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The interactive optical fiber fabrics for smart interior environment

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Abstract. Comparing to conventional textiles, interactive photonic textiles can emit light, present different colors, change the surface pattern and can interact with users. They are particularly suitable for decorative purpose. Home furniture is one possible application [1]. With attractive illumination and color effect, the photonic textiles can also be used in hotels, exhibition halls, restaurants and many other circumstances to enhance the interior environment. However, the functionality of the interactive photonic textile for interior purpose is still underdeveloped, since there are still sever challenges about how to improve the usability and functionality of the interactive textile. This project aims to study how to improve the interactive function of photonic textiles, which can enhance the well-being of the end-user. In the end, a color-changeable interactive cushion which can detect the main primary particulate matter (PM) 2.5 was developed.

1. Design concept

The initiative of the project is the serious air pollution in China. The quality represents a major public health burden and is a long-standing concern to Chinese citizens. PM2.5 is one of the major index people care every day. People get used to check PM2.5 by using their smart phone. But is there possible to visualize the air quality in the peoples living environment? People may easily get the air quality information by seeing the color change of a cushion in their home.

2. Materials and methods

2.1 Optical fiber fabrics

PMMA (Polymethyl methacrylate) optical fiber was insert on to fabrics as weft yarn. Several structures of textile design were examined by using sample loom. MITSUBISH® optical fibers of 0.25mm in diameter together with polyester threads were inserted as weft yarns, and the proportion of

the optical fibers to polyester threads is 1:1. The warp is white polyester yarn. The weaves were designed by ArahWeave® software.

2.2 Controlling system development
The highlight of the system is the air quality can be visualized by using color-changeable cushion which is made from optical fiber fabric. The system consists of the sensor module, master control module and display module. The sensor modules could be distributed in different places in the room to detect the denseness of indoor pm2.5. The detected data is transmitted to the master control module through a wireless communication technology, the ZigBee® technology. After calculating and comparing, the master control model transmits the processed data to the display module through ZigBee® technology again. The display module is the interactive luminous cushion embedded with integrated circuit.

2.3 Coupling
A customized coupler was designed for connecting the optical fibers bundles and all the LED light sources. The coupler is made from lightweight materials to reduce the whole weight of cushion.

The structure of the coupler is shown in Figure 1. Part A is the main part of the coupler. Integrated Circuit embedded with microprocessor and LED lamp is installed in Part A. A hole is dig at the end of Part A for the LED lamp to be exposed. Part B is a black screwed plastic tube where the exposed LED lamp and the fiber bundle are connected. The top of the tube is a shrinkable clamping jaw for binding a sufficient amount of fine fiber bundles. Part C is a plastic tight cap. Strengthen the nut may fix the fiber bundle and reduce the light loss.
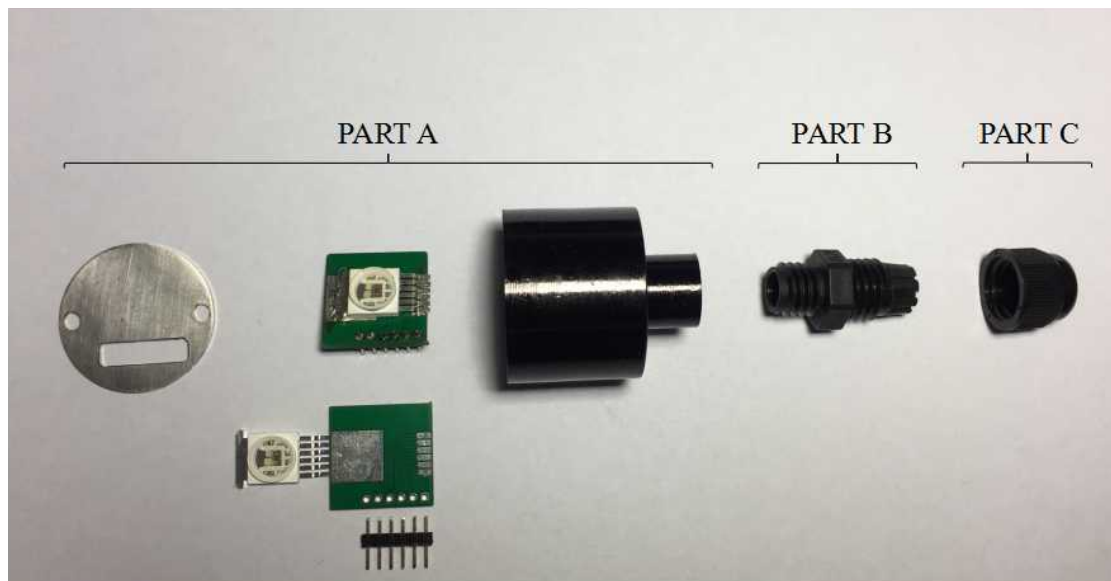

Figure 1 Design of the customized coupler

2.4 The controlling system
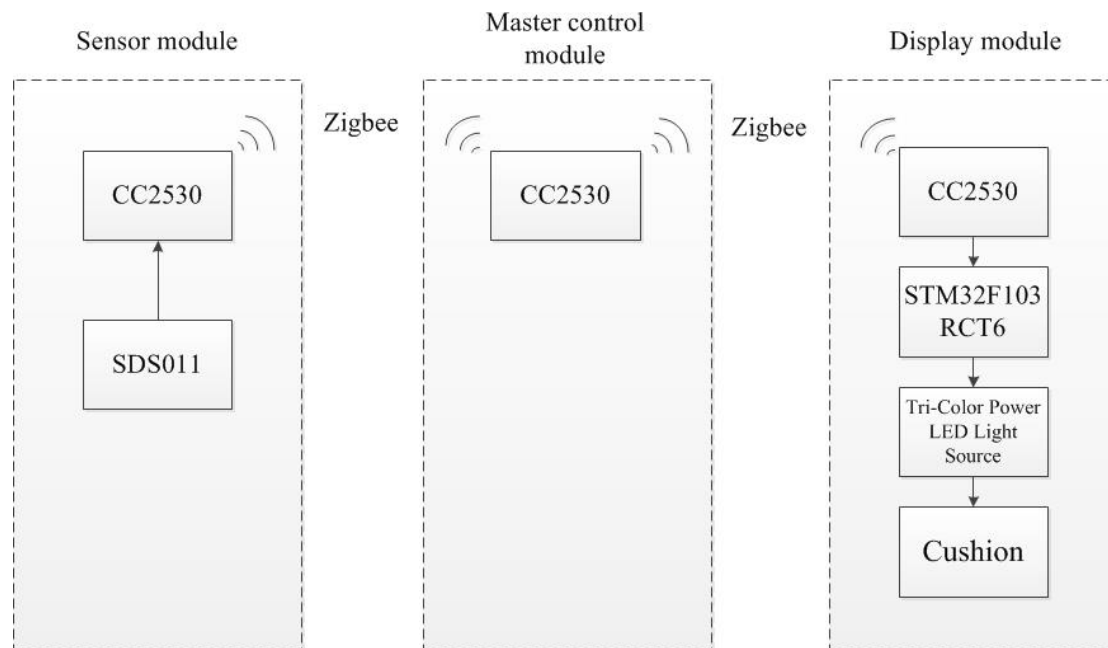The system consists of the sensor module, master control module and display module, as shown in Figure 2.

Figure 2 Composition of color-changeable interactive cushion

The sensor module consists of SDS011 PM2.5 sensor and CC2530 module. CC2530 module processes the data sampled by PM2.5 sensor, then transmits it to the master control module. CC2530 chip produced by Texas Instruments contains enhanced 8051 CPU, and the industry-leading gold unit ZigBee protocol stack (Z-Stack ™). As a low-power LAN protocol based on the IEEE802.15.4 standard, ZigBee could satisfy the design requirements for self-organization, low power consumption and low data rates.

The master control module is the base station of the system. Consists of CC2530, it receives the sensor data while transmits the lighting instruction to the display module.

The display module consists of CC2530 module, STM32F103RCT6 microprocessor, LED light source and the cushion. The microprocessor connects LED light source and CC2530 module while the customized coupler connects the LED light source and fiber bundles in the cushion.

In the display module, the Moonstone® Tri-Color Power LED Light Source produced by Avago Technologies combines the red, green and blue lamps. The intensity of each lamp could be controlled by current flowing into the corresponding pin. Adjusting the light intensity of these three lamps can change the color of the LED light.

In order to control the pin voltage, the microprocessor generates a square wave with a constant cycle and adjustable duty cycle according to PWM (Pulse Width Modulation) technology. Particularly, a method named VVVF (Variable Voltage Variable Frequency) is engaged in the PWM method. STM32F103RCT6 chip is selected in the proposed lighting system to produce PWM pulse signal, which is able to generate up to 24 channels PWM signals, and hence drive 8 LED light Sources.

3. Results and discussion

A color-changeable interactive cushion which can detect PM2.5 for domestic use was developed (Figure 3). The working mode of the interactive luminous cushion is as follows: When the system is properly turned on, the pillow sequentially displays red, green and blue lights in normal speed. If the denseness of PM2.5 is below 50 milligram per cubic meter, the pillow shows blue and green lights alternately in slow speed. When the denseness is between 51 and 150, the pillow shows green and

yellow lights alternately in faster speed. Finally, when the denseness is above 151, the pillow shows yellow and red lights alternately in high speed. This would remind the user to take action for cleaning indoor air, for instance turning on the air purifier device automatically.

Figure 3. Color-changeable Interactive PM2.5 cushion

This project combines the both technology and the design considerations. The functionality of the interactive photonic textile was improved. There are potential marketing demands for the interactive textiles which can enhance the well-being of the end-users.

References

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