

ELECTRODEPOSITION OF TIN USING TIN(II)
METHANESULFONATE FROM MIXTURE OF IONIC LIQUID
AND METHANE SULFONIC ACID

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FACULTY OF SCIENCE
UNIVERSITY OF MALAYA
KUALA LUMPUR

2010

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DISSERTATION SUBMITTED IN FULFILMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE

FACULTY OF SCIENCE
UNIVERSITY OF MALAYA
KUALA LUMPUR

2010

To my parents, brothers and Ying Hui,

For their love and prayers.

UNIVERSITI MALAYA

ORIGINAL LITERARY WORK DECLARATION

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Name of Degree: *Master of Science*

Title of Project/ Paper/ Research Report/ Dissertation/ Thesis ("this work"):
Electrodeposition of tin using Tin(II) Methanesulfonate from mixture of Ionic Liquid and Methane Sulfonic Acid

Field of Study: *Electrochemistry*

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ACKNOWLEDGEMENT

I would like to express my extreme gratitude to my supervisor, Associate Professor Dr. Wan Jeffrey Basirun for his invaluable help during this project. He has continuously shared his knowledge, advised and supported me all the way through.

I would like to thank the PhD students and also my seniors Koay Hun Lee, Mehdi Ebadi and Mohammad Reza Mahmoudian for their experience and knowledge sharing.

I would like to express my thanks to all my friends for their help, moral support and memorable days we shared together.

Last but not least, deepest gratitude is expressed to my parents and brothers whose moral support and encouragement gave me the strength to complete this study. No words are there to show my profound gratitude to Ying Hui, for her inspiration and patience during the study.

TABLE OF CONTENTS

	Page
LIST OF TABLES.....	vi
LIST OF FIGURES.....	vii
LIST OF SYMBOLS.....	xiii
LIST OF ABBREVIATIONS.....	xv
CHAPTER 1: INTRODUCTION.....	1
CHAPTER 2: LITERATURE REVIEW.....	
2.1 Electrodeposition.....	4
2.2 Electroplating mechanism.....	6
2.2.1 Migration.....	7
2.2.2 Convection.....	8
2.2.3 Diffusion.....	8
2.3 Components of plating bath.....	14
2.4 Ionic Liquid.....	16
2.4.1 Deposition with Ionic Liquid.....	17
2.4.2 Electrodeposition of Tin with Ionic Liquid.....	20
2.4.3 Electrodeposition of Copper with Ionic Liquid.....	24
2.4.4 Electrodeposition of Nickel with Ionic Liquid.....	26
2.4.5 Electrodeposition of Cobalt with Ionic Liquid.....	27
2.4.6 Electrodeposition of Aluminum with Ionic Liquid.....	28
2.4.7 Electrodeposition of Palladium with Ionic Liquid.....	39
CHAPTER 3: METHODOLOGY.....	
3.1 Electrochemical Method.....	41
3.1.1 Cyclic Voltammetry	41
3.1.2 Chronoamperometry	45
3.2 Spectroscopy and Microscopy Analysis.....	48
3.2.1 Scanning Electron Microscopy (SEM).....	48
3.2.2 Energy-dispersive X-ray spectroscopy (EDX).....	52
3.2.3 Atomic Force Microscope (AFM).....	54

3.2.4 Fourier Transform Infrared Spectroscopy (FTIR).....	57
3.3 Wetting Balance Test.....	59
3.4 Electrochemical Experiments.....	62
3.4.1 Reagent and Chemicals.....	62
3.5 Cyclic Voltammetry and Chronoamperometry Experiments.....	63
3.5.1 Oxygen Removal.....	64
3.5.2 NiChrome Wire.....	67
3.6 Electroplating Experiments.....	68
CHAPTER 4: RESULT AND DISCUSSION.....	
4.1 Cyclic voltammetry.....	70
4.2 Chronoamperometry.....	75
4.3 Electroplating experiments.....	90
4.4 FTIR analysis on electrolyte.....	102
4.5 Reliability Test.....	107
4.5.1 Results and Discussion for Wetting Balance Test.....	107
CHAPTER 5: CONCLUSION.....	
5.1 Project Conclusion and overall discussion.....	111
CHAPTER 6: PUBLICATION.....	114
CHAPTER 7: REFERENCES.....	115

LIST OF TABLES

Table		Page
1.1	Main physical properties of Tin.....	1
3.1	Component of Tin Methane Sulfonate.....	62
3.2	Component of Ionic Liquid: 1-butyl-1-methyl-pyrrolidinium trifluoro- methanesulfonate, (BMPOTF).....	62
3.3	Quantity of tin methane sulfonate and ionic liquid-BMPOTF in 15 mL electrolyte.....	64
3.4	Physical properties for Nichrome.....	67
4.1	Peak current density and tin diffusion coefficient obtained at different Sn ²⁺ concentration.....	74
4.2	Chronoamperometry data of 0.1 M Sn ²⁺ at BMPOTF.....	77
4.3	Chronoamperometry data of 0.2 M Sn ²⁺ at BMPOTF.....	79
4.4	Chronoamperometry data of 0.3 M Sn ²⁺ at BMPOTF.....	81
4.5	Chronoamperometry data of 0.4 M Sn ²⁺ at BMPOTF.....	83
4.6	Chronoamperometry data of 0.5 M Sn ²⁺ at BMPOTF.....	85
4.7	Tin diffusion coefficient obtained at different Sn ²⁺ concentration through Chronoamperometry- Cottrell equation.....	88
4.8	Tin diffusion coefficient based on literature review.....	88
4.9	Current efficiency obtained at different Sn ²⁺ concentration.....	92
4.10	Time-to-zero reading for IL based and Acidic based plated samples.....	109

LIST OF FIGURES

Figure		Page
2.1	Schematic diagram showing an electroplating process.....	5
2.2	A d.c. rectifier used in electroplating industry.....	6
2.3	Metal ion concentration profile as a function of distance from the surface.....	9
2.4	Structure of the electrical double layer at a metal-solution interface.....	11
2.5	Dependence of cathodic current density on potential. Graphical determination of $\epsilon_{Me/Me^{Z+}}$, i^0 , and α by drawing a tangent to the curve.....	12
2.6	Shape of the current-voltage plot: (1) under activation control, (2) intermediate region with both mechanisms rate-determining and (3) under diffusion control	13
2.7	Periodic table showing those metals (inside frame and shaded) which can be deposited from aqueous solution.....	14
2.8	Summary of the elements deposited as single metal or alloys.....	20
2.9	Linear relationship between the cathodic peak potential of Sn(II) reduction & the logarithm of potential scan rate in the [EMIm]BF ₄ containing 25 mM Sn(II).....	21
2.10	SEM micrographs of metal electrodeposits from the [EMIm]BF ₄ ionic liquid containing 25 mM Sn(II).....	22
2.11	Cyclic voltammogram of a Pt electrode in BMPTFSI containing 0.05 mol dm ⁻³ Sn(II) at 25 °C; scan rate: 20 mVs ⁻¹	23
2.12	SEM image of the deposit on the Cu substrate in BMPTFSI containing 0.05 mol dm ⁻³ Sn(II). The current density was -0.05 mA cm ⁻²	23
2.13	SEM of copper deposits in the absence and in presence of [BMIM]HSO ₄ . (a) Blank, (b) [BMIM]HSO ₄ :10 mg dm ⁻³ , (c) [BMIM]HSO ₄ : 50 mg dm ⁻³	25

2.14	Effect of [BMIM]HSO ₄ on the cathodic polarization for copper electro-deposition with different concentrations: (■) blank, (●) 10 mg dm ⁻³ , (▲) 50 mg dm ⁻³	25
2.15	SEM micrographs of the nickel electrodeposits in the 0.1 M NiCl ₂ EMI-DCA solutions at 301 K. a: -1.4V, b: -1.45V, c: -1.5V, d:-1.6V.....	26
2.16	AFM micrographs of nickel electrodeposits in the 0.1 M NiCl ₂ EMI-DCA solutions at 301 K. a: -1.4 V, b: -1.6 V.....	27
2.17	SEM of cobalt deposits on platinum wires obtained from a solution of 0.5M Co(II) in BMIMBF ₄ ionic liquid at different bath temperatures: (a) 40 °C and (b) 60 °C.....	28
2.18	(a) A biphasic mixture of the ionic liquid 1-butyl-1-methylpyrrolidinium bis(trifluoromethylsulfonyl)imide containing 1.6 M AlCl ₃ at room temperature. (b) The biphasic mixture becomes monophasic at 80 °C.....	30
2.19	Cyclic voltammogram in the ionic liquid ([BMP]-Tf ₂ N) containing 1.6M AlCl ₃ at room temperature.....	31
2.20	Cyclic voltammogram in the ionic liquid ([BMP]-Tf ₂ N) containing 1.6M AlCl ₃ at 100 °C.....	31
2.21	SEM micrographs of electrodeposited Al in the upper phase of the mixture AlCl ₃ and [BMP]Tf ₂ N: (a) at room temperature; (b) at 100 °C.....	32
2.22	SEM micrographs obtained from the carbon steel samples coated with aluminum layers. The samples named a' are obtained after 1 hour deposition, b' after 2 hours and c' after 4 hours.....	33
2.23	OCV curves of different thickness aluminum coated samples compared with the bare carbon steel and the pure aluminum in 3.5 wt% NaCl aqueous solution.....	34
2.24	Salt spray test corrosion kinetics for the aluminum coated carbon steel.....	35
2.25	Sequence of images showing the process of degradation for a carbon steel sample coated with 10 μm of aluminum during the NSS test. The pictures are taken, respectively, after (a) 5, (b) 8, (c) 14, (d) 30 days of exposure.....	35
2.26	Electrical conductivities of AlCl ₃ -[EMIm]Cl ionic liquids as a function of the temperature and composition. The inset shows the Arrhenius plot of data.....	36

2.27	A typical voltammogram recorded on Al electrode in 2:1 molar ratio AlCl_3 -[EMIm]Cl at 60 °C. Scan rate: 0.1 V/s.....	37
2.28	SEM micrographs of aluminum electrodeposits obtained on Al substrates from 2:1 molar ratio AlCl_3 -[EMIm]Cl at 90 °C with different current densities for 1 hour. a) 20 mA/ cm^2 , b) 30 mA/ cm^2 , c) 50 mA/ cm^2 , d) 70 mA/ cm^2	38
2.29	Cyclic voltammograms of a Pt electrode in BMPTFSI containing 10 mM PdCl_4^{2-} (—) and 10 mM PdBr_4^{2-} (- - -) at 25 °C. Scan rate: 50mVs ⁻¹	39
2.30	SEM images of the deposits on the Ni substrates by the galvanostatic electrodeposition in 10 mM PdBr_4^{2-} / BMPTFSI at 25 °C. The current densities were (a) -0.05 mAcm^{-2} , (b) -0.01 mAcm^{-2}	40
3.1	Typical excitation signal for cyclic voltammetry – a triangular potential waveform with switching potential at 0.8 and -0.2V versus SCE.....	43
3.2	A typical cyclic voltammogram.....	43
3.3	Chronoamperometry Diffusional <i>i-t</i> profile.....	47
3.4	SEM and EDX: Philips XL and EDAX Analyzer Genesis.....	48
3.5	Schematic for an SEM.....	50
3.6	Schematic for an EDX.....	52
3.7	AFM: Digital Instruments Nano Scope 3a.....	54
3.8	Schematic for an AFM.....	55
3.9	FTIR: Perkin Elmer Spectrum RX1.....	57
3.10	Instrument diagram for a basic FTIR spectrometer.....	58
3.11	Semiconductor component that electroplated with tin.....	59
3.12	Schematic of wetting balance gauge.....	60
3.13	RHESCA SAT-5100 wetting balance gauge.....	60
3.14	Typical wetting balance curve.....	61
3.15	Typical wetting balance curve.....	61
3.16	Cyclic voltammetry and Chronoamperometry experiments set up.....	65

3.17	3-electrode cell, A:Counter electrode, B:Reference electrode, C:Working electrode.....	65
3.18	Structure of working electrode- Copper.....	66
3.19	Structure of counter electrode- Platinum wire.....	66
3.20	Structure of Silver-silver chloride reference electrode.....	66
3.21	Electroplating experiments set up.....	68
3.22	Schematic for an electroplating experiments.....	69
4.1	Voltammograms of 0.1 M Sn ²⁺ at BMPOTF, potential sweep rate at 50 mVs ⁻¹	71
4.2	Voltammograms of 0.2 M Sn ²⁺ at BMPOTF, potential sweep rate at 50 mVs ⁻¹	72
4.3	Voltammograms of 0.3 M Sn ²⁺ at BMPOTF, potential sweep rate at 50 mVs ⁻¹	72
4.4	Voltammograms of 0.4 M Sn ²⁺ at BMPOTF, potential sweep rate at 50 mVs ⁻¹	73
4.5	Voltammograms of 0.5 M Sn ²⁺ at BMPOTF, potential sweep rate at 50 mVs ⁻¹	73
4.6	Cyclic voltammogram at 50 mVs ⁻¹ for solution X M (CH ₃ SO ₃) ₂ Sn, A=0.1M, B=0.2M, C=0.3M, D=0.4M, E=0.5M....	74
4.7	Effect of Sn ²⁺ concentration on peak current density.....	75
4.8	Chronoamperometry profile i vs. t, 0.1 M Sn ²⁺ at BMPOTF.....	78
4.9	Chronoamperometry profile i vs. t ^{-1/2} , 0.1 M Sn ²⁺ at BMPOTF...	78
4.10	Chronoamperometry profile i vs. t, 0.2 M Sn ²⁺ at BMPOTF.....	80
4.11	Chronoamperometry profile i vs. t ^{-1/2} , 0.2 M Sn ²⁺ at BMPOTF...	80
4.12	Chronoamperometry profile i vs. t, 0.3 M Sn ²⁺ at BMPOTF.....	82
4.13	Chronoamperometry profile i vs. t ^{-1/2} , 0.3 M Sn ²⁺ at BMPOTF...	82
4.14	Chronoamperometry profile i vs. t, 0.4 M Sn ²⁺ at BMPOTF.....	84
4.15	Chronoamperometry profile i vs. t ^{-1/2} , 0.4 M Sn ²⁺ at BMPOTF...	84
4.16	Chronoamperometry profile i vs. t, 0.5 M Sn ²⁺ at BMPOTF.....	86
4.17	Chronoamperometry Profile i vs. t ^{-1/2} , 0.5 M Sn ²⁺ at BMPOTF...	86

4.18	Chronoamperometry diffusional i-t profile from 0.1-0.5 M Sn ²⁺ at BMPOTF.....	87
4.19	Chronoamperometry profile I vs. $t^{-1/2}$ from 0.1-0.5 M Sn ²⁺ at BMPOTF.....	87
4.20	SEM for 0.1 M Sn ²⁺ at BMPOTF with 1 ASD and 7 ASD electrodeposition.....	95
4.21	EDX for 0.1 M Sn ²⁺ at BMPOTF with 1 ASD electrodeposition..	95
4.22	EDX for 0.1 M Sn ²⁺ at BMPOTF with 7 ASD electrodeposition..	95
4.23	SEM for 0.2 M Sn ²⁺ at BMPOTF with 1 ASD and 7 ASD electrodeposition.....	96
4.24	EDX for 0.2 M Sn ²⁺ at BMPOTF with 1 ASD electrodeposition..	96
4.25	EDX for 0.2 M Sn ²⁺ at BMPOTF with 7 ASD electrodeposition..	96
4.26	SEM for 0.3 M Sn ²⁺ at BMPOTF with 1 ASD and 7 ASD electrodeposition.....	97
4.27	EDX for 0.3 M Sn ²⁺ at BMPOTF with 1 ASD electrodeposition..	97
4.28	EDX for 0.3 M Sn ²⁺ at BMPOTF with 7 ASD electrodeposition..	97
4.29	SEM for 0.4 M Sn ²⁺ at BMPOTF with 1 ASD and 7 ASD electrodeposition.....	98
4.30	EDX for 0.4 M Sn ²⁺ at BMPOTF with 1 ASD electrodeposition..	98
4.31	EDX for 0.4 M Sn ²⁺ at BMPOTF with 7 ASD electrodeposition..	98
4.32	SEM for 0.5 M Sn ²⁺ at BMPOTF with 1 ASD and 7 ASD electrodeposition.....	99
4.33	EDX for 0.5 M Sn ²⁺ at BMPOTF with 1 ASD electrodeposition..	99
4.34	EDX for 0.5 M Sn ²⁺ at BMPOTF with 7 ASD electrodeposition..	99
4.35	AFM for 0.1 M Sn ²⁺ at BMPOTF with 7 ASD electrodeposition..	100
4.36	AFM for 0.2 M Sn ²⁺ at BMPOTF with 7 ASD electrodeposition..	100
4.37	AFM for 0.3 M Sn ²⁺ at BMPOTF with 7 ASD electrodeposition..	101
4.38	AFM for 0.4 M Sn ²⁺ at BMPOTF with 7 ASD electrodeposition..	101
4.39	AFM for 0.5 M Sn ²⁺ at BMPOTF with 7 ASD electrodeposition..	102

4.40	FTIR of pure Ionic Liquid – BMPOTF, Tin Methane Sulfonate at 0 M.....	104
4.41	FTIR of Mixture of Ionic Liquid – BMPOTF and Tin Methane Sulfonate at 0.1 M.....	105
4.42	FTIR of Mixture of Ionic Liquid – BMPOTF and Tin Methane Sulfonate at 0.5 M.....	106
4.43	Wetting balance graph for samples plated at Ionic Liquid based electrolyte.....	108
4.44	Wetting balance graph for samples plated at Acidic based electrolyte.....	108
4.45	t Test diagram.....	109

LIST OF SYMBOLS

e^-	: Electron
n	: Number of electron
n^*	: Diffusion current density
D	: Diffusion coefficient ($\text{cm}^2 \text{s}^{-1}$)
C_∞	: Metal ion concentration in bulk solution
C_c	: Metal ion concentration at the electrode surface
δ_N	: Thickness of the double layer
i_D	: Diffusion-limiting current density
i_C	: Cathodic current density
F	: Faraday's constant, $96,485 \text{ C} \cdot \text{mol}^{-1}$
z	: Number of electrons per ion being transferred
φ_{Me}	: Potential of the metal electrode
φ_L	: Potential of the solution
$\Delta\varphi$: Difference between φ_{Me} and φ_L
$\varepsilon_{\text{Me}}^{Z+}$: Potential of the metal ions
i_{pa}	: Anodic peak current
i_{pc}	: Cathodic peak current
E_{pa}	: Anodic peak potential
E_{pc}	: Cathodic peak potential
$E^{\circ'}$: The formal reduction potential
A	: Electrode area in solution (cm^2)
C	: Concentration (mol cm^{-3})
v	: Scan rate (V s^{-1})
i	: Current

t	: Time (s)
Y	: Desired Molarity of Sn ²⁺
V	: Volume of electrolyte make-up in L
k	: Boltzmann constant
T	: Temperature in Kelvin
η	: Viscosity of the solvent
r	: Dynamic radius of the diffusing species
ε %	: Current efficiency in %
Q	: Total electric charge that passed through the solution (in coulombs)
q	: Electron charge = 1.602×10^{-19} coulombs per electron
n	: Valence number of the substance as an ion in solution (electrons per ion)
M	: Molar mass of the substance (in grams per mole)
N _A	: Avogadro's number = 6.023×10^{23} ions per mole

LIST OF ABBREVIATIONS

BF_4^-	: Tetrafluoroborate
CF_3SO_3^-	: Tri-fluoro-methanesulfonate
$(\text{CF}_3\text{SO}_2)_2\text{N}^-$: Bis (trifluoromethanesulfonyl)imide
$(\text{CF}_3\text{SO}_2)_3\text{C}^-$: Tris (tri fluoro methanesulfonyl)methide
Sn	: Tin
BMPOTF	: 1-Butyl-1-methyl-pyrrolidinium trifluoro-methanesulfonate,
MSA	: Methane Sulfonic Acid
$(\text{CH}_3\text{SO}_3)_2\text{Sn}$: Stannous Methane Sulfonate,
D.C.	: Direct Current
M	: Metal
IL	: Ionic Liquid
PVD	: Physical Vapor Deposition
CVD	: Chemical Vapor Deposition
CV	: Cyclic voltammogram
RE	: Reference electrode
WE	: Working electrode
CE	: Counter electrode
SCE	: Saturated calomel electrode
Ag AgCl	: Silver silver chloride electrode
CA	: Chronoamperometry
SEM	: Scanning electron microscopy
BSE	: Back-scattered electrons
SEI	: Secondary electron imaging
WD	: Working distance

EDX/ EDS	: Energy dispersive X-ray spectroscopy
AFM	: Atomic force microscope
SFM	: Scanning force microscope
MFM	: Magnetic force microscope
FTIR	: Fourier Transform Infrared Spectroscopy
ASD	: Current density (A/ dm^2)
HCD	: High Current Density
LCD	: Low Current Density
%T	: % Transmittance
IC	: Integrated circuit
SAC	: Sn-Ag-Cu (Tin-Silver-Copper)