Chapter 74
Applied Research and Development of New Smart Clothing Material

Ming Yang and Jing Sun

Abstract With the rapid development of clothing industry, enterprises enlarged the market space. As new high-tech fiber, smart clothing has become more and more popular among industrially developed countries, some experts regard smart fabric and smart clothing as the future of fiber clothing industry.

Keywords Smart clothing material • High-tech • Clothing industry

Introduction

Smart clothing is the combination of new fabric material and electronic technology, some well-known clothing companies, calculator giants, electrical equipment manufacturers have began to research and develop smart clothing controlled by computers (Hao Xinmin and Yang Yuan 2010). The market of smart clothing is expanding. Some large clothing manufactures overseas have stepped into this market. Madura clothing company in India introduced Icetouch series shirts. These shirts can reduce 5°C of body surface (Hao Xinmin and Yang Yuan 2010). Compared with other functional clothing, smart clothing is surely with higher price, however this will not affect its market potential.

Chinese research and development of smart clothing is still at the beginning, compared with other developed countries, there are still large gaps. Environmental protection, ecology, intelligentize and digitalize fiber clothing have become the global subject of twenty-first century, smart clothing will be for sure one of the competitive focus point of this century. If China wants to accomplish the change from big clothing country to clothing power, to occupy a place in smart clothing research is very important, the research and development of smart clothing rely on not only

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clothing enterprises, but also need the cooperation of chemistry company, optics company, fabric company and electronic equipment manufacturing.

Smart Clothing Material Should Highlight 'Unique' in Developing Function, Fashion, Health and Low Carbon as the Main Subjects

Functional Requirement

As the second skin, clothing in selecting material pays attention on comfortableness and functionality, which should have external environment perception and internal change reaction. When the temperature changes, the phase-change material in fiber will have reversible phase change, absorbs heat or releases heat, when temperature is higher than phase-change material melting point, it will turn from solid to liquid, meantime absorbs the heat, while when the temperature is lower than phase-change material melting point, it will turn from liquid to solid, and releases heat (Hu Jinlian 2006).

Healthy Experience

Nowadays, people pay more attention on life quality, and emphasize more on green. Lately the United States fabrics association stated that in the past 10 years, this industry has spent one billion dollars on environmental protection. There is a company called DIXI Cotton Hill like this in Tennessee, which uses cotton weaving produced by organic fertilizer, and natural dye to dyeing. Meantime the clothing civilization of producing biofibre by technology is rising around the global, which has formed the strict and quantitative standards of PH, color fastness, residual formaldehyde, halogenated dyeing carrier, special odor, and flame retardance.

Low Carbon Needs

Low carbon has become the subject of development economy of all kinds of countries, clothing industry is no exception. Smart clothing material will use all kinds of renewable resources of extraction fiber to do the research through the energy transformation produced by electronic technology. Such as Michael Redhill research group of Philippine (Gong Jixin 2004). It changes the current status of smart clothing has to come into play through electric wire, to supply

Table 74.1 Smart clothing function

Function	Intension
Perception	Perceiving outer world and its surroundings
Feedback	Contrasting with information, provide for control system
Information identification and accumulation	Accumulating all kinds of information
Response	Reacting timely accordingly to the change of external and internal environment
Autodiagnosis	Analyzing current and the past situation, have self diagnosis and correction
Self healing	Making appropriate response to external change of material system through a optimistic way

power with 9 V battery may finally produce electric power from the heat of human body.

Fashionable Tendency

Smart clothing not only has high-tech function of clothing, but also contains various fashion elements. Such as Phillips invented smart clothing, which is to put stereo speaker into the collar of jacket. When turn down the collar, people around can also hear the music, while when the collar is up, only people who wear it can hear the music (Ye Xiumin 2004). More and more clothing and electronic companies developed smart clothing together, to put fashion element into high-tech clothing and be popular has become a certain tendency, which will bring endlessly business opportunity and develop activity to clothing industry.

Methodology

Smart Clothing Material Concept

Smart material concept is first proposed by an American professor called Craig Rogers. In 1989, a Japanese called Gao Mujunyi developed this concept, and defined it as a new material which has perceiving, responding and function found ability of environment (Wang Xuejiao 2002). Smart material refers to the material which has system that can imitate life and function of perceiving and driving (see Table 74.1).

Smart clothing material is an overall development, new fiber material derived from fiber consumer goods, its smart fabric running through fiber, clothing, electronic, chemistry, biology and iatrology (Shan 2005). Due to the diversity and

Table 74.2 Clothing application of shape memory PU material

Material	Application	Characteristic
Shape memory polyurethane emulsion	Textile finishing of cotton, fiber, silk	Anti-wrinkle, iron free, heat preservation, setting
Shape memory polyurethane membrane	Sportswear, military combat uniform, climbing wear	Gas separation, heat preservation, waterproof, breathable
Shape memory polyurethane fiber	Collar, bellyband, lining, underwear	Adjust the shame and size at will, deformation recovery after heat, with small stress and big deformation
Shape memory polyurethane foam	Shoulder pad	Deformation recovery through temperature

technology of the material, it can remedy the damage of human body caused by bad environment, in order to provide better protection.

Smart Clothing Material Classification

1. *Shape memory material*: Shape memory material can percept the stimulation of environment change (such as temperature, stress, magnetism, dissolvent), and affect this change, to adjust its mechanical parameters (such as shape, location, strain), therefore made it recover to preset material. Shame memory PU material has temperature memory, it is also of wide range, light weight, handing ease, deformation variety and easy to re-deformation, is one of the fastest developed memory polymer materials (see Table 74.2).
2. *Waterproof breathable material*: Waterproof breathable material also called proofed breathable fabric, foreign "breathable fabric" refers to water with certain pressure, rain with certain kinetic energy, or snow, dew, frost out of the clothing, cannot transmit or soak fabric. While sweat can transmit to outside in the form of steam, without accumulating or con den sating on the surface or between fabric, in order to make people feel cool and warm, thus achieve the unity of waterproof, heat dissipation, comfortableness of fabric.
   Waterproof breathable materials usually used in uniforms, work clothes and outdoor sports. In addition, the application of waterproof breathable materials in common clothing is increasing, such as raincoat, wind coat, jacket, sportswear, tourism suits, leather clothing, gloves and hat (Yi Jikai and Hou Yuanbin 1999).
3. *Thermal control material*: Thermal control material is the high-tech fiber material that can sense the change of outer temperature automatically and adjust the temperature intelligently. It improves the clothing comfortableness as the major objective, can also absorb, store, re-distribute and release heat. When the surroundings temperature is low, it can heighten clothing temperature automatically,

while when the temperature is high, it can lower clothing temperature, which made clothing temperature at a comfortable range (Lin Min and Ding Jinhua 2005).
So far, the mature thermal control fabric manufacturing craft are coated finish, composite spinning and microcapsule spinning (Ma Shaoping and Zhu Xiaoyan 2004). The material is used in jacket, ski suit, underwear, cap, gloves and sockets, the products sales have increased these years.

4. *Discoloration*: Discoloration material refers to when the light, heat, water or radiation receives outside stimulation, it can change the color of the material automatically and reversibly, including thermo sensitive discoloration material and photosensitive discoloration material. Thermo sensitive discoloration material is the material that changes its color under specific temperature. Photosensitive discoloration material is the material that changes its color under the reflection of specific wavelength. The thermo sensitive discoloration material is to seal thermo sensitive fuel into microcapsule, and then coated on the fabric surface (Ding Yongsheng 2004).
5. *Electronic intelligence material*: Electronic information smart textile is the hot topic of technology fabric field, it blends micro electric, information and computer into fabrics, in order to collect signal according to the set in advance, thus dealt with the signal and received the feedback. In developed products, flexible electronic component embedded inside the textile, and integrated with sensor, flexible fabric switch, flexible power circuit board and conductive yarn.

Results

Medical Monitoring Care Clothing

Sensatex introduced sports T-shirt, which can monitor heart rate, body temperature, breathing and how many calories being consumed. The T-shirt can give an alarm in time when people who wears it has a heart attack, thus reduces the probability of sudden death (Shi Hongbin and Wang Nongyue 2006). It looks like rib cotton knitwear, while in fact the conductive fiber and cotton fiber blend together, in order to receive data from embedded sensor, transferred into a special receptor. To put this receptor at the waist to store information, then showed on mobile phone, PC or wrist monitors, in order to monitor the important vital signs of people who wears it, and to give an alarm in time (Fig. 74.1). Health surveillance used in smart clothing will finally solve the questions between combination of fabric and sensor that collected and solved physiologic signal and relevant equipment (Huang Canyi 2008). The clothing can provide support for these equipments, in order to effectively reduce their shortages of wearing them directly (Fig. 74.2).

Development idea: Smart clothing needs to combine with advanced technology of electronic information technology. sensor technology, textile science and

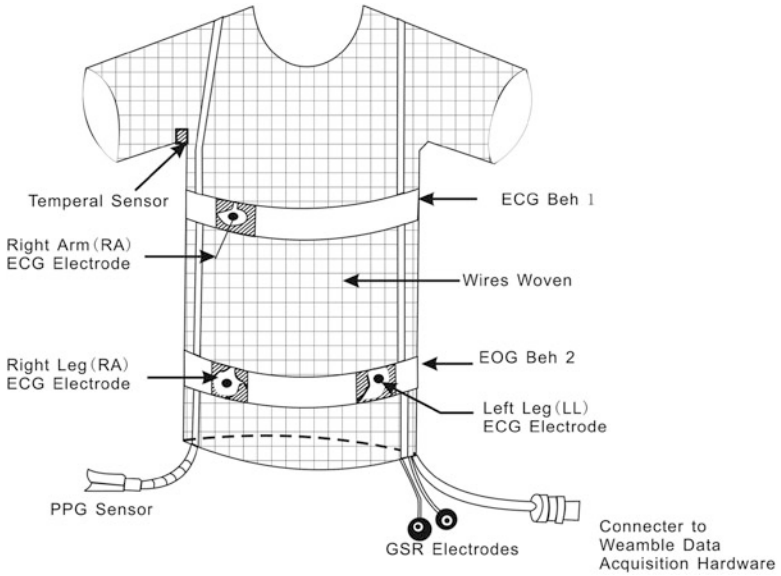

Fig. 74.1 Medical surveillance T-shirt

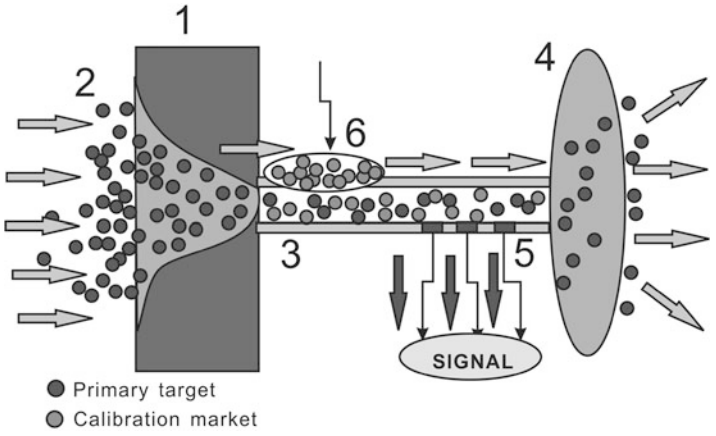

Fig. 74.2 Collection and transmission process of fabric sweat

material science, in order to achieve self intelligence by two ways: one is to use smart clothing material, including shape memory material, phase-change material, discoloration material, stimulated and reacted hydrogel, the other one is to bring information technology and micro electronic technique into people's daily clothing, including application conductive materials, flexible sensor, wireless communication technology and power supply (Liu Feng 2005).

Military Protective Smart Clothing

With the tendency of world multiplarzation, international local conflict, ethnic contradictions of various countries, upgrade and spread of arms weapon, chemical and biological warfare agents lead to loss of life and personal injury frequently. Therefore, functional nuclear biochemical protective clothing emerged. The fabric of surface layer uses functional inflaming retarding tape or aramid fiber fabric, to form functional nuclear biochemical protective layer with PTFE selective osmosis membrane. Meantime, to use glue or linen activated carbon fiber as the adsorption layer, in order to improve adsorption effect, increases life time, prevents carbon fiber infiltrates. To fix up activated carbon fiber non woven to two layers' fabric by laminating and quilting, in order to effectively prevent gas invasion and make it convenient to wash (Jiao Huiqin 2010).

Development idea: To apply reformed and low cost activated carbon fiber to regular clothing in order to resist the severe environment and violation of toxic gases. Meantime it can develop series production.

Fashionable Smart Clothing

In Europe, Levis first introduced music coat, which cannot only play music but also store favorite music in chips, or listen to favorite radio station. It is developed by Massachusetts Institute of Technology media lab. The coat is made of silk organza, music playback function is controlled by full cloth capacitive keyboard. People only need to press the bottom slightly, and then the clothes will start to play music. Music coat is an environmental music player, the energy mainly are sustainable energy of solar energy, wind energy, temperature and physical energy (Hou Haitou 2006).

Development idea: The manufacturers of smart clothing need to search for fashionable channel, high-tech clothing and material are popular for sportswear and outdoor suit. Therefore, outdoor suit should pay more attention on fashion, color and style.

Conclusion

Key words of low carbon, ecology, intellectualization, digitization will be the subject of global textile clothing of twenty-first century. Smart intelligentize textile clothing will become one of the most competitive focus point of clothing area of this century.

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