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User-Controlled Color-Changing Textiles: From Prototype to Mass Production

Authors : Joshua Kaufman, Felix Tan, Morgan Monroe, Ayman Abouraddy

Abstract : Textiles and clothing have been a staple of human existence for millennia, yet the basic structure and functionality of textile fibers and yarns has remained unchanged. While color and appearance are essential characteristics of a textile, an advancement in the fabrication of yarns that allows for user-controlled dynamic changes to the color or appearance of a garment has been lacking. Touch-activated and photosensitive pigments have been used in textiles, but these technologies are passive and cannot be controlled by the user. The technology described here allows the owner to control both when and in what pattern the fabric color-change takes place. In addition, the manufacturing process is compatible with mass-producing the user-controlled, color-changing yarns. The yarn fabrication utilizes a fiber spinning system that can produce either monofilament or multifilament yarns. For products requiring a more robust fabric (backpacks, purses, upholstery, etc.), larger-diameter monofilament yarns with a coarser weave are suitable. Such yarns are produced using a thread-coater attachment to encapsulate a 38-40 AWG metal wire inside a polymer sheath impregnated with thermochromic pigment. Conversely, products such as shirts and pants requiring yarns that are more flexible and soft against the skin comprise multifilament yarns of much smaller-diameter individual fibers. Embedding a metal wire in a multifilament fiber spinning process has not been realized to date. This research has required collaboration with Hills, Inc., to design a liquid metal-injection system to be combined with fiber spinning. The new system injects molten tin into each of 19 filaments being spun simultaneously into a single yarn. The resulting yarn contains 19 filaments, each with a tin core surrounded by a polymer sheath impregnated with thermochromic pigment. The color change we demonstrate is distinct from garments containing LEDs that emit light in various colors. The pigment itself changes its optical absorption spectrum to appear a different color. The thermochromic color-change is induced by a temperature change in the inner metal wire within each filament when current is applied from a small battery pack. The temperature necessary to induce the color change is near body temperature and not noticeable by touch. The prototypes already developed either use a simple push button to activate the battery pack or are wirelessly activated via a smart-phone app over Wi-Fi. The app allows the user to choose from different activation patterns of stripes that appear in the fabric continuously. The power requirements are mitigated by a large hysteresis in the activation temperature of the pigment and the temperature at which there is full color return. This was made possible by a collaboration with Chameleon International to develop a new, customized pigment. This technology enables a never-before seen capability: user-controlled, dynamic color and pattern change in large-area woven and sewn textiles and fabrics with wide-ranging applications from clothing and accessories to furniture and fixed-installation housing and business décor. The ability to activate through Wi-Fi opens up possibilities for the textiles to be part of the 'Internet of Things.' Furthermore, this technology is scalable to mass-production levels for wide-scale market adoption.

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