Electronic in e-textiles: How to connect electronics with textiles?

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Motivation:

Textile-integrated sensors and electrical components are essential for e-textile applications, e.g. for recording vital data, for ergonomic monitoring or for innovative user interface concepts. This places high demands on the interconnection of electronics and textiles, such as long-term mechanical reliability, washability, wearing comfort, signal quality or cost-effective manufacturing processes.

Approach:

Conventional interconnection technologies for e-textiles such as snap fasteners, conductive adhesives, crimping, soldering or sewing often face problems such as reduced conductivity, low dynamic reliability due to mechanical stress, and lack of or insufficient washability.

The **non-conductive adhesive (NCA) bonding technology** developed at Fraunhofer IZM shows major advantage of this technology because of its ability to reliably bond textile substrates and electronic modules mechanically and electrically in a single step. The bonded contacts show very good reliability results under cyclic temperature or humidity loads. The bonding technology can be used to contact a wide variety of textile-integrated circuits: embroidered, woven, knitted or textile-based circuits, also with (thermoplastic) insulation.

Silicone offers high stretchability, extremely high chemical and mechanical robustness and is therefore ideally suited for integration into stretchable textiles. **Pressure / strain sensors, heating surfaces or skin friendly electrode**s for ECG, EMG, TENS, EMS developed at Fraunhofer ISC can be incorporated into various functional textiles using established printing techniques or adhesive hot-melt processes. The most challenging aspect is the integration of stretchable conductive lines into textiles and should fulfill following requirements:

- Elastic textile and conductive lines should form a smooth surface
- Cables or conductive leads should be as elastic as the textile and withstand high stretching during getting dressed / undressed and wearing
- High electric conductivity (~ 1-10 Ohm/m) is crucial for long lines in the textile
- Electrical and mechanical bonding of electronic components should be processed at low temperature and short time
- Small pitch (2.5 mm) must be realizable for electronic bus systems

Results:

Manufacturing of conductive lines:

- Conventional (shielded) cables can be used in **knitted cable channels** (see figure 1)
- Meander lines allow stretchability in elastic textiles

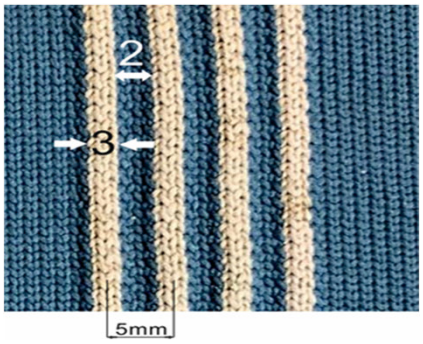

Figure 1: knitted cable channels

Directly knit stitched wires realize an electronic bus system with 4 conductive wires with a pitch of 2.5 mm (see figure 2).

- The conductive yarn is made of elastic Polyester yarn covered by a copper wire with high conductivity
- A subsequent insulation is made by elastic silicone

Figure 2: Directly knit stitched wires

Conductive silicone filled with copper particles or silver inks can be applied by a dispenser or by textile printing (see figure 3). The conductivity is in the range of 100 Ohm/m.

Figure 3: Printed conductive lines

Assembly of electronic modules by Non-Conductive Adhesive (NCA) Bonding:

During the NCA bonding process, the non-conductive adhesive and the optional thermoplastic conductor insulation becomes softer and are displaced in the area of the contact pads.

After cooling, the adhesive cures and **the modules are thus mechanically and electrically interconnected in a single process step** (see figures 4 and 5). In this process, the high-temperature sensitive textiles are only subjected to local thermal stress. Since the contact pads are located on the under-side of the modules, the contacts are better protected from external influences and the mechanical stress at the junction of soft textile to rigid electronics is reduced.

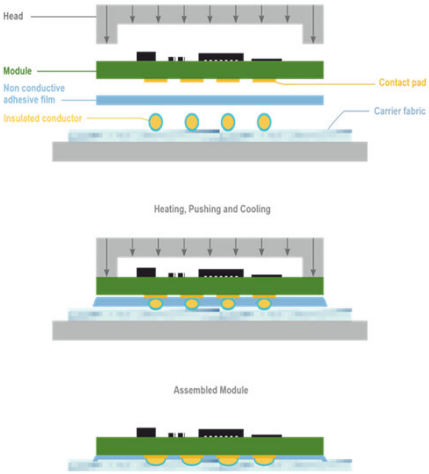

Figure 4: NCA – bonding process

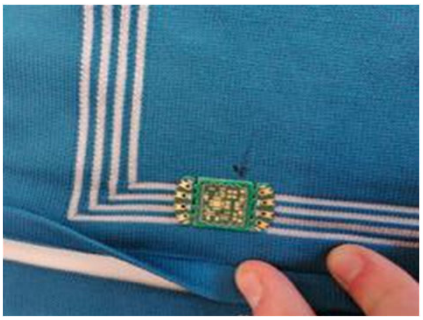

Figure 5: NCA – bonded electronic module on a knitted bus cable

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