Department of Biomedical Engineering

VI Semester

CBM 370 - Wearable Devices

Unit- 4 SMART TEXTILE

4.4 Fabrication Techniques - Conductive Fabrics

- There are different ways to produce electrically conductive fabrics.
- One method is to integrate conductive yarns in a textile structure, e.g., by weaving.
- However, the integration of conductive yarns in a structure is a complex and seldom a uniform process as it needs to be ensured that the electrically conductive fabric is comfortable to wear or soft in touch rather than hard and rigid.
- Conductivity can be established with different thread types (Figure 4.4.1):

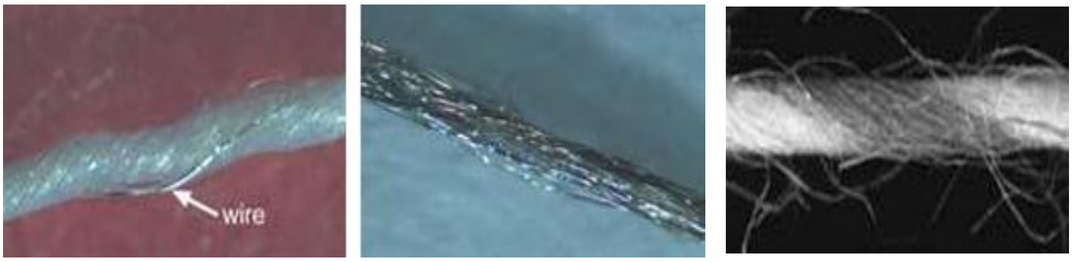

Figure 4.4.1. (a) Twisted metal wire: The metal wire is twisted around the polymer yarn; **(b)** Metal coating: The polymer yarn is physically/chemically coated with a thin metal layer; **(c)** Metal fibers: The conductive yarn consists of metal multifilaments

- However, woven fabric structures can provide a complex network that can be used as elaborated electrical circuits with numerous electrically conducting and non-conducting constituents, and be structured to have multiple layers and spaces to accommodate electronic devices.

- Researchers at the Electronics Department and the Wearable Computing Laboratory at the ETH in Zürich produced a plain-woven textile structure consisting of polyester yarns that are twisted with one copper thread.
- Initially, they started with a standard design (Figure 4.4.2a), then the researchers design a hybrid fabric called PETEX (Figure 4.4.2b).

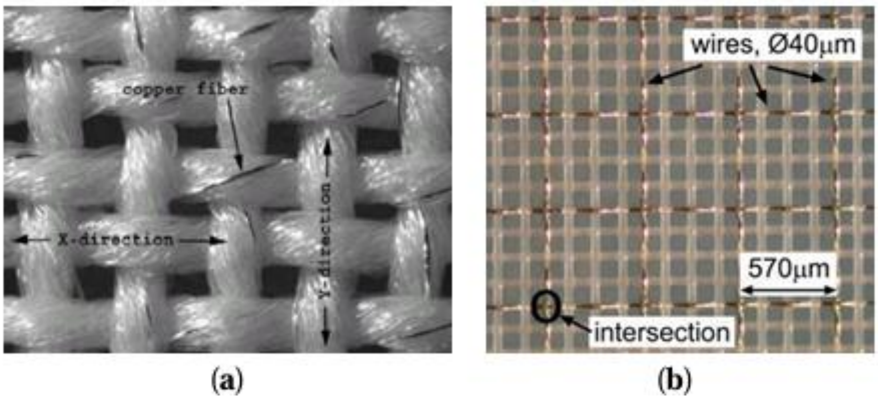

Figure 4.4.2. (a) Standard design of copper yarn twisted with polyester fibers; (b) PETEX.

[Figure Courtesy: Matteo Stoppa and Alessandro Chiolerio, Italy]

- It consists of woven polyester monofilament yarn (PET) with diameter of 42 μm and copper alloy wires with diameter 50 ± 8 μm (AWG 461). Each copper wire itself is coated with a polyurethane varnish as electrical insulation. The copper wire grid in the textile features a spacing of 570 μm (mesh count in warp and in weft is 17.5 cm−1).
- With the PETEX the ETH researchers introduced a new approach to Smart Textiles and in particular a new manufacturing method. The aim was the possibility to realize a custom textile circuit (Figure 4.4.3). The wiring structure among circuit components is established by connecting the fabric embedded copper wires.
- Cuts must be placed at specific locations in the wiring in order to avoid short-circuits between copper wires. In particular, the procedure is as follows:
  a) coating removal on copper wires at defined intersections with laser ablation;
  b) cutting the wires avoiding the signal leakage with laser;
  c) creating the interconnection with a drop of conductive adhesive;
  d) adding mechanical and electrical protection with an epoxy resin deposition.

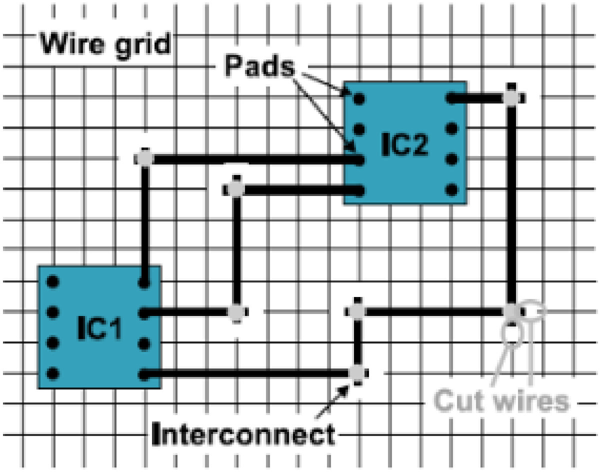

Figure 4.4.3. Approach to integrate circuits in a fabric with wire grid.

Examples: - Case Study 1

- The British company Baltex (Ilkeston, UK) uses the knitting technology to incorporate metal wires in textile structures. Their fabrics, which they commercialize under the name ***Feratec***®, can be used mainly for two purposes, namely heatable textiles and electro-magnetic shielding materials

[Figure Courtesy: baltex.co.uk]

Examples: - Case Study 2

The American company Thremshield LLC (Niagara Falls, NY, USA) produces metallized woven nylon fabrics in different shapes and profiles. The metals they use are silver, copper or a combination of copper and nickel.

Examples: - Case Study 3

The Danish company Chr. Dalsgaard Project Development (Aarhus, Denmark) works with the development of ***weaving electronics into fabrics***, ***electronic conductors in clothing***, operating panels in textiles (soft keyboards, displays, etc.)

and micro-sensors. The conductive yarn they use is a copper thread, plated with a silver layer and coated with polyester.

[Figure Courtesy: https://textilelearner.net/electronic-textiles/]

Examples: - Case Study 4

Another possibility to achieve a conductive fabric is to attach a conductive structure to a ground structure by using the ***embroidery technique***. In 2000, the ***Massachusetts Institute of Technology*** Media Laboratory researches were the first to propose a way of stitching patterns that can define ***circuit traces, component connection pads, or sensing surfaces*** designed with traditional CAD tools for circuit layout (Figure 4.4.4).

(a) (b)

Figure 4.4.4. **(a)** Musical Jacket comprising a fabric keypad on one side, a MIDI synthesizer on the other side, speakers behind speaker grills in the pockets and fabric buses visible inside the jacket; **(b)** The fabric keypad with the circuit board placed behind it.

[Figure Courtesy: Matteo Stoppa and Alessandro Chiolerio, Italy/ Journal of Sensors]

****