RESISTIVE SWITCHING PROSPECTS OF ALOE VERA-BASED THIN FILMS FOR NONVOLATILE MEMORY APPLICATION

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2019

RESISTIVE SWITCHING PROSPECTS OF ALOE VERA-BASED THIN FILMS FOR NONVOLATILE MEMORY APPLICATION

by

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Thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

August 2019

ACKNOWLEDGEMENT

First, I would like to express my utmost gratitude towards my supervisor, Prof. Ir. Dr. Cheong Kuan Yew, for his invaluable advice, guidance, inspiration, encouragement, and patience throughout my postgraduate study. Without his encouragement and enthusiasm for new ideas, significant milestones in this research study could not been achieved. I would also like to sincerely thank my co-supervisor, Prof. Dr. Yeap Guan Yeow, for giving me the opportunity to work under his supervision and for providing me with credible insights in organic chemistry.

My sincere gratitude to Assoc. Prof. Ir. Dr. Syed Fuad Bin Saiyid Hashim, Dean, School of Materials & Mineral Resources Engineering, for his vision and leadership. Special thanks to Mr. Mohd. Azam, Mr. Mokhtar Mohamad, Mr. Kemuridan Md. Desa, Mr. Muhammad Khairi, Mdm. Shalydah, and Mdm. Fong Lee Lee for their continuous supports throughout my research.

My special appreciation goes to colleagues and friends, namely Dr. Tham Wei Ling, Dr. Teo Pao Ter, Dr. Kho Chun Min, Dr. Ooi Chee Heong, Kek Xiang Jie, and Leong Teng Teng, who are always there to lend me a helping hand whenever I need them most. Last but not least, I would like to extend my warmest and heartfelt gratitude to my family, especially my parents and siblings, for their undivided love, patience, and support throughout this period. I dedicate the accomplishment of this thesis to my grandfather, Lim Hock Seah, who had passed away during the final stage of my research. Hopefully, this accomplishment will be a pride for all of you.

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LIST OF ABBREVIATIONS

2D	Two dimension
3D	Three dimension
6F-BAHP-PC PI	Poly[2,2-(4,4'-di(N-benzyloxycarbazole)-3,3'-biphenylene)propane-hexafluoro-isopropylidenediphthalimide]
6F-HAB-CBZ PI	Poly[3,3'-bis(N-ethylenyloxycarbazole)-4,4'-biphenylenehexafluoro-isopropylidenediphthalimide]
8HQ	8-hydroxyquinoline
A. vera	*Aloe barbadensis* Miller
a-C	Amorphous carbon
AFM	Atomic force microscopy
AIDCN	2-amino-4,5-imidazoledicarbonitrile
AIR	Alcohol insoluble residue
ALD	Atomic layer deposition
Alq_3	Tris(8-hydroxyquinolinato) aluminium
a-Si	Amorphous silicon
BE	Bottom electrode
BEOL	Back-end of line
BPhen	Bathophenanthroline
C_{60}	Fullerene
CBRAM	Conductive bridging random-access memory
CNP	Cellulose nanofiber paper
CNT	Carbon nanotube
CTMA	Cetyltrimethylammonium
Cu:TCNQ	Cu:7,7,8,8-tetracyanoquinodimethane
CVD	Chemical vapor deposition

DCJTB	4-(dicyanomethylene)-2-t-butyl-6-(1,1,7,7-tetramethyljulolidyl-9-enyl)-4H-pyran
DI	Deionized water
DNA	Deoxyribonucleic acid
DRAM	Dynamic random-access memory
DSC	Differential scanning calorimetry
DT	1-dodecanethiol
DTG	Derivative thermal gravimetry
e-beam	Electronic beam
ECM	Electrochemical metallization cell
EDX	Energy dispersive X-ray
E-field	Electric field
ESA	Electrostatic self-assembly
FORM	Electroforming operation
FPA	Ferrocenylphenyl
FRAM	Ferroelectric random-access memory
FTIR	Fourier transform infrared
GNF	Graphene nanoflake
GO	Graphene oxide
HAADF	High-angle annular dark field
hBN	Hexagonal boron nitride
HDD	Hard disk drive
HOMO	Highest occupied molecular orbital
HRS	High-resistance state
ITO	Indium tin oxide

I–*V*	Current–voltage characteristics
J-heating	Joule heating
J–*V*	Current density–voltage characteristics
LB	Langmuir-Blodgett
LRS	low-resistance state
LTP	long-term potentiation
LUMO	Lowest unoccupied molecular orbital
MBE	Molecular beam epitaxy
MEH-PPV	Poly(2-methoxy-5(2'-ethyl) hexoxy-phenylenevinylene)
MIM	Metal-insulator-metal structure
NP	Nanoparticle
NPB	*N*,*N*'-di(naphthalene-1-yl)-*N*,*N*'-diphenyl-benzidine
NR	Nanorod
P3HT	Poly(3-hexylthiophene)
PARA	Poly(*O*-anthranilic acid)
PBD	2-(4-tert-butylphenyl)-5-(4-biphenylyl)-1,3,4-oxadiazole
PCBM	(6,6)-phenyl C61-butyric acid methyl ester
PCRAM	Phase-change random-access memory
PCzMA	Poly(2-(*N*-carbazolyl)ethyl methacrylate)
PEDOT:PSS	Poly polystyrene sulfonate
PEO	Polyethylene oxide
PKEu	Poly[*N*-vinylacrbazole-co-Eu(vinylbenzoate)-(2-thenoyltifluoroaceton)2phenanthroline]
PLD	Pulsed laser deposition
PMC	Programmable metallization cell
PMMA	Polymethyl methacrylate

PPF	Paired-pulse facilitation
PS	Polystyrene
PTP	Post-tetanic potentiation
PVA	Polyvinyl alcohol
PVK	Poly(9-vinylcarbazole)
PVP	Polyvinylpyrrolidone
RAID	Redundant array of independent disk
rGO	Reduced graphene oxide
RRAM	Resistive random-access memory
SCLC	Space-charge-limited conduction
SEM	Scanning electron microscopy
SRAM	Static random-access memory
SSD	Solid-state drive
STDP	Spike-timing-dependent plasticity
STEM	Scanning transmission electron microscopy
STP	Short-term plasticity
STT-MRAM	Spin-torque-transfer magnetic random-access memory
TE	Top electrode
TEM	Transmission electron microscopy
TG	Thermal gravimetry
TMV	Tobacco mosaic virus
TOF-SIMS	Time-of-flight secondary ion mass spectroscopy
TPDBCN	bis{4-[4-[di(*p*-tolyl)amino]phenyl]phenyl} fumaronitrile
TTF	Tetrathiafulvalene
UV	Ultraviolet

VL	Vacuum level
WORM	Write-once read-many
WPF-oxy-F	Poly[(9,9-bis((6'-(*N*,*N*,N-trimethylammonium)hexyl)-2,7-fluorene)-alt-(9,9-bis(2-(2-methoxyethoxy)ethyl)-fluorene)] dibromide
XPS	X-Ray photoelectron spectroscopy

LIST OF SYMBOLS

$\Delta\phi$	Work function mismatch
μ	Charge mobility
A	Cell area
d	Thickness
e	Electronic charge
e^{-}	Electron
$E°$	Standard electrode potential
E_a,	Trap activation energy
E_b	Schottky barrier height
E_c	Conduction band
E_t	Trap barrier height
E_{vac}	Energy of vacuum level
F	Minimal feature size of process technology
G_0	Quantum conductance
h	Planck's constant
I_{CC}	Current compliance
I_{e}	Electronic current
I_{G0}	Current at quantum conduction
I_{HRS}	HRS current
I_{ion}	Ionis current
I_{LRS}	LRS current
I_{RESET}	RESET current
J	Current density
J_{Child}	Current density due to Child-Langmuir law

J_{Mott}	Current density due to Mott-Gurney law
J_{Ohm}	Current density due to Ohm's law
k	Extinction coefficient
k_B	Boltzmann's constant
m	Charge mass
m^*	Effective mass
N	Density of states
n	Refractive index
n_0	Intrinsic charge density
n_e	Electronic concentration
N_t	Density of traps
q	Coulombic charge
r	Radius of cylindrical filament
R_0	Resistance of single-atomic contact
R_a	Average roughness
R_{HRS}	HRS resistance
R_{LRS}	LRS resistance
R_{rms}	Root-mean-square roughness
T	Temperature
V	Applied voltage
V_{FORM}	FORM voltage
$\mathrm{V_O}$	Oxygen vacancy
V_{READ}	READ voltage
V_{RESET}	RESET voltage
V_{SET}	SET voltage

$Z(x)$	Height profile function
ε	Dielectric constant
ε_0	Permittivity of free space
ε_r	Relative permittivity
λ	Reflected wavelength
v	Voltage sweep rate
σ	Conductivity
τ_i	Eigenvalue of *i*-th transmission channel

PENSUISAN RINTANGAN PROSPEK FILEM NIPIS BERDASARKAN ALOE VERA UNTUK APLIKASI SEBAGAI MEMORI TIDAK MERUAP

ABSTRAK

Pensuisan rintangan ialah satu peralihan paradigma untuk memori tidak meruap. Fenomena ini ditunjuk melalui struktur MIM yang berlandaskan bahan bio-organik. *Aloe vera* merupakan sejenis penebat bio-organik yang berpotensi untuk aplikasi elektronik. Namun, pensuisan rintangan masih belum ditunjuk oleh peranti yang berdasarkan *Aloe vera*. Oleh itu, objektif pengajian ini adalah untuk membuktikan bahawa pensuisan rintangan boleh ditunjuk dengan strucktur MIM yang berdasarkan jel *Aloe vera*. Peranti ini hanya mempamirkan pensuisan rintangan dwi-kutub jikalau jel tersebut dikeringkan pada suhu 50°C. Ia perlu dikeringkan dengan 20–60 wt% etanol untuk membolehkan pensuisan rintangan pada suhu lain. Mekanisme pensuisan boleh diterangi melalui arus berbatasan ruang-caj. Elektrod atasan mempunyai impak terhadap mekanisme pensuisan kerana pensuisan yang diperhatikan adalah juga dikaitkan dengan pengaliran filamen jikalau Ag atau Al digunakan sebagai elektrod atasan. Peranti tersebut mempamirkan prestasi yang bagus dengan tetingkap baca memori yang luas (~5 V), nisbah ON/OFF yang besar (>10^5), kitaran ketahanan yang panjang (>100 kitaran), dan tempoh pengekalan yang cemerlang (≥10^4). Acemannan dan pectin adalah punca pensuisan tersebut. Peranti berlandaskan polisakarida yang diekstrak mempamirkan kedua-dua se- dan dwi-kutub tergantung kepada elektrod atasan yang digunakan. Mekanisme peranti itu boleh dijelaskan oleh beberapa proses yang bersifat elektronik, eletrokimia, dan termokimia. Ia menyampaikan prestasi yang sangat baik, termasuk tetingkap baca memori selebar 5.2 V dan nisbah ON/OFF sebesar ~10^7. Selain itu, rintangan keadaan OFF peranti ini boleh dimodulasikan lebih daripada 5 perintah magnitude dengan I_{CC} dan *v*. Kuantisasi