DEVELOPMENT OF A TRIBOELECTRIC NANOGENERATOR USING NYLON-HYBRID YARN

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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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Signature of the supervisor: Date:

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 if a rapidly increasing global population. Wearable electronics, which 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 focus 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 cm3/cm2/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 $\mu A/m^2$, the charge density of 6.12 μC/m2 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 μW/m2 through 10 GΩ resistors under the same motion profile.

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

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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