Flexible, Non-emissive Textile Display

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Abstract. This paper describes current progress in the implementation of flexible ubiquitous textile display. We use thermochromic inks and miniature peltier semiconductor elements to create a non-emissive textile display. Here we present some of the initial work into the use of custom made miniature peltier elements. We describe some of the early works into the integration of this technology into the fabric to present a flexible non-emissive display.

Keywords: thermochromic, peltier, thermoelectric, textile, fabric, display.

1 Introduction

Fabrics are a common form of material we interact with daily. Since its recorded uses from prehistoric times fabrics have become an integral part of our daily lives in the form of our clothes, home furnishing, architecture and other numerous range of uses. Besides its common use as a fashion statement nowadays, such uses of fabrics have become a medium for expression allowing arts and crafts to find its way into fabrics.

With the advancement of technology and the introduction of new concepts and smart materials, researchers are able to embed more and more electronics into our fabrics paving way for a new era of fabric displays. With this development, researchers have been looking into various forms of fabric displays that are mainly emissive, such as embedding LEDs, electroluminscent sheets and wires, complete LCD displays, etc. The unnatural and non subtle nature of these technologies present a rather obtrusive emissive displays, preventing their application in fabrics and traditional arts.

With this paper, we present the current progress in the implementation of a, non-emissive fabric display with fast color change allowing us to present novel animations on fabrics. This technology uses an integration of thermochromic ink and peltier semiconductor elements to achieve these properties. Our previous work AmbiKraf [4] which uses this technology has some major limitations such as high power consumption, inflexibility, and the requirement to use heatsinks

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for the display. Here, in the next version of AmbiKraf, we try to overcome these limitations using our latest customized technologies. This paper describes this attempt and some initial results of the system.

2 Related Works

To focus on a more ambient approach for fabric displays researchers have focused many works on non-emissive fabric displays [5]. A more commonly used ink in these works are thermochromic inks. Thermochromic inks change color based on temperature. In 'SMOKS' [2], a wearable display uses a shoulder pad made of thermochromic inks which when touched turns the color by means of the body temperature. Shimmering Flower [1] uses thermochromic inks which are actuated by conductive yarn that is woven into the fabric. When powered up, the conductive yarn heats up and in turn actuates the thermochromic inks to change the color. In 'Mosaic Textiles' [5], authors use liquid crystal inks which work on the same principle as thermochromic inks, actuated by conductive yarn. Almost all of the above non-emissive displays have been used in an omni-directional manner. That is, these works only use a heating source such as body heat or conductive yarn without any cooling method. Due to this reason the absolute controllability thus the ability to animate the display is not profound.

Hence, our approach is to use thermochromic inks due to its non-emissivity and peltier semiconductor elements due to their ability to rapidly heat and cool the fabric allowing it to animate. In addition the use of customzed miniature Peltier semiconductor modules allow the technology to be seamlessly integrated into the fabric compared to our previous version of AmbiKraf.

2.1 Technology

The core components of this technology are thermochromic inks and peltier semiconductor elements. The overall system is shown in Figure 1.

Thermochromic inks work on the principle that when they are heated beyond their 'actuation temperature' they become colorless and reappear when cooled below this actuation temperature. Their actuation temperatures can be customized based on the requirement.

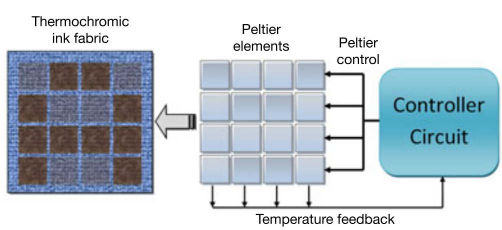
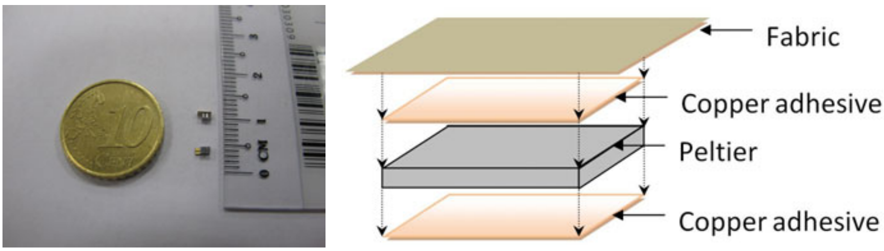


Fig. 1. Overall System

As the thermochromic inks are thermally actuated, we use peltier semiconductor elements since hey have the capability to heat and cool on the same surface by simply reversing the voltage polarity. However, in this newest version of our project we use miniature peltier elements that can be eaisly embedded on to the fabric (Figure 2(a)).



(a) Miniature Peltiers of 2mmx3mm size)

(b) Integration

Fig. 2. Main technologies and the integration of the system

The fabric display is made out of few pixels, with each pixel being a peltier element. A feedback control system with a fine tuned PI (Proportional-Integral) controller circuit accurately controls the temperature of each peltier element thus in turn triggering the color change of each pixel.

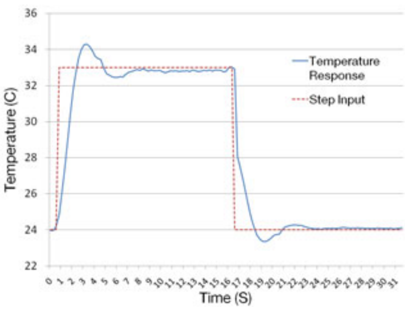
To have a feedback control system, temperature of each pixel should be fed back to the temperature controller. As we use miniature peltier elements, placing individual temperature sensors, on each pixel is unfeasible as it would reduce the heat transfer surface between the peltier and fabric and also require more wiring thus reducing the flexibility of the fabric. Hence, we are investigating the use of the seebeck effect [3], the reverse operation of peltier elements. I.e., as the peltiers change the temperature they produce a voltage proportional to the temperature. This voltage is fedback to the controller completing the feedback loop. Thus, the repeating actuating and sensing cycle, allows us to actuate the pixel while controlling its temperature accurately.

2.2 Integration

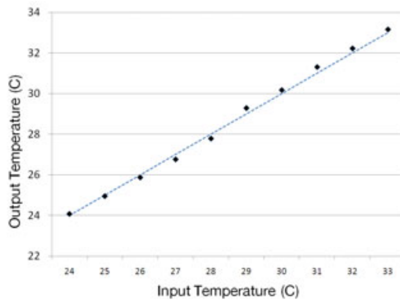
Integration of these peltier pixels on to the textile is a crucial step in implementing this color changing textile. Hence, as a first proof-of-concept attempt in this version of the system, we use thermally conductive adhesives to attach the peltier elements on to the fabric. This first step was an attempt in trying to recognize the optimal arrangement of the pixels in terms of the space in between the textile, and the flexibility of the fabric. Thus, the integration is as in Figure 2(b).

3 Results

The current system uses thermochromic inks that actuate at 32^0C. Thus the transient response of the system, 1.6s for color change, is shown in Figure 3(a). The steadystate error of maximum 2 is depicted in Figure 3(b). Currently, the system depicts acceptable controllability. However, in our further investigations, we hope to fine tune the controller more to increase the response time further thus speeding up the display.



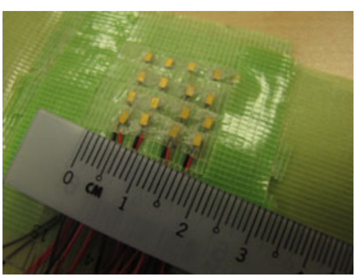
(a) Transient response



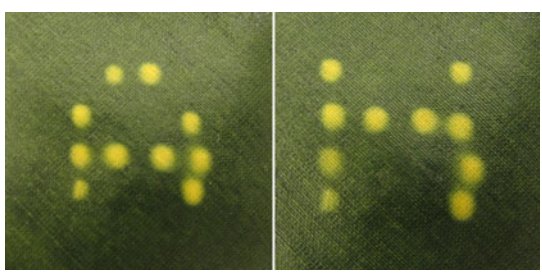
(b) Steady State response

Fig. 3. Temperature controllability results of the system

The first prototype is a 4x4 matrix display as shown in the Figure 4(a). Figure 4(b) shows basic animations of two letters. As seen in Figure 5, with the use of miniature peltiers have resulted in the textile becoming more flexible. In addition, due to low power and higher efficiency of these peltiers, the requirement of heatsinks as in the previous versions of our work was not required.



(a) Integrated Peltiers



(b) Displaying 'A' and 'H'

Fig. 4. Results

Fig. 5. Flexibility with the integrated system

4 Discussion and Future Work

This paper describes our work in progress towards implementing a flexible textile display. The use of miniature peltier elements compared to the previous version has greatly improved the flexibility of the textile. However, still there are some key areas that we are working on as discussed below.

Currently the peltiers are simply attached to the fabric using thermally conductive adhesives. Instead, our main goal is to completely embed these peltiers right into the fabric. For this we are investigating a few techniques including weaving the peltiers using conductive yarns directly into the textile.

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