ChromoSkin: Towards Interactive Cosmetics Using Thermochromic Pigments

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Abstract
Makeup has been a body decoration process for self expression and transforming one's appearance. While the material composition and processes for creating makeup products have evolved, they still remain static and non-interactive. However, as our social contexts demand different representations of ourselves, we propose ChromoSkin, a dynamic color-changing makeup system which gives the wearer ability to seamlessly alter their appearance. As an initial exploration, we prototyped an interactive eye shadow tattoo composed of thermochromic pigments which are activated by electronics or ambient temperature conditions. We present the design and fabrication of these interactive cosmetics, and the challenges in creating skin interfaces that are seamless, dynamic, and fashionable.

Author Keywords
Beauty technology, wearable technology, thermochromic, makeup, skin interfaces.

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous

Introduction
As a body decoration process, humans have been applying makeup as a means for self-expression, communication,

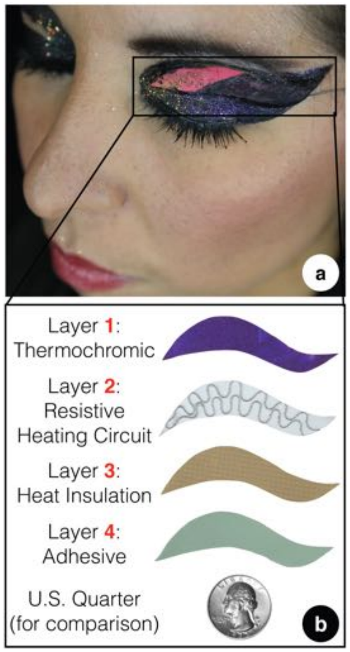

Figure 1: (a) ChromoSkin worn as eyeshadow (b)) ChromoSkin is made of 4 layers. Each layer is shown individually, stacked on top of each other.

and to alter one's appearance. While the material composition of makeup products have evolved, they have remained static and non-interactive. Recently, the miniaturization of electronic devices has given rise to an emerging trend of technology moving towards the human body, such as embedding into fabrics [5], implanted [6] or even onto the skin [13]. The current focus of these technologies, however, are on functionality. Makeup products, on the otherhand, are used for decoration. By embedding electronics into makeup, we are creating an interface close to the skin that balances decoration with interactive functionality. Chromoskin is a dynamic makeup interface that enables the wearer to alter the color of their makeup based on their social context.

We are expected to dress, behave and adorn ourselves differently according to various social scenarios. Women apply makeup of different color intensities and shades to express themselves according to the setting. Chromoskin proposes that in the future, we will no longer need to remove and reapply makeup accordingly, but we will wear one makeup system that is able to automatically alter its color based on social context. Chromoskin also explores the concept of dynamic makeup as an expressive skin display that changes color according to one's mood, bio-signals, or even information input designated by the wearer.

Technically, this work is inspired by recent developments in skin interfaces from Material Science [8, 9] and thermochromic textiles [1, 3, 11]. Beauty Technology [12] propose to integrate electronics into cosmetics and apply directly to one's skin, fingernails, and hair in order to make the body's surface become an interactive platform. The HCI community has also seen an recent increase around on-body electronics close to the body that are decorative as well as functional [7, 13]. There are several artistic exploration leveraging projection to alter the color and information displayed on human skin [4, 10, 2]. Last but not least, the color-changing phenomenons omnipresent in nature inspire this work: from chameleon skin to the chromatophore cells of squids and octopuses. We proposed ChomoSkin as a color-changing second skin that is dynamic, expressive, and fashionable.

System Implementation

Figure 1 presents the ChromoSkin system design which consists of four layers (top to bottom):

1. Thermochromic Layer: This layer is composed of 42°C activated thermochromic pigments (Hali Pigment) mixed with flexible molding paste (Liquitex), which were layered onto tattoo transfer paper (Silhouette Cameo). The pigment was prepared by mixing 0.05 oz of pigment with 0.25 oz of water and 0.30 oz of flexible molding paste at room temperature. We have experimented with pigments which activate below 35°C, but as they are around human body temperature, they would immediately change color when placed on human skin. With pigments which are activated at higher temperatures, we are able to activate the color change with the resistive heating circuit.
2. Resistive Heating Circuit: This layer comprises of serpentine traced electric heating circuits made from conductive thread, which were able to offer resistance of approximately 10 Ohms.
3. Heat Insulating Layer: Thermalloy "Theragrip" was used to provide thermal and electrical insulation. This tape insulates heat generated by conductive thread and thereby preventing skin burns.
4. Skin Adhesive: Tattoo transfer paper backing (Silhouette Cameo), which is comprised of a thin layer of silicone with adhesive, was used to adhere to skin

and provide a protective isolation layer.

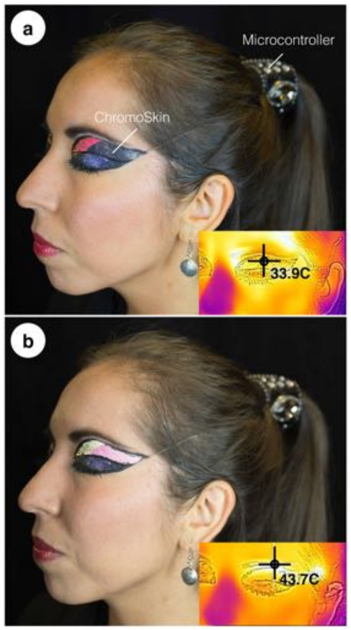

Figure 2: ChromoSkin wired to microcontroller (inside hair accessory) (a) ChromoSkin at 33C (b) 43C

Interaction

We present active and passive interaction modalities of ChromoSkin.

Active ChromoSkin: Circuit Activation
Active ChromoSkin changes color through the resistive heating circuit. ChromoSkin was connected to an Arduino Microcontroller and powered by a 3.7V Lithium battery (Figure 2). The current prototype can change color according to light activation (e.g., day versus night). For example, the wearer might prefer darker eye shadow when she is working during the day, but change to brighter colors for evening social functions. By embedding additional sensors (e.g., temperature, accelerometers), the system can activate according to more complex scenarios.

Passive ChromoSkin: Ambient Activation
Passive ChromoSkin responds to ambient temperatures. It is comprised of the first and fourth layers of Figure 1, without the heating components. It changes color when ChromoSkin is exposed to warm versus cold temperature settings (normal temperature setting maintained at 27°C)

Discussion

Thermochromic pigments are available off-the-shelf in a wide range of colors and activation temperatures. Pigments below 38°C are used in the passive ChromoSkin. Pigments that activate below normal human body temperature (33 °C) were used for cold environmental settings and the pigments with activation between 33° C to 37° C were used in warmer zones. Passive cold and warm tests were conducted in Boston, MA and Miami, FA respectively. Pigments with activation temperatures (>38°C) were used for active tests which included the heating circuity. Various materials such as silver ink, conductive ink and conductive fabric were experimented for the circuit traces but conductive thread was the most promising as it achieves sufficient resistance with flexibility and durability.

Aesthetics is an important design consideration for Beauty Technologies. Glitter and commercialized eye shadow pigments are used in our thermochromic formulation to achieve eye shadow appearance and coloration. Our designs consist of two different colors to mimic traditional eye shadow makeup: a darker outer layer and lighter inner layer (Figure 2). The shape was designed in an eye shadow silhouette taking into account the spacing between the eyebrow bone and the crease. We decided to provide a bigger shape to give users the option to cut it according to their eye shape.

ChromoSkin was applied to the eyelids with a tattoo paper adhesive layer and eyelashes glue for reinforcement. The durability on the skin was about 5 hours. Commercialized makeup was used for covering the eyelid up to the crease for completing the eye shadow makeup. ChromoSkin can be reused. The thermochromic layer is also changeable; the user can replace it with different colors.

Conclusion

The importance of aesthetics cannot be ignored for the design of technology intimate to the human body. Beauty Technology envisions that the beauty industry will contribute to this wave and future skin interfaces will start looking more like cosmetics. ChromoSkin proposes the use of skin as a display that resembles makeup. Aesthetically, it blends into the human skin canvas, as compared to LED displays which use light as emitters. This seamless aesthetic is achieved though thermochromic pigments; they are not individually addressable, but achieve a free-form and expressive appearance. ChromoSkin also imagines a new form of interaction where information is revealed according to both the environment and user's preferences. Future applications could extend to temperature-activated color change for revealing a specific illness, or context-aware changes (e.g., from office to social environment or from warm to cold weather). We present this initial prototype of a color-changing eyeshadow system as an example of this vision; we hope that this work will stimulate future explorations which expand the purpose of makeup products beyond decoration.

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