Tattio: Fabrication of Aesthetic and Functional Temporary Tattoos

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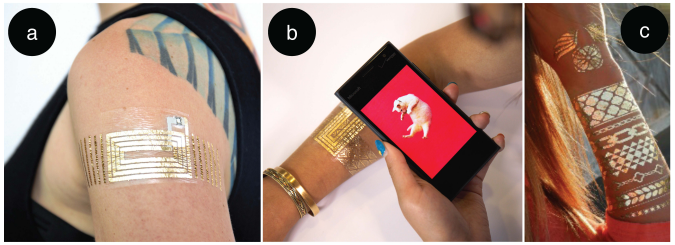

Figure 1: (a) Functional NFC tag tattoos created with DIY fabrication process, (b) using phone to read from tag, (c) decorative metallic jewerly tattoos inspire our work.

Abstract

We present Tattio, a fabrication process that draws from current body decoration processes (i.e., jewelry-like metallic temporary tattoos) for the creation of on-skin technology. The fabrication process generates functional components such as NFC tags, circuitry, to Thermochromic tattoos, while maintaining the aesthetics and user experience of existing metallic temporary tattoos. The fabrication process is low cost, accessible and customizable; we seek to enable individuals to design, make, and wear their own skin technology creations. We present the fabrication flow, fabricated components, and also an initial user study probing perceptions towards wearing Tattio circuitry.

Author Keywords

Beauty technology; on-body electronics; self-expression; RFID; DIY; fabrication; tattoo; stickers.

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous. J.5 Arts and Humanities.

Introduction and Background

The near-ubiquity and miniaturization of electronics enables technology close to our bodies, redrawing the line between technology and ourselves. Human skin, the largest organ on the body, has been recognized as a promising surface for human-computer interactions. Skin has also been a canvas for decoration throughout

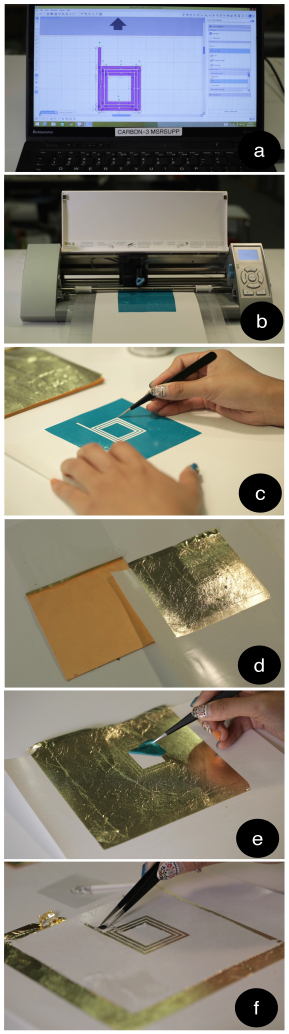

Figure 2: Gold Leaf Fabrication: (a) Designing NFC tag stencil, (b) Silhouette Cameo cutting traces, (c) remove positive film, (d) attach gold foil, (e) remove remaining negative film, (f) attach chip

human history [1]; from ancient tribal tattoos signaling identity, to recent fashion trends around jewelry-like metallic temporary tattoos (Figure 1 (c)). Tattio is a fabrication process that draws from current body decoration practices (i.e., metallic jewelry tattoos) for the design of on-skin technology. The fabrication process generates functional components such as RFID NFC tags, circuitry, Thermochromic tattoos, while maintaining the aesthetics and user experience of existing metallic temporary tattoos.

Existing temporary tattoos are low cost, easy to apply, and customizable; individuals can design, make, and apply their own tattoos onto their bodies [8]. For technology close to the body, we see a need for greater levels of customization, personal meaning, and intimacy, which could be achieved through a bottom-up approach that resemble this body decoration process, as compared to a top-down approach of purchasing a one-size-fits-all skin circuit. Tattio maintains this user experience; the process is accessible and extendable, leveraging off-the-shelf craft materials and enabling individuals to create their own designs.

Tattio relates to the emerging stream of on-body interaction [4-7]. It also blends aesthetics and functionality as explored by cosmetics-inspired on-body electronics [9, 11, 12]. It is technically inspired by advances in Epidermal Electronics [2, 13], an active research field in material science, while culturally drawing from existing body decoration processes. Tattio is a novel fabrication process for integrating electronics on skin in an aesthetically sensitive fashion. We present the fabrication process of Tattio, along with fabricated components.

Design Consideration

We outline the design considerations of Tattio as follows:

- Accessible: The materials for Tattio are accessible and affordable; the cost of making a Tattio NFC tag is $1.5 USD. The process is also extendable, individuals can easily customized their circuitry designs.
- Skin-Safe: For technology close to the human body, we leverage fabrication materials that are commercially used and know to be safe for the human skin.
- Removable: Tattio is a temporary tattoo and can be easily applied and removed by the wearer, giving individuals control over the level of intimacy of technology to their bodies.
- Aesthetic: Inspired by body decoration, we select material (i.e., gold metal leaf) that emulates the aesthetics of metallic temporary tattoos while being conductive.

Fabrication Process

The process of gilding, applying fine gold or metal leaf onto solid surfaces to give a thin coating for decoration, has been in human history for over 5000 years. Gold leaf has also been used in foods and cosmetics [7], making it safer for applying to human skin. Current metal leaves are conductive and composed of a mixture of gold alloy, aluminum, and other materials. Based on experimentation with multiple materials, we landed on a process of applying gold imitation leaf onto tattoo paper with stencil traces cut out by a Silhouette Cameo Cutter, a tabletop cutter. The following three basic steps served as building blocks for creating a Tattio. For explanation purposes, we present it in the context of creating a NFC tag. More details are in the accompanying video.

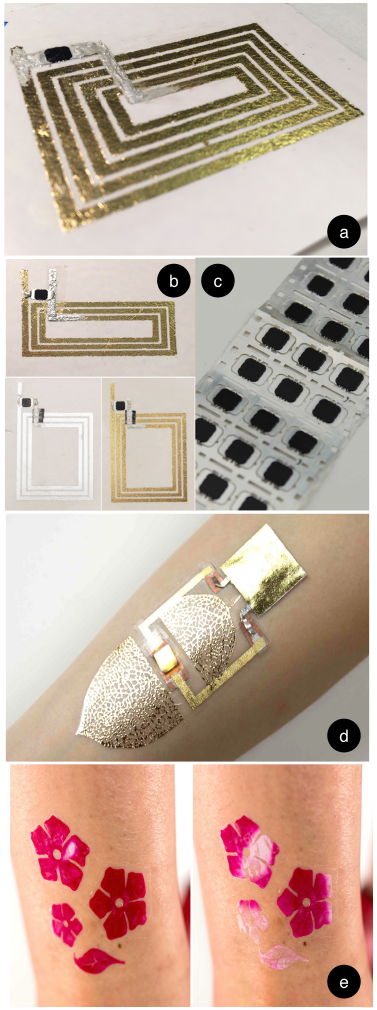

Figure 3: (a) Fabricated RFID tag tattoo, (b) customized to various dimensions, (c) RFID chips, (d) basic circuitry with battery LED, (e) thermochromic components

1. Stencil Design: Create a stencil design with the Silhouette Cameo Software (Figure 2 (a)).

2. Stencil Cutting: Apply a layer of coverseal film (Clear Covering Self-Adhesive Privacy Film, Con-Tact) on tattoo paper (Temporary Tattoo Paper, Silhouette) and adjust Silhouette Cameo Cutter blade so it only cuts over the film layer for the stencil. Remove the positives from the film stencil. (Figure 2 (b)(c))

3. Apply Material: Apply spray adhesive (Metal Leaf Adhesive, Speedball Mona Lisa) onto tattoo paper with stencil, and carefully attach a layer of metal foil (Gold Simple Leaf, Speedball Mona Lisa). Carefully remove the negatives of the coverseal film stencil, leaving only the metal foil traces remaining. Attach the RFID chip, and attach layers of tattoo paper adhesive on top. (Figure 2 (d) ~(f))

Fabricated Components

NFC Tag

In our explorations, we started with the fabrication of a functional component that is passive and would not require power such as a NFC tag. For implementation, we repurposed Marquardt et. al's [15] Instructables tutorial on creating simple and inexpensive NFC tags for our gold leaf process. We leveraged a similar NFC chip (NXP MF1S5030XDA4, www.digikey.com) (Figure 3 (c)). This chip's larger size made it possible to connect to the tag's antenna by hand.

Individuals can easily customize the antenna to different sizes (Figure 3 (b)). There are two points to consider for achieving sufficient radiation efficiency. First, radiation efficiency is limited by the conductivity of the traces; a lower resistance will increase the efficiency of the tag. This can be achieved by applying additional layers of gold leaf. Second, the size of the antenna dictates the relative aperture to harvest power from the reader. A smaller antenna, while able to blend more seamlessly into one's body, would harvest less power. Size and power harvested are design tradeoffs for individuals to consider when fabricating their own Tattio NFC Tags.

Circuitry

We fabricated wire components (Figure 3 (c)) to create basic circuitry. We could design wires that were curvy as well as geometric, and easily alter the shape and size. In fabricating the wires, we through-holed the tattoo paper at the wire ends, and connected small pieces of double-sided conductive fabric tape to the ends. When tattooed on skin, the conductive fabric would be exposed, which enabled us to place electronic components and make connections. Connected with a battery, we could light up LEDs and power vibration motors with the wires. By integrating other surface mount sensors and actuators on flex circuits, we see capability for creating more complex circuitry on skin.

Thermochromic Tattoos

By fabricating gold leaf serpentine resistive heating traces and applying a layer of thermochromioc paint on top, we created heat-activated color-changing tattoos (Figure 3 (d)).

Experiencing Tattio Componenets

To understand how participants experienced and interact with the fabricated components, we conducted an initial study where 6 participants applied pre-fabricated NFC tags onto their skin. Temporary metallic jewelry tattoos were provided for participants to

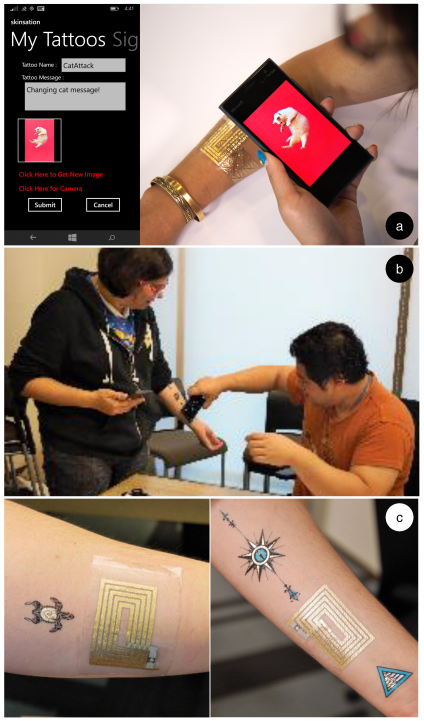

Figure 4: (a) Phone and user scanning tattoo, (b) Participants scanning each other's tattoos in workshop session, (c) Antenna designs (both on lower arm) (left) the participant's favorite animal is the turtle, (right) the aesthetics of the antenna was important to the participant

decorate their antennas (Figure 4 (c)) to give it personal meaning.

A phone application (Figure 4 (a)) was developed for participants to interact with each other though their tattoos (Figure 4 (b)). Participants could associate a "digital identity" (i.e., an image and text) to their NFC tag, and could change their identity throughout the day. By scanning each other's tattoos, participants would reveal each other's identities.

We found the NFC tags to be robust enough to last around a day, and caused no significant discomfort. Participants also reported on wearing the tag throughout the day, with reactions as to feeling cyborged and how it generated excitement and concern with onlookers. For the Interactivity demonstration, we will fabricate Tattio NFC Tags for participants to experience along with the accompanying phone app.

Conclusion

Inspired by metallic jewelry tattoos, we present an accessible fabrication process that generates on-skin circuitry that is aesthetic and functional. We hope our work inspires in bridging the emerging field of on-skin electronics to the everyday maker, while rethinking cultural and aesthetic perspectives for the design of on-skin technology.

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