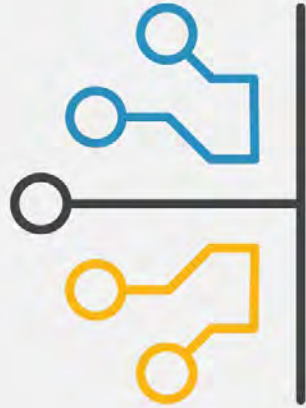


Welcome to



**EMERGING
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EXPO[®]

Workshop

Crafting Biomaterials for Interactive Interfaces

PhD Candidate Eldy Lazaro

eldylazaro@colorado.edu
@sust_ainable

Sep. 2024

ATLAS

 University of Colorado
Boulder

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What are biomaterials?

Bio-based:

derived or sourced from renewable biological matter, including plants, animals, bacteria, fungi, and other life forms.

Biodegradable:

naturally* break down into biomass and carbon dioxide within a timeframe of weeks to months, usually without leaving toxic residues.

*Some biomaterials may require specific environmental conditions for effective degradation.

Compostable:

break down into organic matter in a composting environment, ideally without the need for industrial facilities.

Facilitator: Eldy Lázaro



Schedule

- 9:00 Introduction & Overview
- 9:05 Hands-on: Making bioplastics and biofoams
- 9:45 Short break, clean up
- 9:50 Loom Making with Bioplastics
- 10:10 Demo: Interactive Bioplastic Loom
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Hands-on: Making bioplastics and *biofoams

Materials

Agar-agar

Glycerin

Water

*Liquid soap

Add-ons:

Food dye

Sensitive pigments

Tools

Petri dishes

Non-stick mat

Stirring sticks

Microwave

Cups

Syringes

Microwave

Electric Kettle

Scale

*Milk frother handheld

Facilitator: Eldy Lázaro

An underwater photograph showing a dense cluster of brown seaweed or kelp against a background of clear, rippling blue water. The seaweed has a textured, leafy appearance. The lighting is bright, creating highlights on the water's surface and the seaweed's fronds.

Agar-agar (biopolymer)

Agar is a jelly-like material made of polysaccharides biopolymer that are extracted from cell walls of some red algae species [1].

It is commonly used as a food gelling agent or thickening, and a vegan substitute for gelatin.

[1] <https://en.wikipedia.org/wiki/Agar>

Agar – Bioplastic

*Recipe adapted from open-source bioplastic recipes**



**learn more*



Ingredients

- 1g agar
- 0.5mL glycerin
- Optionally:
 - 0.25mL for more brittleness
 - 0.75mL for more flexibility
- 25mL water

Add on

- 2 drops of food dye
- 0.25g (0.01oz) thermochromic or photochromic powder

Instructions

- **Prepare Syringes:** Fill with glycerin and water.
- **Weigh Agar:** Use the scale.
- **Mix:** Combine agar, glycerin, and hot water in a cup. Stir until well combined.
- **Optional:** Add food coloring or thermo/photochromic powders.
- **Heat:** Microwave for 10 seconds. Remove, stir, and repeat this heating and stirring process 3 times
- **Pour:** Carefully pour the mixture to a petri dish in a single stream.
- **Dry:** Leave uncovered at room temperature or use a dehydrator on low.
 - Drying may take 3-4 days.
 - Peel off when it feels at room temperature to the touch; if cold, it's not dry yet.

Agar – Biofoam

*Recipe adapted from open-source bioplastic recipes**



**learn more*



Ingredients

- 1g agar
- 0.75mL glycerin
- Optionally:
1mL for a bit more flexibility
- 25mL water
- 2-3 drops liquid soap

Add on

- 2 drops of food dye
- 0.25g (0.01oz) thermochromic or photochromic powder

Instructions

- **Prepare Syringes:** Fill with glycerin and water.
- **Weigh Agar:** Use the scale.
- **Mix:** Combine agar, glycerin, and hot water in a cup. Stir until well combined.
- **Optional:** Add food coloring or thermo/photochromic powders.
- **Heat:** Microwave for 10 seconds. Remove, stir, and repeat this heating and stirring process 3 times
- **Foam:** Add liquid soap and whisk using a milk frother handheld or electric whisk
- **Pour:** Carefully pour the mixture to a petri dish in a single stream.
- **Dry:** Leave uncovered at room temperature or use a dehydrator on low.
 - Drying may take 3-4 days.
 - Peel off when it feels at room temperature to the touch; if cold, it's not dry yet.

Gelatin-based Foam – Biofoam

Recipe from: Eldy Lazaro, Netta Ofer, Shanel Wu, Mary West, Mirela Alistar, Laura Devendorf



learn more



Ingredients

- 24g Gelatin
- 24g Glycerin
- 10g Liquid soap
- 300 ml Water

Optional

- food dye, natural pigments, thermochromic or photochromic powders

Tools

- Electric or hand whisk

Instructions

1. Combine gelatin, and water
2. Heat on a stovetop and stir until the mixture has a honey-like consistency
3. Add the glycerin and liquid soap
4. Optionally mix in food dye, natural pigment, or thermo/photochromic powders.
5. Turn off the stovetop and whisk until achieved a foamy mixture
6. Pour the mixture onto a mold or clean, flat, heat resistant surface.
7. Optionally use a syringe or piping bag to extrude biofoam strings ([see tutorial](#))
8. Dry at room temperature
9. Remove the biofoam sample off of the mold or surface for use



Hands-on: step by step through documentation camera

(Streamed live)

Facilitator: Eldy Lázaro



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Loom Making with Bioplastics

Materials

Bioplastic Loom

Bioplastic strips

Weaving Instructions copy



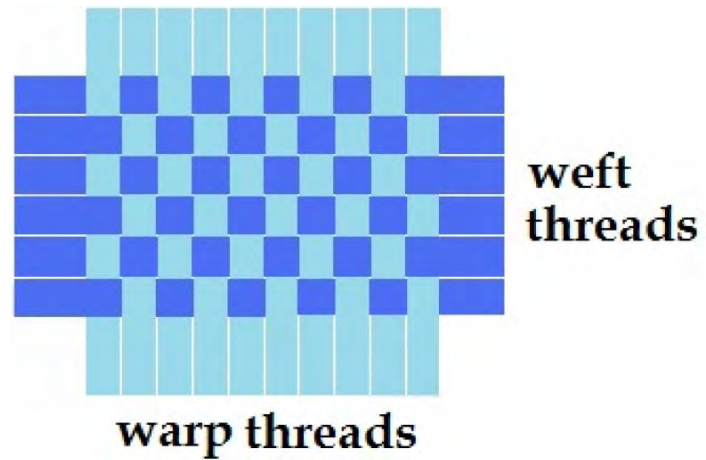
Demo: step by step through documentation camera

(Streamed live)

Facilitator: Eldy Lázaro



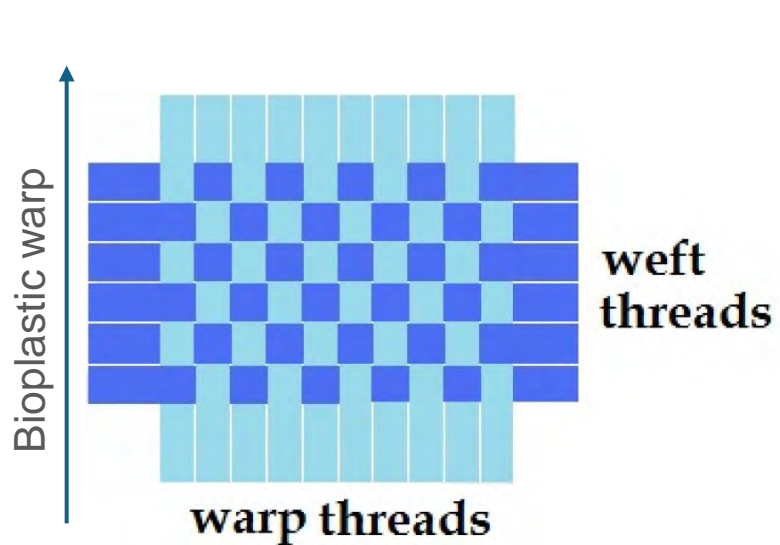
Loom Making with Bioplastics



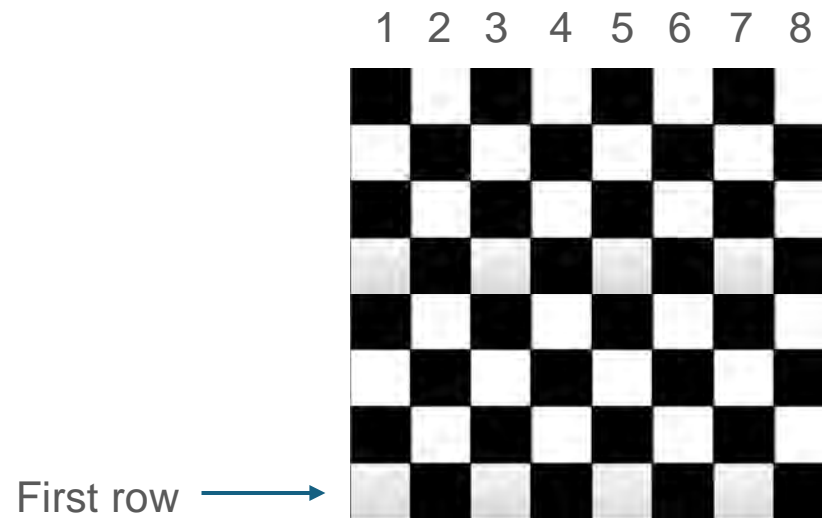
<https://www.trc-leiden.nl/trc-needles/techniques/weaving/tabby-weave>

Facilitator: Eldy Lázaro

Loom Making with Bioplastics



<https://www.trc-leiden.nl/trc-needles/techniques/weaving/tabby-weave>



Plain or Tabby Weave

- Lift warp (insert weft)
- Lower warp

Facilitator: Eldy Lázaro

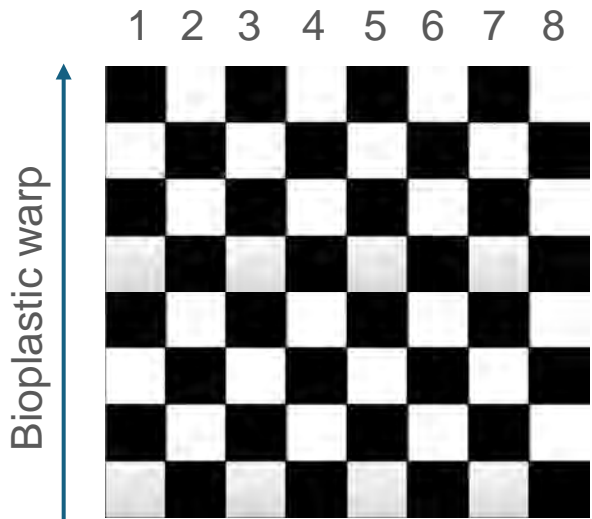
Demo: step by step through documentation camera

(Streamed live)

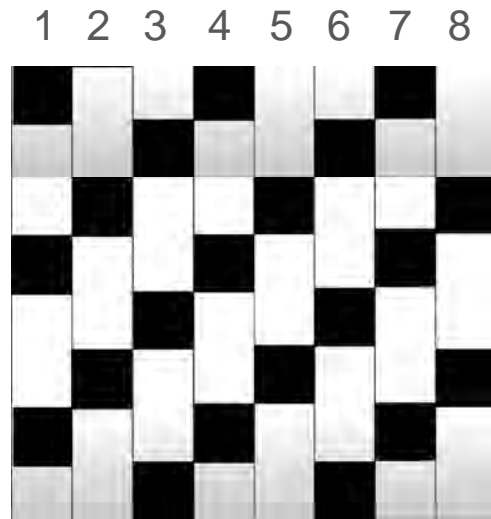
Facilitator: Eldy Lázaro





Loom Making with Bioplastics

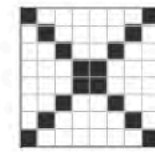


Plain or Tabby Weave



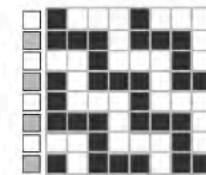
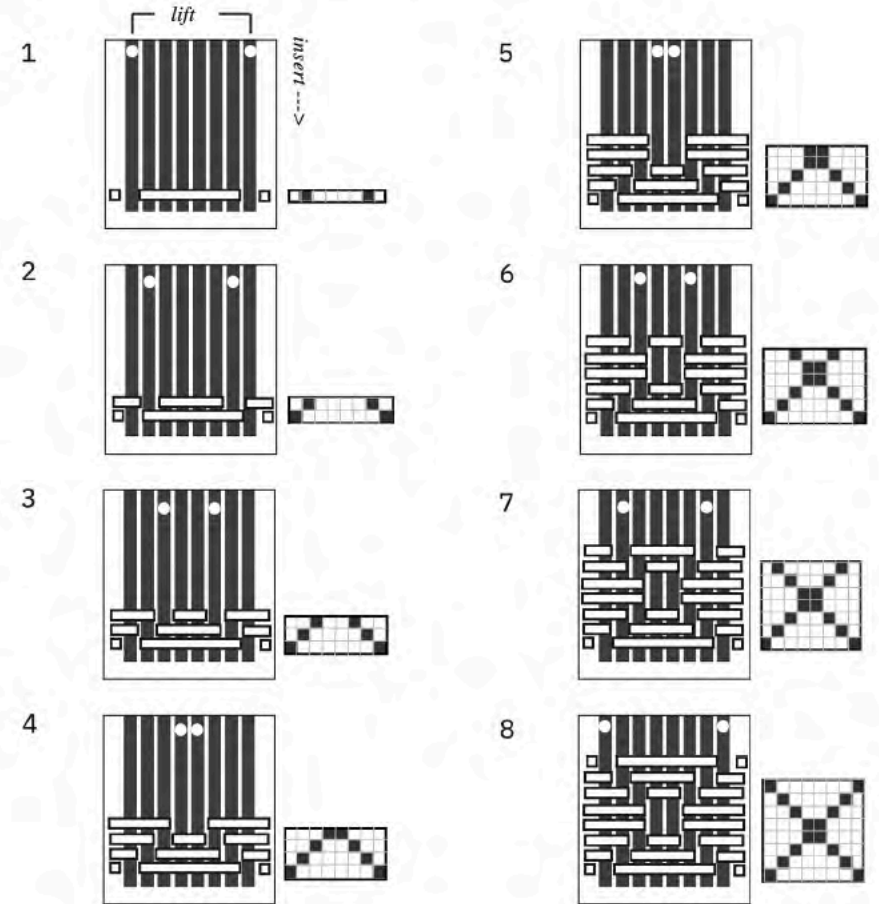
Twill Weave

-  Lift warp (insert weft)
-  Lower warp



TRY THIS.

Cut out the paper loom on the left and we'll weave a draft together. Lift the black warps and insert the wefts as indicated below



TRY THIS NEXT

Weave this draft to make two layers at once. Using alternating colors in the weft can help you understand how it works

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Demo: Interactive Bioplastic Loom

(Streamed live)

Facilitator: Eldy Lázaro



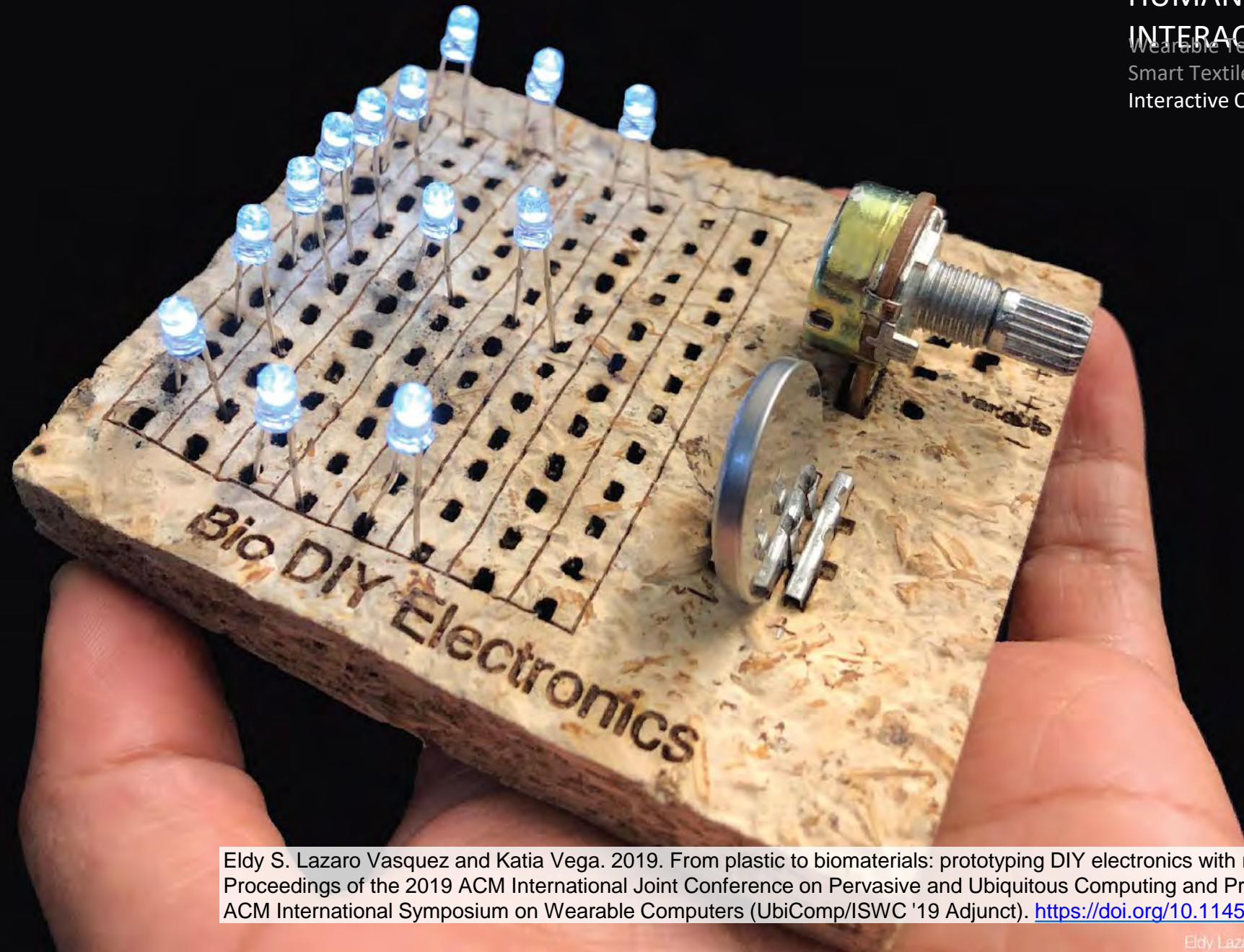
Biomaterials for Interactive Interfaces

HUMAN-COMPUTER INTERACTION (HCI)

Wearable Technology

Smart Textiles

Interactive Objects

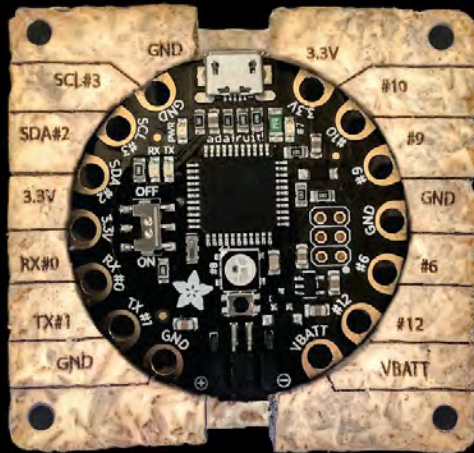


Myco-electronics

Eldy S. Lazaro Vasquez and Katia Vega. 2019. From plastic to biomaterials: prototyping DIY electronics with mycelium. In Adjunct Proceedings of the 2019 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2019 ACM International Symposium on Wearable Computers (UbiComp/ISWC '19 Adjunct). <https://doi.org/10.1145/3341162.3343808>

HUMAN-COMPUTER INTERACTION (HCI)

Wearable Technology
Smart Textiles
Interactive Objects



Myco-electronics

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HUMAN-COMPUTER INTERACTION (HCI)

Wearable Technology

Smart Textiles

Interactive Objects

HUMAN-COMPUTER INTERACTION (HCI)

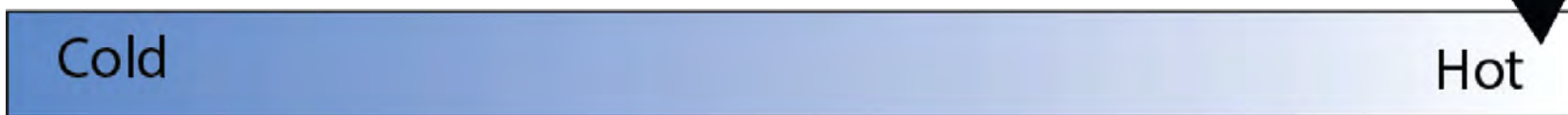
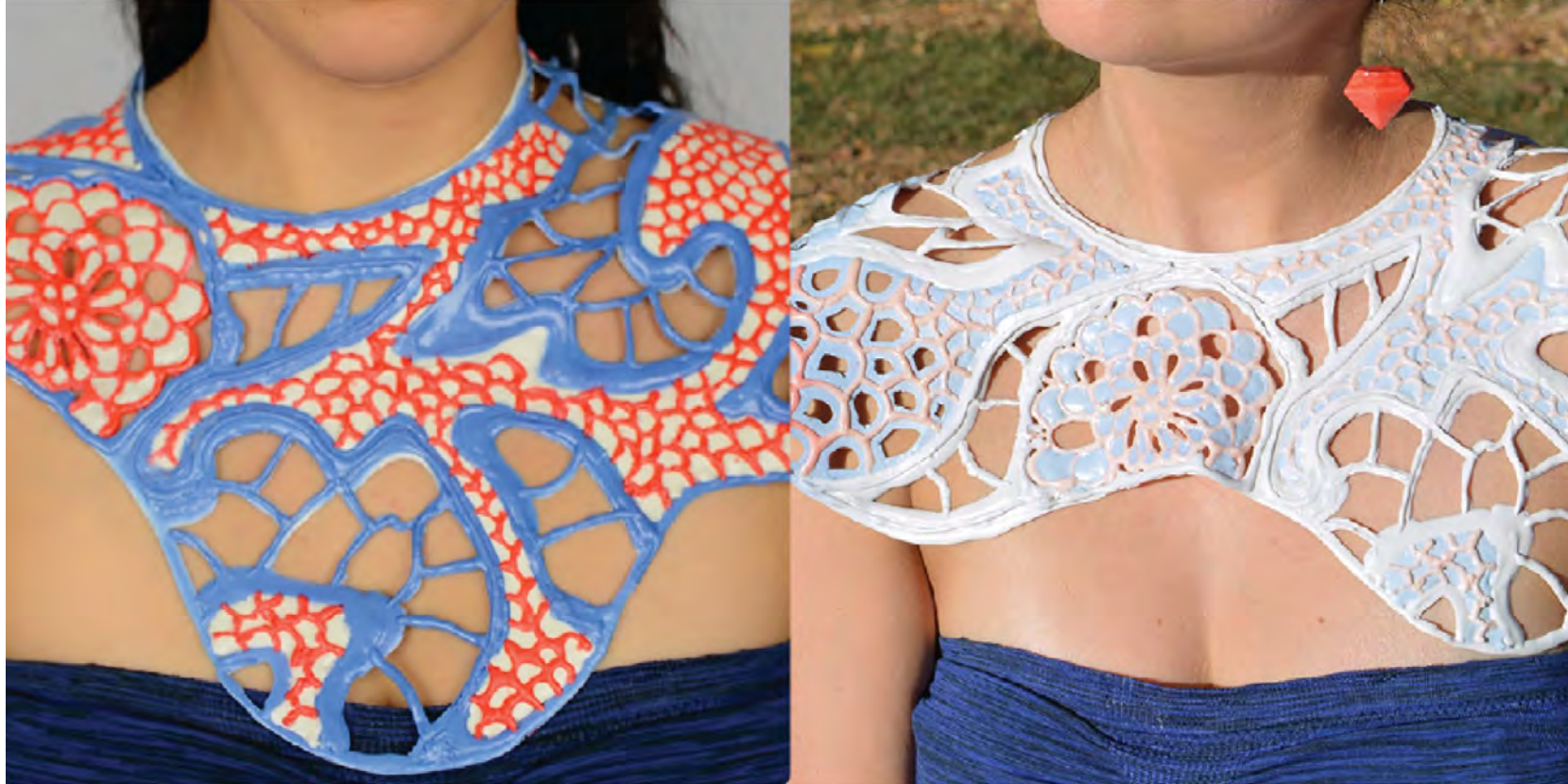
Wearable Technology

Smart Textiles

Interactive Objects

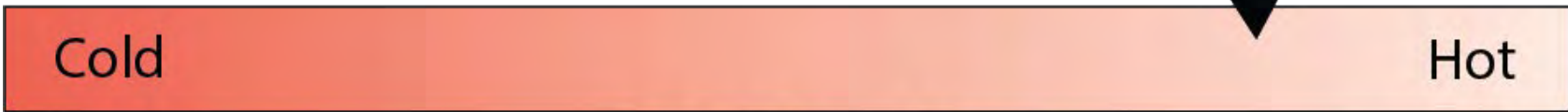
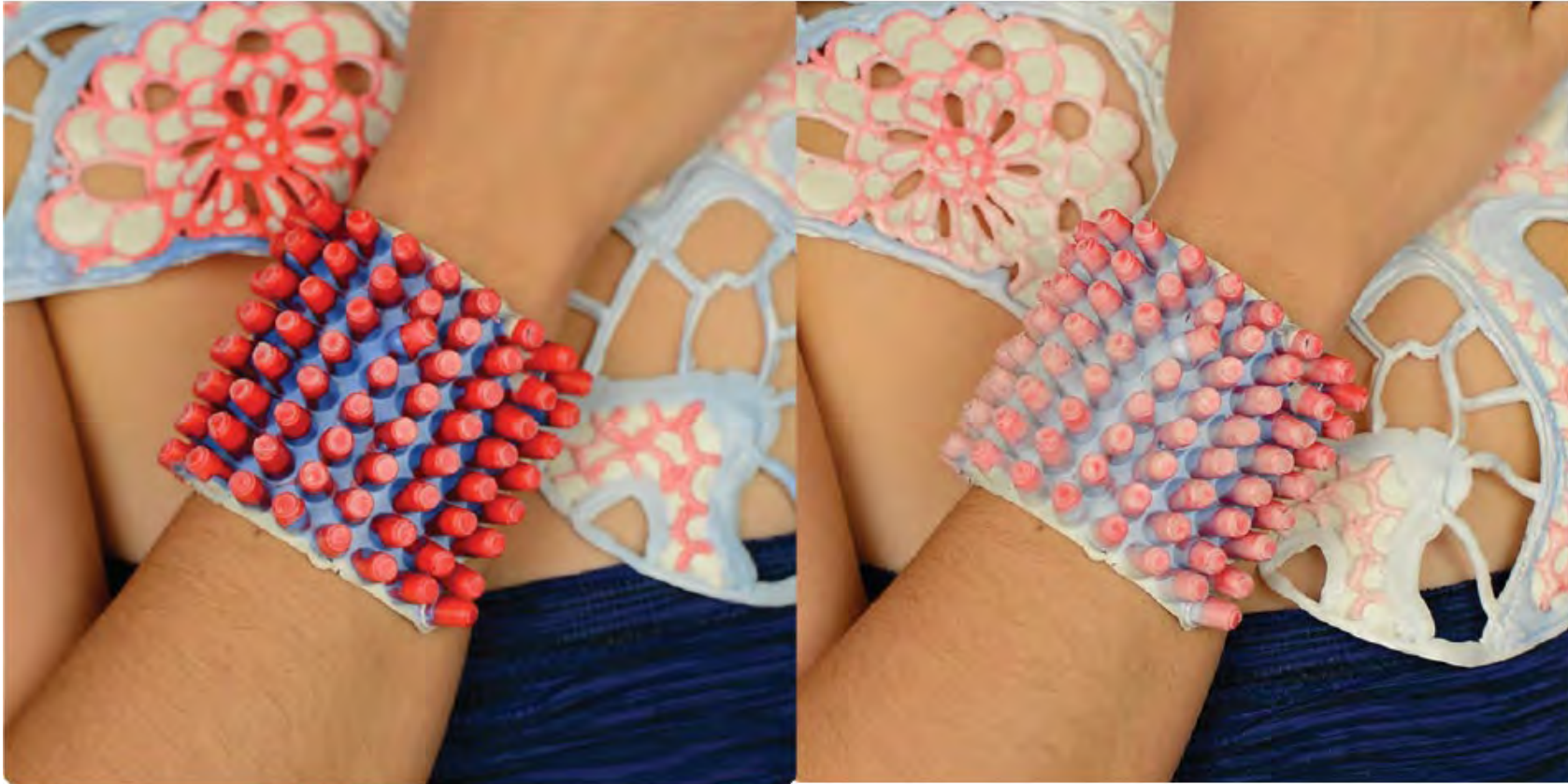
Chameleon accessories

Exploring Biofoam as a Material for Tangible Interaction. In Proceedings of the 2022 ACM Designing Interactive Systems Conference (DIS '22). Association for Computing Machinery, New York, NY, USA, 1525–1539. <https://doi.org/10.1145/3532106.3533494>



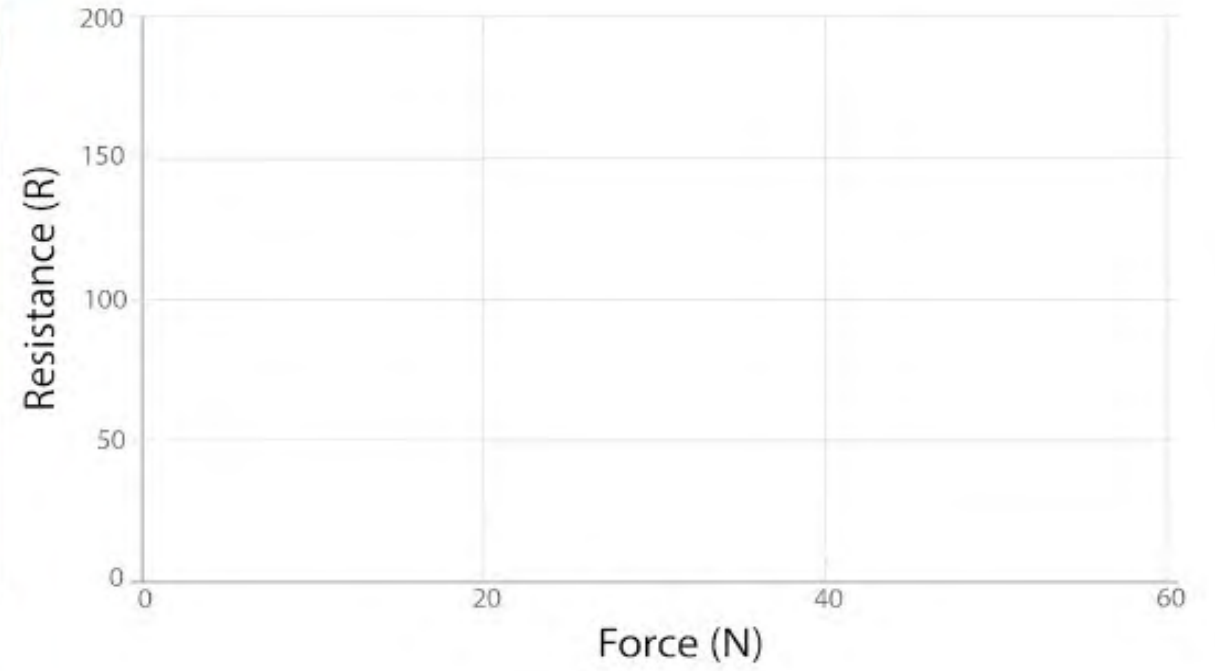
Heat Sensitive

Chameleon accessories



Heat Sensitive

Chameleon accessories



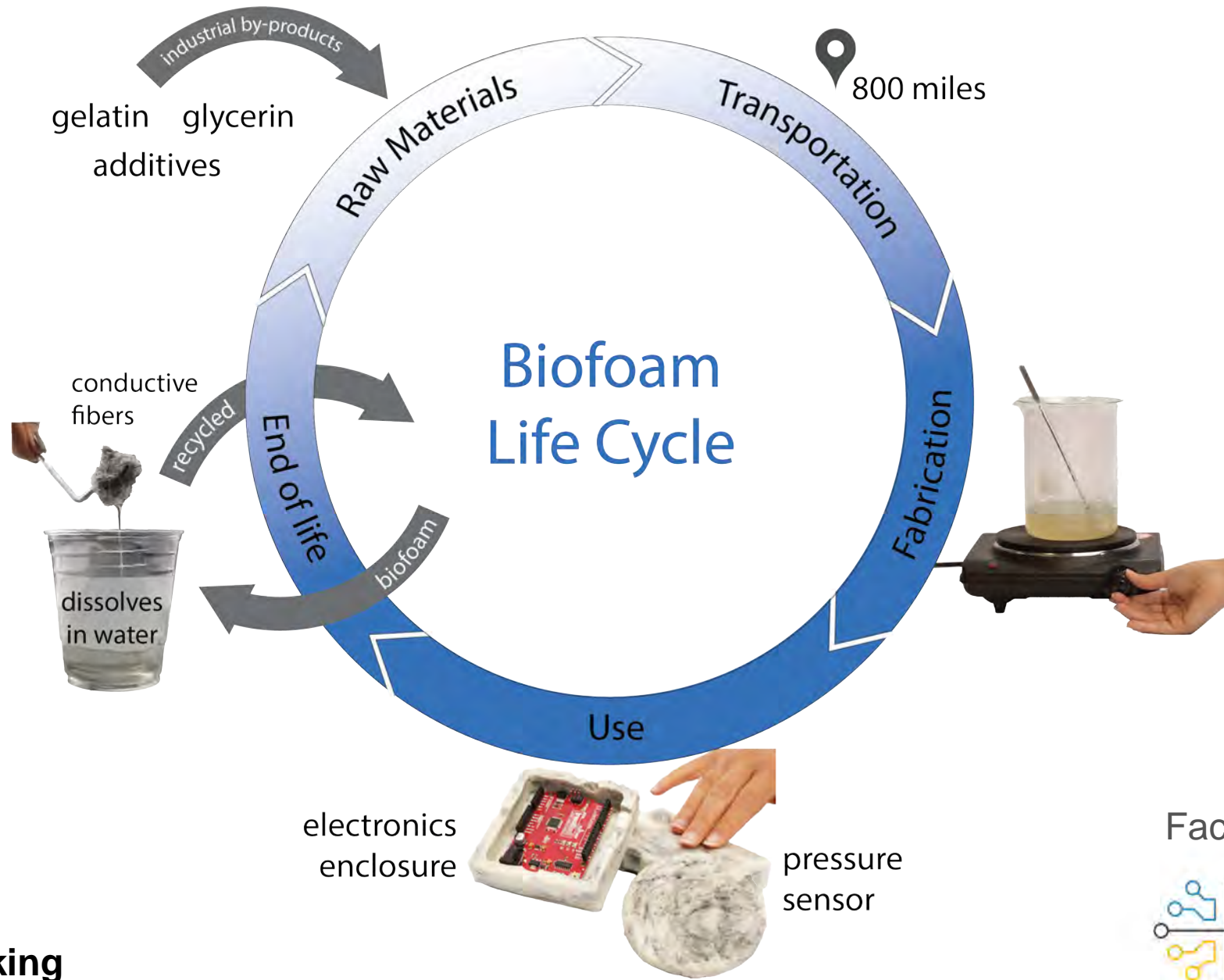
Smart biofoam



At the end of life, biofoam can also be dissolved in warm water



The conductive fibers can be recovered with a magnet



Lifecycle thinking

Facilitator: Eldy Lázaro

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HUMAN-COMPUTER INTERACTION (HCI)

Wearable Technology
Smart Textiles
Interactive Objects



Designing Dissolving Wearables

Lazaro Vasquez, E. S., Gabriel, L. M., Friske, M., Wu, S., De Koninck, S., Devendorf, L., & Alistar, M. (2023). Designing Dissolving Wearables. Adjunct Proceedings of the 2023 ACM International Joint Conference on Pervasive and Ubiquitous Computing & the 2023 ACM International Symposium on Wearable Computing, 286–290.

<https://doi.org/10.1145/3594739.3610781>

Biofoam yarns





Figure 4: "Unfolding Lace Top" swatch to test the unfolding stitch structure. a. before, and b. after dissolving the swatch in cold water.



Dissolving Wearables

HUMAN-COMPUTER INTERACTION (HCI)

Wearable Technology

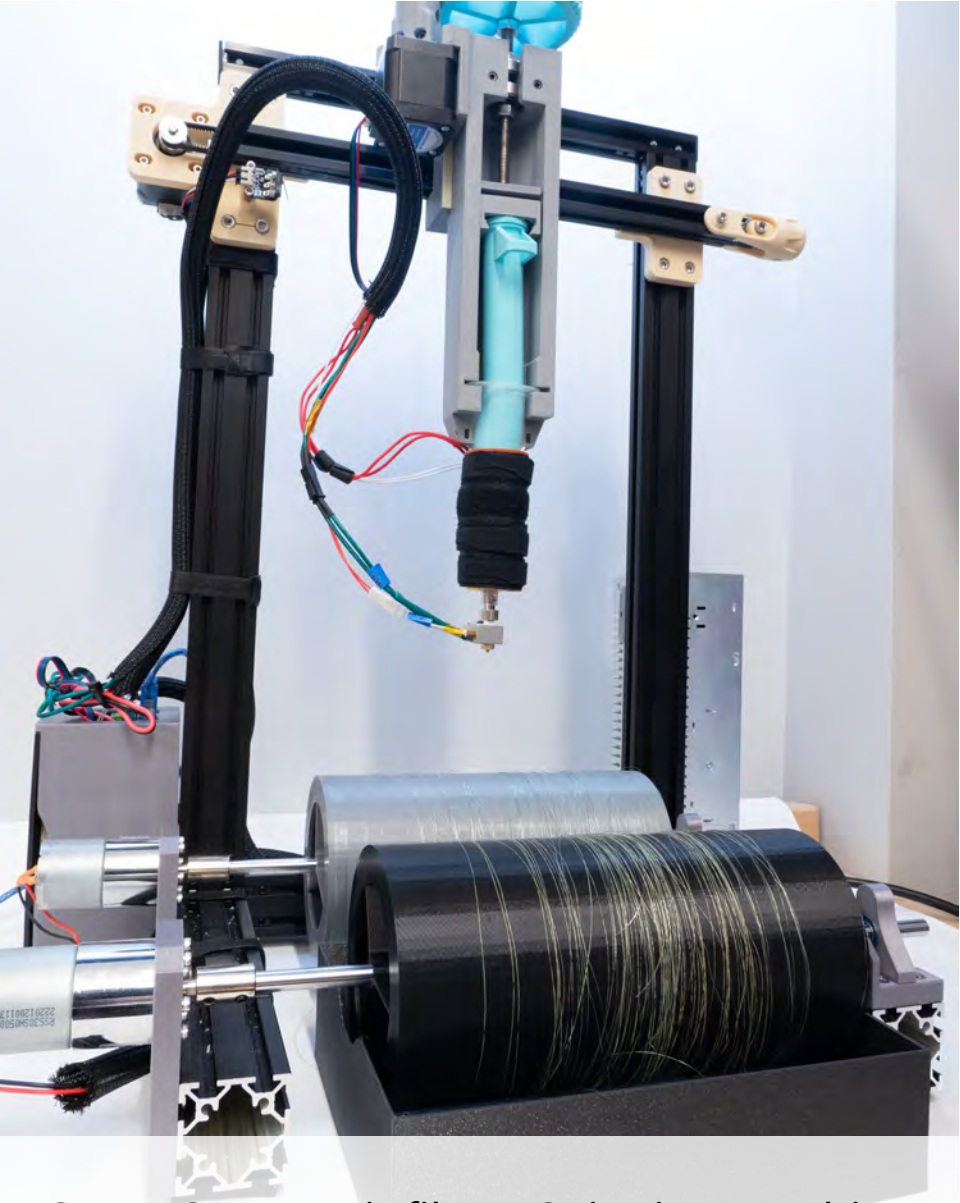
Smart Textiles

Interactive Objects

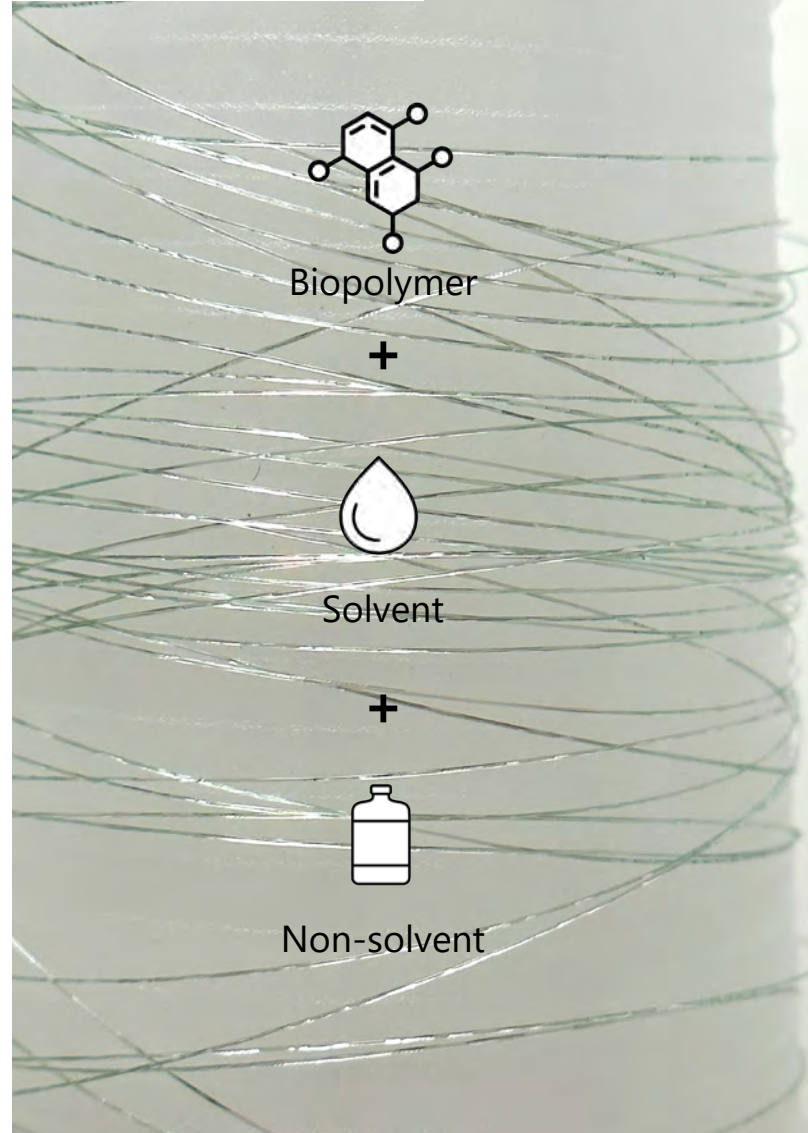
BioFibers Machine

Eldy S. Lazaro Vasquez, Mirela Alistar, Laura Devendorf, and Michael L. Rivera. 2024. Desktop Biofibers Spinning: An Open-Source Machine for Exploring Biobased Fibers and Their Application Towards Sustainable Smart Textile Design. In Proceedings of the CHI Conference on Human Factors in Computing Systems (CHI '24). <https://doi.org/10.1145/3613904.3642387>

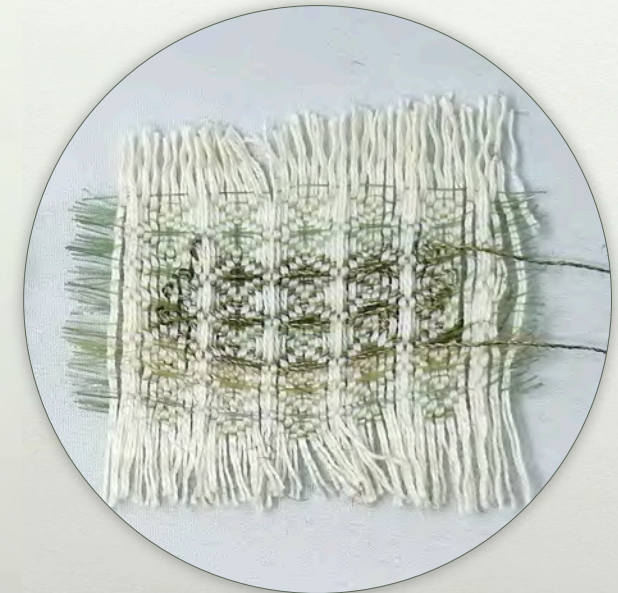
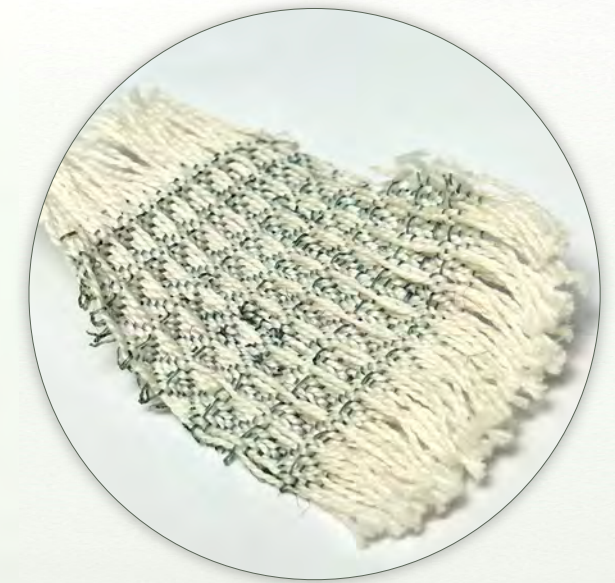
Our Approach to Sustainable Smart Textiles



Open-Source Biofibers Spinning Machine

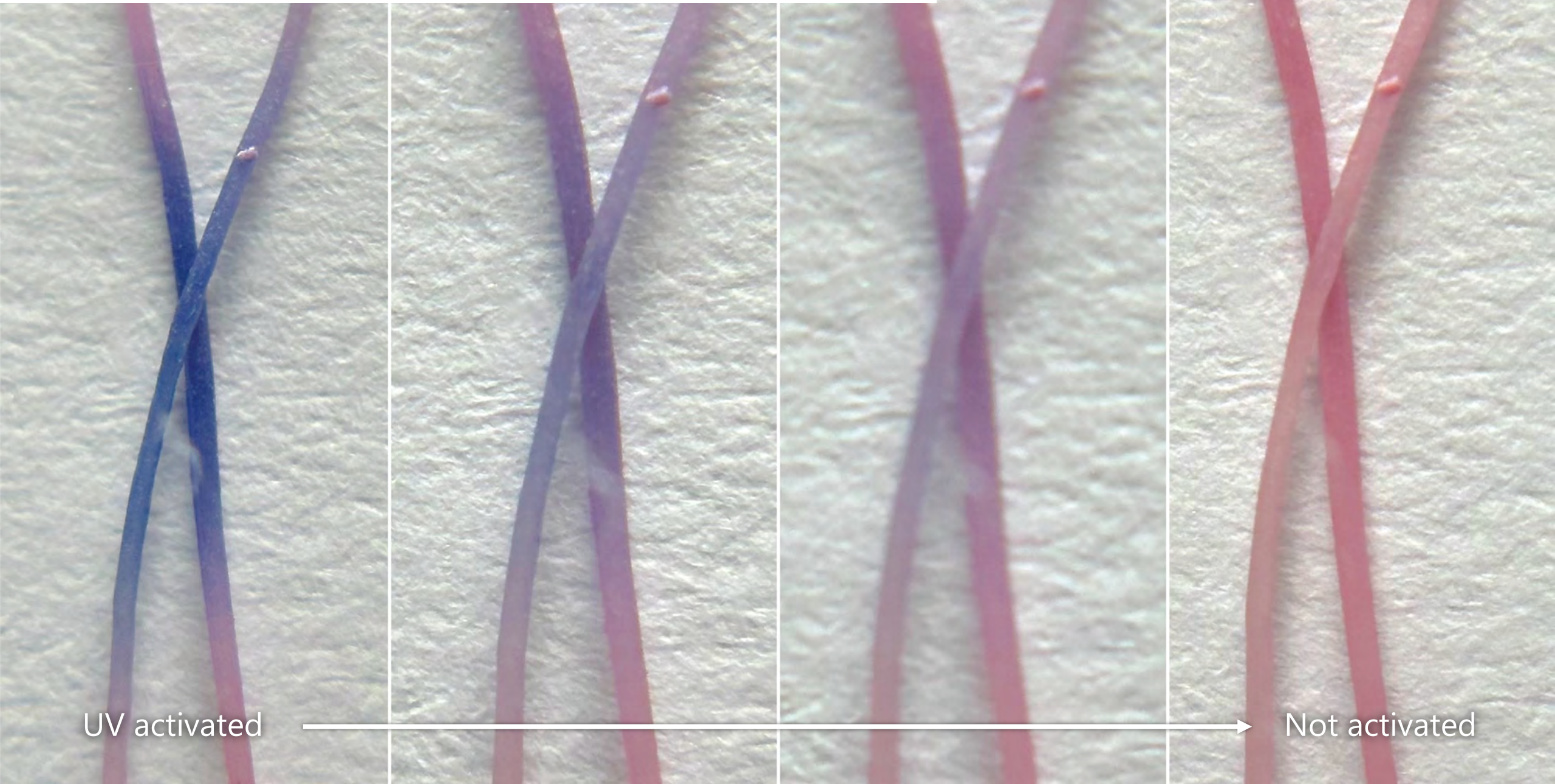


Gelatin Spinning Solutions
and Biofibers Customization



Smart Textile Applications

Photosensitive gelatin biofibers through coating



UV activated

Not activated

The biofibers diameter correlates with extrusion rate and collector speed

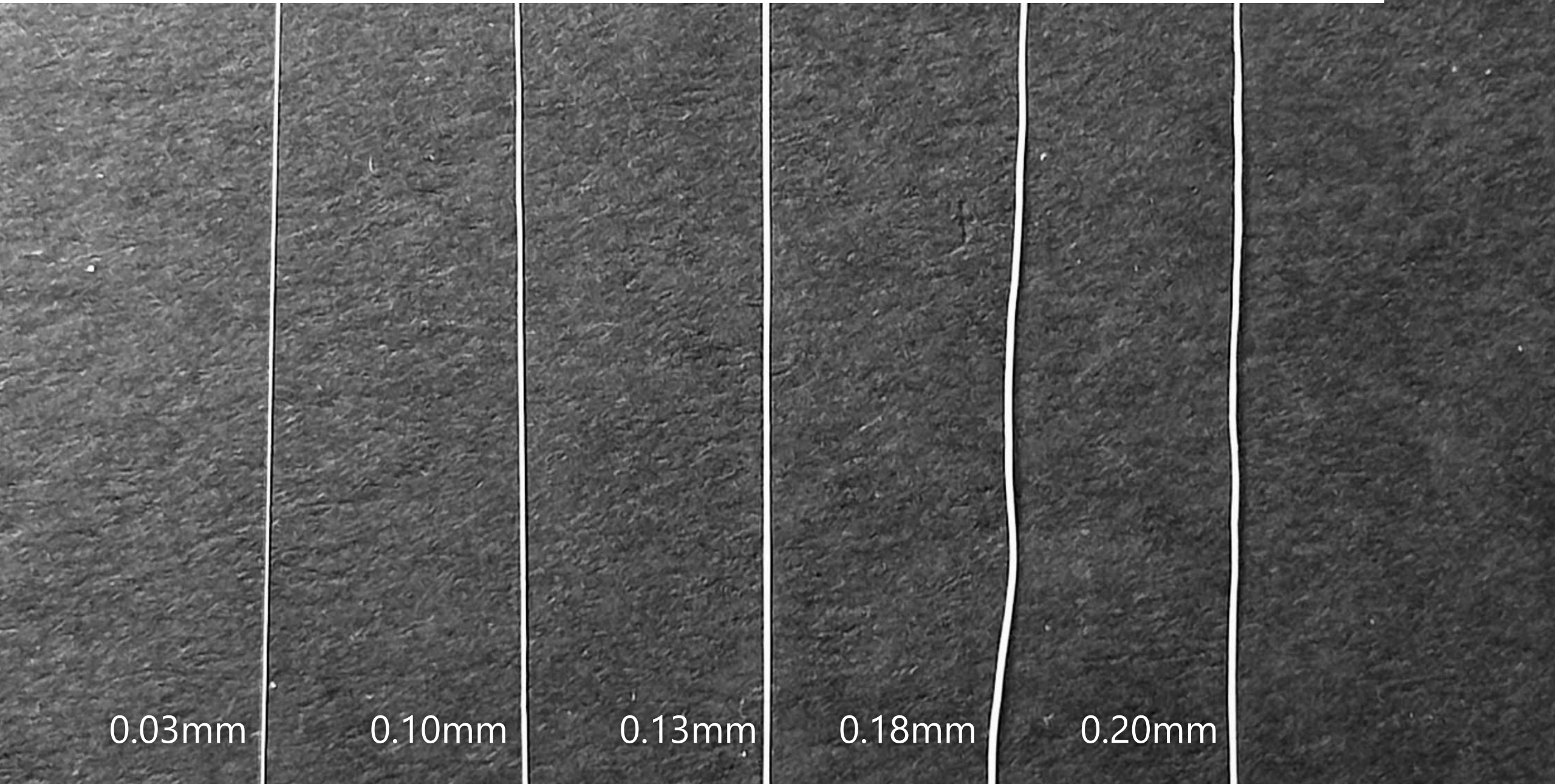
0.03mm

0.10mm

0.13mm

0.18mm

0.20mm



Single-use woven sensors

Cotton threads

Conductive threads

Gelatin biofibers



Moisture sensor

Pressure sensor

Dissolving for recycling and reharvesting



Woven moisture sensor

Dissolving for recycling and reharvesting



Dissolving for recycling and reharvesting



Silver threads

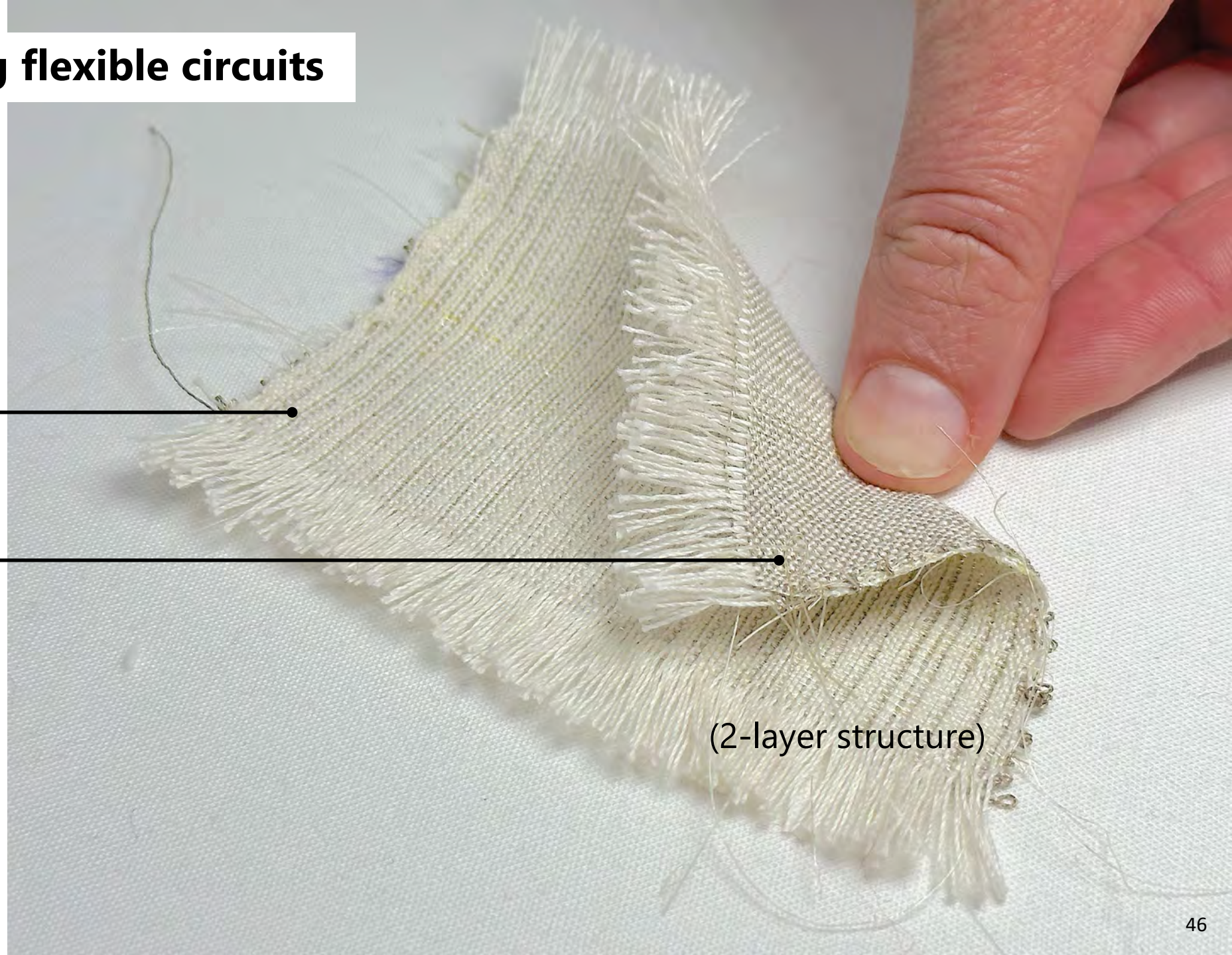


Cotton threads

Dissolving for etching flexible circuits

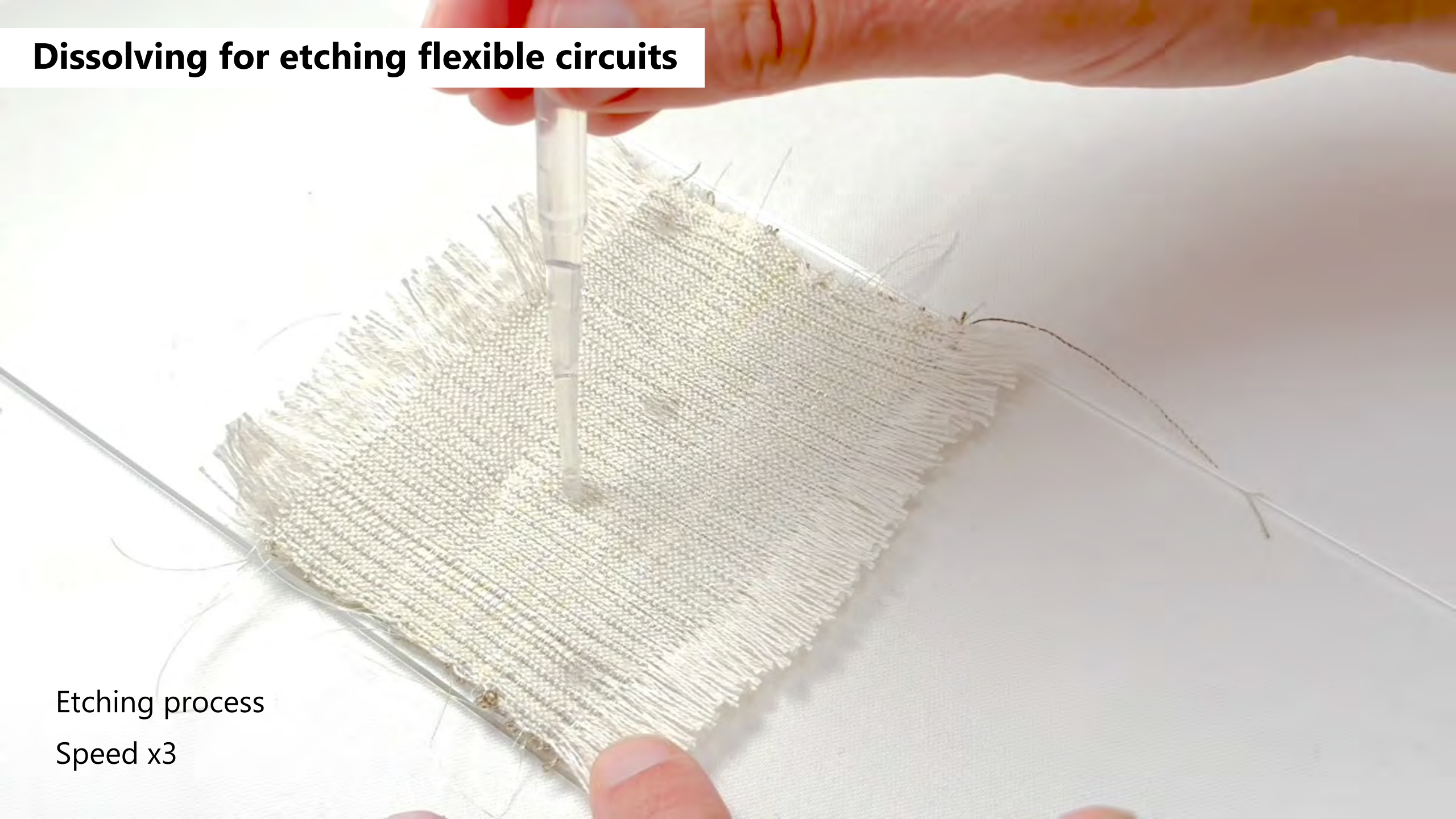
Biofibers
(top layer-weft)

Silver thread
(bottom layer-weft)



(2-layer structure)

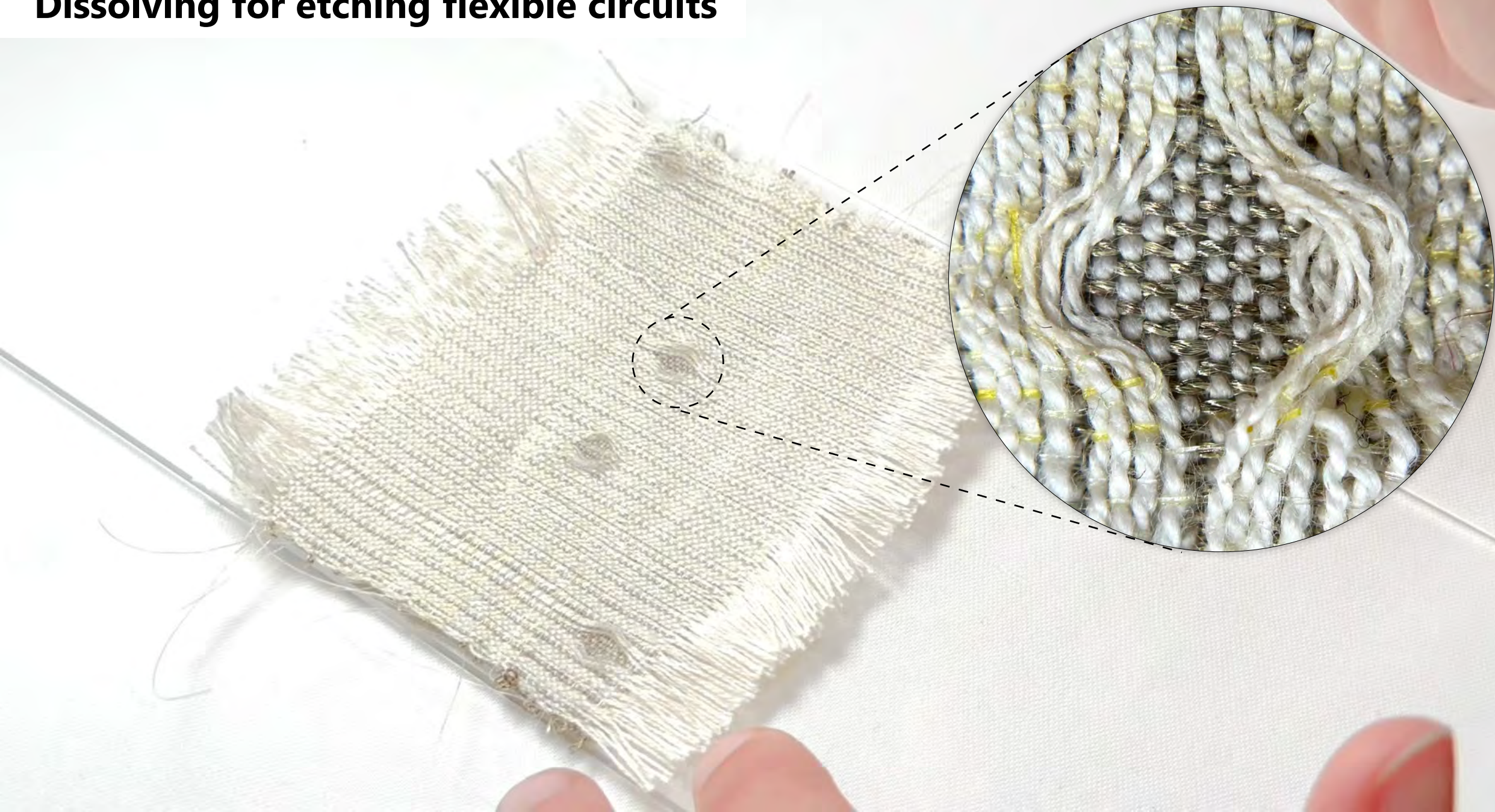
Dissolving for etching flexible circuits



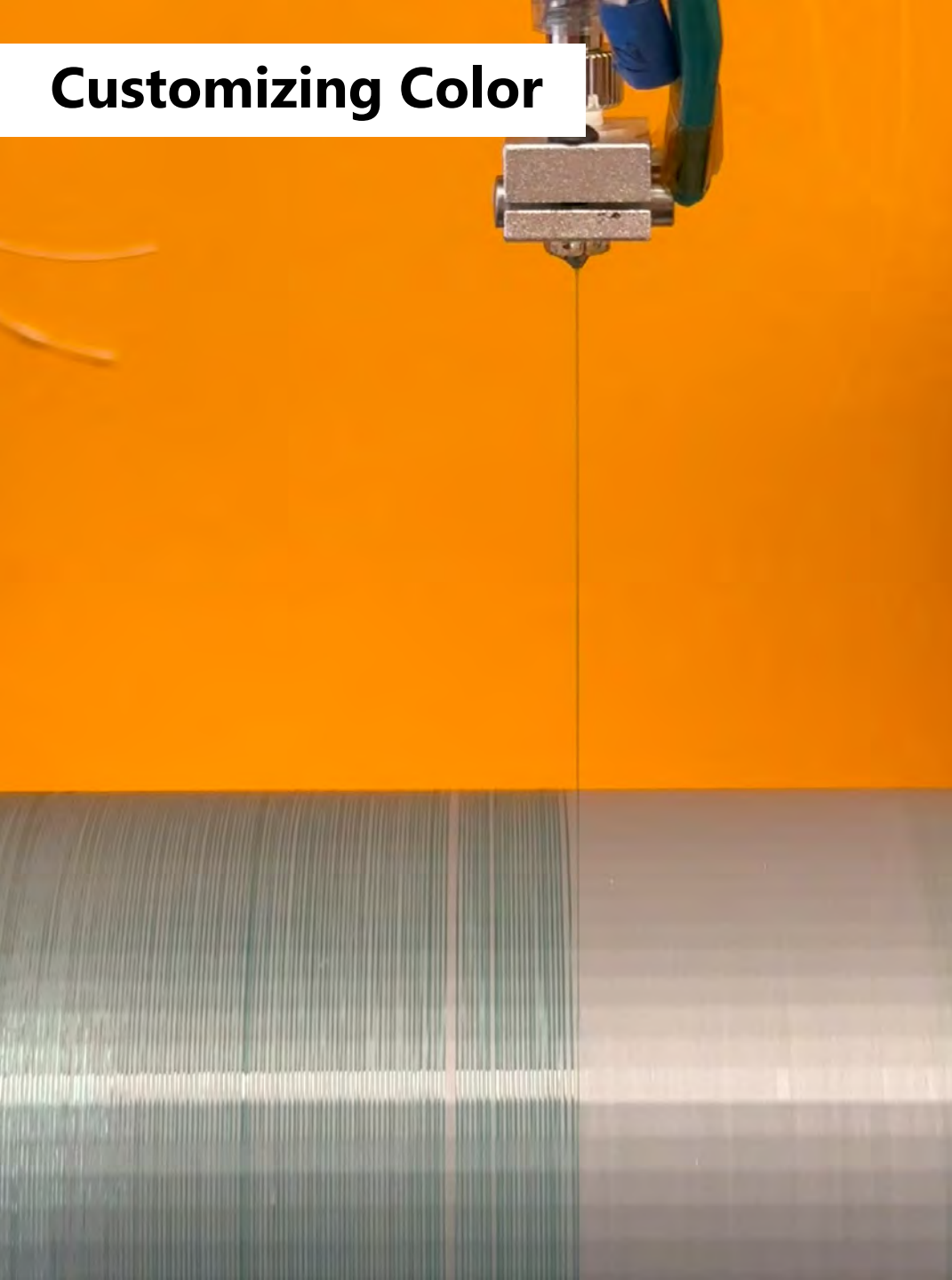
Etching process

Speed x3

Dissolving for etching flexible circuits



Customizing Color



Facilitator: Eldy Lázaro



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Group discussion: biomaterials use in Smart Textiles

How do you see these materials being used in smart textiles?

What other design opportunities can you imagine?

What challenges do you foresee in integrating biomaterials into smart textiles?

Facilitator: Eldy Lázaro



Thank you!

Questions?

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Sep. 2024

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Video: Stefan Hermann from @CNCKitchen

Material formulation advice: Philipp R. Stoessel and Carson Bruns

Machine's interface development: Xin Wen

Workshop preparation assistant: Lily Gabriel

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