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USING SELF-ADHESIVE CONDUCTIVE TEXTILE AND COPPER TAPE ON TEXTILE

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Abstract: *The application of conductive layers on textiles is considered. Tapes or foils of conductive textile and thin copper tape were used. The good and bad characteristics of textiles as a substrate and conductive tapes on textiles are considered, especially during use. The method of cutting conductive tapes and transferring them to textiles by means of a special self - adhesive tape is shown. An example made in the microwave technique, which is important due to high frequencies, is also presented.*

Keywords: *electronic textile, conductive textile, microwaves.*

1. INTRODUCTION

Electronic textile is increasingly used in modern electronics [1-10]. The field developed very quickly and acquired a large number of applications from ordinary life to special medical controls. This substrate also has its limitations, which are reflected in the variation of up to 10% of the values of parameters such as dielectric constant and thickness [6].

In addition to the substrate, the use of conductive textiles as metallization is very actual [8-13]. It lags behind pure metal in conductivity but also has advantages. The advantage over the pure metal layer is primarily in the flexibility and mechanical resistance coupled with the use of textiles [9-11]. Despite this, the use of self-adhesive metal tapes, especially copper but also aluminum, are very current. The biggest advantage over conductive textiles is conductivity, but also easier bonding, especially copper with soldering. Both self-adhesive conductive textile and copper tape give the possibility of easy removal of the conductive structure and installation of a new one without damaging the substrate.

An important application of self-adhesive conductive textile with conductive adhesive is the creation of a multilayer structure of the conductive layer that increases the conductivity [11] or electrically connects parts of the structure [12-14].

One of the problems is the transfer of the formed conductive structure to a given textile substrate, which is a general issue with other bases as well. Complicated sacrificial layers or etching and cutting on the textile base itself are used, which is often demanding due to a possible defect on the substrate. There is also the problem of large areas, such as clothes, as well as curved surfaces where it is impossible to easily cut.

The application of electronic textiles in defense technology is also significant. It is at the forefront of new technologies in the application of textiles in defense [15-19]. Application for defense sector will hold nearly 45% of the conductive textile market by 2031 [17].

The example application is on microwave structures, like in [18,19] but can be also on lower frequencies. The microwave structure is taken as an example as the most demanding due to the high frequencies.

2. APLICATION

Grid conductive cloth tape, *Xinst0402/12*, *Shenzhen Xinst Technology Co., Ltd*, total thickness (textile + conductive glue) 120 μm was used for conductive textiles with conductive adhesive. The conductivity of a given textile with a copper-nickel structure and polyester is about 10^5 S/m (copper bulk is $58 \cdot 10^6$ S/m, layer usually takes $18 \cdot 10^6$ S/m). A photograph of the surface and its photomicrograph is shown in Fig. 1. The disadvantage is the presence of plastic that makes it difficult to common soldering or bonding with silver epoxy paste.

The cutting was done by hand with a precision scalper given in [12]. In Fig. 2 are photographs from [12] of a cut structure on copper tape (copper 30 μm + non-conductive glue 30 μm) and of a cut structure on the given conductive textile. There is a tendency to wrinkle the copper tape while the conductive textile has remained flat.

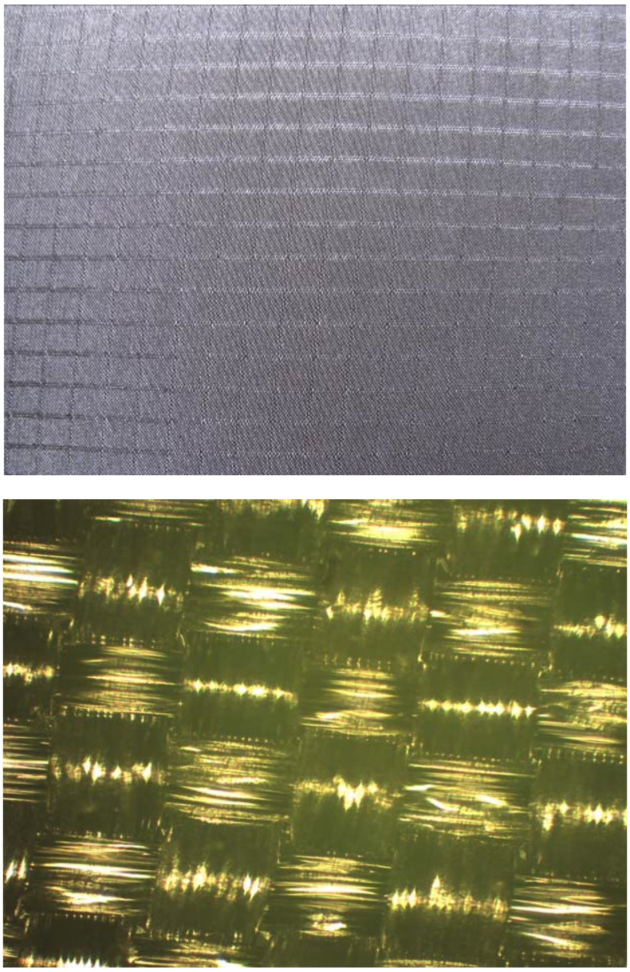
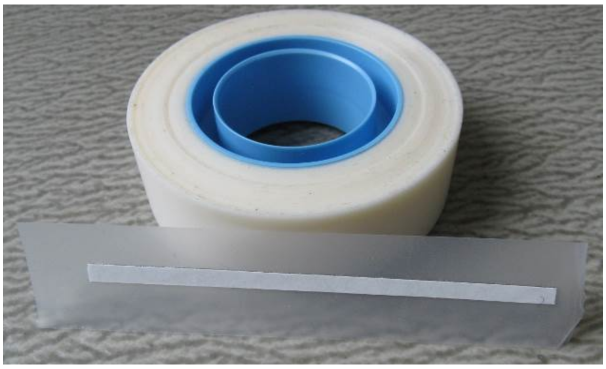


Figure 1. Photography and microscopic photography of conductive textiles (Motic 100x) [12].

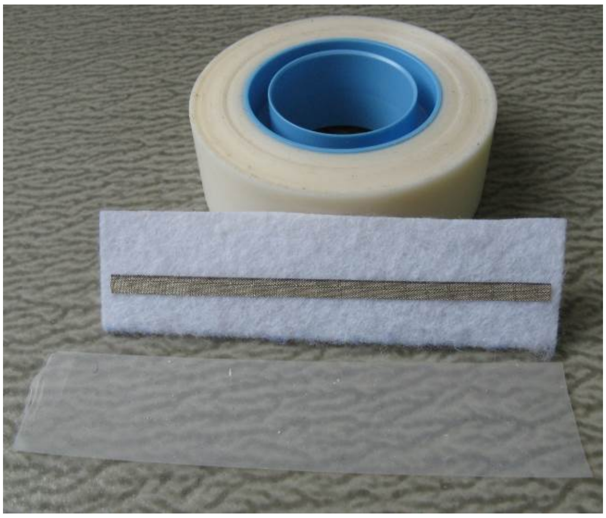
Figure 2. Copper tape and conductive textiles cut with a precision scalper [12].

Using a special self-adhesive tape (*Scotch Removable*), as a sacrificial layer, the conductive structure is transferred to the textile. Fig. 3a, 3b and 3c show the procedures on the example with one strip of the sacrificial layer.



a) Self-adhesive transparent tape (Scotch Removable) is glued to conductive textiles. Only supporting white paper carrying conductive textiles can be seen.

b) The supporting white paper was removed and the entire construction was glued to the substrate (felt). One can see the glued conductive textile and the self-adhesive transparent tape glued to it.



c) Removed self-adhesive transparent tape (below) as a sacrificial layer and only conductive textile remains on a felt substrate.

Figure 3. Using a special self-adhesive tape as a sacrificial layer

In Fig.4. photos from above and below of the filter with copper strip are given. You can see the use of short-circuited edges using conductive textiles with conductive glue. The use of short-circuiting at the edge is much closer to the definition of short-circuited branches than the usual conductive holes (via). Wrinkled copper surface can be seen.

In Fig. 5 is a photograph of the structures with conductive textiles from above using a short circuit at the edge. The application of conductive textiles with conductive adhesive can be seen here, similar to that in [11-14]. Even the author's work [12] was published before [14]. Fig. 6 presents SMA connectors details above and below. For better soldering next to the connector is copper, which is partly covered with the conductive textiles.

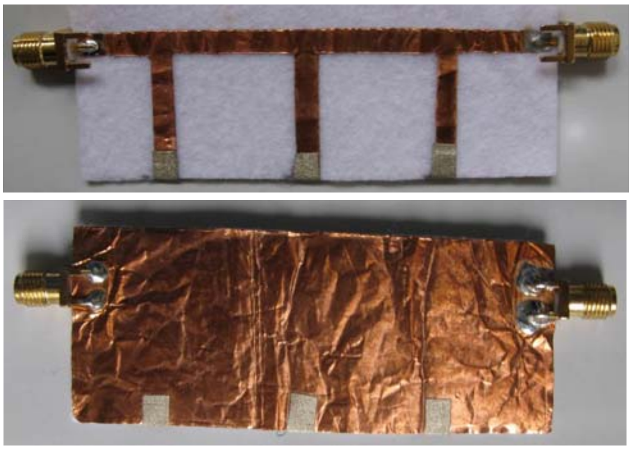


Figure 4. Structure with copper strip from above and below. You can see the use of short-circuited edges using conductive textiles with conductive glue.

Wrinkled copper surface can be seen.

Figure 5: Structure with conductive textiles from above.

One can see the use of shorting on the edge.

Figure 6: SMA connectors details above and below.

For better soldering next to the connector is copper, which is partly covered with the conductive textiles.

Both filters were made on a felt substrate with a thickness of about 0.85 mm, ε_r = 1.2 and tg (δ) about 0.02. All microstrip lines are taken to be 50 Ω. Since it was cut by hand, 3.5 mm was taken for the conductive textile and 4 mm for the copper strip. Stubs are 21.5 mm long. Simulation is in Program Package WIPL-D Microwave Pro v5.1 [20] for the metallized via holes. Models are in Fig. 7 for the conductive textile and in Fig. 8 for the copper tape. Corrections for the short-circuited edges (shorting on the edge) were done according to simulation and measurements. Simulated and measured *S*-parameters are given in Fig. 9. There are still needs for full wave EM-simulations.

It can be seen that conductive textiles have higher losses, which is logical. Without loses, the conductive textile would follow the copper tape filter.

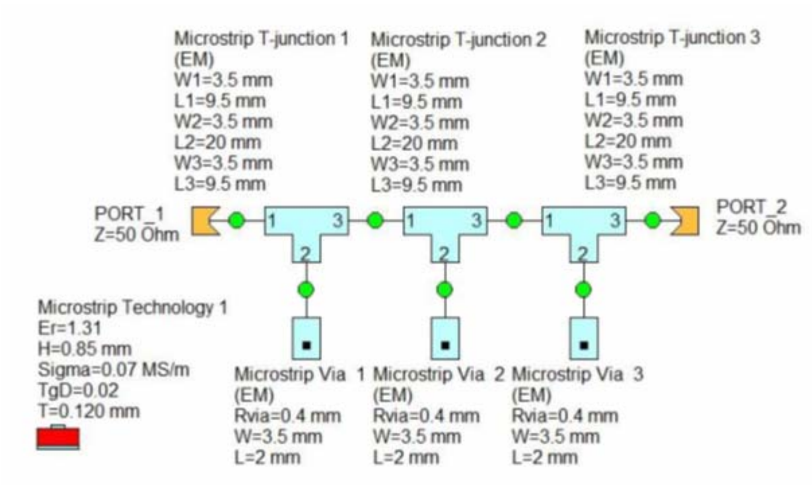


Figure 7: Simulation model with the conductive textile (including conductive adhesive in the metallization).

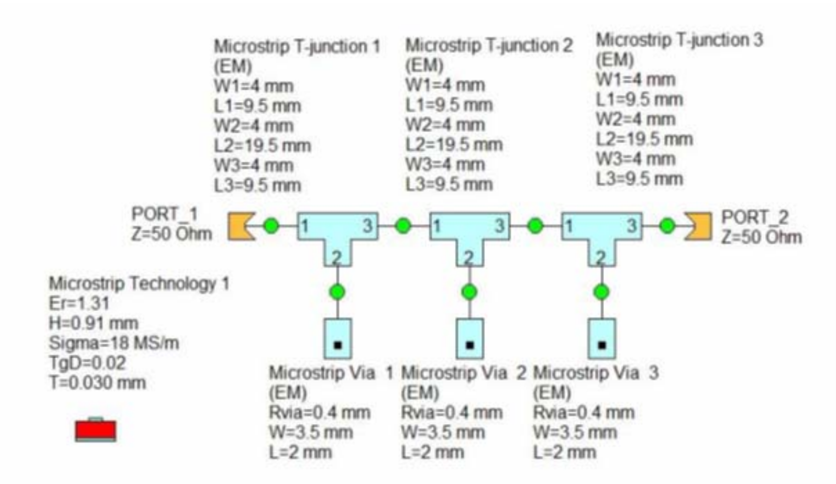


Figure 8: Simulation model with the copper tape (including nonconductive adhesive 2 x 0.030 mm).

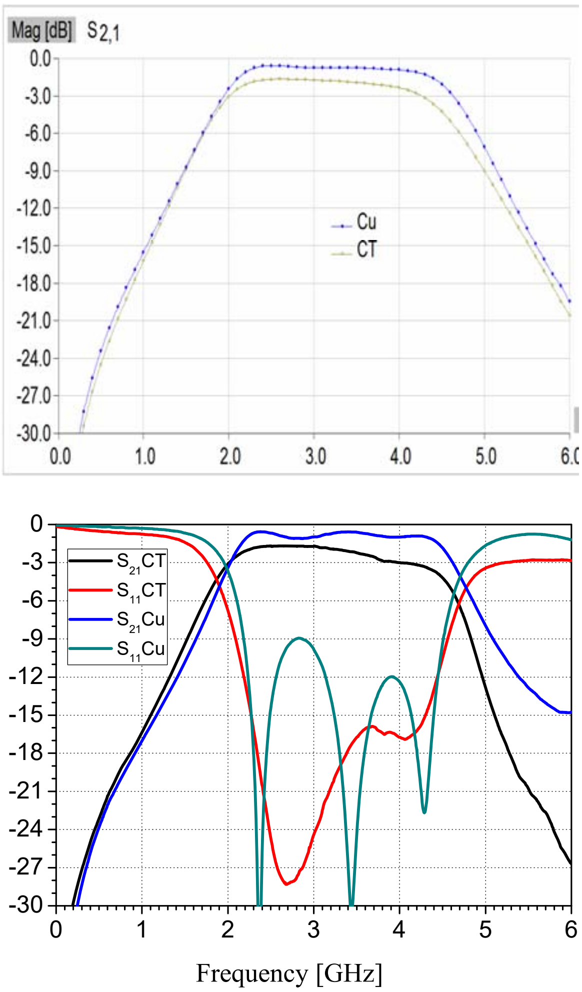


Figure 9. Simulation and measured S-parameters: CT-conductive textile; Cu-copper tape.

5. CONCLUSION

The advantage of conductive textiles is the applicability of electronics to clothes and other textile materials, while making them functional for use.

The lack is a textile material as a substrate that does not have a precisely defined thickness and dielectric constant. Some problems can be with washing and friction. It is also problem with connector bonding due to the nature of the material (difficult bonding of textile conductor and low resistance to high temperatures of textiles and glue).

The microwave structure is taken as an example as the most demanding due to the high frequencies. The branches are short-circuited with a conductive strip on the edge (short-circuited edge) and not with conductive via.

The advantages over other techniques such as applying conductive ink or paste and embroidery with conductive thread are:

- By applying a special self-adhesive tape as a sacrificial layer, it is possible to transfer the formed conductive structure in the form of a self-adhesive conductive layer to surfaces where etching or other invasive shaping methods are difficult to perform.
- The definition of thickness of the conductive layer is like in common electronic structures (better simulations).
- The self-adhesive conductive structure allows removing or even repairing the conductive layer and forming a new one without damaging the substrate.

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