

**DEVELOPMENT OF A TRIBOELECTRIC
NANOGENERATOR USING NYLON-HYBRID YARN**

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Science by Research

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Declaration

I K.R.S.D. Gunawardhana (198014T) declare that this is my own work, and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text. Also, I hereby grant to University of Moratuwa the non-exclusive right to reproduce and distribute my thesis/dissertation, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

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Dedication

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මෙය උපහාරයක් වේවා.....

let this be a tribute to

my mother

my father

my teachers

and my love....

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Abstract

Human needs are continually changing with the enhancement of novel electronic technologies. The Internet of Things (IoT), Artificial Intelligence, and 5G technology have led to state-of-the-art products to improve the living standards of a rapidly increasing global population. Wearable electronics, which are closely associated with human activities, are typically powered with replaceable or rechargeable batteries. There are significant drawbacks of existing power supplies for wearable electronics, including low flexibility and stretchability, limited autonomy, low biocompatibility and high weight. Portable and renewable energy harvesting are possible from a wearer's physical movements in an ambient environment. In recent years, this has been achieved using Piezoelectric and Triboelectric nanogenerators, which act as an alternative to batteries for powering wearable electronic devices. However, such technologies' challenges include the magnitude and consistency of power output, fabrication for mass-scale production and operation under small mechanical movements. This project focuses on developing a triboelectric nanogenerator using silver-coated nylon yarn, silicone and polyurethane with a rib knitting structure. The basic fundamental methods of applying triboelectric layers such as dip coating, printing and yarn coating methods analysis for wearable and electrical outputs. Yarn coated sample shows the best results with even coverage, good air permeability ($101 \text{ cm}^3/\text{cm}^2/\text{s}$), high moisture management properties and high stretchability (Stretchability -75.82%, Recoverability- 76.67% and elastic modulus of 1.4093). Furthermore, when polyurethane bonded air textured sample used as a secondary triboelectric layer, the final device shows a maximum short circuit current of $3.412 \mu\text{A}/\text{m}^2$, the charge density of $6.12 \mu\text{C}/\text{m}^2$ and maximum open-circuit voltage of 51.08 V under the 1 mm amplitude over 1 Hz frequency. Finally, the device used to generate a peak power of $116.8 \mu\text{W}/\text{m}^2$ through $10 \text{ G}\Omega$ resistors under the same motion profile.

Key Words: Triboelectric Nanogenerator, Wearable Energy Harvesting. Knitting, Air Texturing

Table of Content

Declaration	i
Dedication	ii
Acknowledgement	iii
Abstract	v
Table of Content	vi
List of Figures	ix
List of Tables	xiii
List of Abbreviations	xiv
Chapter 1	1
1. Introduction	1
1.1. Background to The Study	1
1.2. Research Problem	1
1.3. Significance of The Project	3
1.4. Aim and Objectives of The Study	3
1.4.1. Aim	3
1.4.2 Research objectives	3
Chapter 2	5
2. Literature review	5
2.1. Introduction to The Chapter	5
2.2. Operation Principle and Working Mechanism Of TENG.	5
2.3. Wearable TENG Development	8
2.4. Electrical and Wearable Output Enhancement	14
Chapter 3	16
3. Research Methodology	16
3.1 Introduction to The Chapter	16

3.2. Literature Survey	16
3.3. Electrode Selection	16
3.4. Selection of Triboelectric Material	17
3.5. Application of Material on Conductive Fabric	18
3.6. Development of Yarn Coating System	19
3.7. Development of Comparative Samples	20
3.8. SEM Examination for Surface Topography	23
3.9. Testing for Charge Density, Voltage and Current	23
3.10. Testing for Textile Performance	25
3.10.1. Air permeability testing	25
3.10.2. Moisture management testing	25
3.10.3. Stretch and recovery testing.	26
3.11. Incorporate the Air Texturing Technique	28
Chapter 4	30
4. Results and Discussion	30
4.1. Selection of Yarn	30
4.2. Selection of Triboelectric Material	31
4.2.1. SEM result comparison	31
4.2.2. Comparison of Charge, Voltage and Current	34
4.3. Selection of Triboelectric Layer Application Technique	38
4.3.1. Comparison of the morphology of printed, dip-coated and yarn coated samples.	38
4.3.2. Comparison of charge, voltage and current for structure modification	41
4.3.3. Final prototype with air textured secondary electrode	45
4.4. Textile Properties of TENG Layer Application Techniques	47
4.4.1. Air permeability test results	47

4.4.2. Moisture management test result	48
4.4.3. Stretch and recovery test results.	53
Chapter 5	57
5. Conclusion and recommendations	57
5.1. Key Conclusion	57
5.2. Recommendations	58
Publications from this project	59
Reference	60

List of Figures

	Page
Figure 2.1: Working modes and triboelectric series for TENG devices, a) Common TENG Architecture, b) Triboelectric Series for Textile Material Adopted from [11], c) VCSTENG Mode TENG Architecture, d) LSTENG Mode TENG Architecture, e) SETENG Mode TENG Architecture, f) FSTENG Mode TENG Architecture	7
Figure 2.2: fibre/yarn, fabric based TENG devices, a) Silk/ Stainless Steel and PTFE/Stainless Steel Core-Sheath Based TENG Device. SEM Images for (ii) Silk/ Stainless Steel and (iii) PTFE/Stainless Steel. (b) (i) Piezoelectric and Triboelectric Hybrid Nanogenerator Constructed Using sandwich structure. SEM Images of (ii) Silk Nanofibers and (iii) PVDF Nanofibers., c) TENG Architecture of Harnessing Energy from Mechanical Movement, (ii) Schematic of Fabric Substrate-based TENG (iii) PDMS Microrods on Fabric., d) (i) Copper PET Yarn-based Woven TENG, Yarn Interlacing View from Side (ii) and Top (iii), (iv) Cross-sectional View of the Interlacing Point Under Pressure (Top) and Without Stress (Bottom), (v) Charge Distribution at Yarn Interlacing Point. (e) Schematic of 3D Knitted TENG Device, f) Full Cardigan Structure-based TENG Architecture	11
Figure 3.1: Triboelectric layer printing a) Conductive Fabric, b) Screen Printing Technique	18
Figure 3.2: Optical Microscopic Image of Dip Coated Yarn a), b) at 50X, Microscopic Image of Yarn Coated with Tube c) at 50X.	19
Figure 3.3: New Yarn coating method, a) Schematic Diagram for Bespoke Yarn Coating System, b) Mini Stenter Machine, c) Yarn Coating with the Developed System, d) Heater Controller of Stenter Device, e) Temperature Controller System	21

Figure 3.4: Developed samples, a) Yarn Coated 3.5G Sample, b) Yarn Coated 5G Sample, c) Printed 5G Sample, d) Dip-coated 5G Sample, e) Printing Machine Used for Printed Sample Preparation.	22
Figure 3.5: Electrical characterization setup, a) The Bespoke Test Setup for the Characterization of Vertical Charge Polarization TENGs. The Modification of the Design for the b) Non-parallel Secondary Electrode SETENG, c) Dielectric Free-standing Layer FSTENG.	24
Figure 3.6: Wearable characterization machinery, a) Air Permeability Testing Machine, b) Moisture Management Tester	26
Figure 3.7: Instron Tensile Testing Machine	27
Figure 3.8: Incorporation of air texturing mechanism, a) Charge Trapping Increased When Closing the Pores, b) Before Air Texturing, b) After Air Texturing Yarn Reprinted from Ref [4], [57]	28
Figure 4.1: EDAX Report for a) Silver Coated Yarn, b) sample area	30
Figure 4.2: SEM of a) RTV Silicone Coated Sample 100X. b) Back Scattered Image 100X. (c) 500X. EDAX Report of d) RTV Silicone	31
Figure 4.3: SEM of a) Polyamide Coated Sample 100X., b) Back Scattered Image 100X., c) 500X., d) EDAX Report of Polyamide	32
Figure 4.4: SEM of a) PTFE Coated Sample 100X., b) Back Scattered 100X., c) 500X., d) EDAX Report of PTFE	33
Figure 4.5: SEM of a) Silicone-coated Sample 100X., b) Back Scattered Silicone 100X., c) 500X. d) EDAX Report of Silicone	33
Figure 4.6: Schematic of Electrical Result Characterization of the Triboelectric Layer Selection Process	34
Figure 4.7: Motion Profile Used for Characterization	35
Figure 4.8: Comparison of Max Charge Generation for Selected Triboelectric Materials	36
Figure 4.9: Comparison of Close Circuit Current for Selected Triboelectric Materials	36
Figure 4.10: Comparison of Open Circuit Voltage for selected Triboelectric materials	37

Figure 4.11: SEM images of Dip-coated Sample a) Side View of the Sample 100X, b) Surface of the Sample 50X, c) Cross-section of the Sample 200X, d) Elemental Mapping of the Top Surface of the Sample.	38
Figure 4.12: SEM images of Printed Sample a) Unprinted Side of the Fabric Sample 100X, b) The Printed Surface of the Sample 50X, c) Unprinted Areas in the Surface of the Sample, d) EDAX Report for the Surface.	39
Figure 4.13: SEM Images of Yarn Coated Sample a) Side View of the Yarn 368X, b) Surface of the Coated Yarn 150X, c) Cross-section of the Yarn 200X (d) Elemental Mapping of Coated Yarn.	39
Figure 4.14: EDAX report for Silicone Coated Yarn.	40
Figure 4.15 : Schematic for Electrical Characterization of Triboelectric Layer Application Process Analysis	41
Figure 4.16: Current Comparison for Different Layer Modification Techniques	42
Figure 4.17: Voltage Comparison for Different Layer Modification Techniques	43
Figure 4.18: Charge Comparison for Different Layer Modification Techniques	43
Figure 4.19: Electrical Output Comparison Between Yarn Coated 5G and 3.5G Samples a) Short Circuit Current, b) Open Circuit Voltage and c) Open Circuit Charge	44
Figure 4.20: Schematic of the a) Final Prototype, b) 5G Knitted Sample, c) Air Textured PU Bonded Sample.	45
Figure 4.21: Electrical Characterization Between PDMS Yarn Coated Sample and Air Textured PU Bonded Sample (a) Short Circuit Current, (b) Open Circuit Voltage (c) Open Circuit Charge.	45
Figure 4.22: Current and Power Through Different Resistors Attached to the Final TENG Device.	46
Figure 4.23: Air Permeability Result for a) Silicone Printed Sample, b) PU Bonded Sample, c) Air Permeability Test Initialization State, Samples set up d) PU Bonded Sample, e) Silicone Printed Sample	47
Figure 4.24: water location vs time for a) Dip Coated, b) Printed Sample Printed Side Top, c) Printed Sample Unprinted Side Top, d) Yarn Coated and PU Bonded Samples	53

Figure 4.25: Stretch and Recovery Test for Dip-coated Sample.	55
Figure 4.26: Tensile Test for Uncoated Sample	55
Figure 4.27: Tensile Test for Coated Sample	56
Figure 5.1: Places on Garments to Place the Developed TENG Device	58

List of Tables

	Page
Table 2.1: Summary of Selected Sandwich and Core-Sheath Based TENG Devices Available in the Literature.	9
Table 2.2: Summary of Selected Knitted and Woven Based TENG Devices Available in the Literature.	12
Table 3.1: Characteristics of Core Yarn	17
Table 3.2: Chemicals for Triboelectric Layer Modification	17
Table 3.3: Dip Coated, Yarn Coated and Printed Sample Preparation.	20
Table 3.4: Standards and specifications for air permeability test	25
Table 3.5: Air Texturing Parameters	29
Table 4.1: Linear Resistance of Selected Yarns	30
Table 4.2: Comparison of Charge, Voltage and Current of Different Materials	34
Table 4.3: Summarization of Charge, Voltage and Current for Different Application Methods of the TENG Layer	41
Table 4.4: Air Permeability Test Results	48
Table 4.5: Summarization of Moisture Management Test Results for All Samples	51
Table 4.6: Summarization of the Stretch and Recovery Results	54
Table 4.7: Summarization of Tensile Behaviour of Coated and Uncoated Yarn	54

List of Abbreviations

Abbreviation	Definition
3.5G	Gauge three point five
5G	Gauge Five
7G	Gauge seven
AATCC	American Association of Textile Chemists and Colourists
AC	Alternative Current
ASTM	American Standards of Testing Materials
BS	British Standards
CNT	Carbon Nanotube
DDEF	Distance Dependent Electric Field
EDAX	Energy dispersive X-ray Analysis
FSTENG	Freestanding Mode Triboelectric Nanogenerator
ISC	Short Circuit Current
JSC	Short Circuit Current Density
LSTENG	Lateral Sliding Mode Triboelectric Nanogenerator
PDMS	Polydimethylsiloxane
PET	Polyethylene Terephthalate
PLA	Polylactic Acid
PTFE	Polytetrafluorethylene
PU	Polyurethane
PVDF	Polyvinylidene Difluoride

PZT	Lead Zirconate Titanate
RTV	Room Temperature Vulcanized
SEM	Scanning Electron Microscope
SETENG	Single Electrode Triboelectric Nanogenerator
TENG	Triboelectric Nanogenerator
VCSTENG	Vertical Contact Separation Mode Triboelectric Nanogenerator
VOC	Open Circuit Voltage