Electric properties of electronic conductive yarn for smart fabric with environmental conditions

YoungJoo Jee, HongJae Kim, KwangNyun Cho, YoungMin Park, SangWoo Jin and YunYoung Kim

Research Development Division, Korea Sewing Technology Institute
20-11, Nowon-3Ga, Buk-Gu, Daegu, Korea
E-mail: jeeyj@sewtec.re.kr

1. INTRODUCTION

The smart fabrics has been widely developed using sensor to recognize human body and wearable computing systems to comfortable life[1,2]. The smart fabric requires several devices such as sensors, computing systems and display, and each device needs both the power supply and numerous communication channels[3].

To transmit the power and signals, there are two possible methodologies for implementation of sensors and wearable computing systems. One is the wired system using conventional electrical wires and the other is the wireless system which is fabricated with electronic conductive yarns[4]. The wired system has a few problems in applying to clothing. Because it is relatively heavier than wireless system and it is hard to arrange the physical layout of the devices. Therefore, electronic conductive fabrics are preferred to be used in smart fabrics[5].

Electronic conductive yarns are produced by many different methods such as sheath/core type, coated type and braid type. Specially, silver coated conductive yarns are greatly attractive to smart fabrics due to their outstanding electric conductivity and relatively lower joint resistance[6].

However, recently researches focus on the applications and the techniques of measurement for smart fabrics rather than research the electrical properties of electronic conductive yarns when exposed the external conditions such as strain by the pose, body temperature and sweat.

The aims this study is to investigate the effects of external stimulations on electric properties of silver coated electronic conductive yarns. The results will be useful a fundamental data to find the relationship of the electrical properties and many other external conditions.

2. EXPERIMENTAL

The electronic conductive yarns were composed of the nylon 6.6 fibers coated with a thin layer of silver by electroless deposition. The silver coated yarns are 11tex, 172 filaments obtained from Ajinelectron N6D-100-A®.

The morphological structures of yarns and individual fibers were examined using the FE-SEM(JEOL, S-4200) with ×100 magnification and ×1000 magnification. And the tensile testing for the electronic conductive yarns was performed to obtain initial modulus, strength and elongation at break. There were performed by using tensile testing machine(Tinius Olsen Ltd, H5KT-0236), following ASTM D2256.

Electrical properties of conductive yarns were measured by digital multi-meter(HIOKI, Digital Hitester, 3803) using two point prove methods. The samples were tested by applying a known current of 10mA, through the sample by means of contact with copper wire leads and measuring the voltage drop per 10cm length. The electrodes are positioned on separated platforms; one fixed and the other free to move in the axial direction of the samples. Fig. 1 appears the schematic diagram of testing platform.

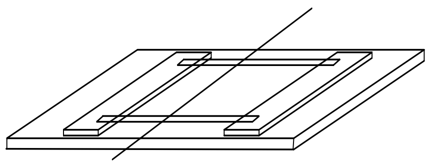

Fig. 1 Schematic diagram of testing platform.

Two environmental factors were applied in measuring electrical properties of the samples. One is strain and the other is heat exposure. Strain applied by tensile testing machine at 10%, 20% and 30% from original sample length. The convection dry oven (E-flex, 2-03-TAPE) were used for thermal exposure of 40℃, 10hours.

3. RESULTS AND DISCUSSION

Fig. 2 shows the surface structures of silver coated fibers. Silver particles were evenly coated on the fiber surface when no strain was applied the sample and it appears traditional fiber structures. The coated silver particle fall off from the surface of the samples, the higher strain was applied. Especially, the most cracks were found the surface when 30% stain was applied.

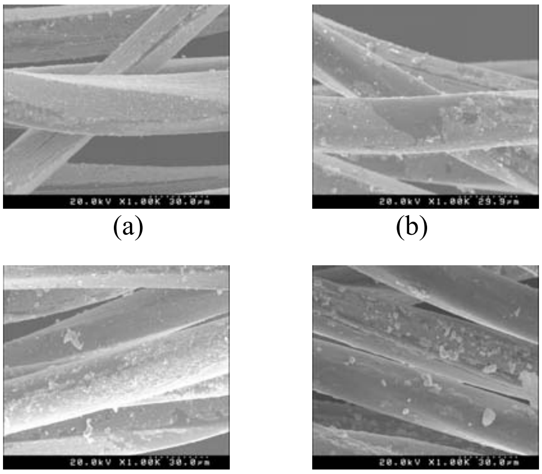

Fig. 2 Morphological structures of samples.
(a: virgin, b: 10% strain, c: 20% strain, d: 30% strain)

Physical properties of electronic conductive yarns were shown the table 1. Initial modulus is 1.8cN/tex, strength is 45.9cN/tex and breaking strain is 37.7%. It shows that we considered adequate strain ranges for measuring electrical properties.

Table 1. Physical properties of conductive yarn.

Sample	Initial modulus (cN/tex)	Strength (cN/tex)	Breaking strain (%)
N6D-100-A	1.8±0.2	45.9±1.6	37.7±1.2

Resistance changes of samples are shown Fig. 3. Virgin yarns have 368.2Ω per 10cm length. Voltages of samples are increased with increasing physical strain when 10% applied 1.1mv drop, 20% applied 2.3mv drop and 30% applied 3.2mv drop. It causes that diameter of sample are decreased with strain and coated silver particles breakaway from surface of yarns.

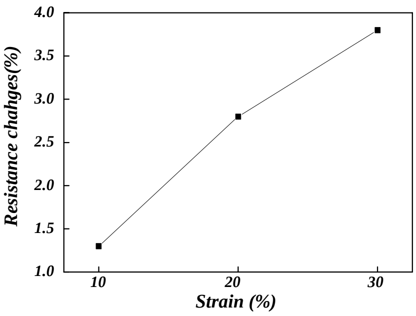

Fig. 3 Resistance changes with strain.

There is no significant change under 40℃, 10hours heat exposure condition. But it appears only 0.4mv voltage drop and it is relatively smaller change than strain condition. These behaviors due to the heat expansion of nylon 6.6 fibers and generate the crack to fiber surface.

4. CONCLUSION

The electric properties of smart fabrics do not normally evaluate by environmental effects. But changes of electrical properties on smart fabrics must be considered external stimulation when they perform the fabricating process such as weaving and finishing.

We have shown in this study that the behavior of the silver coated electronic conductive yarn was affected physical strain and thermal exposure. And it appeared 4% resistance change on 30% strain condition where, it was affected by surface particle separation and dimensional change of fiber. And silver coated yarns also had a subtle resistance change for 10hours, 40℃ heat exposure. Therefore electrical properties on smart fabrics must be considered with environmental conditions and physical strain is more important factors than thermal exposures.

5. REFERENCES

[1] T J. Akita, T. Shinmura, S. Sakurazawa, K. Yanagihara, M. Junita, M. Toda and K. Lwata; *Artificial Intelligence in Medicine,* 42, pp.99-108, 2008.

[2] S. M. Lobodzinski and M. M. Laks; *Journal of Electrocardiology*, 39, pp. 41-46, 2006.

[3] E. Wade and H. H. Asada; Proceedings of the 26th Annual International Conference of the IEEE EMBS San Francisco, CA, USA·September 1-5; pp.5376-5379, 2004.

[4] J. Akita, T. Shinmura, T. Murakami, M. Y. Kanazawa and M. Toda; Proceedings of the 7th International Conference on Mobile Data Management(MDM'06), 2006.

[5] J. Akita, T. Shinmura, T. Murakami, M. Y. Kanazawa and M. Toda; Proceedings of the 26th IEEE International Conference on Distributed Computing Systems Workshops(ICDCSW'06), 2006.

[6] M. Amberg, K. Grieder, P. Barbadoro, M. Heuberger and D. Hegemann; *Plasma Processes and Polymer*, 5, pp. 874-880, 2008.

[7] S. Bosselman; TECHNICAL Report Natick /TR-07/022, 2007.