DESIGN AND FABRICATION OF SWNT-FET BASED BIOSENSOR

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by

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This thesis is dedicated to my beloved wife, family and my supervisor as mentor and friend

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LIST OF ABBREVIATIONS

AC	Alternating current
AFM	Atomic force microscope
Al	Aluminum
Au	Gold
BOE	Buffer Oxide Etch
CNT	carbon nanotubes
CNTFET	Carbon nanotube field effect transistor
CV	Capacitance-Voltage
DC	Direct current
DEP	dielectrophoresis
DNA	Deoxyribonucleic acid
FET	Field effect transistor
IV	Current-Voltage
MWNT	Multi-walled carbon nanotubes
NMOS	N-channel MOSFET
O_2	Oxygen (gaseous)

PMOS	P-channel MOSFET
Pt	Platinum
RBM	Radial breathing mode
RNA	Ribonucleic acid
Rpm	Revolution per minute
SEM	Scanning electron microscope
Si	Silicon
SiO_2	Silicon dioxide
SPA	Semiconductor Parameter Analyzer
SWNT	Single-walled carbon nanotubes
SWNT-FET	Single-walled carbon nanotubes field effect transistor
STM	Scanning tunneling microscope
TEM	Transmission electron microscope
UV	Ultraviolet

LIST OF SYMBOLS

Symbol	Description	Unit
I_D	Drain current	A
V_D	Drain voltage	V
V_G	Gate voltage	V
V_{TH}	Threshold Voltage	V
W	Width of Area	µm
d	Diameter	µm
L	Length of Area	µm
μ_p	Electron mobility	cm2/V.s
C_0	Oxide capacitance per unit area	F/m^2
V_{DSAT}	Drain voltage at saturation	V
φ	Work function	eV
φ_B	Ohmic contact of p-type	eV
φ_M	Work function of metal	eV
e	Electron charge	eV
h	Planck constant	eV.s
E_g	Band gap	eV
χ_s	Work function of semiconductor	eV
G	Conductance	Ω
R	Resistance	Ω

LIST OF SYMBOLS

Symbol	Description	Unit
t_{ox}	Oxide thickness	nm
C_i	Gate insulator capacitance per unit area	F/m^2

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Rekabentuk dan Fabrikasi biosensor SWNT-FET

Abstrak

Nanotiub telah menjana aktiviti penyelidikan yang sengit daripada saintis pelbagai bidang kerana ia mewakili kelas baru bahan-bahan untuk kajian fizik satu dimensi. Nanotiub karbon berdinding tunggal (SWNTs) mempunyai banyak sifat-sifat lain yang menarik dan mengagumkan dalam ketiga-tiga aspek iaitu mekanikal, elektrik dan biologi kerana keupayaan nanotiub karbon berdinding tunggal (SWNTs) untuk mempamerkan lapisan pemasangan sendiri (SAM). Objektif utama projek ini adalah untuk mereka bentuk, membina dan menciri karbon nanotiub biosensor untuk aplikasi diagnostik perubatan untuk masa depan. Pengangkutan elektrik semikonduktor nanotiub karbon berdinding tunggal dengan diameter ~1.5 nm dan panjangnya berukuran 2 μm hingga 6 μm untuk aplikasi sebagai pengesanan biomolekul telah disiasat. Transistor kesan medan karbon nanotiub berdinding tunggal (SWNT-FET) telah difabrikasikan dengan menggunakan tiga topeng yang telah direka. Pada mulanya backgated transistor kesan medan (FET) telah difabrikasikan dan diikuti dengan pertumbuhan oksida sebagai lapisan penebat. Logam dwilapis bagi platinum, Pt dan emas, Au ditumbuhkan di atas lapisan oksida dan akhirnya diikuti dengan integrasi nanotiub karbon berdinding tunggal (SWNTs). Ketebalan oksida yang dicapai adalah ~18 nm dan logam dwilapis platinum, Pt berketebalan ~10 nm dan emas, berketebalan ~90 nm. Integrasi nanotiub karbon berdinding tunggal (SWNTs) dengan transistor kesan medan (FET) telah dilakukan dengan menggunakan teknik AC dielectrophoresis nanomanipulation menghasilkan keputusan menggalakkan. Ini telah terbukti melalui Scanning Electron Microscope (SEM).Peranti yang telah difabrikasikan dengan menghasilkan konduktans G ~ 0.03 x $4e^2/h$ dan lubang pergerakan μ_h ~ 3060 cm^2/Vs dalam mod tepu. Peranti ini juga menunjukkan ciri-ciri yang bersamaan dengan konvensional jenis-p logam oksida-semikonduktor FET (MOSFET) melalui graf I_{DS}-V_{DS} dan dan kajian ini menunjukkan ia bergantung kepada nilai voltan gate melalui graf voltan get konduktans. Oleh itu, keputusan ini membuktikan bahawa ia boleh digunakan untuk mengesan biomolekul seperti protein dengan hanya memantau perubahan I_{DS}-V_{DS}.