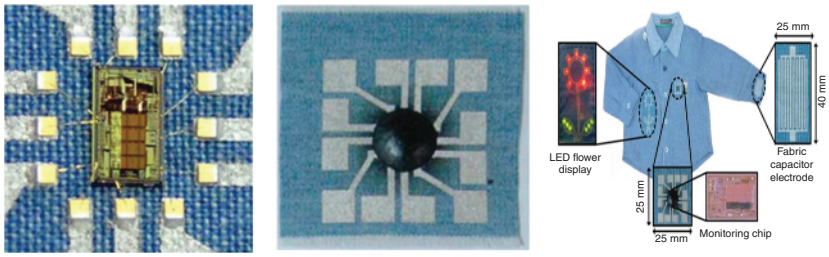

Figure 1.23 The screen-printed process. (a) Electronic component bonding on a P-FCB. (b) Electronic component packaging on a P-FCB. (c) System integration on P-FCB with capacitive sensor, chip, and LED display. Source: Adapted with permission from Wang et al. [18]. Copyright (2019) by WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim.

components, e.g. system-on-a-chip, chip capacitors, resistors, and LEDs, can be bonded directly on the textile lead frame (Figure 1.23c). Liquid molding epoxy was then coated on the chip after bonding process, which provided robust protection against stretching.

Compared with the first two technical solutions, intelligent textile woven from fiber-shaped electronic devices are soft and deformable, and the structure of textile can be designed into various patterns with high integration degrees. By integration of fiber-shaped electronic devices into textiles, it shows unique and attractive application prospects in the field of wearable/portable electronic products.

During the weaving process, there are two main assembling strategies for device units. The first strategy is to make complete fiber-shaped electronic devices, such as sensor, solar cells, lithium ion batteries, and light-emitting devices, and then integrate them into textiles through weaving or embroidery technologies. The second strategy is to weave fiber-shaped cathode and anode with an interlaced structure to directly construct textile-type electronic devices. Comparing with the first strategy, the second strategy has been verified by successfully fabricating solar cell textiles, in which the warp and weft yarns serve as the anode and modified cathode, respectively. As a matter of fact, Fan et al. have already presented a cloth-like 24/7 private AI nursing system based on fully interwoven IC fabric, for which both devices (Figure 1.24a) assembling and circuit wiring (Figure 1.24b) were completely accomplished along polymer wires or at their cross-nodes during weaving, rather than on a PCB. Figure 1.24c and 1.24d shows a designed interwoven IC textile and the practical interwoven IC textile, respectively. Such a body-fitted cloth has demonstrated its capabilities of uninterrupted physiological monitoring, signal amplifying, logic computing, and wireless communication, as an independent mobile electronic system for routine monitoring and emergency assistance.

Starting with the lightweight, low-cost polymer fibers and taking advantage of industrial weaving technology, flexible wearable electronic intelligent textiles are an increasingly expanding field that has raising value for both academicians and industry, in areas such as energy harvesting and storage, environment monitoring,

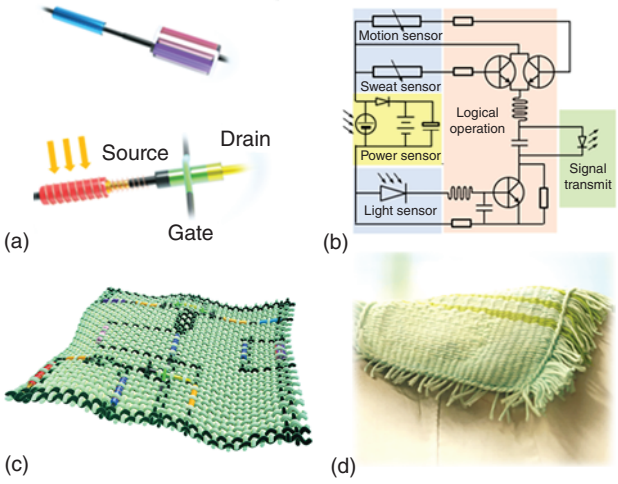

Figure 1.24 Integration of fiber-shaped electronic devices into textiles by interwoven IC. (a) Fiber-shaped field-effect transistor. (b) Design drawing of IC. (c) A designed interwoven IC textile. (d) The practical interwoven IC textile. Source: Based on Fan et al. [15].

healthcare systems, and entertainment products. Clothing is a feature of all human societies. Merging electronics and textiles is becoming increasingly important. Global industry giants have been exploring an efficient way of merging electronics with common cloth by pursuing an ultimate dream of "fabric computer" [19].

Although the integration of different functions of fibers has been widely demonstrated, the mismatch in material, structure, and fabrication requirement among the different kinds of devices still remains to be a critical barrier for practical applications. It is vital to develop efficient processing techniques to integrate different fiber electronic devices into textiles with a better and more comfortable human/textile interface design. Moreover, reliable connecting technique and IC are desired to achieve the higher integration of electronic textile. Apart from the problems mentioned above, safety issues are important for practical applications. Some fiber-shaped electronic devices such as batteries often require the use of flammable and toxic organic electrolytes, and they suffer from risks of fires and explosions induced by short circuit during deformation.

1.4 Conclusions

This chapter has discussed the definition, classification, characteristics, and applications of fibers, textiles, and intelligent textiles.

Fibers are closely related to every human life. Nature fibers such as silk and cotton were woven into textiles by human, which can keep human warm and comfortable. Because nature fibers are limited by natural conditions, they cannot meet with human needs, so people began to synthesize chemical fibers by processing methods, which appeared same as nature fibers but greatly enhanced human lives.

However, traditional textiles only have the basic functionalities, which can cover the ugliness and adorn the beauty, keep out the cold wind, and protect the body from insects. They cannot meet with human demands for healthcare, medicine, etc. Then, various functional fibers and textiles with special functions are constantly emerging, which are obtained through special processing of the original fibers or textiles.

Recently, textiles have faced a new challenge with the advancement of electronics and the Internet. Therefore, textiles are now expected to exhibit intelligent functionalities besides healthcare, protection, and medicine. Intelligent textiles are the product of the effective combination of high technology and traditional textile technology. They have broad market prospects and have great application potential in clothing, construction, military, etc., even though many new varieties are still under development.

In the near future, varieties of intelligent fibers and textiles will become more and more abundant, and the scope of application will become more and more extensive. The intelligent textiles can lead an important development direction and become a new economic growth point of the textile industry.

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