

*DEDICATED TO
MY BELOVED FATHER, MOTHER AND
BROTHERS*

Declaration

I, Nithin Joseph Panicker, hereby declare that the present thesis, entitled “**A Study of Graphene based 2D heterostructures for high performance Supercapacitors**”, is the record of work done by me under the supervision of **Prof. Partha Pratim Sahu, Professor, Department of Electronics and Communication Engineering, Tezpur University, Tezpur**. The contents of the thesis represent my original works that have not been previously submitted for any Degree/Diploma/Certificate in any other University or Institutions of Higher Education.

This thesis is being submitted to Tezpur University for the Degree of Doctor of Philosophy in Electronics and Communication Engineering.

Place: Tezpur University, Tezpur

Date:

(Nithin Joseph Panicker)



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Certificate

This is to certify that the thesis entitled, “**A Study of Graphene based 2D heterostructures for high performance Supercapacitors**”, submitted to the School of Engineering, Tezpur University in partial fulfillment for the award of the degree of Doctor of Philosophy in Electronics and Communication Engineering is a record of research work carried out by **Mr. Nithin Joseph Panicker** under my supervision and guidance.

All help received by him from various sources has been duly acknowledged.

No part of this thesis has been submitted elsewhere for the award of any other degree.

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Certificate of the External Examiner

This is to certify that the thesis entitled “**A Study of Graphene based 2D heterostructures for high performance Supercapacitors**”, submitted by **Mr. Nithin Joseph Panicker**, Department of Electronics & Communication Engineering, School of Engineering, Tezpur University in partial fulfillment for the award of the degree of Doctor of Philosophy in Electronics and Communication Engineering has been examined by us on _____ and found to be satisfactory.

The committee recommends the award of the degree of Doctor of Philosophy.

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List of Abbreviations

SC	Supercapacitor
EDLC	Electrochemical Double Layer Capacitor
AC	Activated Carbon
CNT	Carbon Nano Tubes
IHP	Inner Helmholtz Plane
OHP	Outer Helmholtz Plane
DI	Deionized
ASC	Asymmetric Supercapacitors
ESR	Equivalent Series Resistance
CV	Cyclic Voltammetry
GCD	Galvanostatic Charge/Discharge
EIS	Electrochemical Impedance Spectroscopy
2D	2-Dimensional
rGO	reduced graphene oxide
FTIR	Fourier transform infrared spectroscopy
ITO	Indium doped tin oxide
GO	Graphene Oxide
JCPDS	Joint Committee on Powder Diffraction Standards
RPM	Rotation per Minutes
SEM	Scanning Electron Microscopy
UV-vis	Ultraviolet Visible
XRD	X-ray diffraction
TGA	Thermogravimetric Analysis
SAED	Selected Area Electron Diffraction

EDS	Energy-dispersive X-ray Spectroscopy
TMOs	Transition Metal Oxides
TMS	Transition Metal Sulphides
CPs	Conducting Polymers
h-BN	hexagonal-Boron Nitride
CVD	Chemical Vapor Deposition
HOG	Highly Oxidized Graphene
PPy	Polypyrrole
NMP	N-Methyl-2-pyrrolidone
PVDF	Polyvinylidene fluoride
NCS	NiCo_2S_4
GNCS	rGO@ NiCo_2S_4
NPs	Nanoparticles
GCN	g- C_3N_4
CCN	carbon self-repairing g- C_3N_4
pCCN	porous carbon self-repairing g- C_3N_4
pCRNCS	porous carbon self-repairing g- C_3N_4 /rGO@ NiCo_2S_4