

List of Abbreviations

AM	Active Matrix
AMOLED	Active Matrix Organic Light Emitting Diode
a-Si:H	Hydrogenated Amorphous Silicon
BC	Bottom Contact
BCB	benzocyclobutene
CAD	Computer Aided Design
CMOS	Complementary Metal Oxide Semiconductor
CNTFET	Carbon Nanotube Field Effect Transistors
CSA	Common Source Amplifiers
CTE	Coefficient of Thermal Expansion
CVD	Chemical Vapour Deposition
CYTOP	A Commercially available Fluoro Polymer
DoS	Density of States
EDA	Electronic Design Automation
EGOFET	Electrolyte-Gate Organic Field Effect Transistor
FET	Field Effect Transistor
GDM	Gaussian Disorder Model
HIFET	Hygroscopic Insulator Field Effect Transistors
IC	Integrated Circuit
ISOFET	Ion-Sensitive Organic Field Effect Transistors
LB	Lower Boundary
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LHS	Left Hand Side
LTSP	Low Temperature Solution Processing
MCDM	Multi-criteria Decision Making
MOOSRA	Multi Objective Optimization by Simple Ratio Analysis
MOSFET	Metal Oxide Semiconductor Field Effect Transistor
MTR	Multiple Trap and Release

OCMFET	Organic Charge Modulated Field Effect Transistors
OEET	Organic Electro Chemical Transistors
OFET	Organic Field Effect Transistor
OSC	Organic Semi-Conductor
OTFT	Organic Thin Film Transistor
OTR	Oxygen Transmission Rate
PC	polycarbonate
PDA	Personal Digital Assistant
PEN	polyethylene-naphthalate
PES	polyethersulfone
PET	polyethylene-terephthalate
PI	polyimide
PMMA	polymethyl methacrylate
PVA	polyvinylalcohol
PVP	polyvinyl phenol
RFID	Radio Frequency Identification
RHS	Right Hand Side
SPICE	Simulation Program for Integrated Circuit Environment
SS	Subthreshold Swing
TC	Top Contact
TFT	Thin Film Transistor
TOPSIS	Technique for Order Preference by Similarity to Ideal Solution
UB	Upper Boundary
VIKOR	ViseKriterijumska Optimizacija I Kompromisno Resenje
WVTR	Water Vapour Transmission Rate
VTC	Voltage Transfer Characteristics
PDN	Pull Down Network

List of Figures

Figure 1-1 Major Industry Sectors which are target applications of Organic Electronics	4
Figure 1-2 A Schematic view of the Bottom Gate Top Contact (BGTC) Organic Thin Film Transistor (OTFT)	6
Figure 1-3 A classification of Organic Thin Film Transistors based on the mechanism involved in charge carrier modulation in the channel region	7
Figure 1-4 List of possible thrust areas in the field of OTFT technology	10
Figure 2-1 Four different reported OTFT structures which vary by the placement of the contacts (source/drain) and gate terminal	17
Figure 2-2 Geometrical dimensions of an OTFT which can influence its characteristics	18
Figure 2-3 I-V characteristics of a n-type OTFT, $W/L=10, \mu C_i=1 \mu A/V^2, V_T=1V$	21
Figure 2-4 Performance parameters of an OTFT	26
Figure 2-5 Energy level barriers for electron and hole injection near the metal-semiconductor junctions of an OTFT	29
Figure 2-6 A few commonly used organic semiconducting materials	30
Figure 3-1 Chemical structures of the low-k polymer dielectrics used for gate dielectric material	43
Figure 4-1 Chemical structures of a few frequently used polymer substrates in flexible electronic applications	59
Figure 4-2 Bending of a substrate-thin film bi-layer	66
Figure 4-3 Surface strain as a function the ratio of thickness of the film to substrate as a function of various Young's moduli ratio for a given bending radius (R)	66
Figure 5-1 Lowest unoccupied molecular orbital (LUMO), highest occupied molecular orbital (HOMO) and localized states in an organic semiconductor	79
Figure 5-2 Double exponential density of states (DoS) distribution in an organic semiconductor. Plot shown for the case: $N_{Deep}=10^{19} \text{ cm}^{-3} \text{ eV}^{-1}, N_{Tail}=10^{21} \text{ cm}^{-3} \text{ eV}^{-1}, \phi_{Tail}=20 \text{ meV}, \phi_{Deep}=60 \text{ meV}$	80

Figure 5-3 Energy band diagram of a metal-oxide-semiconductor structure showing various potentials and energy levels, metal work function ($q\Phi_M$) and electron affinity of the semiconductor ($q\chi_s$).....	81
Figure 5-4 Variation of surface potential as a function of V_{GF} for various V_{ch}	86
Figure 5-5 Comparison of surface potential obtained from analytical expression and numerical simulation.....	87
Figure 5-6 Percentage of absolute error in surface potential calculated from numerical solution and analytical expression as a function of V_{GF} at $V_{ch}=7$	88
Figure 5-7 Normalized drain current I_{DS} as a function of V_{DS} and V_{GS} in an n-channel OTFT.....	89
Figure 5-8 I_{SD} Vs V_{SD} as a function of V_{SG} for a p-channel OTFT based on our model to fit the experimental data provided in [170]. $\mu=0.10$ cm^2/Vs , $W/L=50$, $C_i=11.5$ nF/cm^2 , $N_{Deep}=4.2\times 10^{19}$ $\text{cm}^{-3}\text{eV}^{-1}$, $N_{Tail}=3\times 10^{21}$. $\text{cm}^{-3}\text{eV}^{-1}$, $\phi_{Tail} = 18$ meV , $\phi_{Deep} = 46$ meV	90
Figure 5-9 I_{SD} Vs V_{SD} at $V_{SG}=30\text{V}$ using a constant mobility model. $\mu=0.10$ cm^2/Vs , $W/L=50$, $c_{ox}=11.5$ nF/cm^2 , $N_{Deep}=4.2\times 10^{19}$ $\text{cm}^{-3}\text{eV}^{-1}$, $N_{Tail}=3\times 10^{21}$. $\text{cm}^{-3}\text{eV}^{-1}$, $\phi_{Tail} = 18$ meV , $\phi_{Deep} = 46$ meV . Experimental data from [170]	90
Figure 5-10 I_{SD} Vs V_{SD} for various V_{SG} : comparison of our model (symbols) with experimental data (solid lines) [170] using a simple power law mobility model $\mu=\mu_0\times(V_{SG}-V_{T0})^\alpha$. $\mu_0= 0.02$ cm^2/Vs , $\alpha=0.78$, $V_{T0}=16.2\text{V}$	91
Figure 6-1 Small signal equivalent model of an OTFT	96
Figure 6-2 A flow-chart demonstrating the parameter extraction and model fitting...	97
Figure 6-3 Structure of a bottom-gate to-contact (BGTC) OTFT and a symbol used for p-channel OTFT.....	99
Figure 6-4 Comparison between simulated and experimental data (a) Transfer Characteristics (b) Output Characteristics: dotted lines indicate experimental data and solid line indicate Simulation output. Legend: Squares $V_{GS}=-2\text{V}$, Circles $V_{GS}=-1.6\text{V}$, Cross $V_{GS}=-1.2\text{V}$ and Triangles $V_{GS}=-0.8\text{V}$	101
Figure 6-5 Circuit schematic and symbol of a resistive load inverter implemented using a p-type OTFT as a driver.....	102

Figure 6-6 Voltage transfer characteristics (VTC) of the designed resistive load inverter	102
Figure 6-7 Circuit schematic for a 7-stage ring oscillator, each inverter is a resistive load inverter shown in Fig.6-5	104
Figure 6-8 Free oscillations of 7-stage oscillator.....	104
Figure 6-9 Transient analysis on the 7-stage ring oscillator using a square wave input (V_{in}) and the output at each stage (V_3 to V_8). These Voltages are marked in Fig.6-7	105
Figure 6-10 Circuit schematic of common source amplifier with a voltage gain of 18dB and 3-dB bandwidth of 74kHz.....	106
Figure 6-11 Transient analysis of the common source amplifier	107
Figure 6-12 Voltage transfer characteristics for the common source amplifier	107
Figure 6-13 Frequency response of the common source amplifier.....	108

List of Tables

Table 1-1 Comparison of a:Si-H TFT with an OTFT [13]–[15]	8
Table 3-1 List of polymer dielectric materials and their parameters	43
Table 3-2 Performance score of each polymer dielectric based on MOOSRA technique	51
Table 3-3 Rank based on TOPSIS analysis	53
Table 3-4 Rank based on VIKOR analysis	54
Table 4-1 Comparison of various substrate materials used in TFT technologies	61
Table 4-2 Commonly used polymer substrates and their material properties	67
Table 4-3 Classification of the criterion and weight assignment based on their relative importance.....	69
Table 4-4 Weight normalized decision matrix.....	69
Table 4-5 Ideals' calculation for polyimide (PI) substrate material	70
Table 4-6 Separation measures for each alternative from the ideal solutions	72
Table 4-7 Interval calculation, mid-point and half width for each alternative and their ranks assigned	72
Table 5-1 Parameters used in the simulation [16]	86
Table 6-1 SPICE Level 3 parameters and a short note on their extraction procedure.	98
Table 6-2 Values of the extracted SPICE Level-3 Parameters	100
Table 6-3 Important performance parameters of the resistive load inverter shown in Fig.6-5.....	103
Table 6-4 Performance parameters of the 7-stage ring oscillator	105
Table 6-5 Performance parameters of the common source amplifier.....	108