CONTACT RESISTANCE MEASUREMENTS ON MULTIFILAMENT SILVER YARN

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ABSTRACT

A method for measuring the contact resistance between interlaced electro-conductive yarns has been developed. Measurements were succesfully conducted on multifilament silver-coated yarns in a plain weave structure. The highest intensity was found to be at

$$R_c \approx 0.14\ \Omega$$

The results are in accordance with previous research on silver-silver contacts.

INTRODUCTION

Little research has been done on the contact resistance between interlaced electro-conductive yarns in interactive textile structures. Hence the community can not know whether or not it poses a problem. Banaszczyk et. al. [1] showed with their modeling that the contact resistance in fact has a crucial influence on the current distribution in an electro-conductive plain weave, but had no experimental data on it. We hereby present a study on the contact resistance between interlaced multifilament yarns in a plain weave.

The yarn used in this study is *Statex 235/34 Dtex* which is a 2-ply multifilament yarn where each filament has a silver coating off approximately 7 micron radial thickness[3]. We have developed a method for measuring the contact resistance in a unit cell of a plain weave and successfully used it to determine the numerical value of the contact resistance.

In this study we have used silver yarns which turns out to have quite small values of contact resistance but the method poses no constriction on what kind of yarns one uses. For instance one might in the future do the same measurement on conductive polymer fibres. In the figure below, different magnifications of the samples are shown .

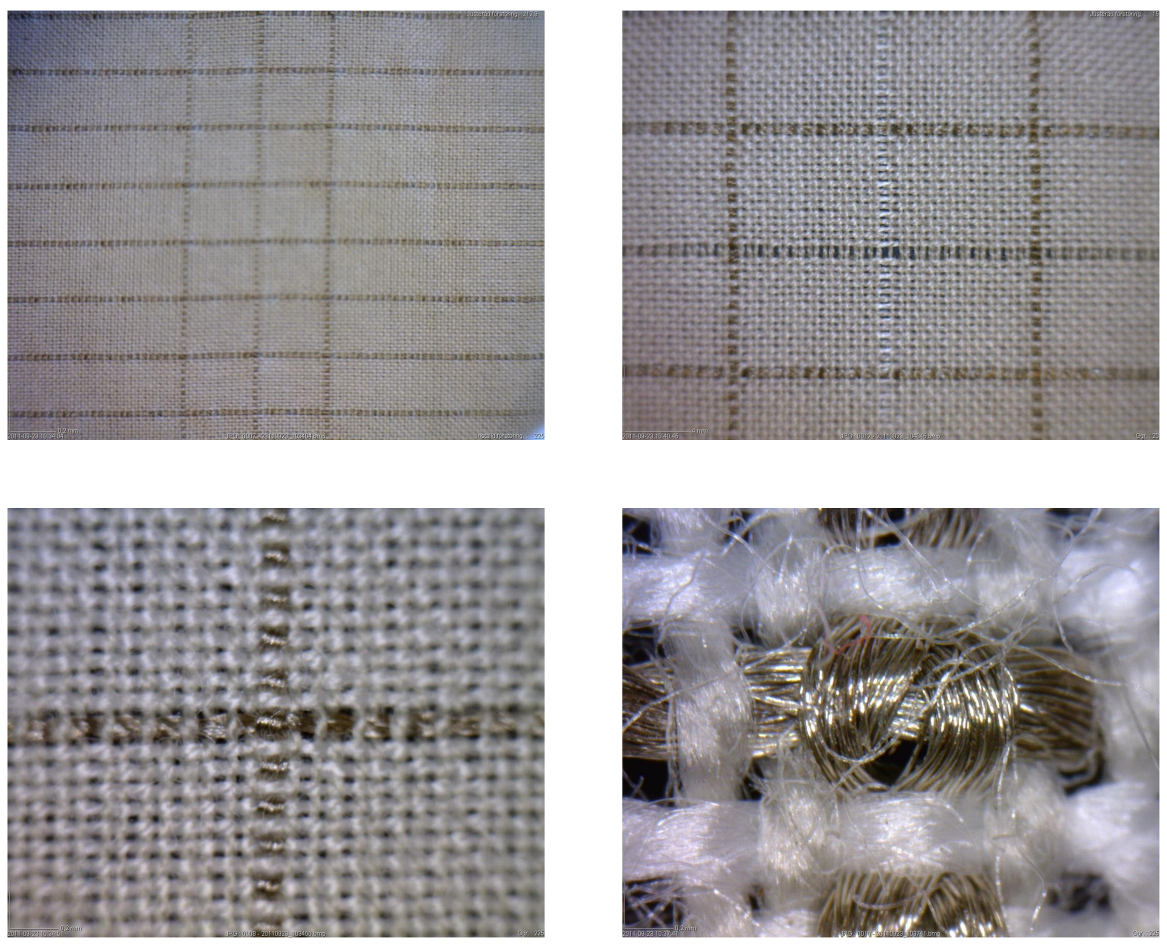

Figure 1: Different magnifications of a sample. N.B., the middle yarns in both weft and warp has been removed in the top right pane.

EXPERIMENTAL METHOD

A plain weave can be modeled as a three-dimensional resistance matrix (figure 2) that may be transformed in to the equivalent circuit displayed in figure 3 below, applying Ohm's law on all elements and Kirchhoffs Current Law on all nodes allows us to determine the fraction of the total current flowing in each branch. Thus all resistances can be calculated. All voltages, as indicated in figure 3, were recorded while injecting a known current at one of the nodes. This was repeated four times for each sample with the source and sink at different nodes. This gives all information to extract the resistances. The realization is pictured to the bottom right in figure 4.

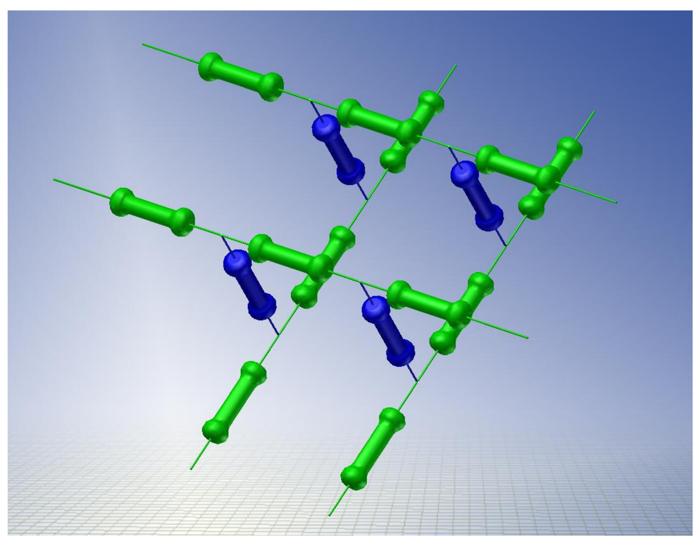

Figure 2: Three dimensional resistance matrix model

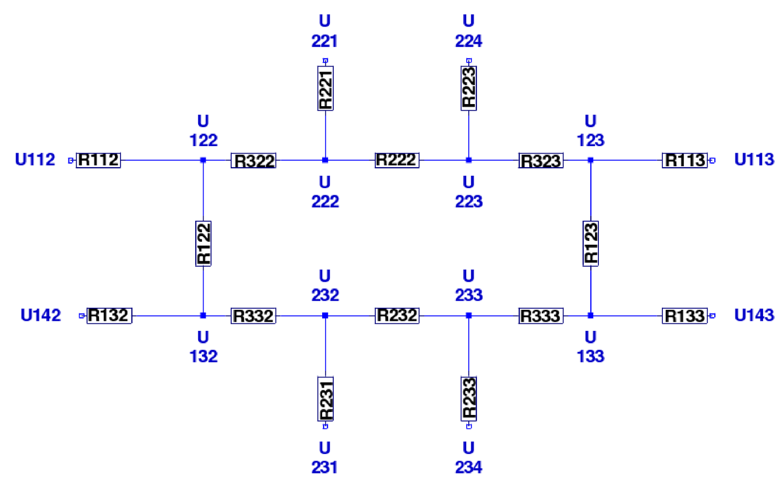

Figure 3: The equivalent circuit of the three dimensional matrix.

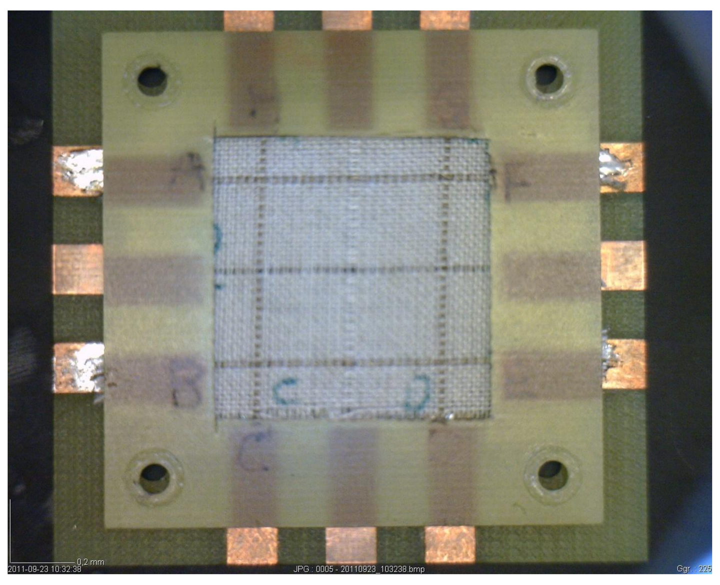

Figure 4: A sample placed in the measuring rig, only the outermost contacts are used.

RESULTS

Measurements were made on 25 samples giving a total of 100 points, the distribution is displayed in figure 5. A fit with a mixed normal distribution can be seen in figure 6, one can clearly distinguish three overlapping normal distributions. The highest peak lies on $R_c \approx 0.14\Omega$ and approximatly 50% of the points lay on the interval $0.1\ \Omega \leq R_c \leq 0.2\ \Omega$. A test of what approximate mechanical load this corresponds to was conducted and the load was found to be about 20 mN for Rc ≈ 0.14 Ω, this is in accordance with R. Holm[2].

Previous measurements have also shown that the resistance per length of the used yarn is about $\rho_l \approx 1.15\ ^{\Omega}/_{\mathrm{cm}}$ (suppliers spec. states $\rho_l \approx 100\ ^{\Omega}/_{\mathrm{m}} \pm 10\ ^{\Omega}/_{\mathrm{m}}$ [3]), looking at the distribution for the yarn-elements (figure 7) one sees that there is a peak at $R_{l,1} \approx 2.65\Omega$ and another one at $R_{l,1} \approx 3{,}11\Omega$. This is also reasonable given that the samples were made with the length of the yarns in the span of

$$1.95\mathrm{cm} \leq l \leq 2.35\ \mathrm{cm}$$

Which would result in

$$2.25\Omega \leq R_l \leq 2.7\Omega$$

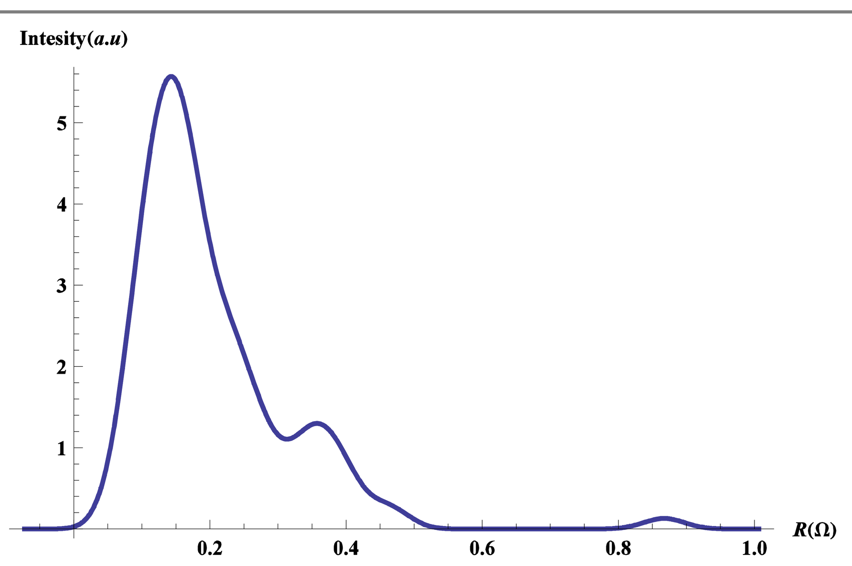

Figure 5: Distribution of the contact resistance

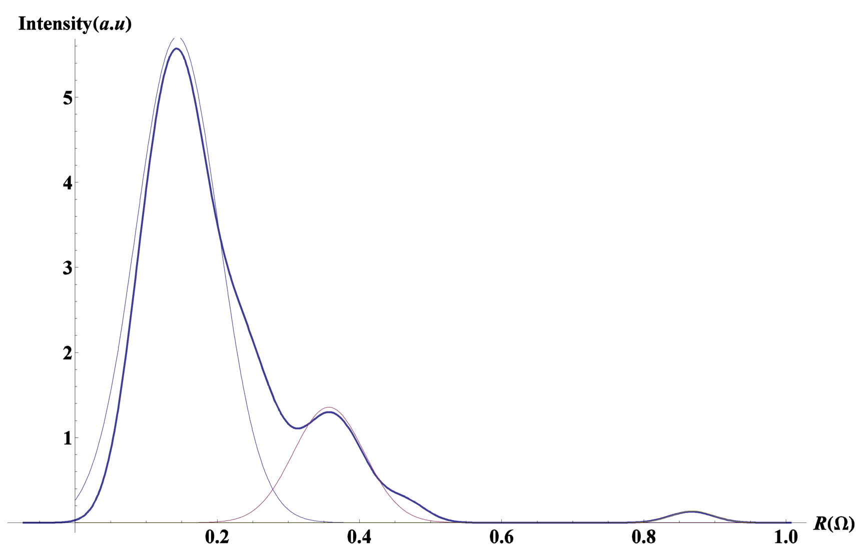

Figure 6: The contact resistance distribution along with a fitted mixture of normal distributions..

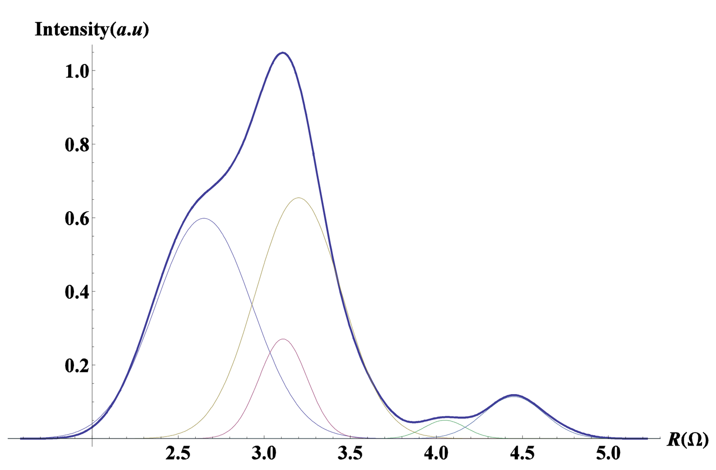

Figure 7: The distribution of the yarn resistances along with a fitted mixture of normal distributions.

CONCLUSIONS

The conclutions can be stated as:

•The method for determining contact resistances in a textile is well working

•contact resistance between interlaced silver yarns seems to be in the order of $R_c \approx 0.14\Omega$

What this suggests is that the method can be used for other electroconductive yarns as well. Since our samples had an length of either ca 1.95 cm or ca 2.35 cm and the resistance is centered around $R_l \approx 2.65\Omega$ or $R_l \approx 3.11\Omega$, the resistance per length is found to be $\rho_l \approx 1.3\Omega/\mathrm{cm}$ that corresponds well with the previously measured $\rho_l \approx 1.15\Omega/\mathrm{cm}$. This also suggests that the ratio between the contact resistance and the length resistance would be 0.1. In accordance with Banaszczyk et.al. [1], this would mean that a fabric made in such a manner as our samples would distribute the current sent trough it quite uniformly but if the conductive yarns were more densely spaced the current distribution would not be as uniform.

REFERENCES

[1]. Banaszczyk, J., De Mey, G., Schwarz, A., Van Langenhove, L. (2009). Current Distribution Modelling in Electroconductive Fabrics. *FIBRES & TEXTILES in Eastern Europe 2009*, Vol. 17, No. 2 (73), pp. 28-33.

[2]. Holm, Ragnar. (1967). Electrical Contacts Theory and Application *Springer-Verlag*, Berlin/Heidelberg 1967, Library of Congress Catalog Card Number 66-29437

[3]. Statex, *Shieldex 235/34 Dtex 2-ply HC Technical data sheet*, Statex Produktions & Vertriebs GmbH

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