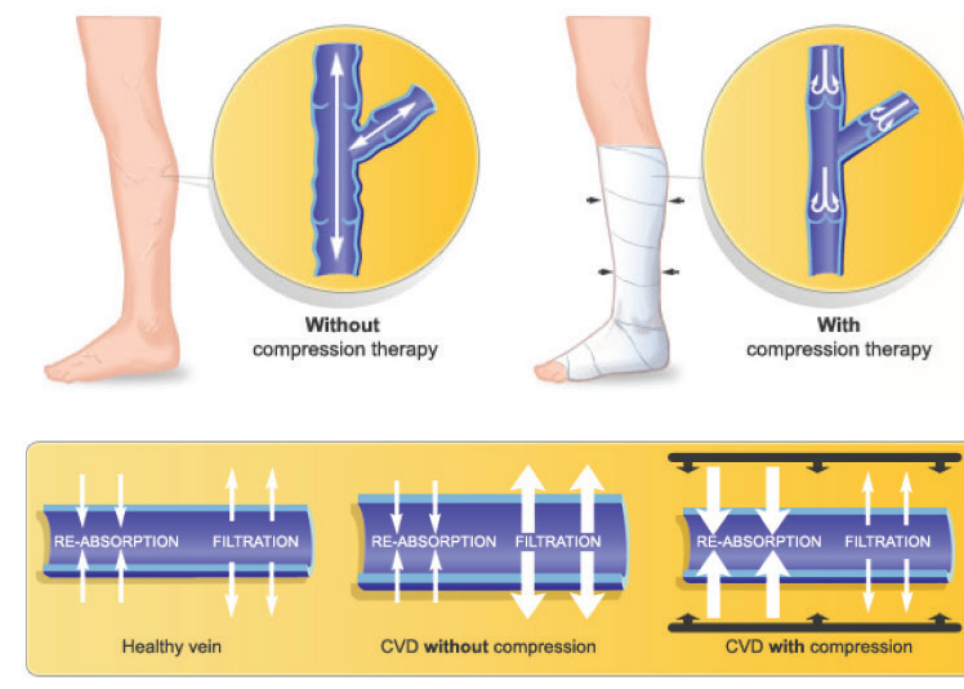


Ultraflexible Organic Photonic Skin, Science Advances (2016)



Skin 2.0 Sleeve, Front View

Skin 2.0 Sleeve, Side View



The Mechanism of Action of Compression Therapy on the Veno-lympatic systems, Urgocauk (Curent)

## Compression Sleeves

Compression sleeves are used across a variety of end users from the elderly, hospital patients, to professional athletes and astronauts. It applies pressure to veno-lympatic systems for better blood flow and vessel tension which are key to efficient recovery or during high performance stress.

Skin 2.0 (a full body layer of sensors) connects us more deeply with our internal bio rhythms and external environments. A smart compression system would extend the interface (a bodysuit, sleeves, leggings) functionality with particular multi-sensor combinations, warning us of low blood sugar or toxic gas leak in our proximity. It will alert us of extreme weather conditions such as high UV rays as well as let us regulate our bodily functions more effectively.



Tattoo Turtleneck, Vetements



Kobe Bryant in Compression Sleeve (2005)

Sensor Sleeve Concept

Skin 2.0

Moon\_Tong-June, Portfolio

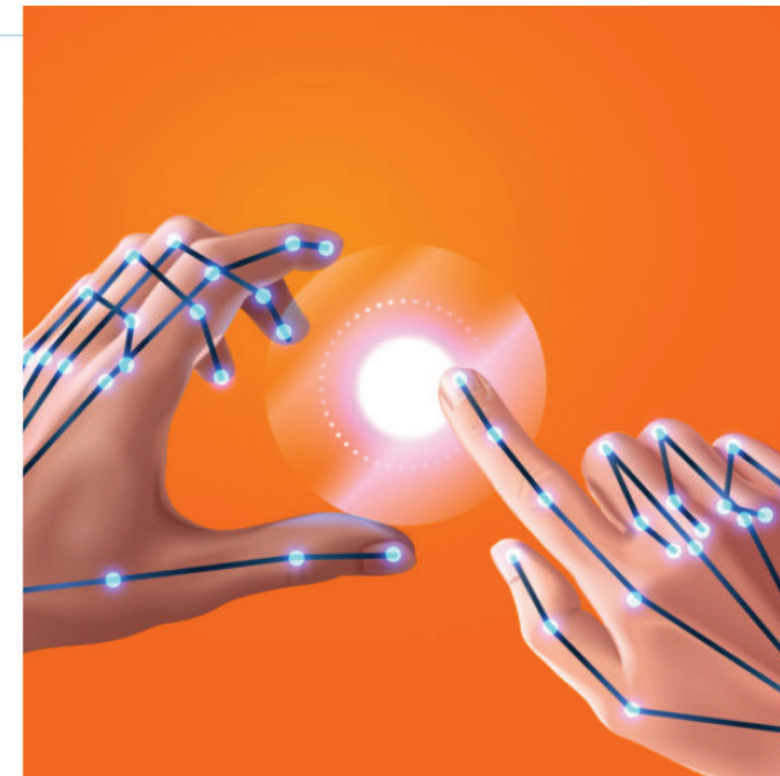
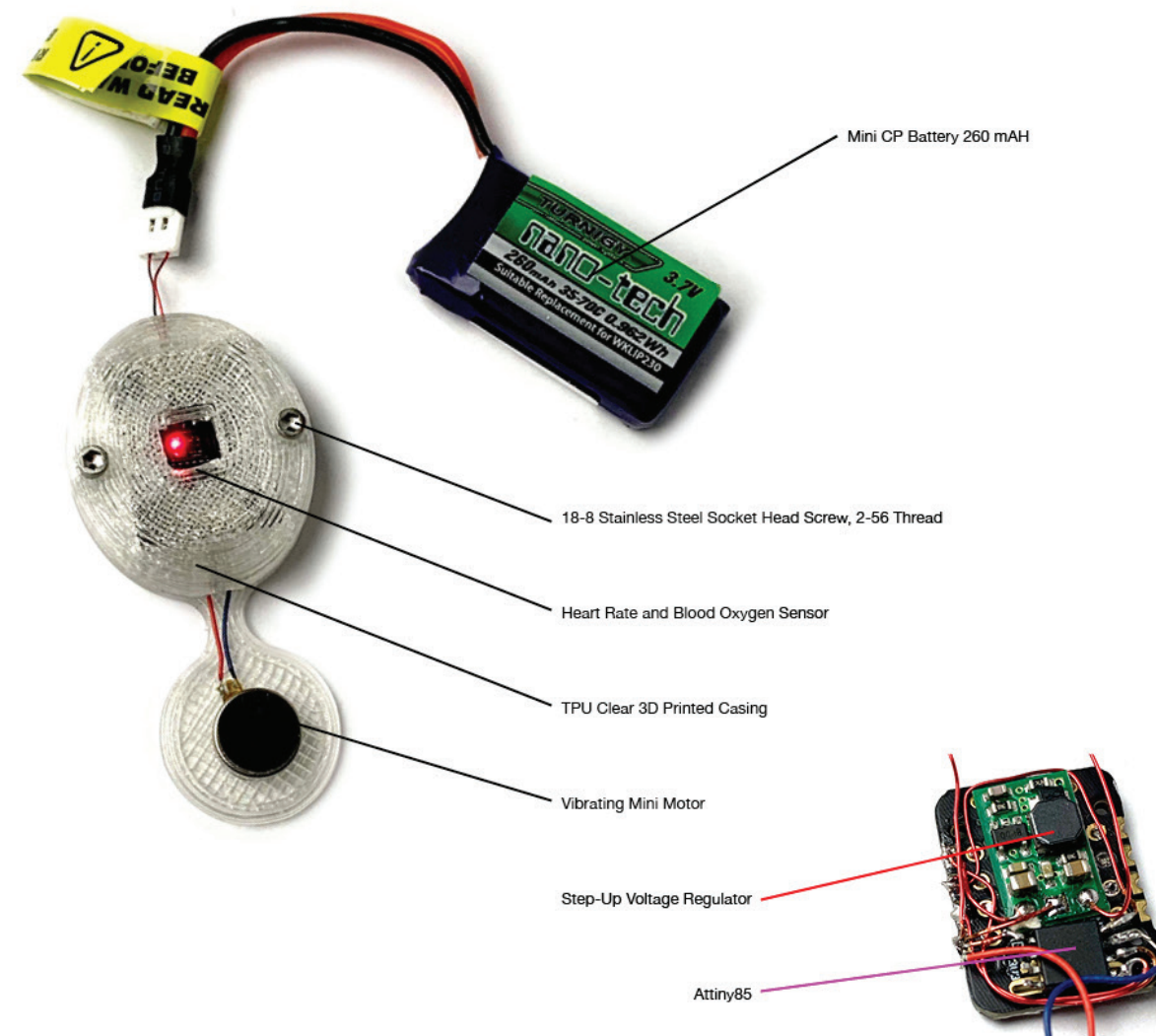
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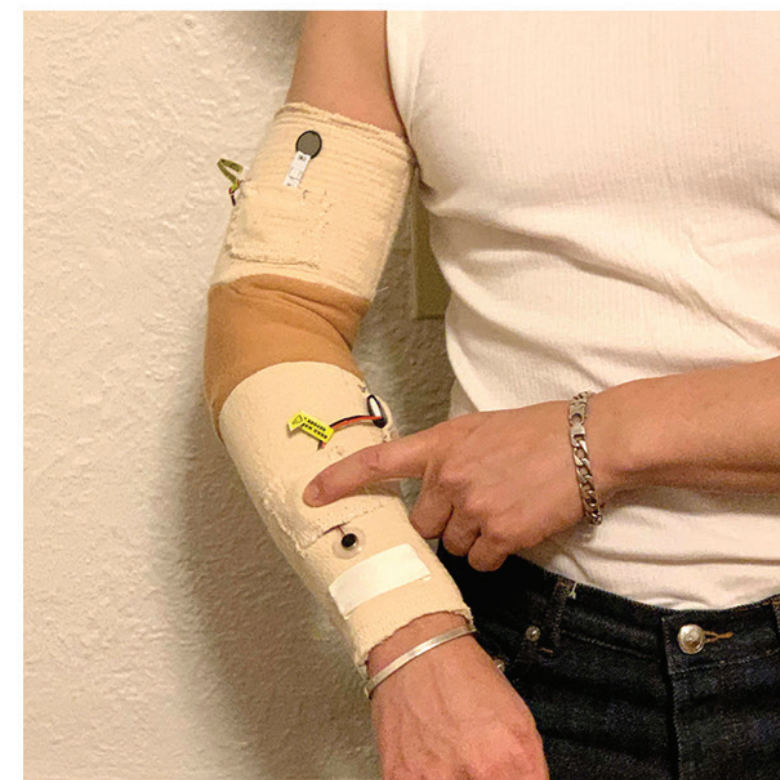
# Previous Grad-ID Studio

## Wearable Heartbeat Amplifier

By augmenting the biometrics of our bodies through sensations like touch, haptic feedback offers another way to materialize the internal rhythms that our body is communicating about our health. This prototype turns the heart rate into vibrations to quickly feel the users pulse. For an ER doctor seeing numerous patients to blind users, this prototype is an exploration on finding other way to output information by engaging other senses.



New Haptic Armband Gives VR a New Sense of Touch, edgy.app (2018)



Wearable Prototyping

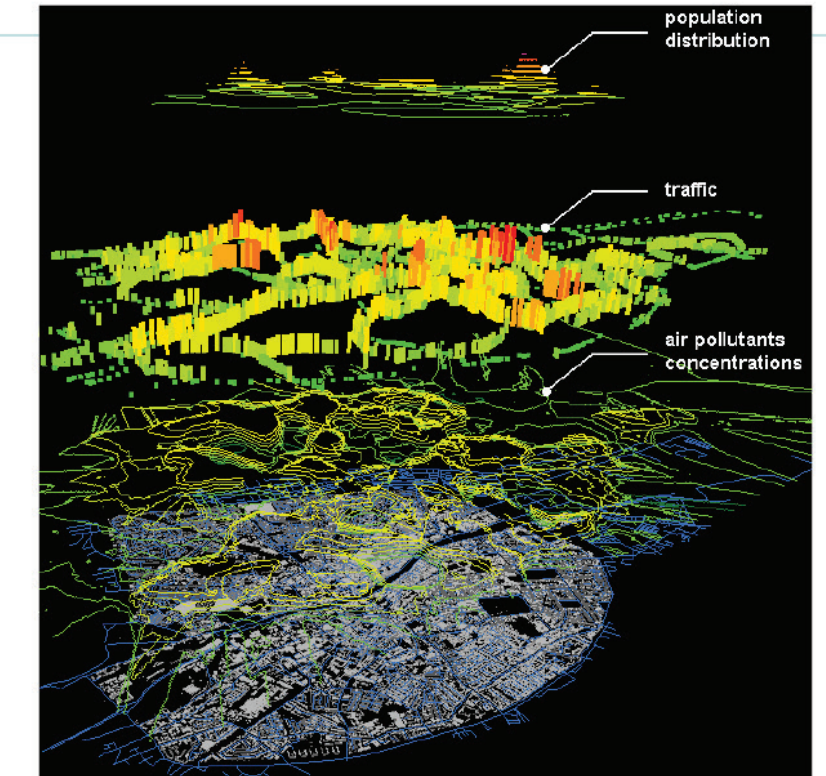
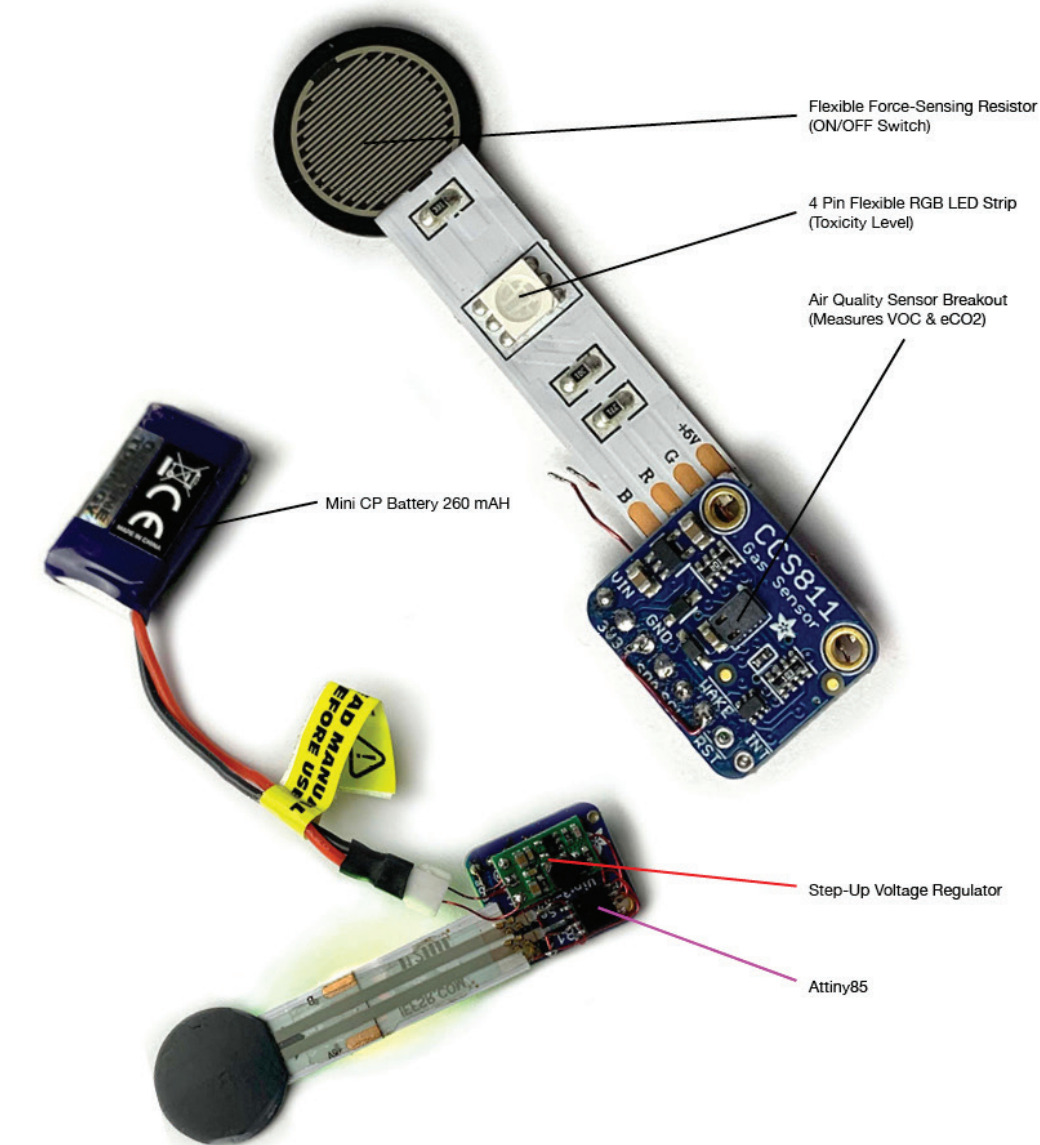
Skin 2.0

Moon\_Tong-June, Portfolio

17

## Wearable Atmospheric Sensor

Whether air quality or UV exposure, users have real time awareness about external conditions they are immersed in at any given moment. Crowd sourced data allows users to visualize the changing environment that might otherwise be invisible. Decentralizing our connectivity based on our own daily movements could help us map and pinpoint patterns related to environmental or industrial problems.



Real-time measurement of inhabitants exposure to noise and pollutants with a network of sensors, researchgate.net (2012)



Wearable Prototyping

Skin 2.0

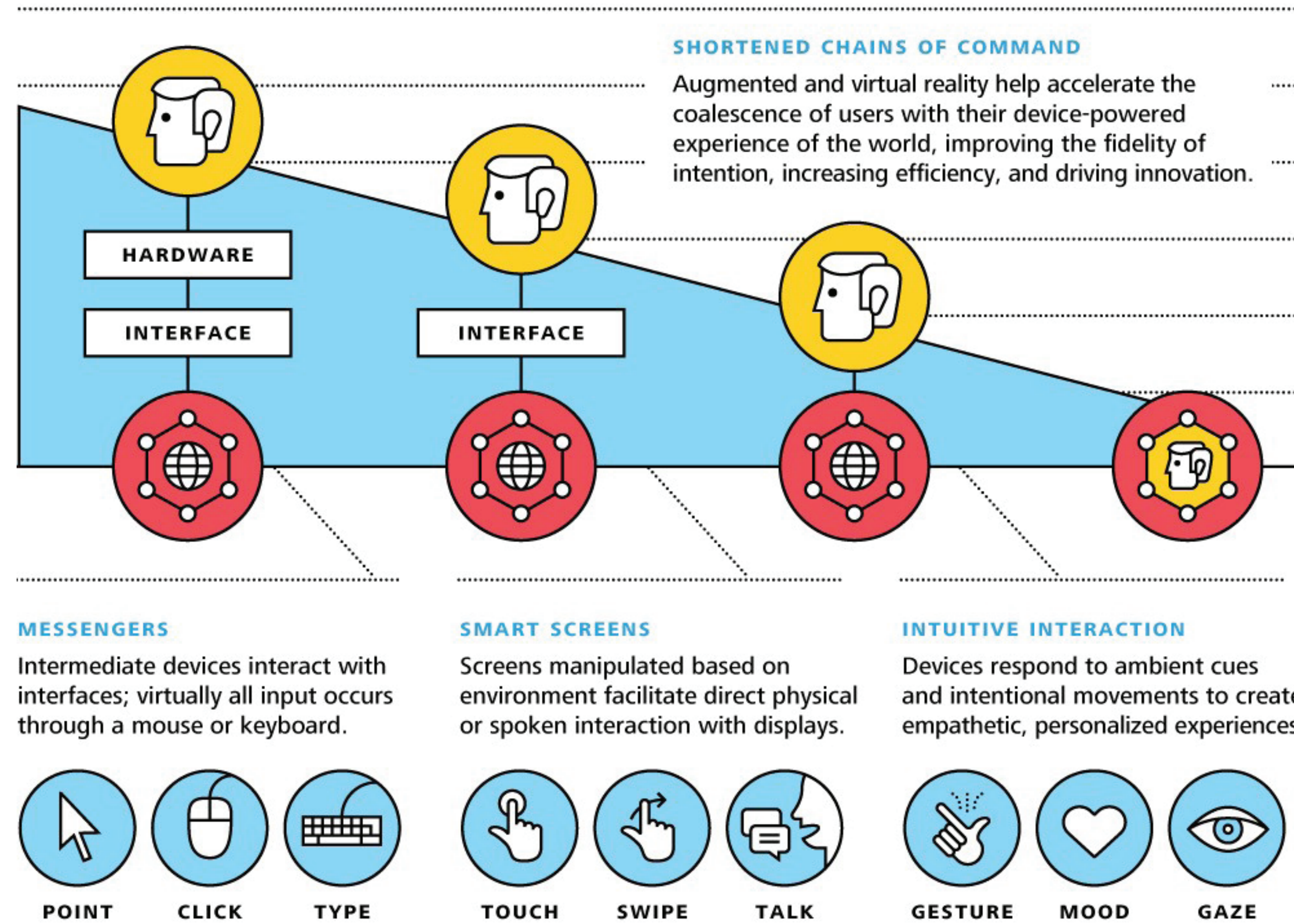
Moon\_Tong-June, Portfolio

18



# Philosophical Proposal

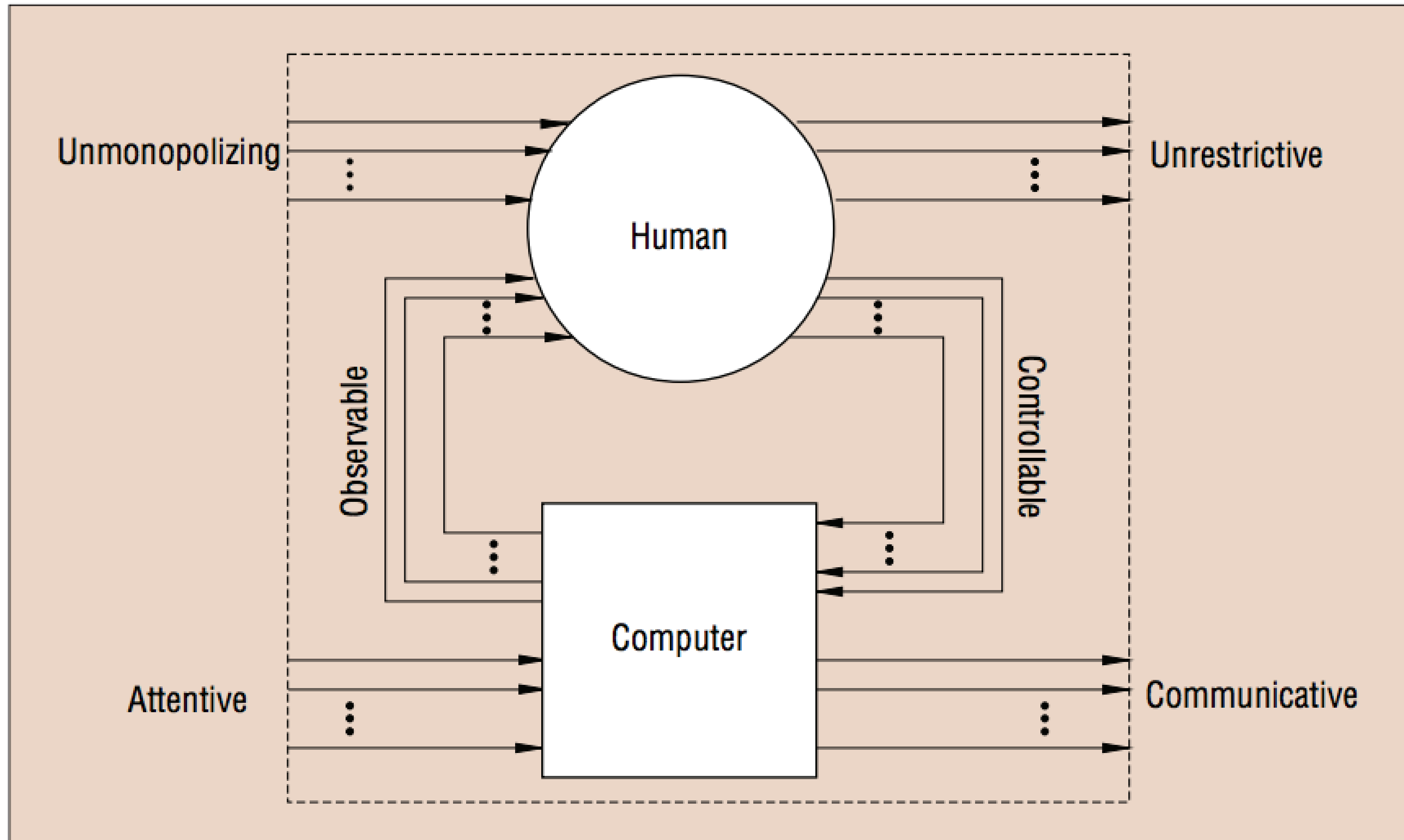
Figure 1. The evolution of interaction



Graphic: Deloitte University Press | DUPress.com

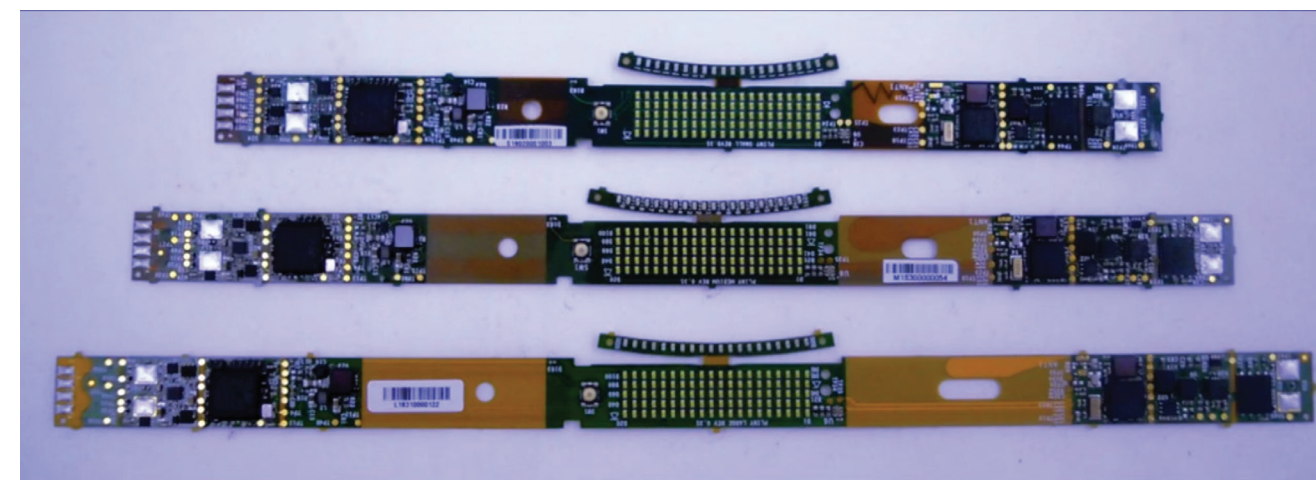
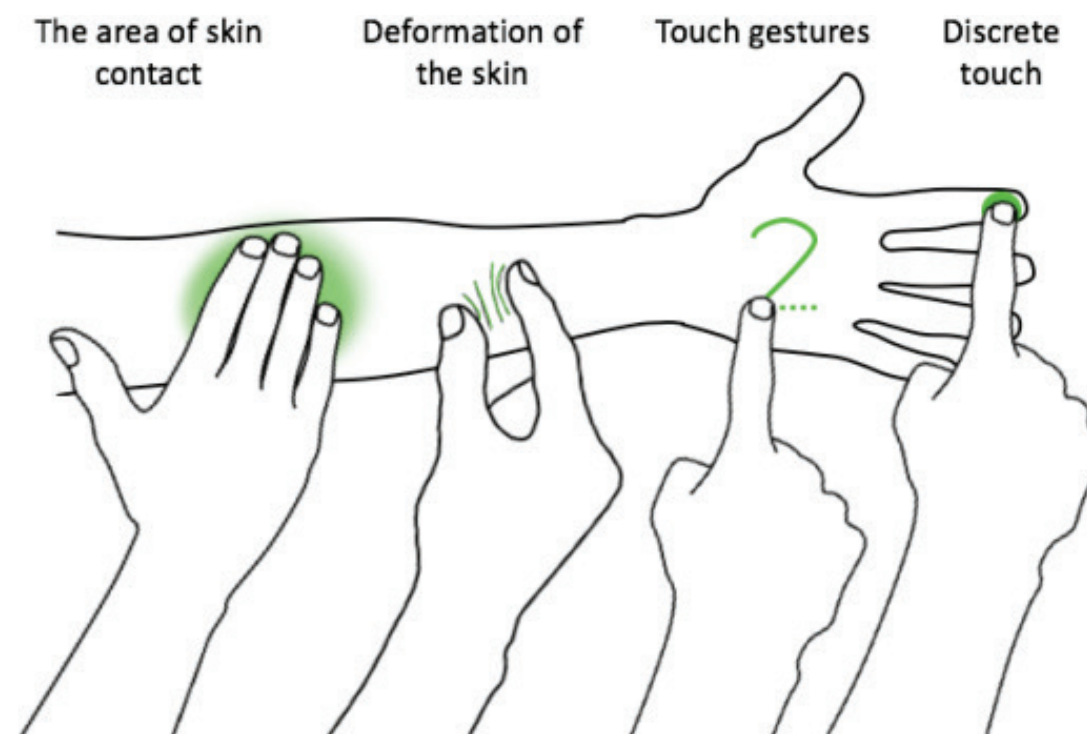
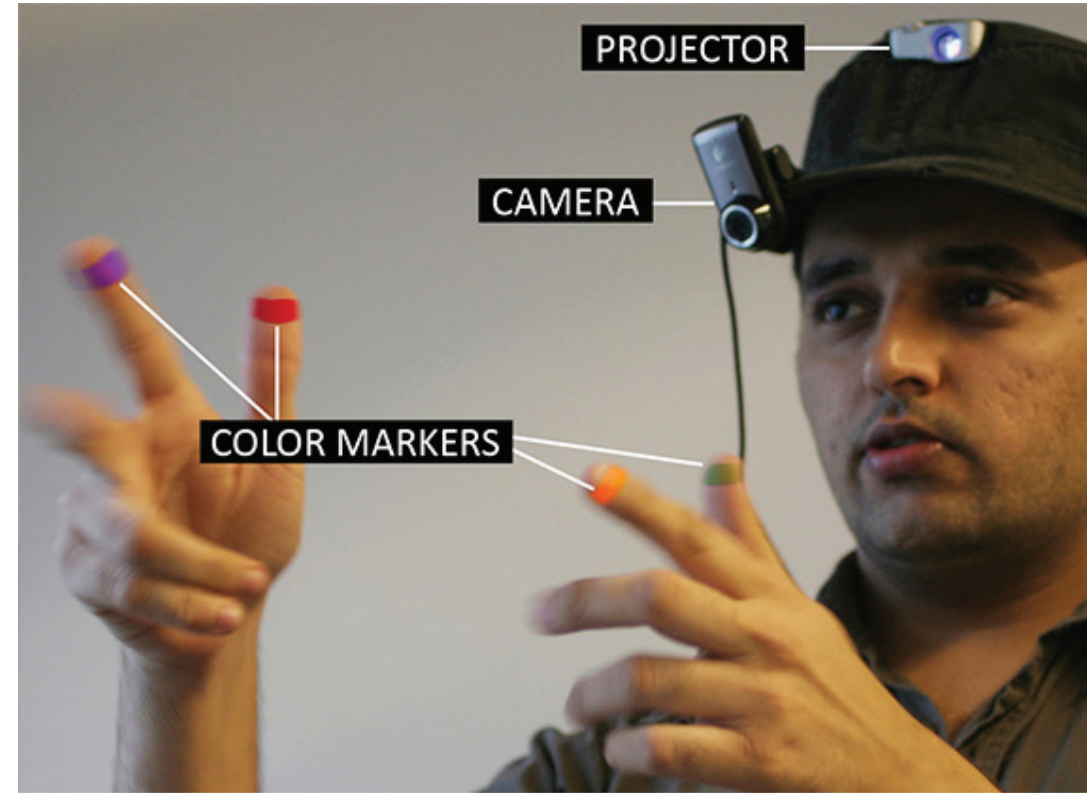
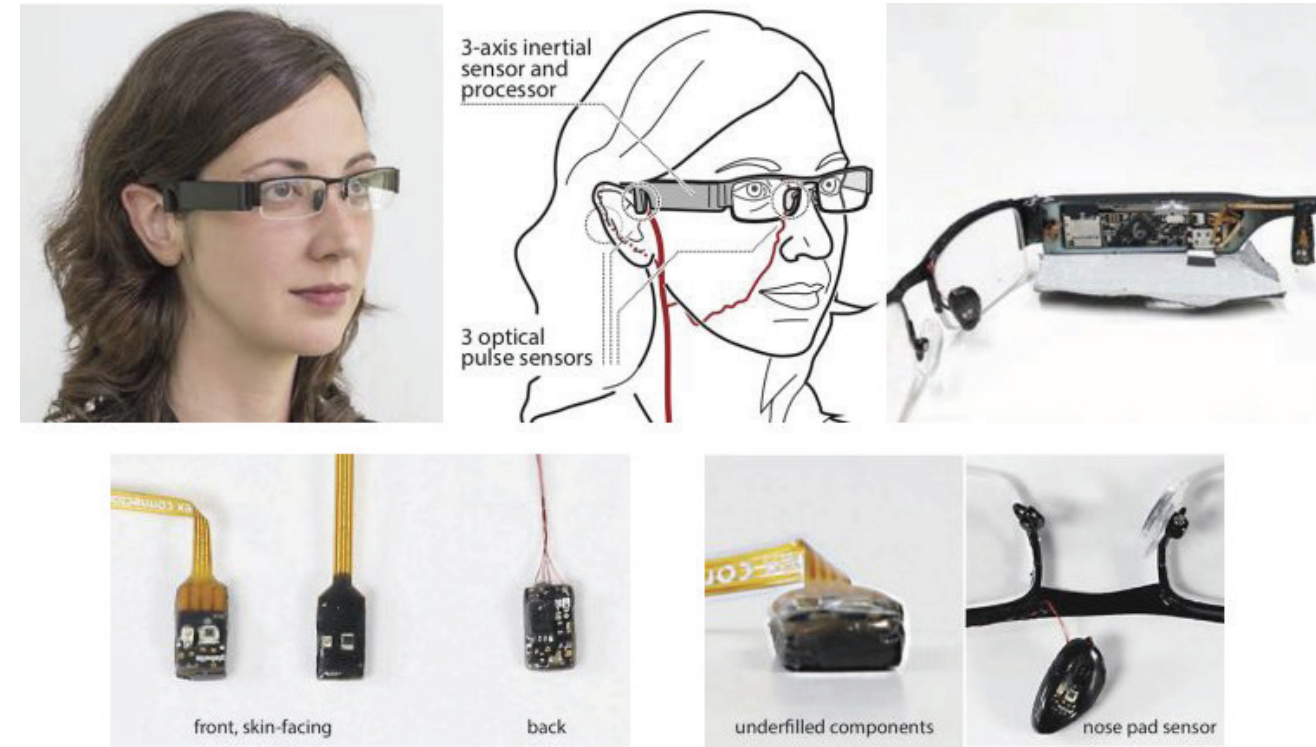


# Philosophical Proposal





# Precedent Research:



**SNC Sensors**

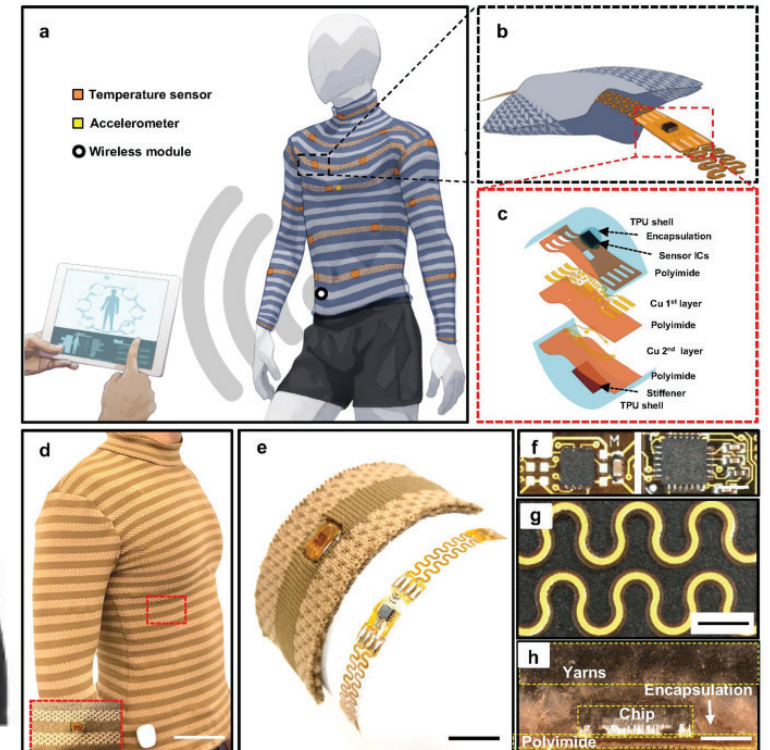
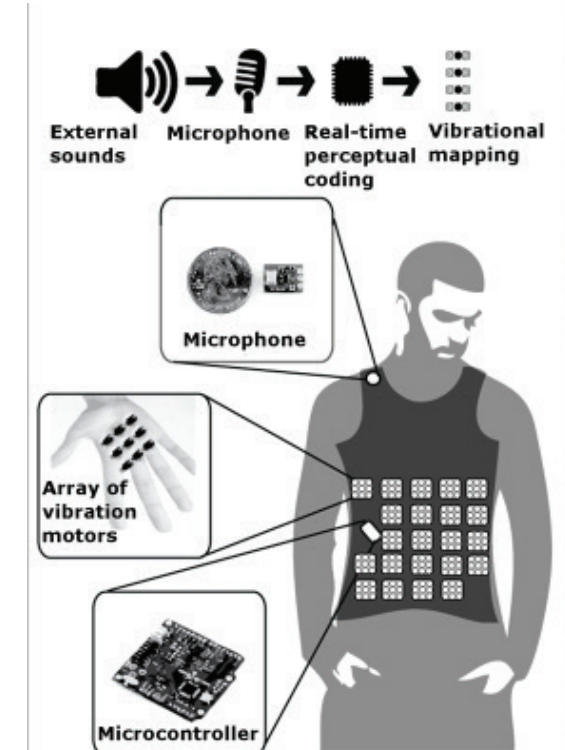
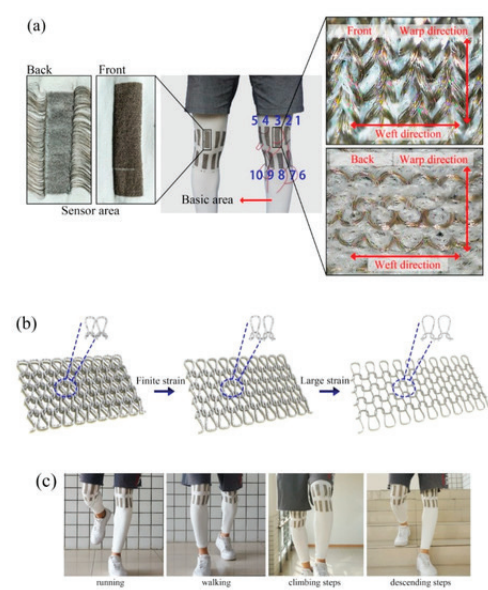
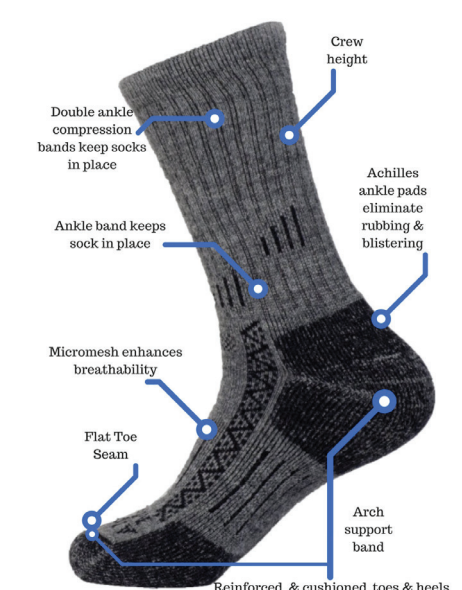
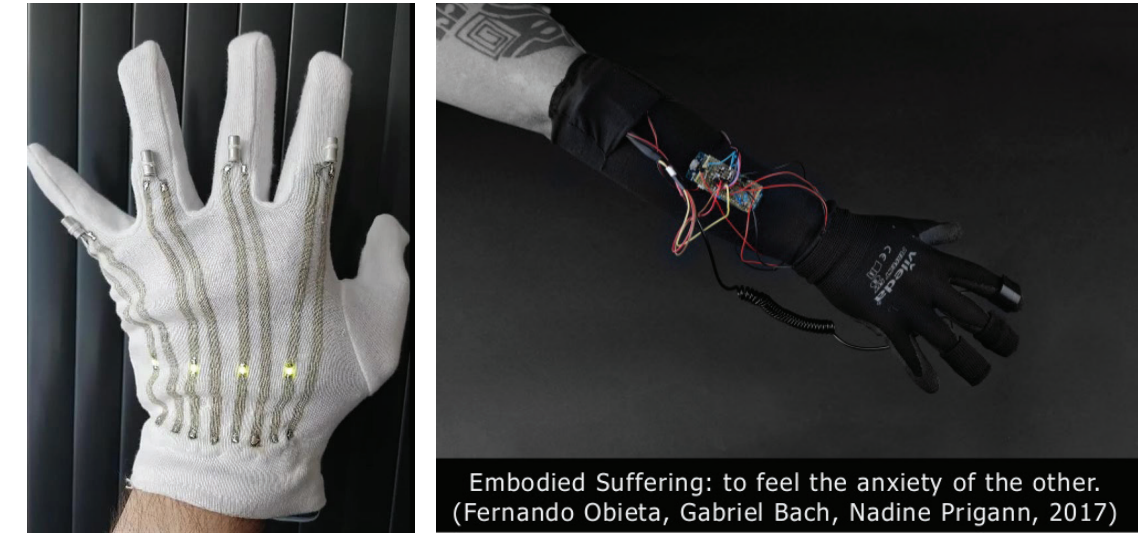
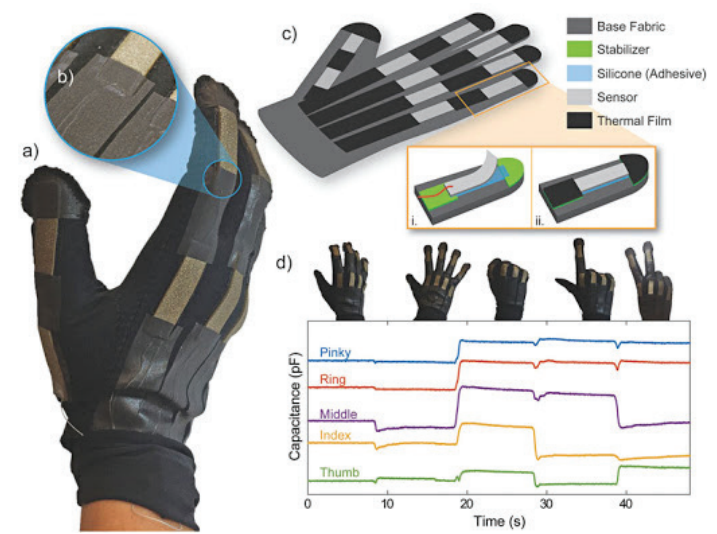
Our proprietary SNC sensors combine:

- 1 Stainless steel medical grade electrodes to keep comfortable skin contact
- 2 Analog front end sensor optimized to capture the minute neural signals

<b>Connectivity</b> BLE	<b>Compatibility</b> All watch screen sizes iPhone OS 7 and above Apple Watch 3 and above	<b>Battery</b> Li-Po 3.7V / 40mAh Over 2 days use time
<b>Charging</b> Pogo-pin Less than 1 hr	<b>IP Code</b> IP56 Dust protected, powerful water jets	<b>Sensors</b> 3 SNC Sensors 6-DOF IMU & Gyroscope
<b>Led</b> Single indicator, colored and flashes	<b>Material</b> Fluoroelastomer	<b>Color</b> ● White ● Black



# Precedent Research:



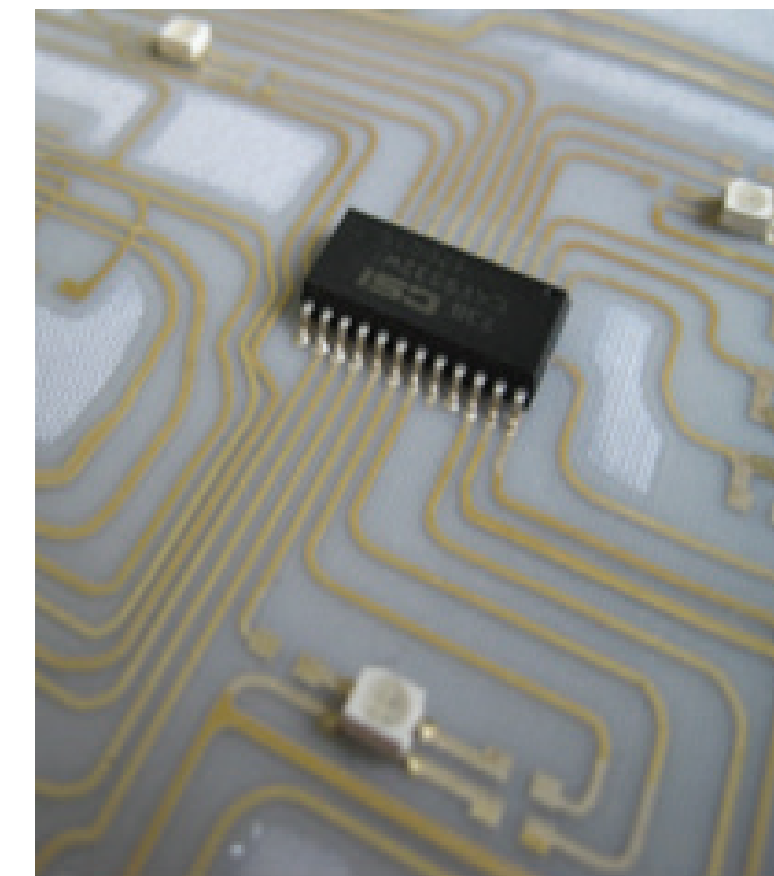
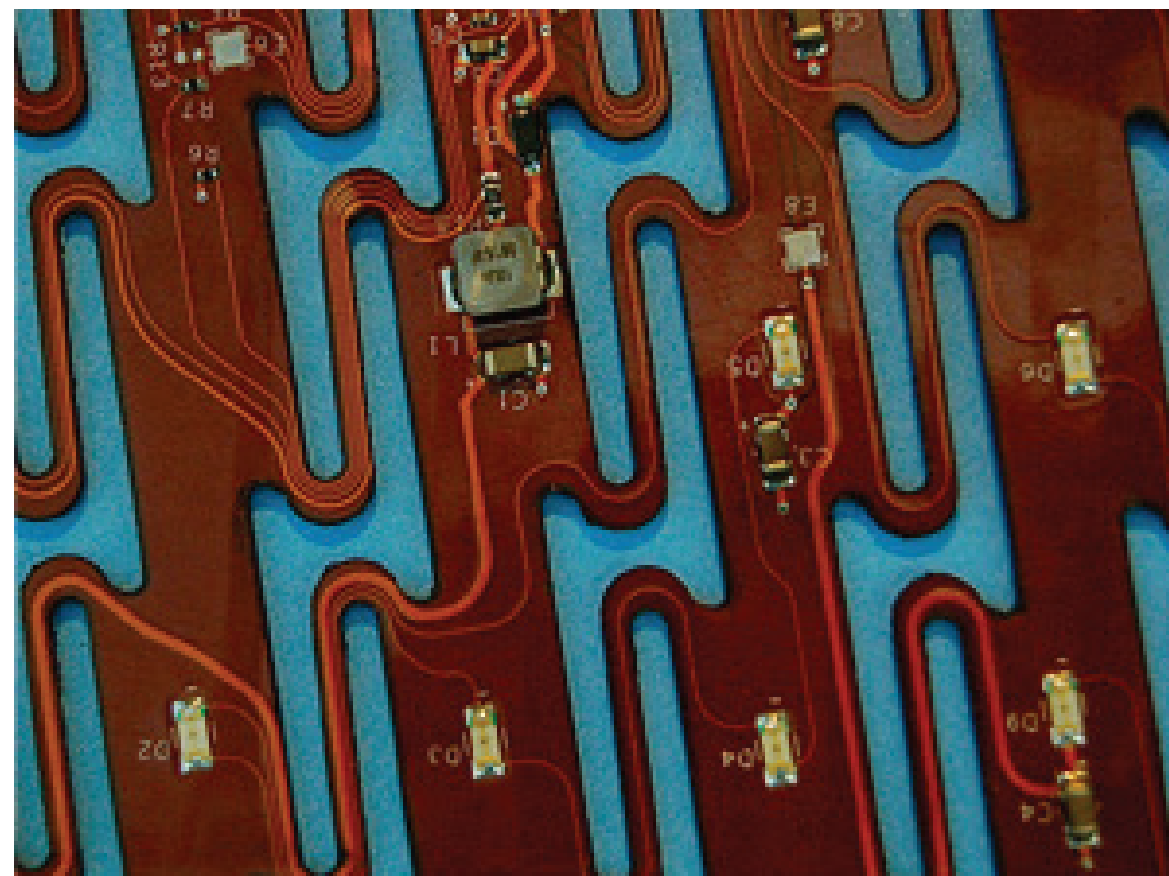
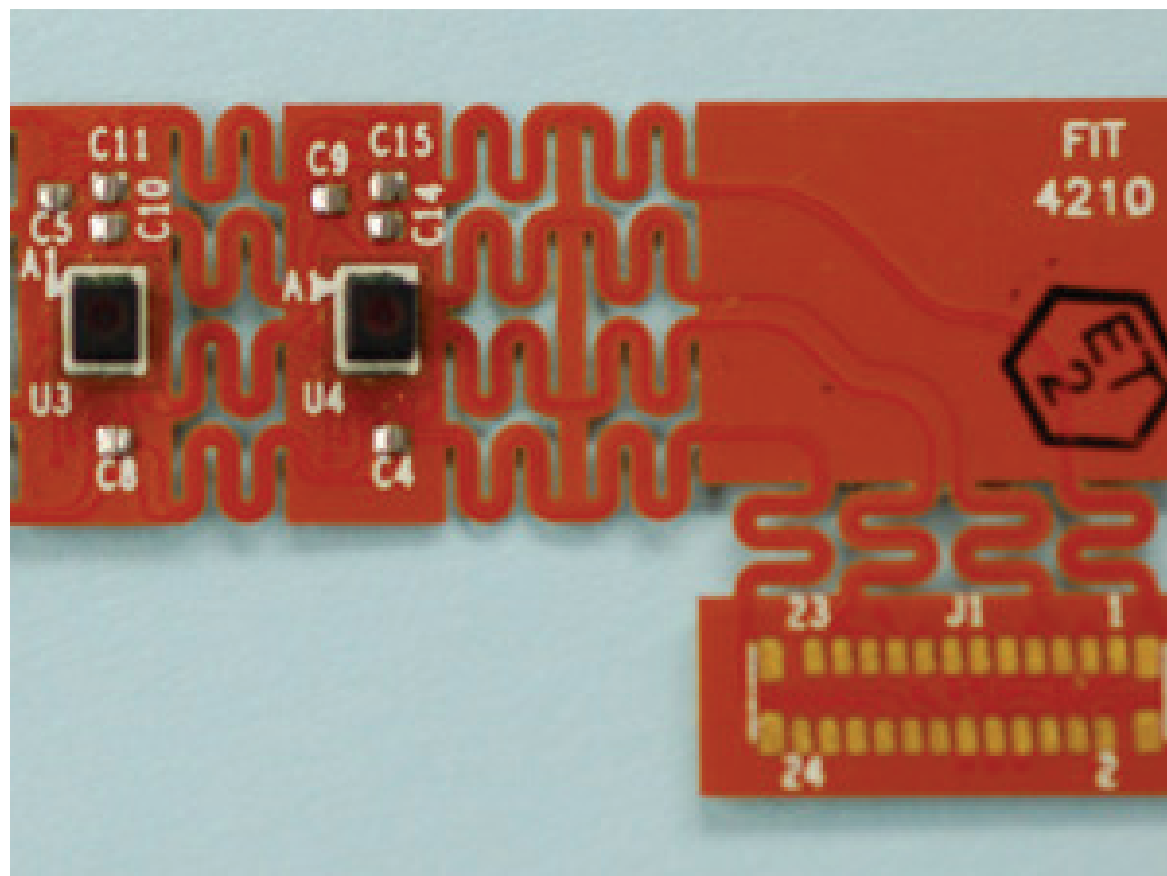
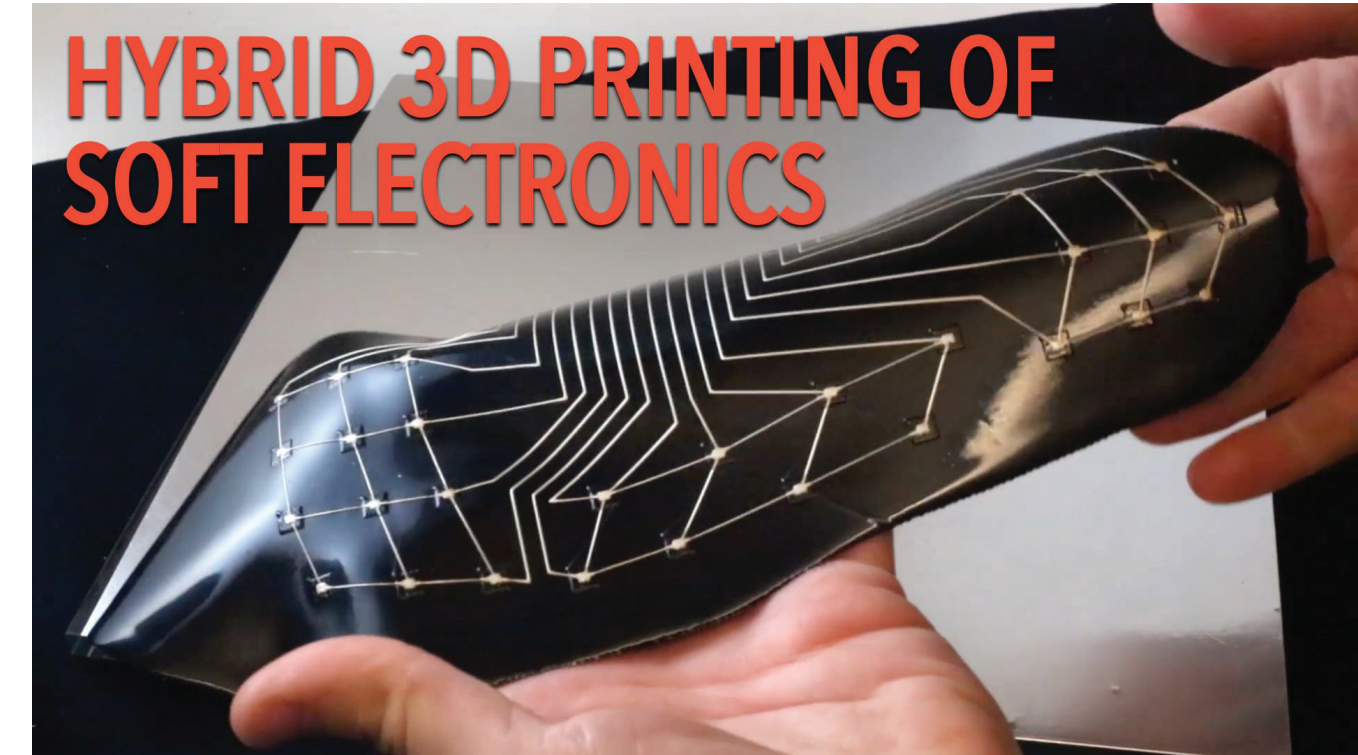
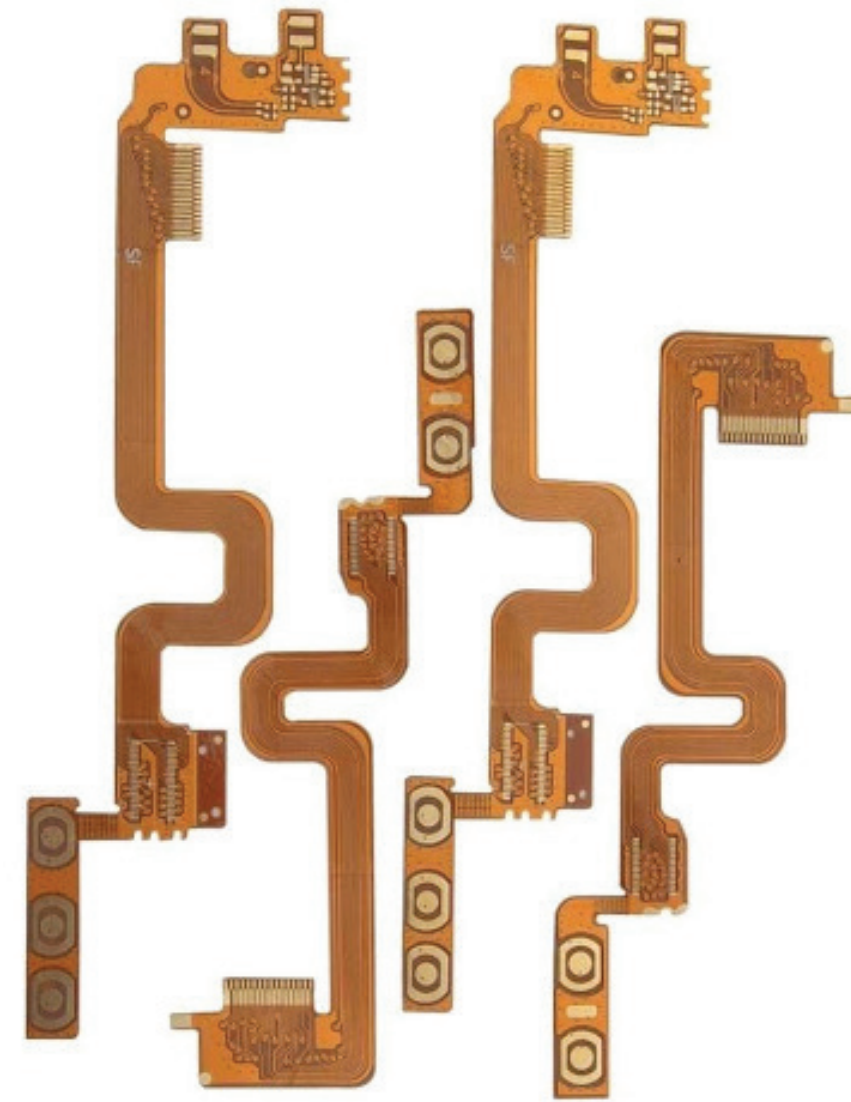
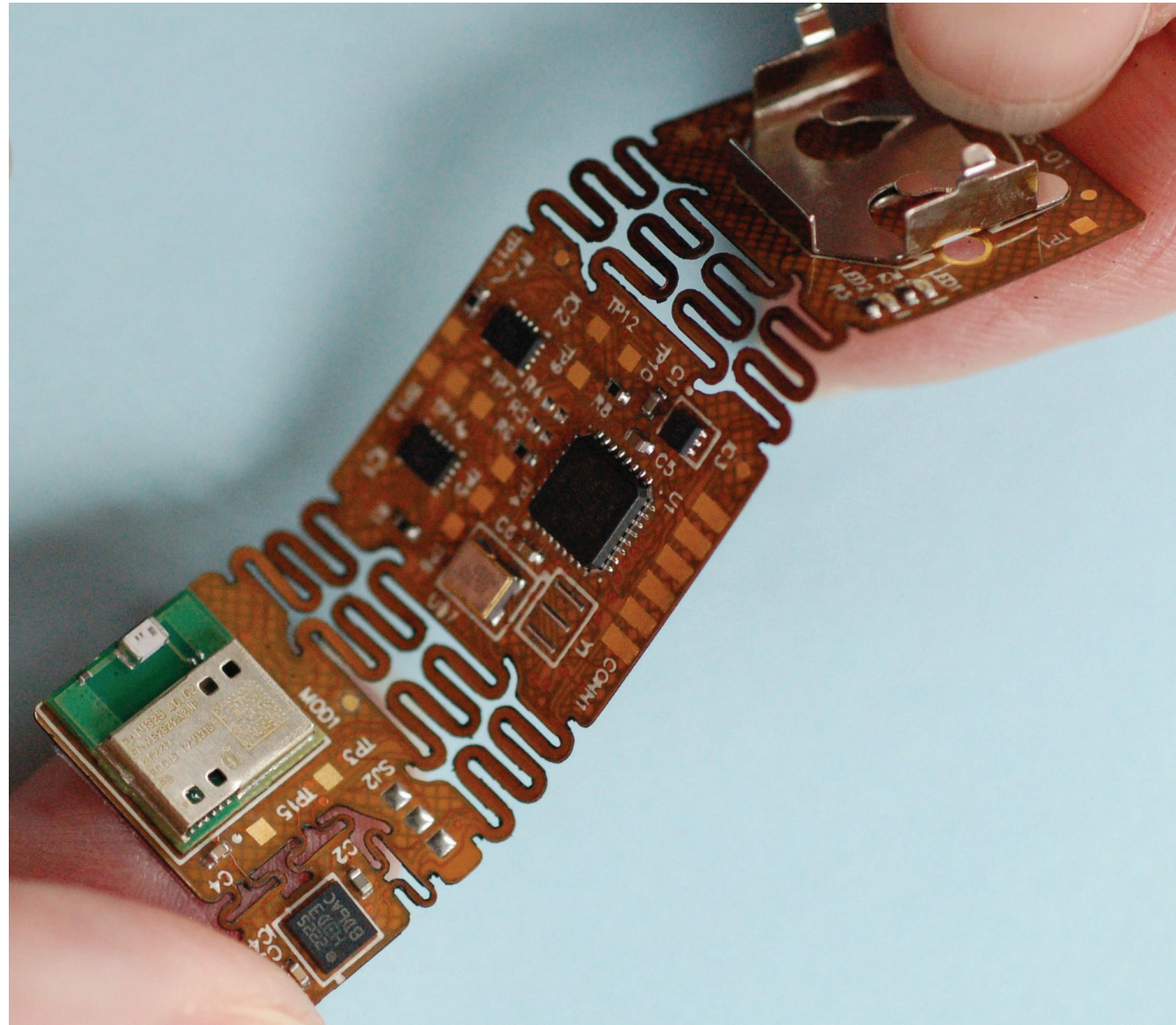


# Design Statement

We are building a PCB that can be directly applied to the fabric. This techno composite membrane will be use to experiment on new types of interfaces that augment our reality and perception of it.

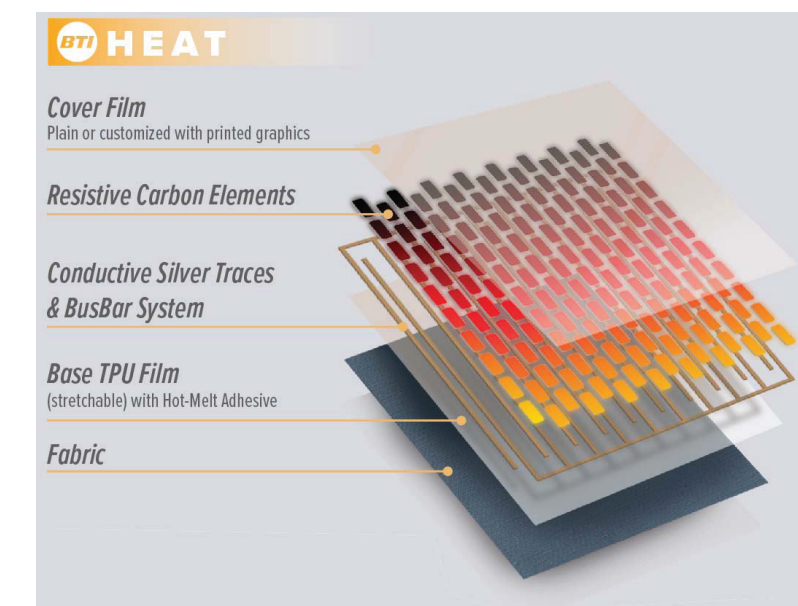
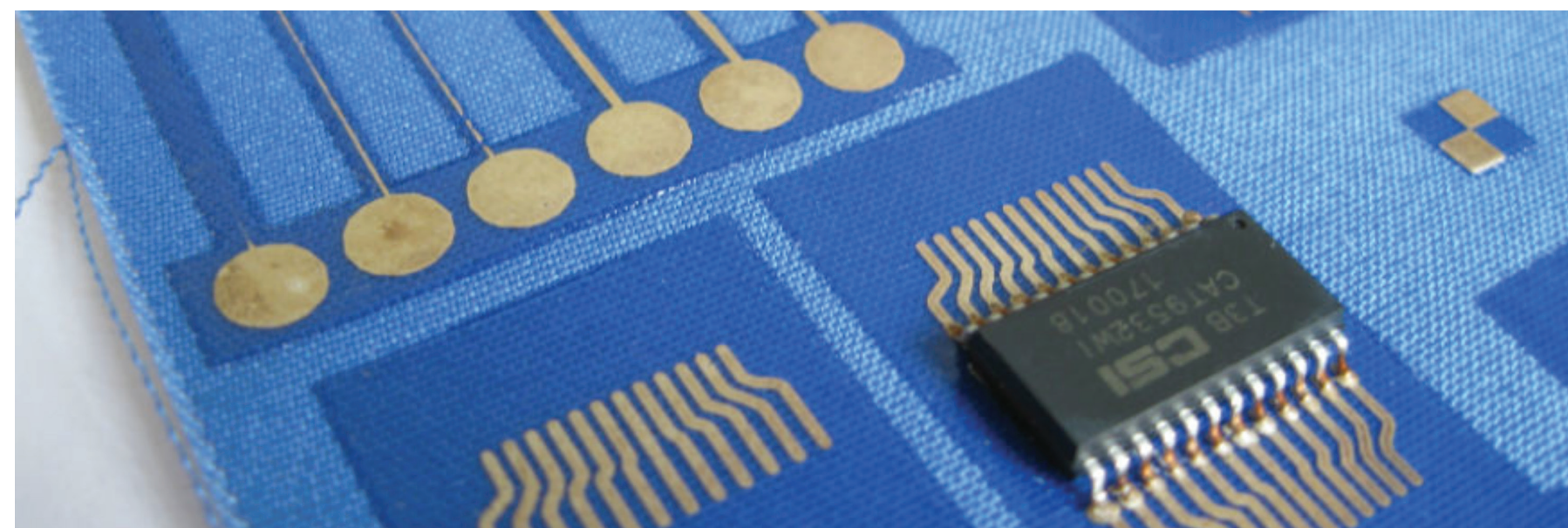
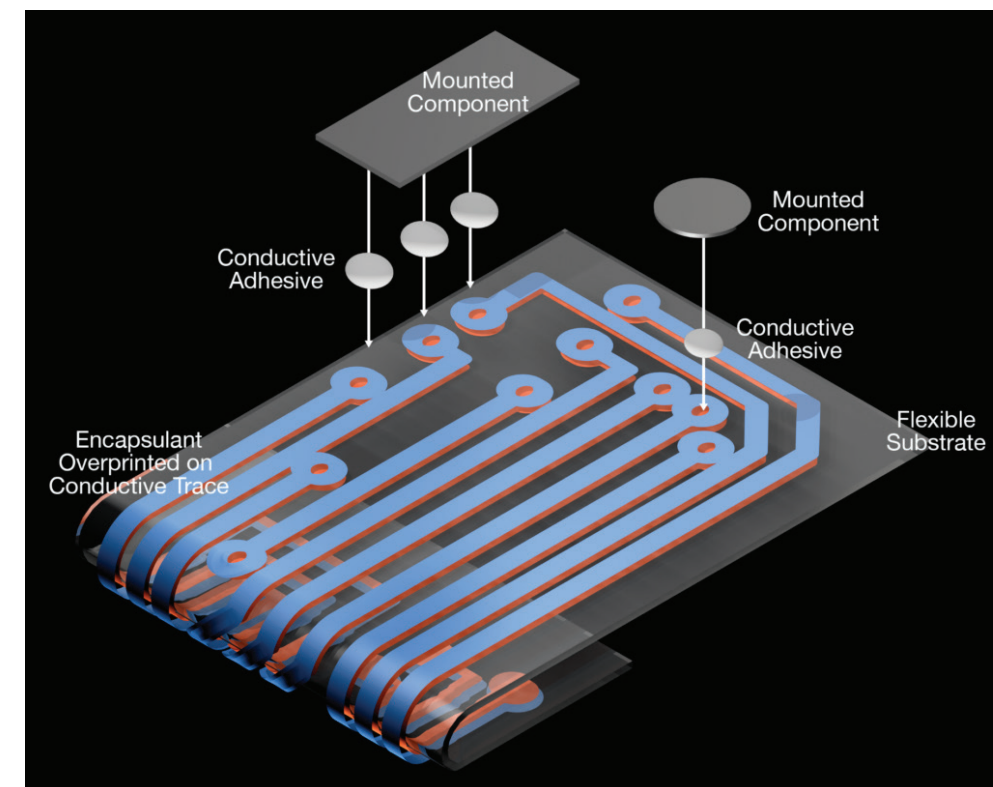
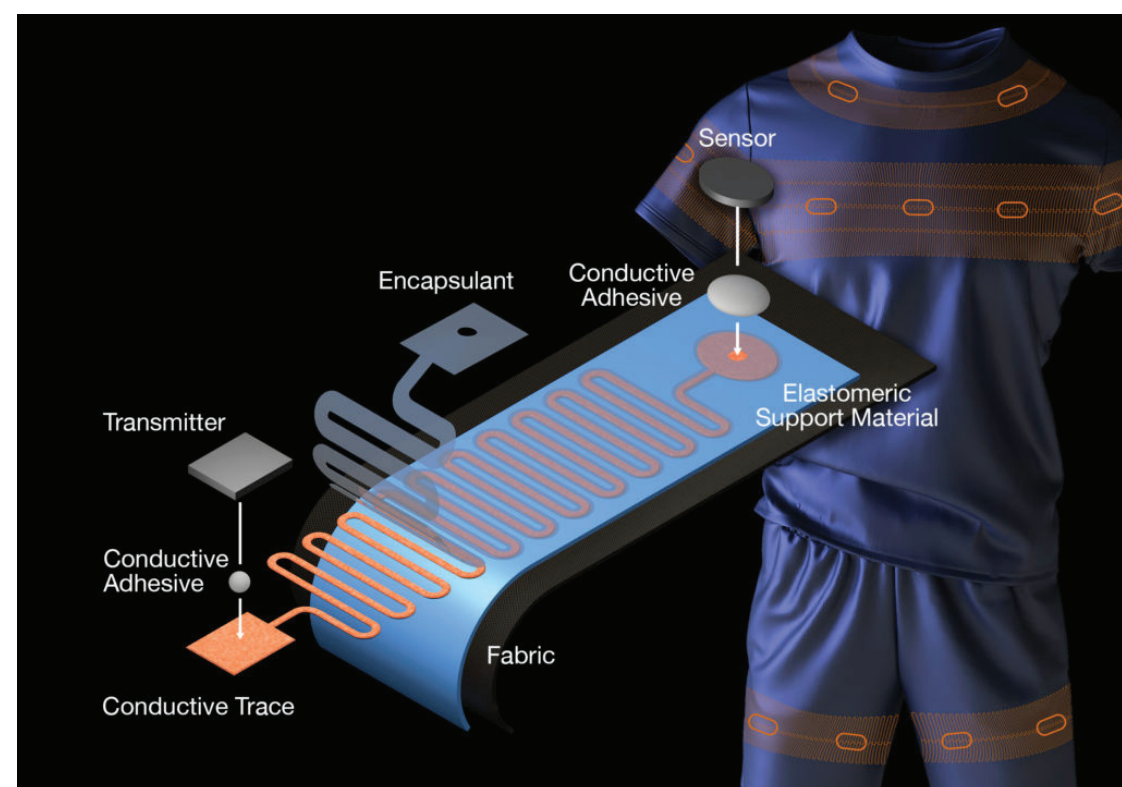
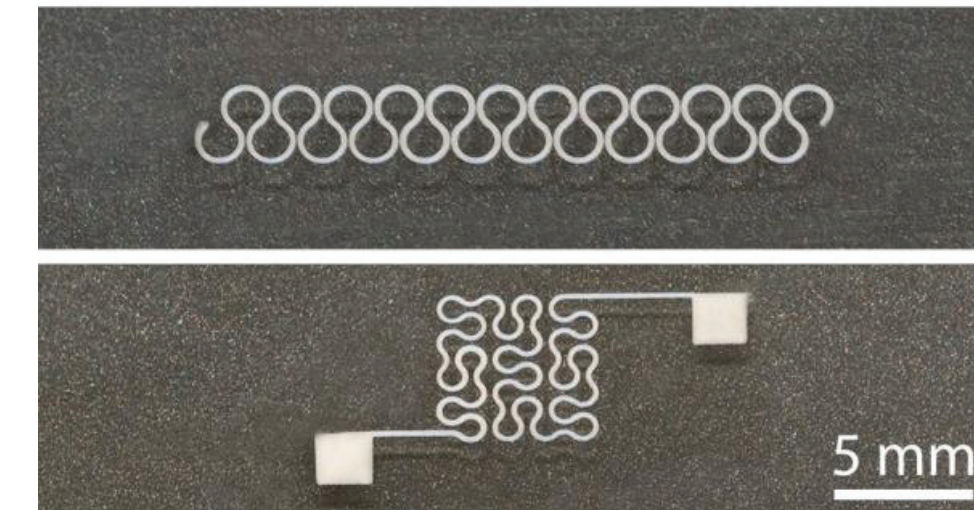
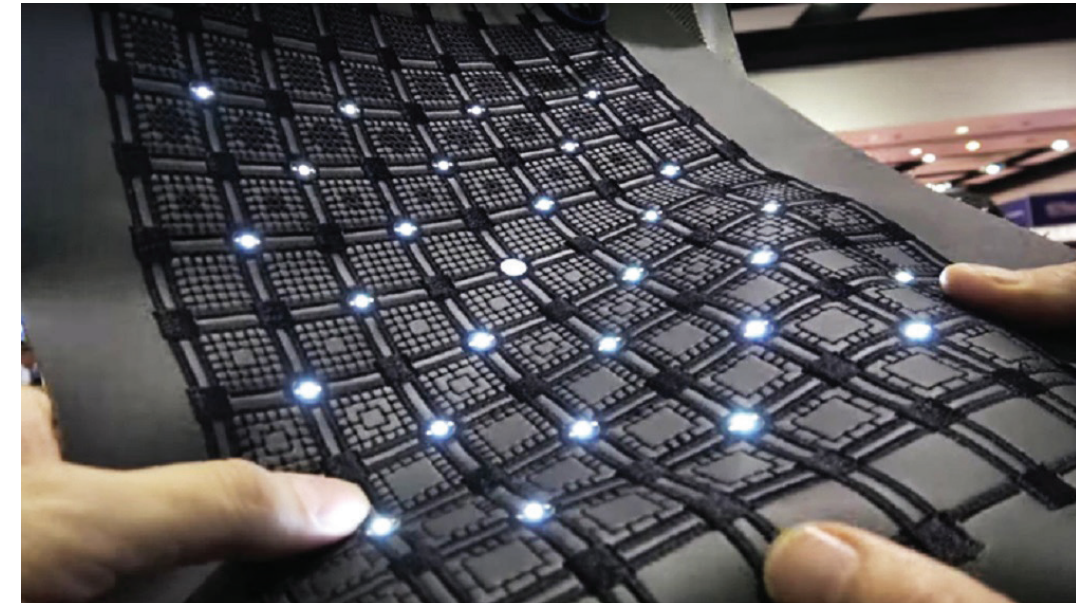
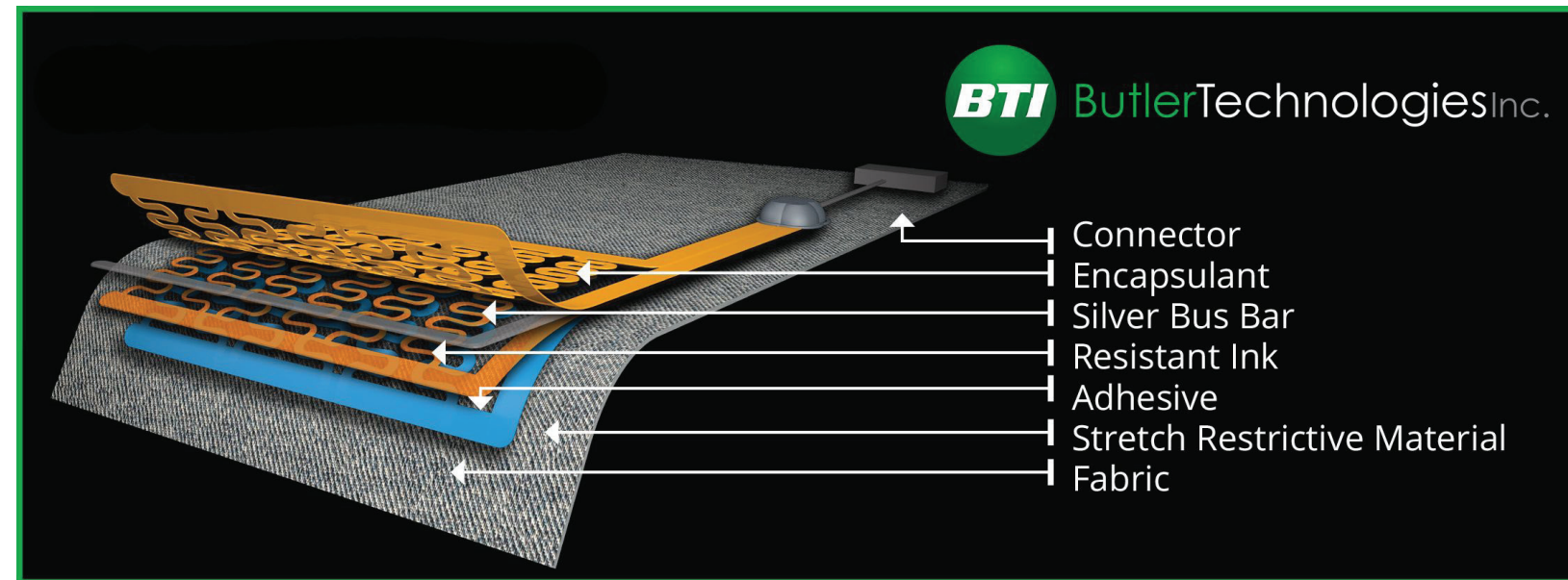


# Flexible Technology



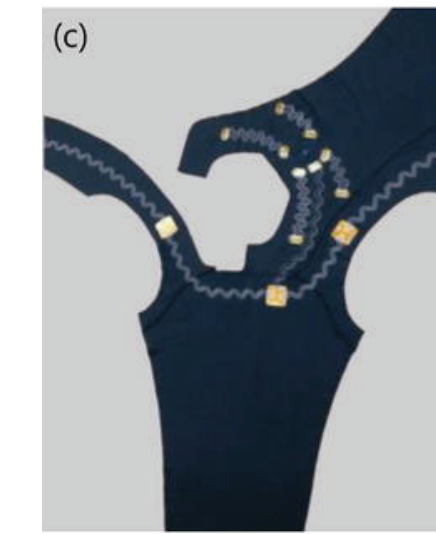
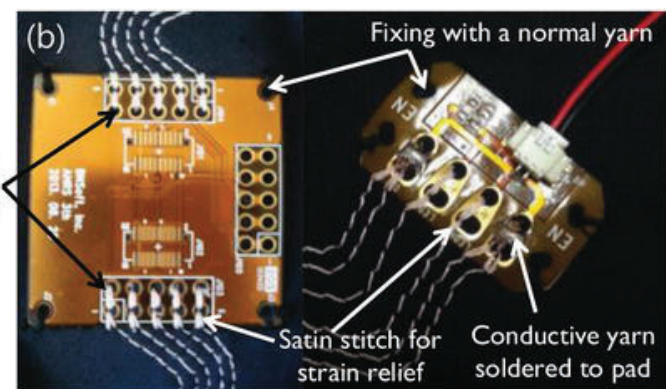
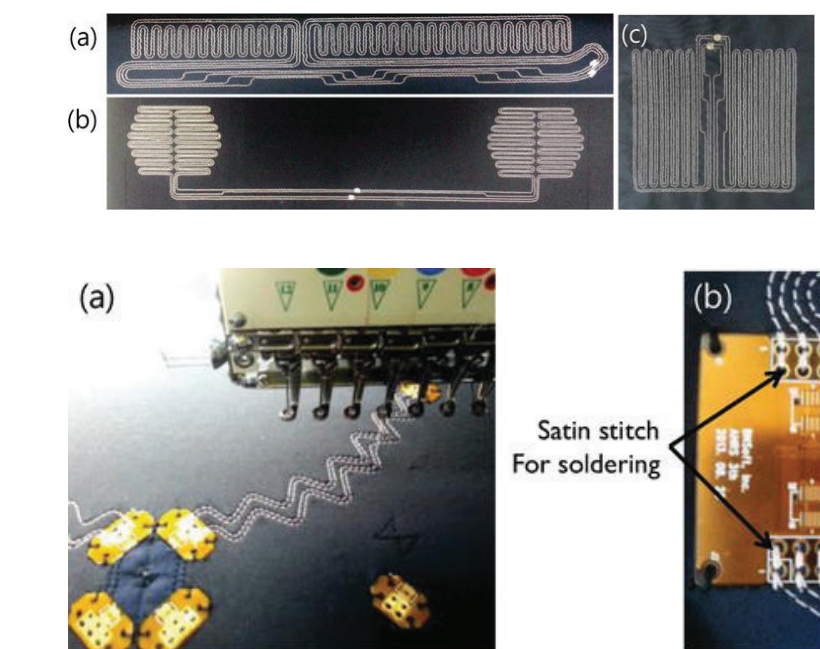
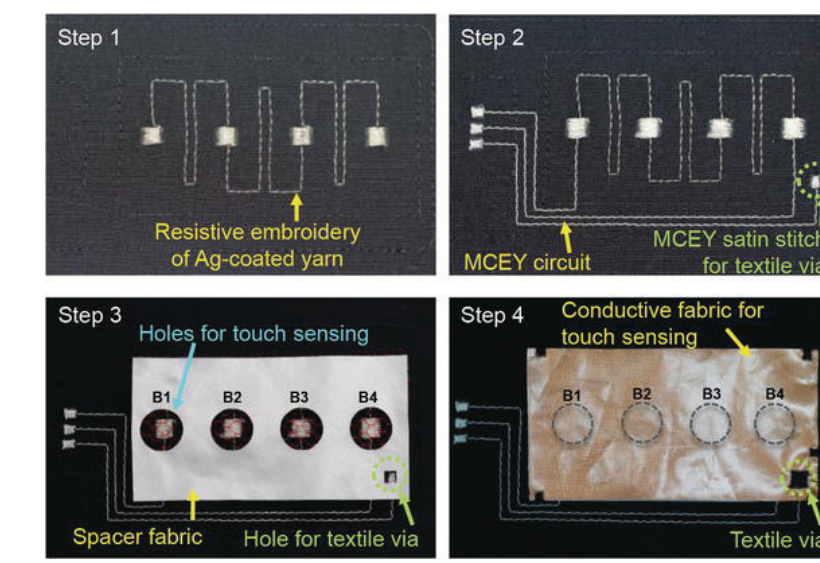
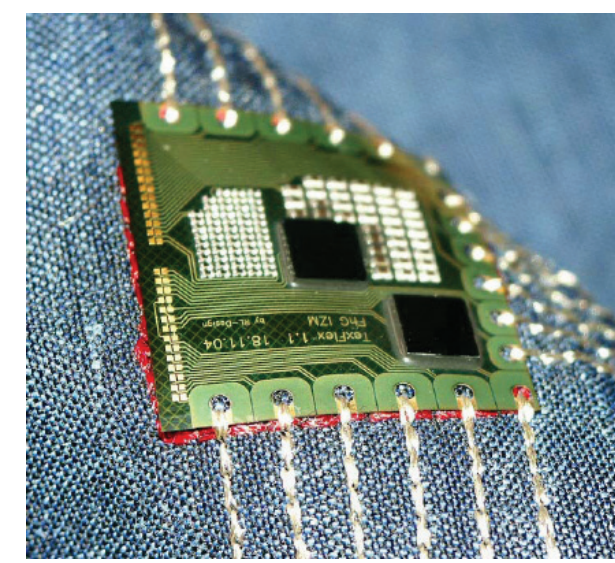
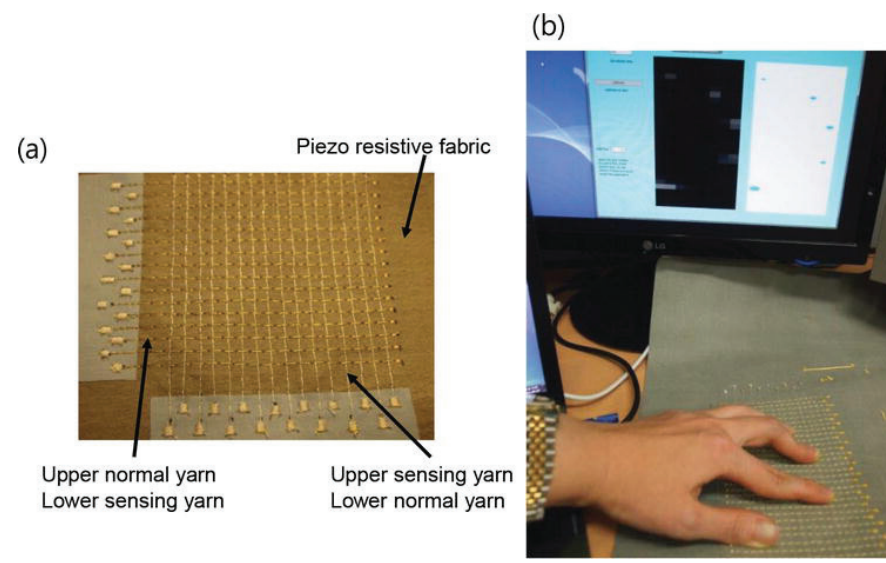
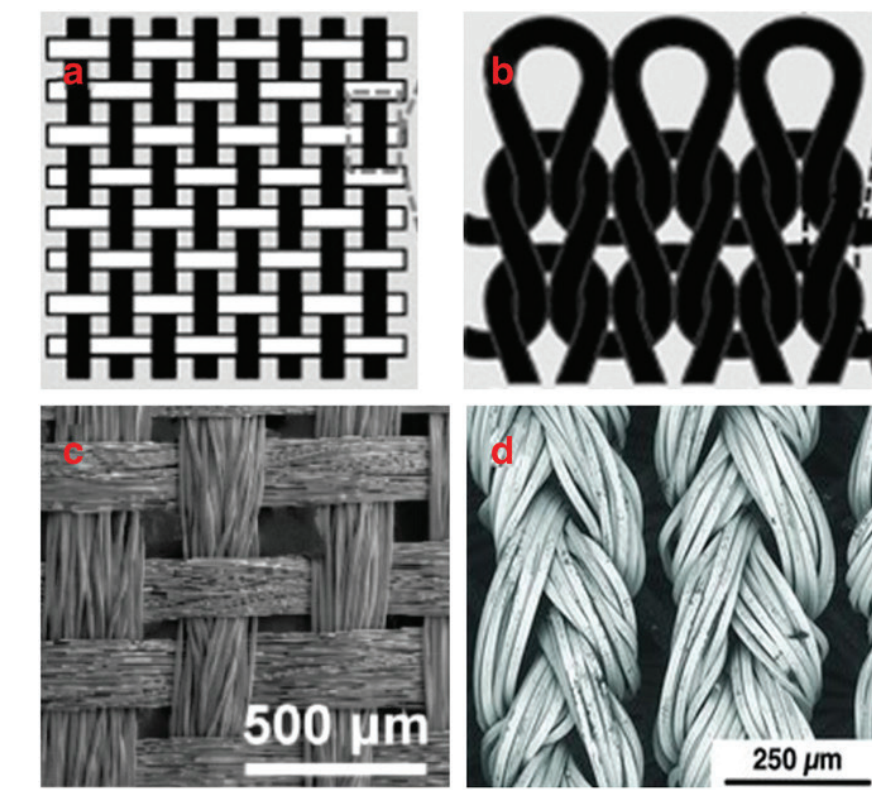
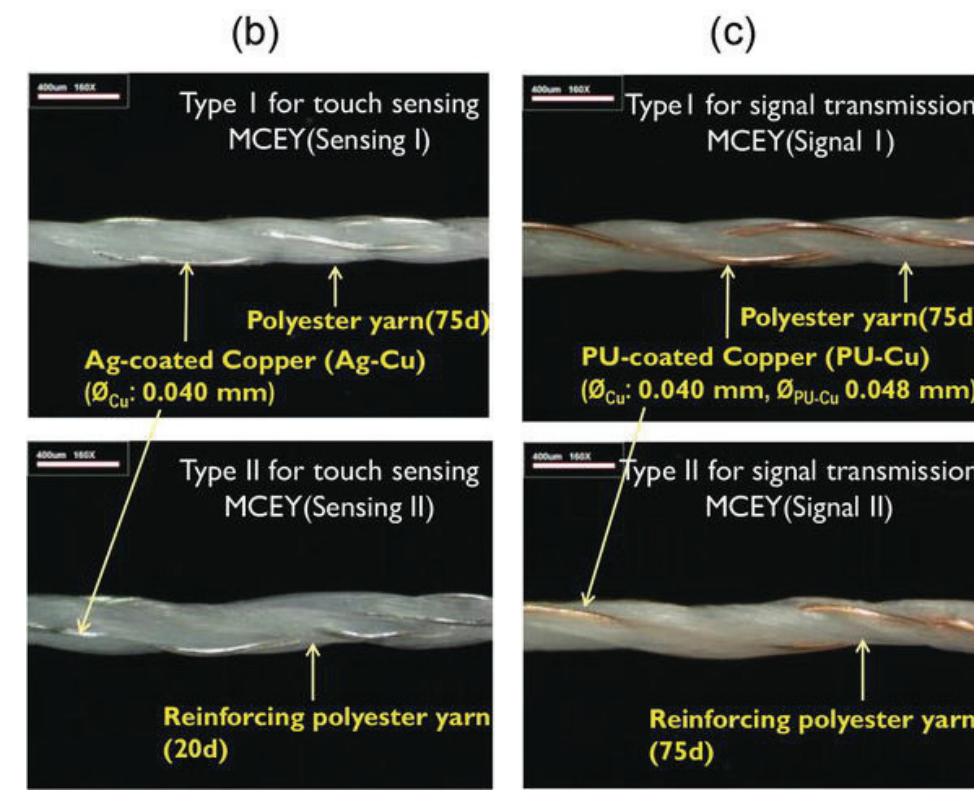
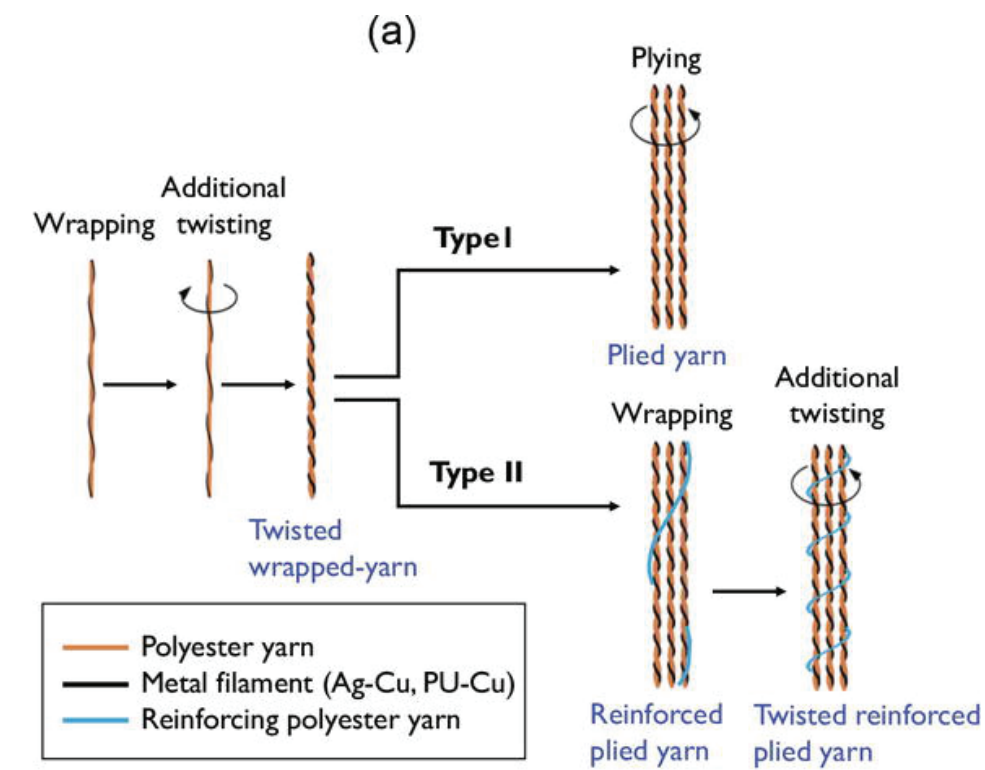
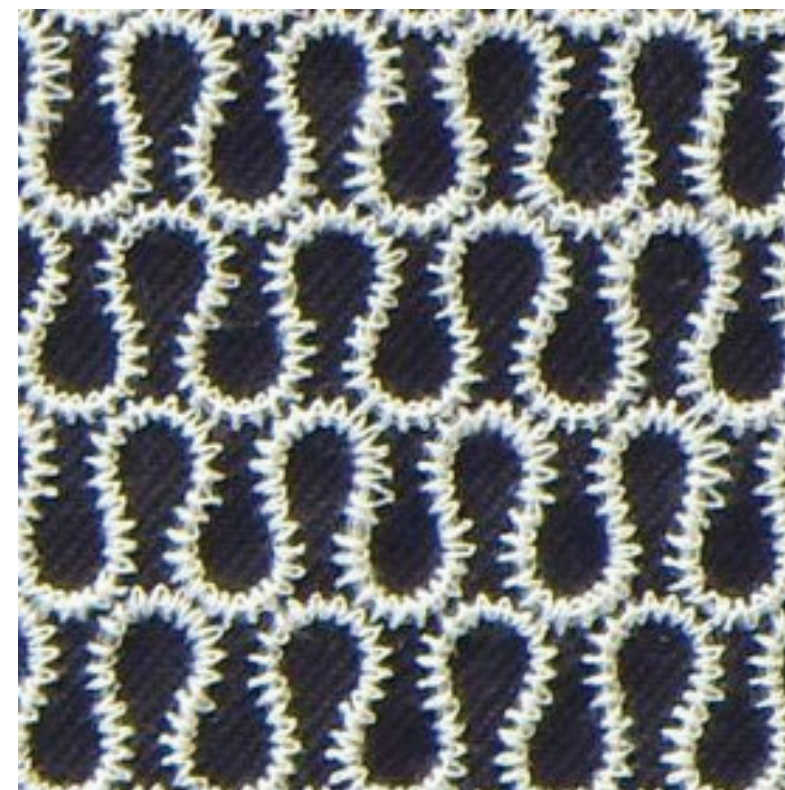


# Seamless Application



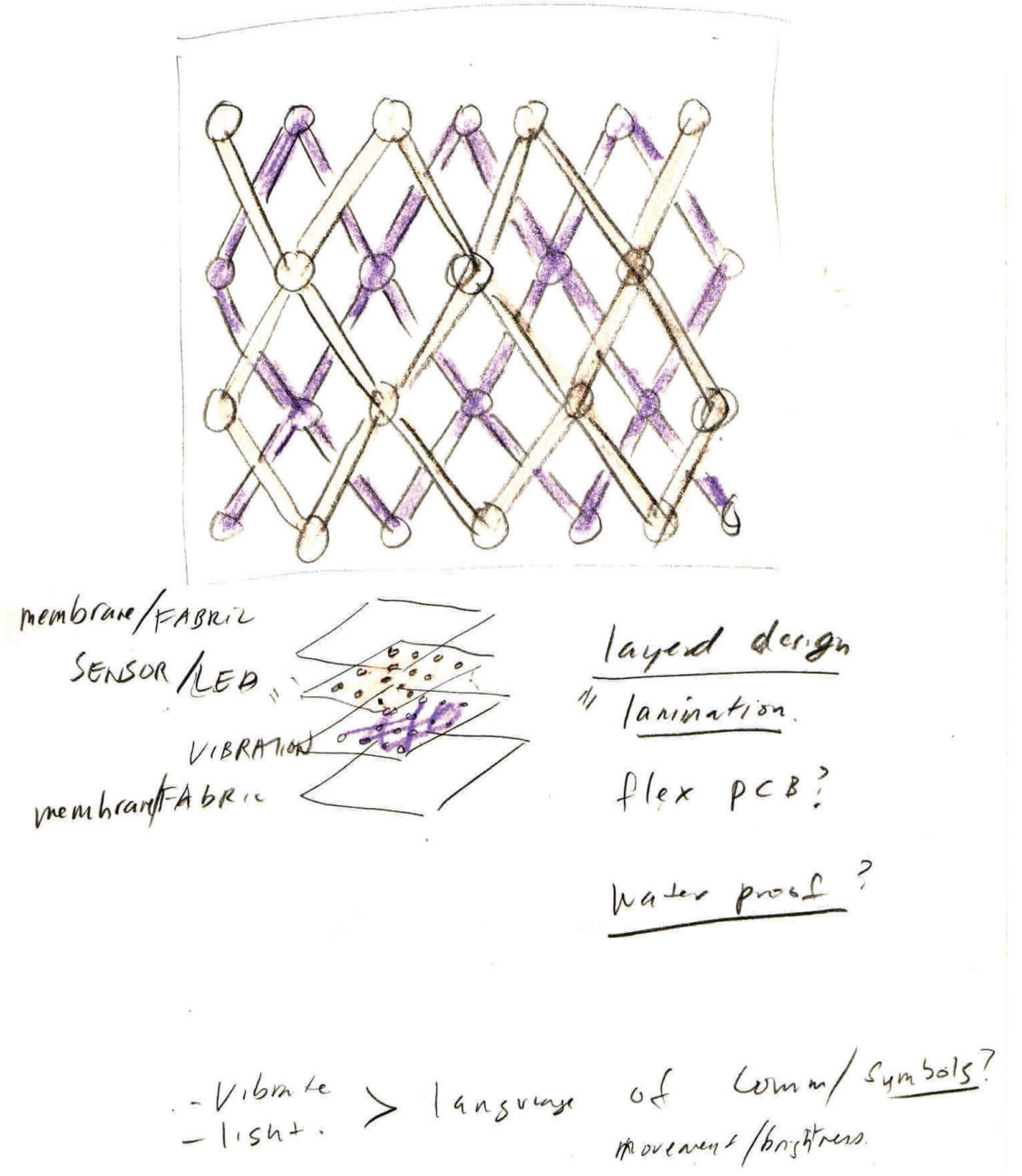
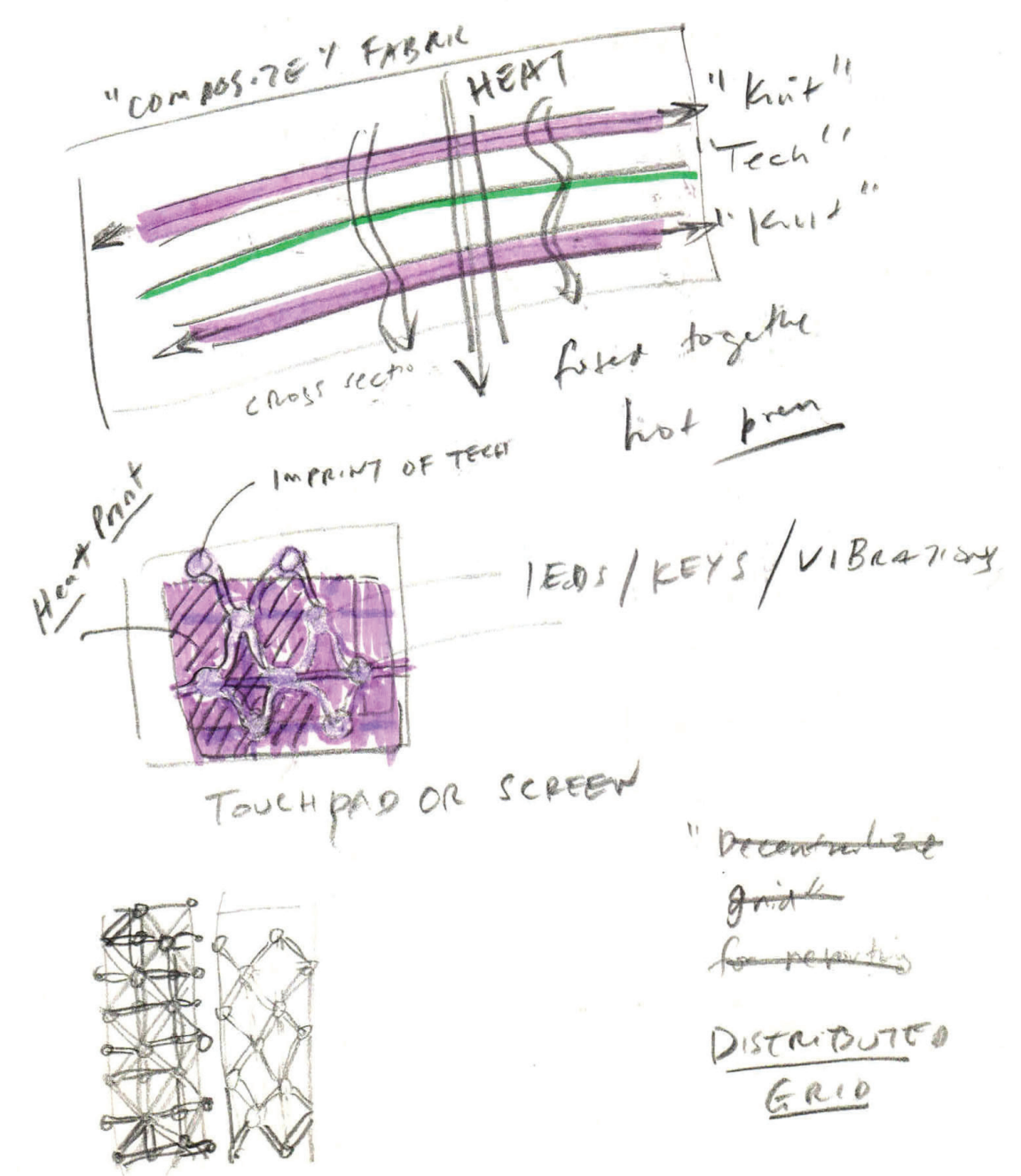
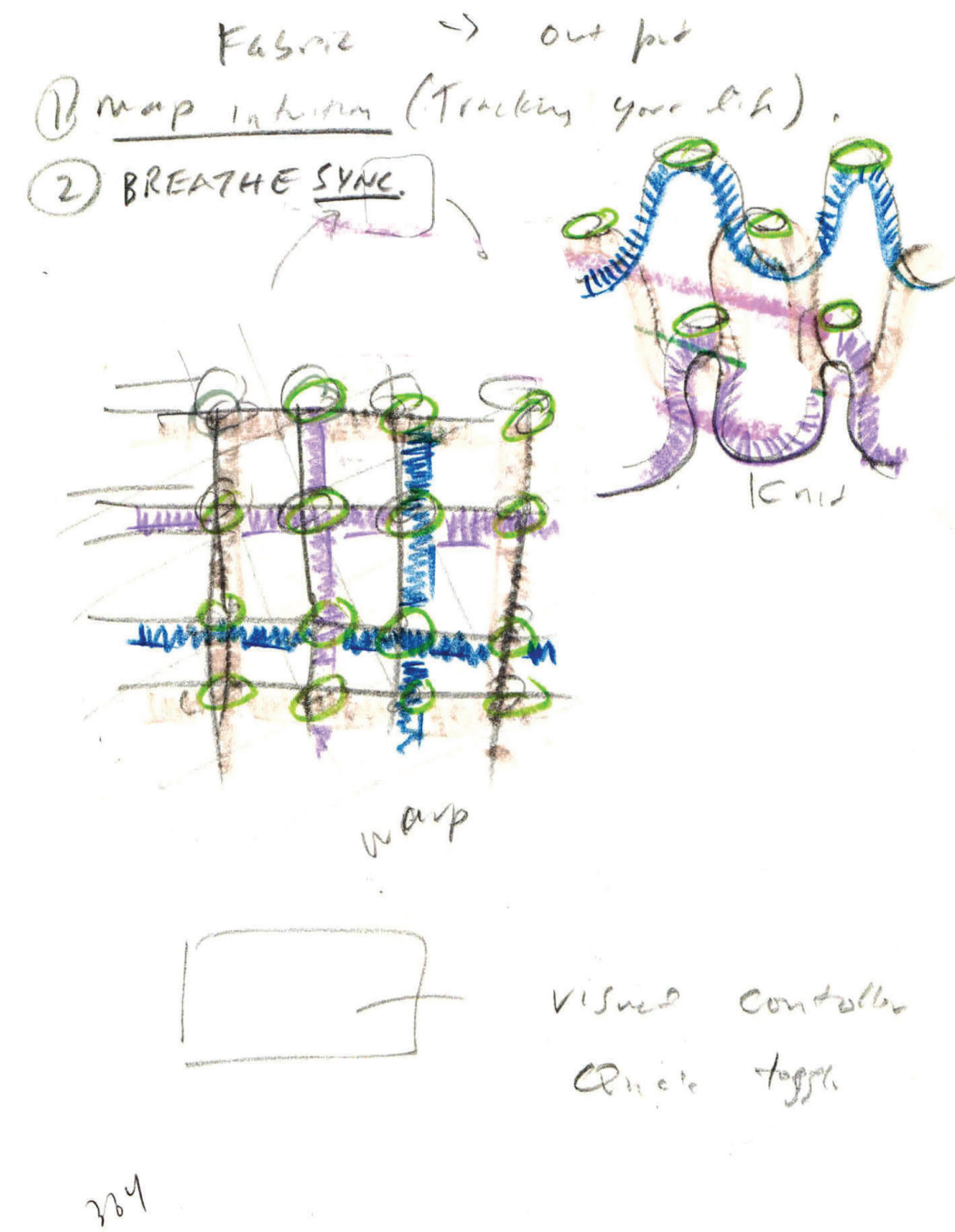
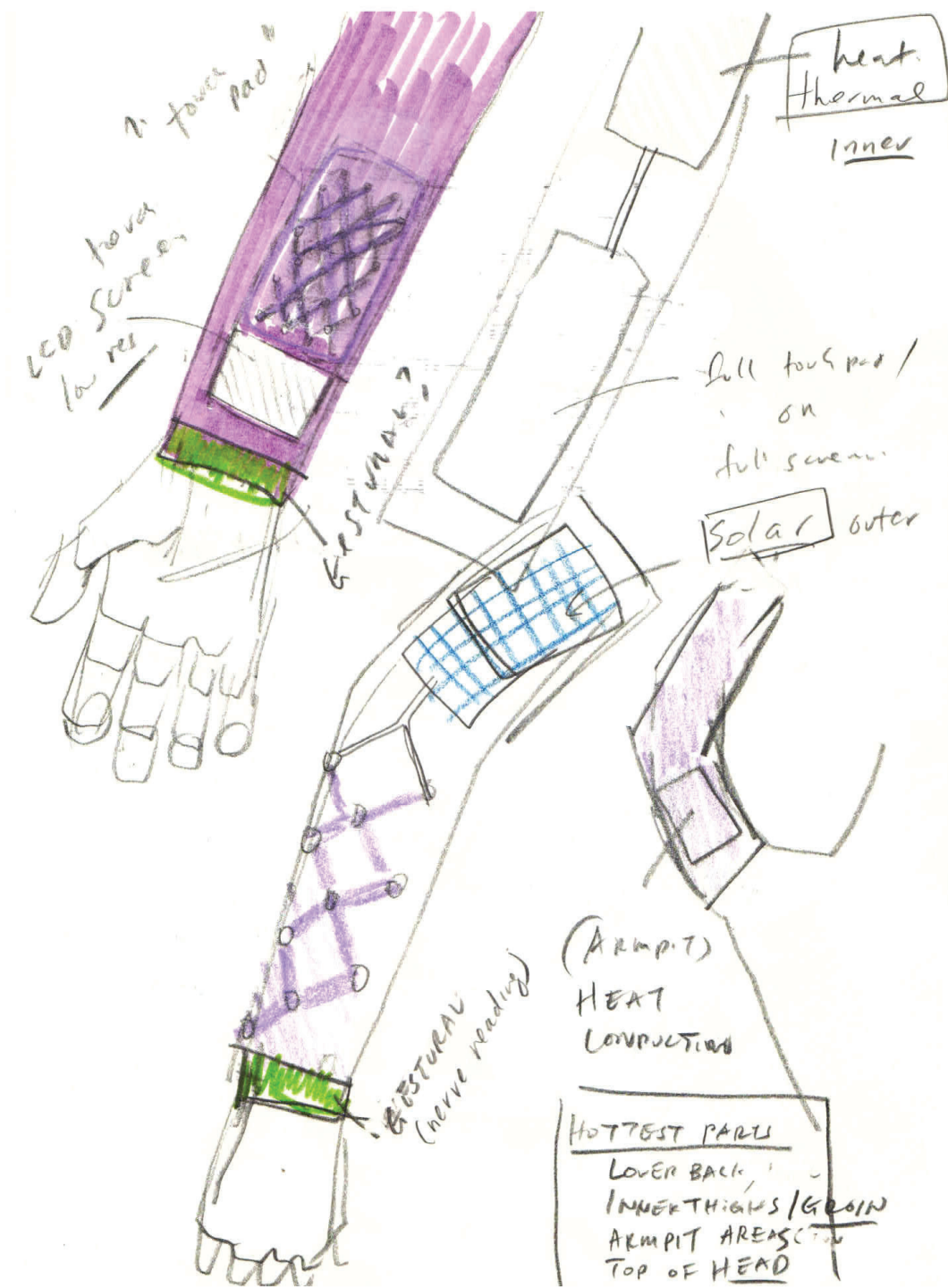


# Seamless Application



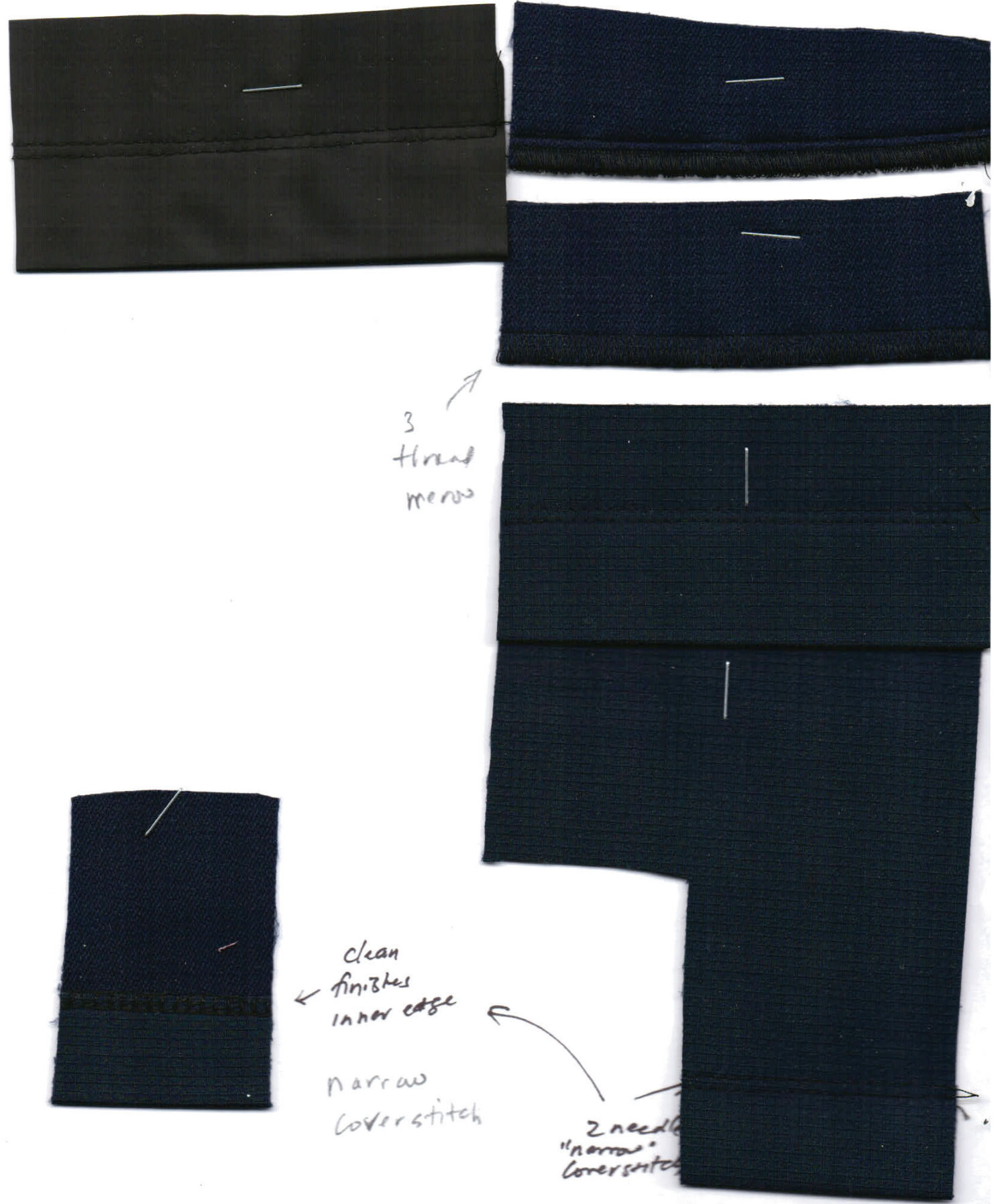
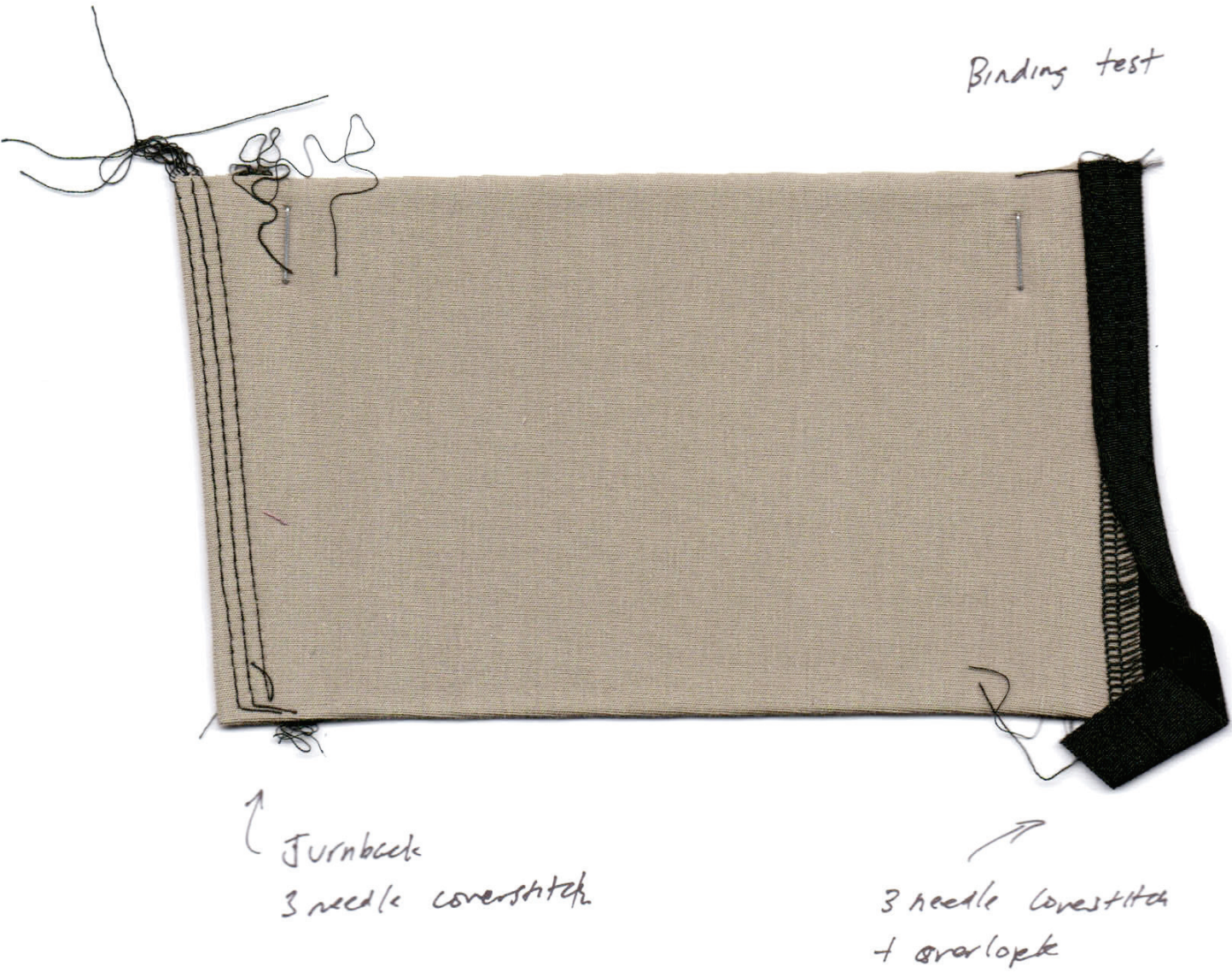
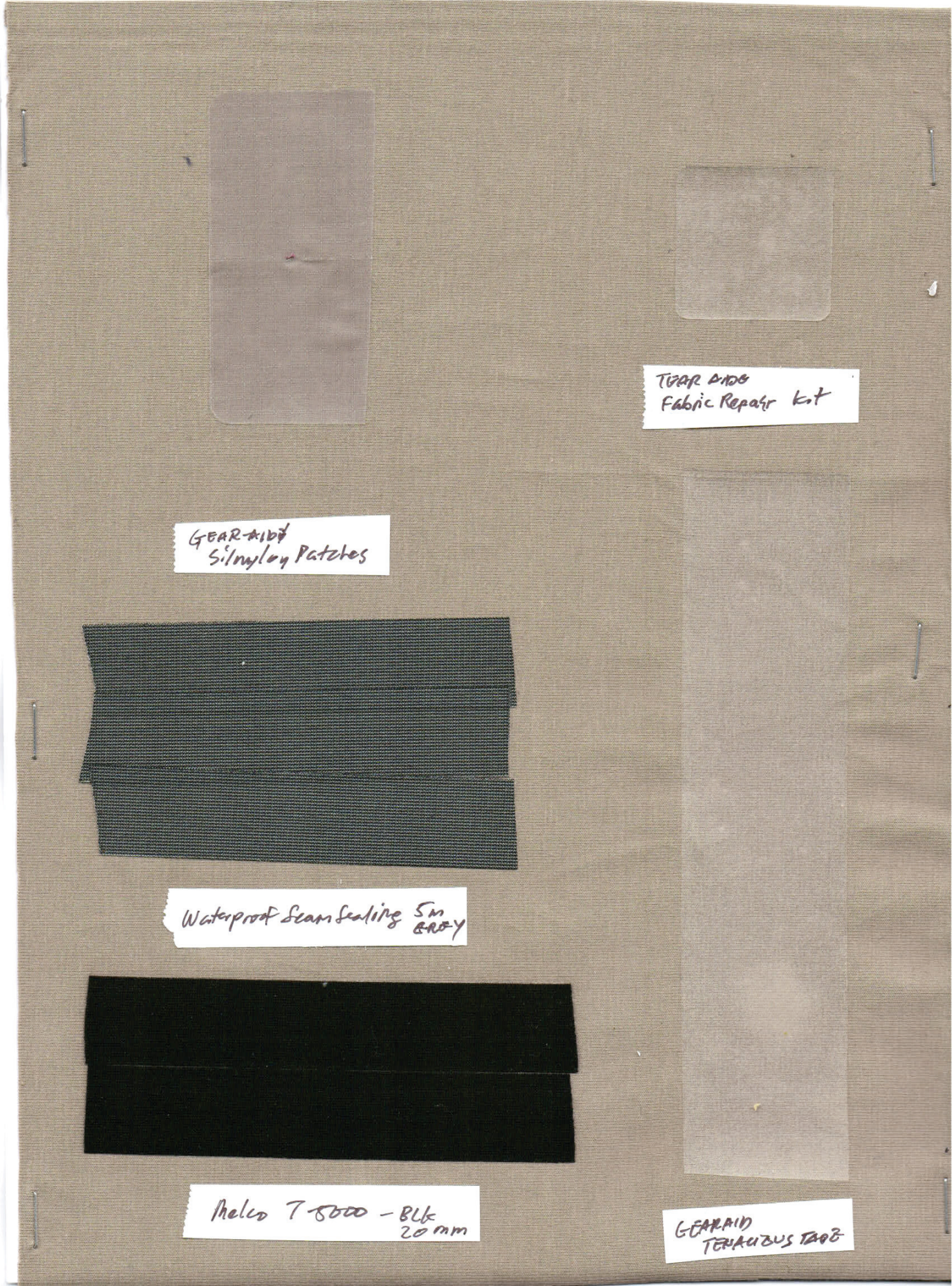


# Seamless Application



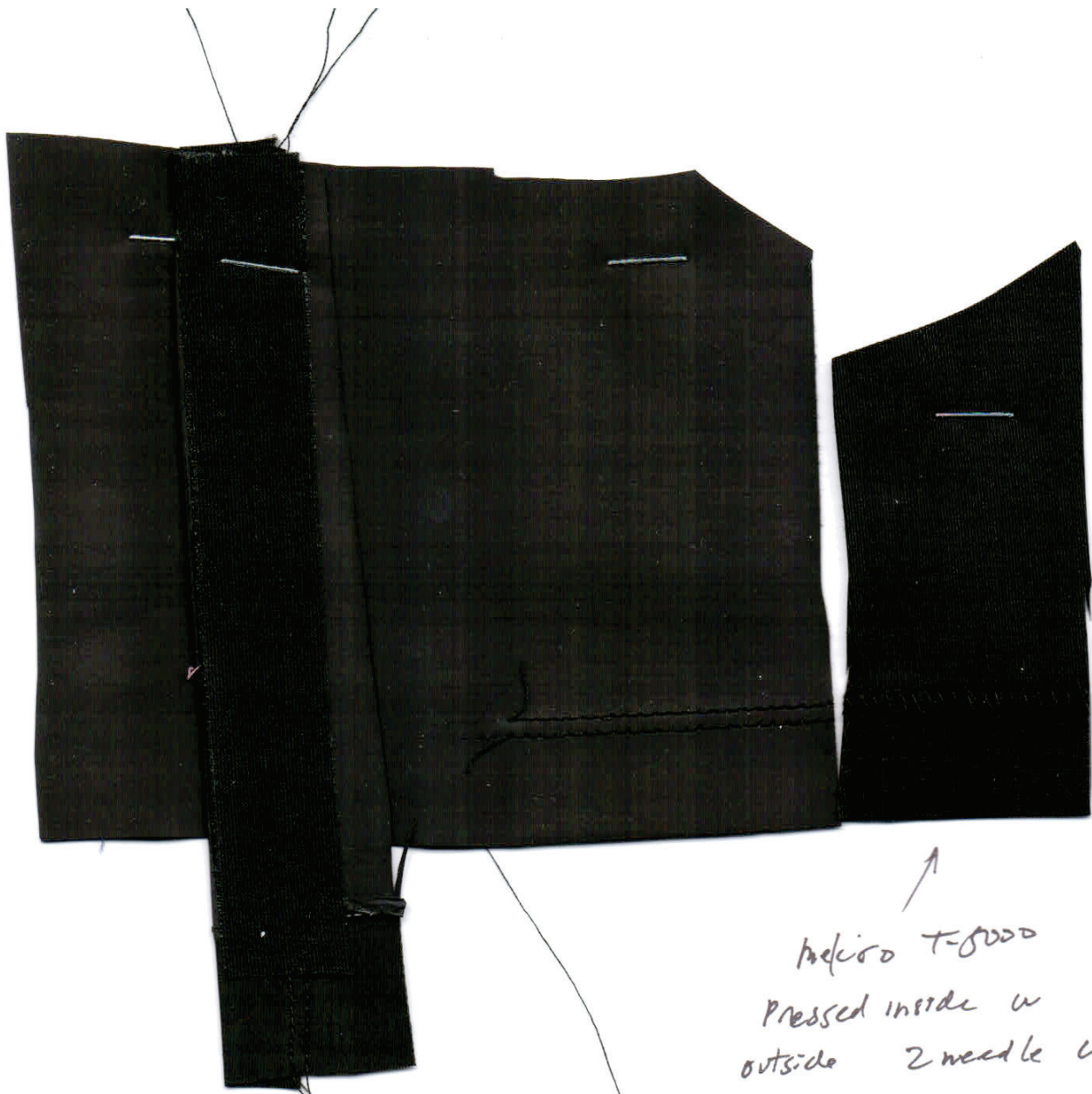


# Fabric Experimentation





# Finish Experimentation



↑ melco T-5000  
Pressed inside w  
outside 2 needle coversitch.

↑ melco Tape outside adhesion



Scuba melco T-5000

narrow wooly nylon

wide Cotton

↑ tent seal seam



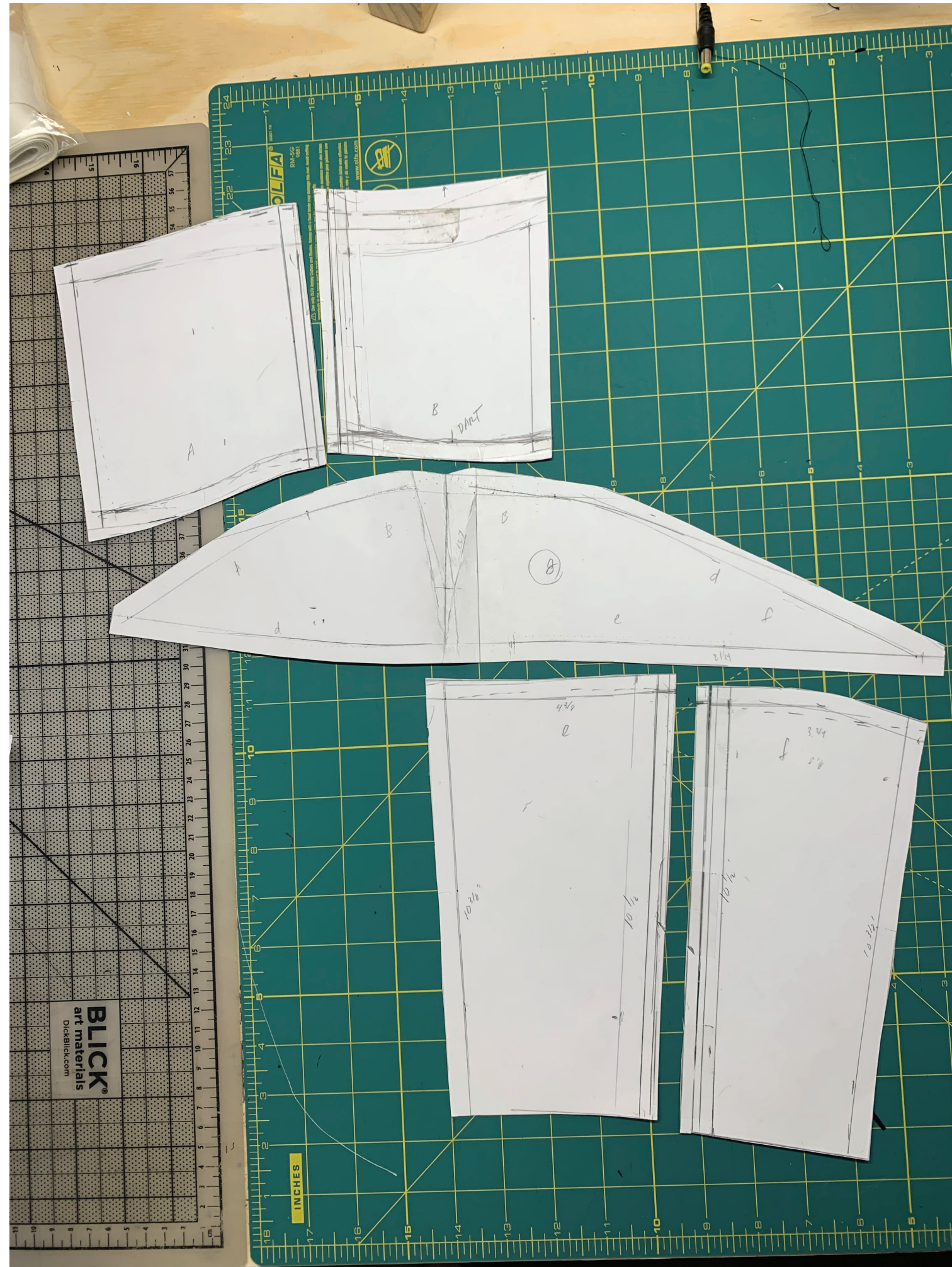
3 thread flat lock variation & test

wide Cotton

narrow wooly nylon



# Pattern Making





# Prototyping





# Finishing Details





# YouTube: Soft Tech RISD

[https://www.youtube.com/channel/  
UC1R14PkbHHb8PCEqFD59\\_yQ](https://www.youtube.com/channel/UC1R14PkbHHb8PCEqFD59_yQ)



# Electroluminescence

## PrintScreen: Fabricating Highly Customizable Thin-film Touch-Displays

Simon Olberding, Michael Wessely, Jürgen Steimle

Max Planck Institute for Informatics and Saarland University  
Campus E1.7, 66123 Saarbrücken, Germany  
{solberdi, mwessely, jsteimle}@mpi-inf.mpg.de

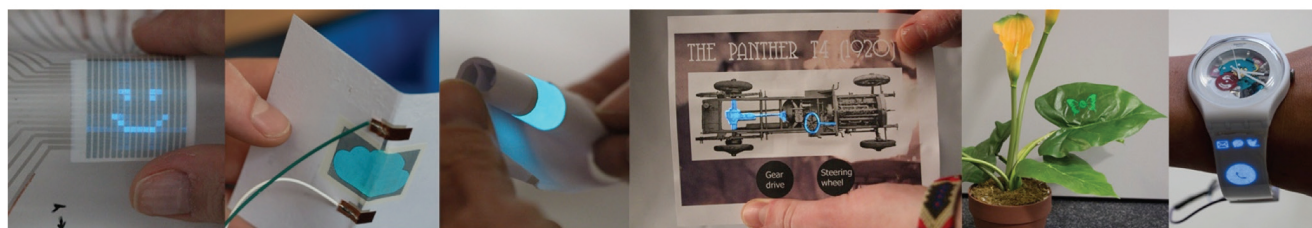


Figure 1. PrintScreen contributes a digital fabrication approach to enable non-experts to print custom flexible displays. They can be fully folded or rolled and enable manifold applications in ubiquitous, mobile and wearable computing.

### ABSTRACT

PrintScreen is an enabling technology for digital fabrication of customized flexible displays using thin-film electroluminescence (TFEL). It enables inexpensive and rapid fabrication of highly customized displays in low volume, in a simple lab environment, print shop or even at home. We show how to print ultra-thin (120  $\mu\text{m}$ ) segmented and passive matrix displays in greyscale or multi-color on a variety of deformable and rigid substrate materials, including PET film, office paper, leather, metal, stone, and wood. The displays have custom, unconventional 2D shapes and can be bent, rolled and folded to create 3D shapes. We contribute a systematic overview of graphical display primitives for customized displays and show how to integrate them with static print and printed electronics. Furthermore, we contribute a sensing framework, which leverages the display itself for touch sensing. To demonstrate the wide applicability of PrintScreen, we present application examples from ubiquitous, mobile and wearable computing.

### Author Keywords

Flexible display; Thin-film display; TFEL; Electroluminescence; Printed electronics; Digital fabrication; Rapid prototyping; Touch input; Ubiquitous Computing.

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### INTRODUCTION

Printed electronics is becoming a powerful and affordable enabling technology for fabricating functional devices and HCI prototypes that have very thin and deformable form factors. For many years already, printing has been a powerful means allowing end-users to produce customized static print products rapidly, inexpensively and in high quality. Recent work has contributed methods for easily printing custom *interactive* components on thin and flexible substrates. While sensing of user *input* has been successfully demonstrated [7, 13], it has not been possible so far to print customized flexible *displays* rapidly and inexpensively. Printing flexible displays, such as OLEDs or Electronic Paper, required a high-end print lab, complex machinery and expert skills, making it prohibitive to fabricate custom displays in low volume.

We present PrintScreen, a versatile platform that enables non-expert users to design and fabricate highly customized flexible interactive displays. The displays are technically based on thin-film electroluminescence (TFEL).

The platform proposes a novel perspective on displays: instead of buying an off-the-shelf display, the designer can create a custom digital design, which meets the specific demands of the application, and then simply print the display. Printing customized flexible displays empowers makers and designers to create customized interactive print products, digital signage, smart objects, personalized computing devices and crafts with embedded display. For HCI researchers and practitioners, this is a powerful enabling technology for mobile, wearable and ubiquitous computing interfaces. It enables rapid and high-fidelity prototyping of functional HCI devices with embedded displays of highly custom shapes, on deformable and on unconventional materials.

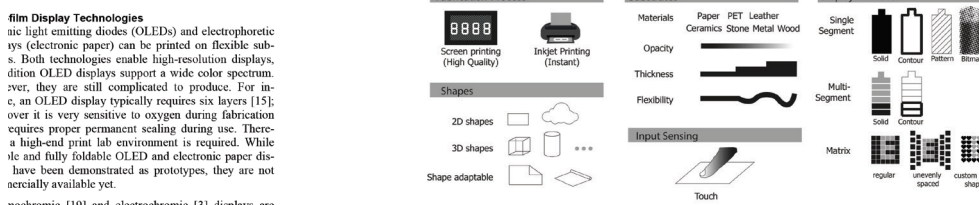


Figure 2. Five-dimensional design of printed displays of customized displays.

form opens up substantially more degrees of freedom in designing custom digital displays for HCI prototypes. **DESIGN SPACE OF CUSTOMIZED DISPLAYS** Custom-made displays open up considerably more degrees of freedom for the design than off-the-shelf displays. We identified five key dimensions for digital fabrication of customized displays, which systematize the design options. This section provides an overview of these dimensions, which form the foundation of the PrintScreen platform. The design space is illustrated in Fig. 2.

**Fabrication Process: How to print** We propose a digital fabrication approach for production of customized displays. The designer generates a digital model of the display and then prints this model. Ideally, printing is as instant and easy as sending a document to an office printer. This would enable prototyping with rapid and many design iterations. We introduce an instant fabrication process based on conductive inkjet printing, which comes close to this use of fabrication. Moreover, we propose a second fabrication approach, which requires screen printing on a beginner's level. While it takes longer to fabricate a display, it is of higher quality and supports the full set of substrate materials, display primitives and sensing modes presented in this paper.

**Substrate Materials: On what to print** Customized displays may be printed on various materials that vary in thickness, flexibility, texture and opacity. PrintScreen supports multiple substrate materials, including highly deformable and foldable office paper, transparent or translucent PET film, leather, wood, ceramics, metal (nickel and metal) and stone. The display adds only 110  $\mu\text{m}$  of thickness to the base substrate.

**Display Primitives: What to print** Customized displays offer a large variety of design options regarding the display elements. In order that regular matrix, which one would intuitively think of, HCI contents are known at design time, segmented and multi-segmented displays are a compelling option. They feature very sharp con-

tours and homogeneous fill, even if printed in large sizes, while nevertheless being easy to control. In addition, we introduce segments that feature an arbitrary bimbo pattern which is defined at design-time. For very dynamic applications, matrix displays are the preferred option. PrintScreen allows for printing conventional matrices in a custom resolution, but adds options for customization by offering non-uniformly spaced matrices and pixels in custom shapes.

**Display Shapes: What form factors are possible** A key question for any application is the size and shape of the display. With off-the-shelf displays, the designer has relatively little choice. Non-rectangular outlines, extreme aspect ratios, curved or 3D shapes are typically not available. However, such non-standard shapes are important to make an embedded display fit within an object or the physical environment. PrintScreen offers the designer a much higher degree of design flexibility. It supports custom 2D outlines, moreover it enables custom 3D shapes, which are created by bending and folding. Moreover, display can be made shape-adaptive and elastic, using bending, folding or rolling, but are not stretchable.

**Integrated Input Sensing: How to interact** User input is a key property of interactive display surfaces. We contribute a generic platform for sensing of user input, which is directly integrated with the display element. As examples we demonstrate touch input.

In the following main part of the paper, we will discuss in more detail the design options for each of these dimensions. **FABRICATION PROCESS** We contribute two approaches to allow non-experts to fabricate customized thin-film electroluminescent displays: a high-quality and an instant process. Both are easy to learn and perform for non-experts and require only off-the-shelf tools and consumables.

**Printed Electroluminescent Displays** Thin-film electroluminescent displays actively emit light. A segment of a TFEL display consists of two overlaid electrodes, which act as a capacitor. Inside the capacitor is a

we create 30 parallel lines per inch, leading to 30 pixels per inch.

Our first design possibilities for matrix displays in two ways: (1) *Unconventional* and (2) *Standard*. The former is the center and lower resolution in the periphery of a display. (2) *Custom-shaped* pixels allow for creating a unique visual appearance of the display, e.g. for digital signage or artistic installations. Both these options come at virtually no extra cost, as it is very easy to modify these parameters in the digital design.

**Translucent Display Segments** To fabricate translucent display segments, the back electrode is printed with translucent conductive ink on the reverse side of a transparent PET film (see Fig. 3b). The film itself acts as the dielectric, eliminating the need for non-transparent dielectric ink. The phosphor and top electrode layers are printed on the front side. The conductor and phosphor ink are translucent, leading to a transparency of 27%, at positions where segments are printed. Note that the display is fully transparent at locations without segments. Fig. 3b shows an application example for a shop window showcase.

**Integration with Static Visual Print** A display can be printed alongside and integrated with static visual print. The designer uses an office laser or inkjet printer to print static visuals onto the paper or PET substrate. Next, display primitives are printed with screen printing onto the static print. This enables the following functionality:

**Advantage** If the display primitive is printed at the reverse side of a slightly translucent substrate (see Fig. 3b), it can glow through static print on the front side and act as a dynamic highlight. The example in Fig. 3c demonstrates a highlight printed on the reverse side of office paper.

**Integration with Printed Electronics** PrintScreen enables integrated display primitives with additional printed electronic applications on a single substrate. The bottom electrode layer can be used for designing additional electronics next to display primitives. Using silver ink for the bottom electrode, users can design printed resistors and components. The principles for silver-ink-printed components from previous work directly transfer to this context, e.g. for printing sensors [7, 9, 13]. Moreover, additional surface-mount components can be soldered onto the substrate.

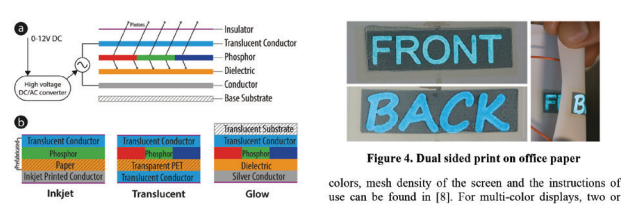


Figure 3. Comparison of the printed layers of an electroluminescent display. Silver conductor (Ag) is used for each additional color. A PET film is used as the dielectric. The phosphor ink is printed on the front side of the display. The conductor and phosphor ink are translucent, leading to a transparency of 27%, at positions where segments are printed. Note that the display is fully transparent at locations without segments. Fig. 3b shows an application example for a shop window showcase.

layer made of phosphor and a dielectric layer. If a high voltage, low current AC signal is applied, the phosphor emits photons (see Fig. 3). TFEL displays are used in many commercial products, e.g., as backlight for car dashboards.

**Digital Design** The designer of the display first creates a digital design in a standard 2D vector graphics editor, such as Adobe Illustrator. Each segment or pixel is created as if it was ordinary vector artwork, using the application's tools for creating lines, polygons, text, fills, etc. Hence, designing an interactive display is pretty much comparable to designing conventional 2D graphics.

For screen printing, the designer generates four adjacent colored copies of the design, one for each print layer (see Fig. 4). If segments and pixels shall be printed in more than two colors, one more layer is added for each additional color. Laying out the copies adjacently allows to create one single print mask that contains all print layers, making screen printing cheaper and faster. For inkjet printing, only one copy is required. Note, the designer lays out the wires that are required for controlling the segments. The phosphor width is 300  $\mu\text{m}$ . On the first copy (bottom electrode), each segment is connected with an individual input pin. For screen printing, all segments on the fourth copy (top electrode) are connected to a shared ground pin. Alternatively, a grid of segments or pixels can be wired as a matrix.

**Screen Printing for High Quality** Interactive displays are printed with off-the-shelf equipment for hobbyists (approx. 200 €). We used a standard manual inkjet screen-printing process [22], which is commonly used for printing on paper and on fabrics and can be easily learned by non-experts. Each layer of the display stack is printed successively, from bottom to top. Details on the inks, available



Figure 4. Application examples. The designer generates four adjacent colored copies of the design, one for each print layer (see Fig. 4). If segments and pixels shall be printed in more than two colors, one more layer is added for each additional color. Laying out the copies adjacently allows to create one single print mask that contains all print layers, making screen printing cheaper and faster. For inkjet printing, only one copy is required. Note, the designer lays out the wires that are required for controlling the segments. The phosphor width is 300  $\mu\text{m}$ . On the first copy (bottom electrode), each segment is connected with an individual input pin. For screen printing, all segments on the fourth copy (top electrode) are connected to a shared ground pin. Alternatively, a grid of segments or pixels can be wired as a matrix.

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of consumables for printing a completely covered A4-sized display is approx. 2 € for the screen mesh and 19 € for the inks. Many applications require segments only on some locations on the substrate, which can further reduce cost quite considerably.

**Conductive Inkjet Printing for Instant Fabrication** The second fabrication process enables instant fabrication, which is important for design iterations in rapid prototyping. No screen print equipment is required. However, it offers fewer design options.

The designer uses a prehabilitated display film (Fig. 5b and Fig. 5). This film contains all printed layers except the bottom electrode. It consists of a sheet of coated paper (Matsuhita N951-342100), which acts as substrate and dielectric. On top of it, a fully filled layer of phosphor (in one color) and a fully filled layer of transparent conductor is printed. This film can be fabricated in bulk using screen printing, as describe above; in the future a paper manufacturer could make it commercially available for purchase.

The designer uses conductive inkjet printing [14] to print the digital design (inks the bottom electrode layer) on the reverse side of the prehabilitated display film. We use an off-the-shelf, consumer-grade inkjet printer (Canon IP-100) with Matsuhita N951-342100 ink. Finally, to seal the bottom electrodes, insulating spray is applied, or a thin layer of dielectric (e.g. office paper) is glued or laminated onto the reverse side of the display.

The number of output pins of the internal microcontroller restricts our controller to up to 40 separate segments or a 20x20 matrix with passive matrix time-division multiplexing. However, the number of segments or pixels can be substantially increased by using multiplexers to increase the number of pins of a flat-board cable (e.g. IBM Electrically Conductive Adhesive Transfer Tape 9703 can be used).

The TFEL-specific glowing effect in passive matrix displays can be significantly reduced by using a slightly modified controller design [11], thus further increasing the contrast of the matrix. To minimize the display with the controller, we solder copper wires onto printed pin areas. For a large number of pins, a flat-board cable (e.g. IBM Electrically Conductive Adhesive Transfer Tape 9703 can be used).

Despite high voltages, the approach is safe and energy efficient because of a variety of materials. Our screen printing process allows for printing the display right onto the substrate material, integrating it fully with the object and making additional circuit materials and lamination obsolete.

We successfully printed displays on a wide variety of materials (see Fig. 6). Among them were office paper, PET, leather, ceramics, marble, stone and untreated wood. Figure 6 shows that the surface structure, contours and color variations are well reproduced.

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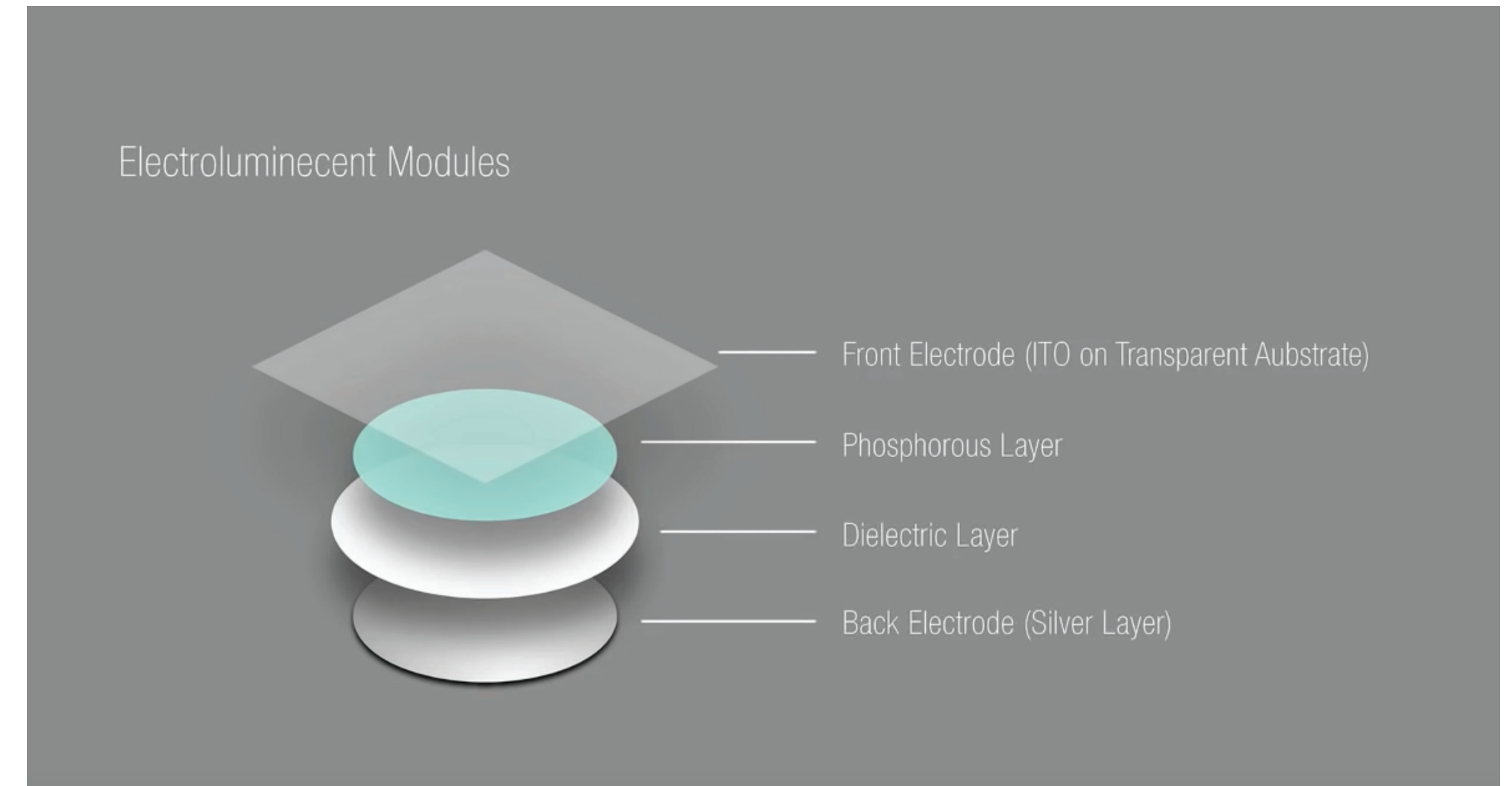
Simon Olberding, Michael Wessely, Jürgen Steimle

Max Planck Institute for Informatics and Saarland University



The slide features three logos at the bottom: the MPII logo (max planck institut informatik), the logo of the University of Saarland (UNIVERSITÄT DES SAARLANDES), and the ACM UIST logo (University of Illinois at Urbana-Champaign).

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