Karma Chameleon: Bragg Fiber Jacquard-Woven Photonic Textiles

Joanna Berzowska
XS Labs, Concordia University
1455 de Maisonneuve W, EV 6-743
Montreal, QC. Canada H3G 1M8
joey@xslabs.net

Dr. Maksim Skorobogatiy
Department of Engineering Physics
École Polytechnique de Montréal,
C.P. 6079, succ. Centre-ville
Montréal, Québec, Canada H3C 3A7
maksim.skorobogatiy@polymtl.ca

ABSTRACT
Karma Chameleon refers to a series of textile prototypes woven on a Jacquard loom, using photonic bandgap fibers that have the ability to change color when illuminated with ambient or transmitted white light. The use of double weave structures and complex Jacquard patterns allows us to further modulate the color and patterns on the textile.

Author Keywords
Photonic displays, electronic textiles, photonic bandgap fibers, Jacquard weaving.

ACM Classification Keywords
B.4.2 Input/Output Devices: Image Display.

General Terms
Design.

INTRODUCTION
The field of electronic textiles has entered the mainstream in recent years but the predominant implementation model still usually consists of layering electronic or mechatronic functionality on top of a textile substrate. Prior work exists in the domain of stitching, weaving, or knitting with conductive yarns to create structures such as electrodes, sensors, or communication lines and subsequently attaching electronic components to that substrate. Few functional yarns (other than conductive or resistive yarns) are currently available commercially to enable functionality such as the display of information, sensing, or energy harnessing in a textile. The ability to integrate the desired functionality on the fundamental level of a fiber remains one of the greatest technological challenges in the development of smart textiles.

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FIBER BASED FUNCTIONALITY
Practitioners in the field of electronic textiles typically resort to attaching stand-alone mechano-electronic or optical devices to textile substrates in order to enable functionality such as the display of information, sensing, or energy harnessing. As a result, the majority of existing textile-based systems are highly non-homogeneous in their manufacturing and cumbersome in utilization and servicing, thus limiting their utility. We believe that major advances in the textile capabilities can only be achieved through further development of its fundamental element: the fiber.

PHOTONIC BANDGAP FIBERS
We have been weaving a novel type of optical fibers, called photonic bandgap (PBG) fibers, on a computer-controlled electronic Jacquard loom, in order to produce dynamic textile surfaces. PBG fibers can be designed to reflect one color when side illuminated with ambient light and emit a different color when transmitting light. One can dynamically change the color of an individual fiber by controlling the relative intensity of guided and ambient light. This allows for creative opportunities in the application of photonic textiles under changing ambient illumination conditions.

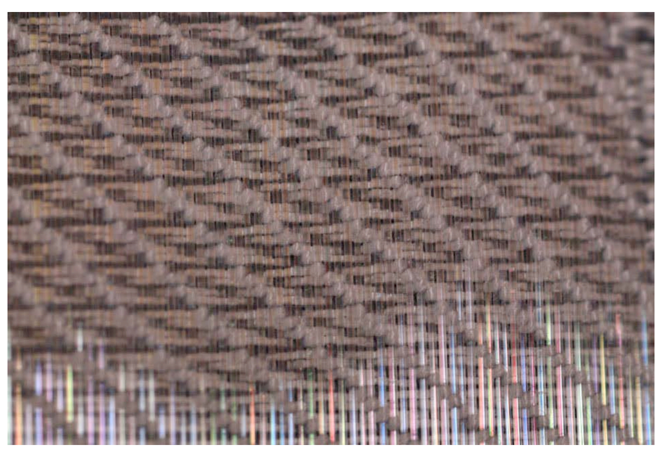

Figure 1. This image shows the many color possibilities when the clear PBG fibers reflect ambient light.

JACQUARD WEAVING

A Jacquard loom allows the weaver to individually address each warp thread so as to create complex weave structures including double and pocket weaves to separate different weft threads into separate layers. Double weave is a type of woven cloth in which two warps and two sets of weft yarns are interconnected to form a two-layered cloth. We use a cotton weft together with a PBG fiber weft, to create individual illuminated images in the textile display.

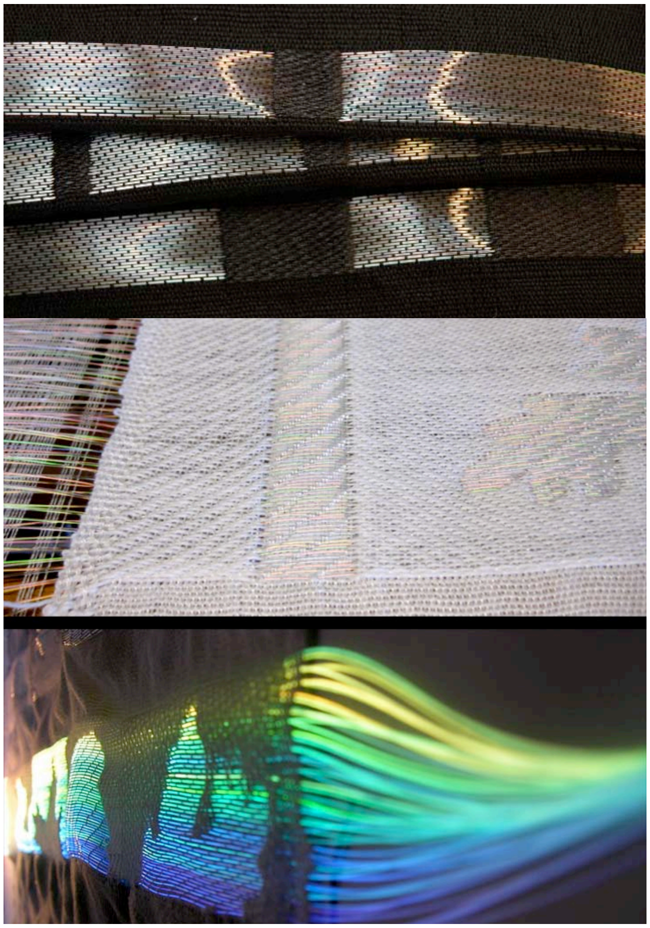

Figure 2. Three early prototypes, the first illuminated by ambient light, the second with transmitted light

We have manufactured connectors out of machined aluminum to connect the fiber bundles to the light source. The connectors are ¾ inch long and 5/16 inch in diameter. The length of the connector assures that the light source remains in line with the fibers. We are using a variety of light sources, including the Philips LUXEON K2 LEDs, together with custom electronics to control and modulate the amount of light directed into individual fiber bundles, in order to create a variety of colorful kinetic illuminated patterns. To implement a PBG fiber-based textile capable of changing its emissive color one can employ a combination of Bragg fibers having a variety of emissive colors.

FUTURE WORK

Key challenges involve tuning fiber fabrication machinery for production of a long fiber of a fixed color; better understanding of relationship between guided color, reflected color, and fiber geometry; development of improved weaving techniques; and the study of a textile's visual and tactile properties as a function of textile fabrication parameters.

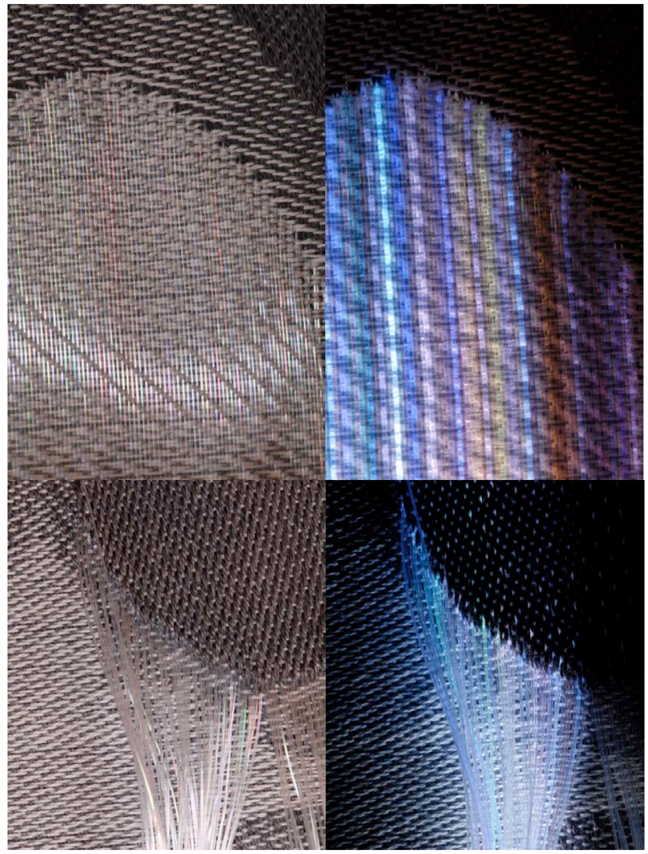

Figure 3. This image shows the reflected colors and the colors that result from transmitted light, on the front and on the back of the textile.

CONCLUSION

We have developed woven Jacquard substrates using Bragg fibers that reflect and emit a variety of colors when side illuminated and when transmitting the light. By controlling the weave structures and the patterns, as well as the intensities of the ambient and guided light, the overall fiber color can be varied and different patterns can be revealed.

ACKNOWLEDGMENTS

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