ABSTRAK

Elektropenyaduran timah daripada *tin(II) methane sulfonate (MSA)* dengan cecair ionik yang stabil di udara dan air, *1-butyl-1-methyl-pyrrolidinium trifluoro-methanesulfonate, (BMPOTF)* telah dikaji pada suhu bilik dengan kepekatan yang berlainan. Kitaran voltammetri telah digunakan untuk mengkaji sifat elektrokimia timah semasa proses penurunan dan pengoksidaan. Pemalar difusi ion timah pada campuran cecair ionik *BMPOTF* dan elektrolit berasaskan *MSA* dikira melalui persamaan Randles-Sevcik dan persamaan Cottrell adalah 2×10^{-7} cm^2/s. Elektropenyaduran timah ke atas kepingan kuprum telah dikaji dengan ketumpatan arus yang berlainan supaya kesan arus di campuran *BMPOTF* dan elektrolit berasaskan *MSA* dapat diketahui. Campuran *BMPOTF* dan elektrolit berasaskan *MSA* telah membawa kesan arus setinggi 99.9%. Tata bentuk bagi penyaduran timah ke atas kepingan kuprum yang disadur menerusi campuran *BMPOTF* dan elektrolit berasaskan *MSA* telah dikaji melalui cara EDX, SEM dan AFM. Struktur penyaduran yang padat, halus dan berbutir poligon dapat diperoleh. Sampel penyaduran yang disaduri menerusi campuran *BMPOTF* dan elektrolit berasaskan *MSA* telah menunjukkan kecekapan pematerian yang cemerlang di mana setanding dengan sampel penyaduran yang disadur di elektrolit berasaskan *MSA*.

ABSTRACT

The electrodeposition of tin from Tin(II) Methane Sulfonate (MSA) with varying concentration in air and water stable 1-butyl-1-methyl-pyrrolidinium trifluoro-methanesulfonate, (BMPOTF) ionic liquid at room temperature was studied. Cyclic Voltammetry served to characterize the electrochemical behavior of tin reduction and oxidation. The diffusion coefficient of stannous ions in the mixture of BMPOTF ionic liquid and MSA based electrolyte obtained via Randles-Sevcik and Cottrell equation was 2×10^{-7} cm^2/s. Electroplating on copper panel was conducted under different current densities to determine BMPOTF based tin plating solution current efficiency. Mixture of BMPOTF and MSA based tin plating solution gave current efficiency as high as 99.9%. The deposit morphology of the mixture BMPOTF and MSA based tin coated substrates was observed by using EDX, SEM and AFM. A dense, fine and polygonal grain structure was obtained. BMPOTF based tin plated substrates have shown excellent solderability which was comparable to MSA based coated material in wetting balance test.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

e-	: Electron
n	: Number of electron
*n**	: Diffusion current density
D	: Diffusion coefficient ($cm^2\ s^{-1}$)
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 C· 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
ε_{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
$E°'$	: The formal reduction potential
A	: Electrode area in solution (cm^2)
C	: Concentration (mol cm^{-3})
υ	: 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
$(CF_3SO_2)_2N^-$	: Bis (trifluoromethanesulfonyl)imide
$(CF_3SO_2)_3C^-$	: Tris (tri fluoro methanesulfonyl)methide
Sn	: Tin
BMPOTF	: 1-Butyl-1-methyl-pyrrolidinium trifluoro-methanesulfonate,
MSA	: Methane Sulfonic Acid
$(CH_3SO_3)_2Sn$	: 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)