5 APPENDICES

APPENDIX 1

Calculation of copper concentration by using Copper Electrode

A calibration curve of Potential versus Log (concentration) was plotted. From the data regression, constant and x coefficient(s) values represent the C and m for the following equation:

$$y = mx + C$$

$$x = \frac{y - C}{m}$$

where , y = potential measured

x = Log (M) (M = concentration of coppper)

$$M = 10^{x}$$

$$\frac{dM}{dx} = x\,10^{x-1}$$

$$\text{Log}(M) = \frac{y - C}{m}$$

$$M = 10^{(\frac{y - C}{m})}$$

$$\delta M = (\frac{y - C}{m}) \times 10^{(\frac{y - C}{m} - 1)} \times \delta x$$

Table A1: Concentration of copper by converting from the potential measured

series	P/mV	x = (y-C)/m	M	δM
1	149.7	0.9975	9.94	1.11
2	48.8	0.8703	7.42	0.53
3	142.8	0.5756	3.76	0.13
4	131.7	0.3115	2.05	0.02
5	122.9	0.0161	1.04	0.00
6	116.1	-0.2069	0.62	0.00

For example, series 5:

Regression Output:

Constant	122.4449 (C)
Std Err of Y Est	0.332176
R Squared	0.99969
No. of Observations	4
Degrees of Freedom	2
X Coefficient(s)	29.7159 (m)
Std Err of Coef.	0.3701705

$$y = 122.9 \text{ mV}$$

$$\therefore M = 10^{\left(\frac{122.9 - 122.4449}{29.7159}\right)}$$

$$= \underline{1.0378}$$

$$\delta M = \left(\frac{122.9 - 122.4449}{29.7159}\right) \times 10^{\left(\frac{122.9 - 122.4449}{29.7159} - 1\right)} \times dx$$

$$= 0.0003$$

$\therefore$ Concentration of Cu = **(1.0378 ± 0.0003) ppm**

APPENDIX 2

Plate No.		1	2	3	4	5
	Thickness	0.23	0.217	0.227		
	±0.001mm	0.207	0.21	0.218		
		0.22	0.206	0.213		
	(before	0.204	0.209	0.212		
	plating)	0.214	0.213	0.216		
		0.206	0.222	0.212		
	Average	**0.2135**	**0.21283**	**0.21633**		
	std	0.00916	0.00534	0.00525		
	Thickness	0.23	0.216	0.233		
	±0.001mm	0.208	0.212	0.213		
		0.229	0.211	0.211		
	(after	0.205	0.226	0.213		
	plating)	0.209	0.22	0.216		
		0.216	0.231	0.22		
	Average	**0.21617**	**0.21933**	**0.21767**		
	std	0.00999	0.00725	0.00743		
mean thickness of Pt deposit / mm		0.00267	0.0065	0.00133		
Weight/g	(after)	0.6407	0.6299	0.6897	0.4814	0.6227
Weight/g	(before)	0.6224	0.6194	0.6781	0.4753	0.6148
±0.0004g	Wt.Pt/g=	0.0183	0.0105	0.0116	0.0061	0.0079
Area/cm²		6.05	5.59	6.1	-	-
Condition:	Current/mA	-60	-110	-100	-100	-60
±1s	Time/min	12	6	6	4	5
	T.charge/C	**43.2**	**39.6**	**36**	**24**	**18**
	±	0.06	0.11	0.1	0.1	0.06

$Pt^{2+} + 2e^- = Pt$ 1 F = 96485 C

	Wt.Pt/g	0.04367	0.04004	0.0364	0.02426	0.0182
	±	6.1E-05	0.00011	0.0001	0.0001	6.1E-05
%(efficiency)=		**41.90**	**26.23**	**31.87**	**25.14**	**43.41**
	error=	0.97	1.07	1.19	1.75	2.34

APPENDIX 3

Results of microanalysis

sample #100	Percentage				
Elements	1	2	mean	mole	ratio
C	54.39	54.65	54.52	4.539	23
H	4.05	4.07	4.06	4.028	21
N	11.71	11.82	11.765	0.84	4
S	6.18	6.25	6.215	0.194	1
O	23.67	23.21	23.44	1.465	8

sample #200	Percentage				
Elements	1	2	mean	mole	ratio
C	53.18	53.16	53.17	4.427	23
H	4.61	4.63	4.62	4.583	24
N	10.38	10.35	10.365	0.74	4
S	6.43	6.51	6.47	0.202	1
O	25.4	25.35	25.375	1.586	8

sample #300	Percentage				
Elements	1	2	mean	mole	ratio
C	55.09	55.56	55.325	4.606	24
H	4.04	4.16	4.1	4.068	21
N	11.69	11.88	11.785	0.841	4
S	6.12	6.19	6.155	0.192	1
O	23.06	22.21	22.635	1.415	7

sample #100 Polyaniline
- 1.0M H2SO4 + 0.1M aniline + 0.05M Orthanilic acid
Cyclic Voltammetry from +1.4V to -0.3V
Working electrode : Ptti

sample #200 Polypyrrole
0.5M pyrrole + 0.5M NaPSS (70,000 m.w.)
Electropolymerization : 50 mA for 30 min
Working electrode : Ptti

sample #300 Polypyrrole
0.5M pyrrole + 0.5M NaPSS (1,000,000 m.w.)
Electropolymerization : 50 mA for 30 min
Working electrode : Ptti

APPENDIX 4

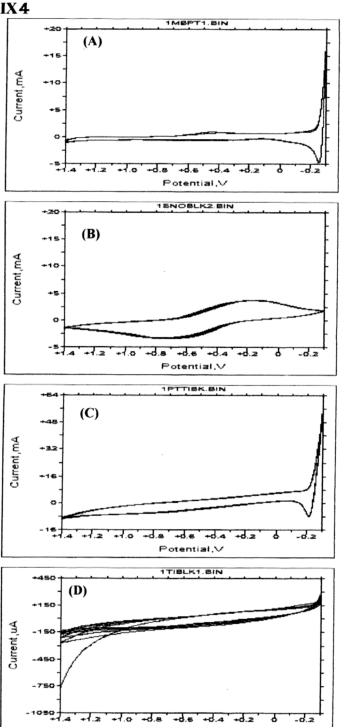

Figure A1. CV for the blank solutions (1.0M H_2SO_4 without aniline) on different working electrodes: -

(A). Pt (B). SnO_2

(C). Ptti (D). Ti

Number of sweep: - 10 each

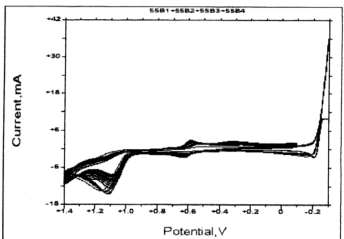

Figure A2. CV for the blank solution (0.05M orthanilic acid in 0.5M H_2SO_4 without aniline) on Pt.
Number of sweeps: - 40

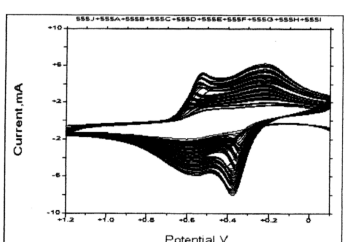

Figure A3. CV for the electropolymerisation of 0.05M aniline and 0.05M orthanilic acid in 0.5M H_2SO_4 on Pt.
Number of sweeps: - 100

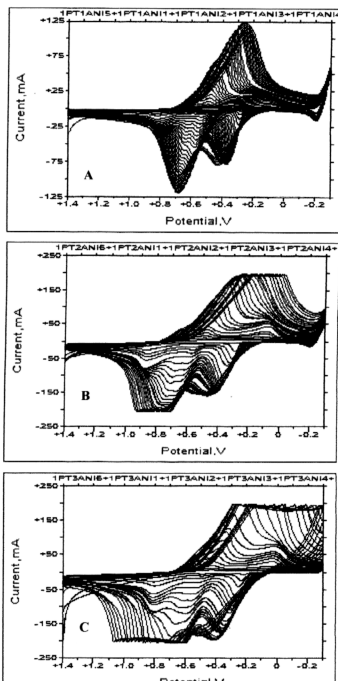

Figure A4. CV for the electropolymerization of different concentrations of aniline in 1.0M H_2SO_4 on Pt. The concentrations of aniline and number of sweeps are as follows: -

(A). 0.1M 70 sweeps
(B). 0.2M 60 sweeps
(C). 0.3M 60 sweeps

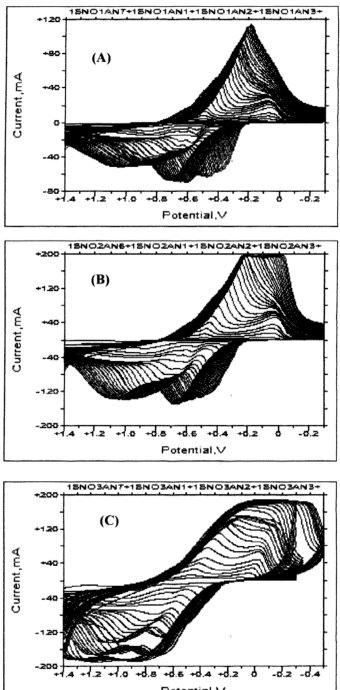

Figure A5. CV for the electropolymerization of different concentrations of aniline in 1.0M H_2SO_4 on SnO_2. The concentrations of aniline are as follows: -

(A). 0.1M 70 sweeps
(B). 0.2M 60 sweeps
(C). 0.3M 60 sweeps

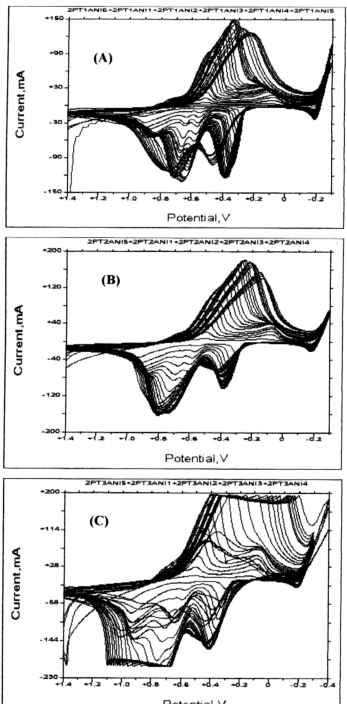

Figure A6. CV is showing the electropolymerization of different concentrations of aniline in **2.0M H_2SO_4** on **Pt**. The concentrations of aniline are as follows: -

(A). 0.1M 60 sweeps
(B). 0.2M 60 sweeps
(C). 0.3M 60 sweeps

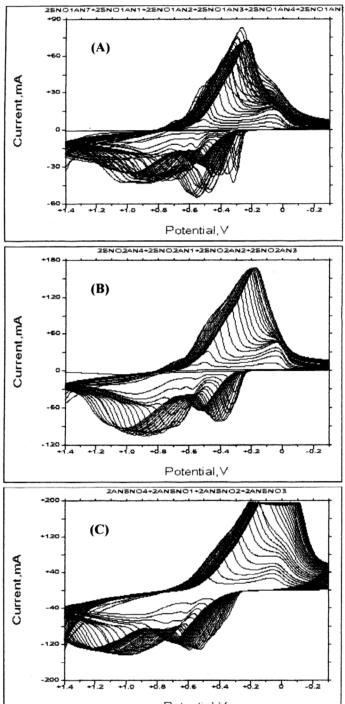

Figure A7. CV for the electropolymerization of different concentrations of aniline in **2.0M H_2SO_4** on **SnO_2**. The concentrations of aniline as given below: -

(A). 0.1M 70 sweeps
(B). 0.2M 40 sweeps
(C). 0.3M 40 sweeps

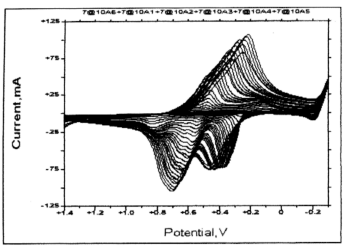

Figure A8. CV is showing the electropolymerization of 0.1M aniline, in 1.0M H_2SO_4 on **Ptti**.
Number of sweep: - 60 sweeps

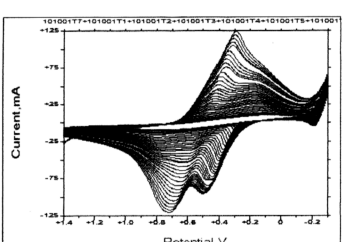

Figure A9. CV for the electropolymerization of 0.1M aniline, 0.01M orthanilic acid in 1.0M H_2SO_4 on **Ptti**.
Number of sweep: - 70 sweeps

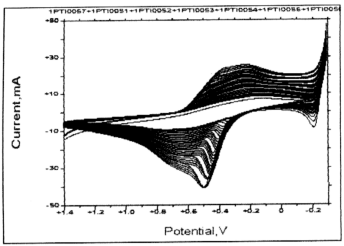

Figure A10. CV for the electropolymerisation of 0.1M aniline and 0.05M Orthanilic acid in 1.0M H_2SO_4 on Ptti. Number of sweeps: - 70

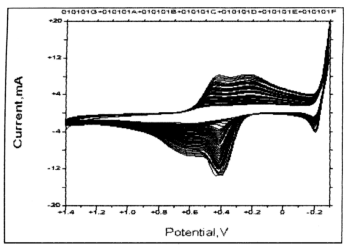

Figure A11. CV for the electropolymerisation of 0.1M aniline and 0.1M Orthanilic acid in 1.0M H_2SO_4 on **Pt**.
Number of sweeps: - 70

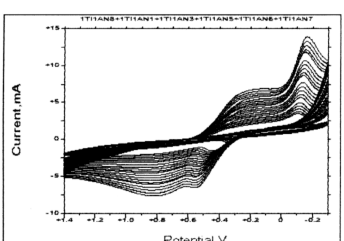

Figure A12. CV for the electropolymerisation of 0.1M aniline in 1.0M H_2SO_4 on Ti.
Number of sweeps: - 80

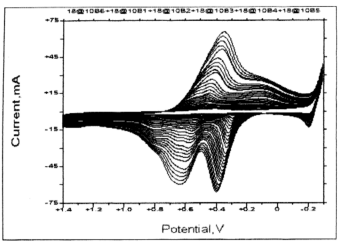

Figure A13. CV for the electropolymerization of 0.1M aniline, 0.01M styrene sulphonic acid in 1.0M H_2SO_4 on **Ptti**. Number of sweep: - 60 sweeps

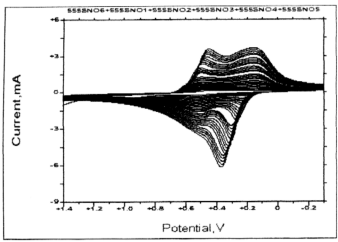

Figure A14. CV for the electropolymerization of 0.05M aniline, 0.05M orthanilic acid in 0.5M H_2SO_4 on SnO_2 at **25°C**
Number of sweep: - 60 sweeps

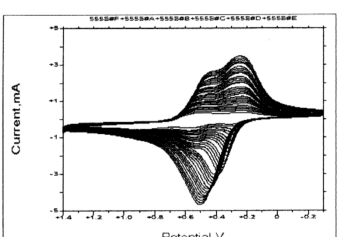

Figure A15. CV for the electropolymerization of 0.05M aniline, 0.05M orthanilic acid in 0.5M H_2SO_4 on SnO_2 at **50°C**
Number of sweep: - 60 sweeps

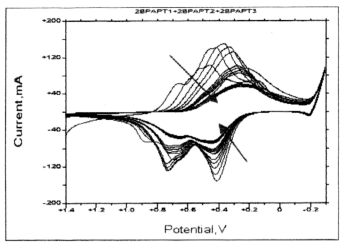

Figure A16. Cyclic Voltammogram for the mixture 1.0M H_2SO_4 + polyaniline
Number of sweeps: - 30 sweeps
Working electrode:- Platinised Titanium

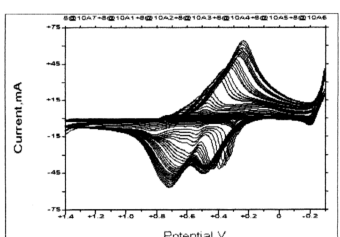

Figure A17. CV for the electropolymerisation of 0.05M aniline and 0.05M orthanilic acid in 0.5M H_2SO_4 on Ptti.
Number of sweeps: - 70 sweeps

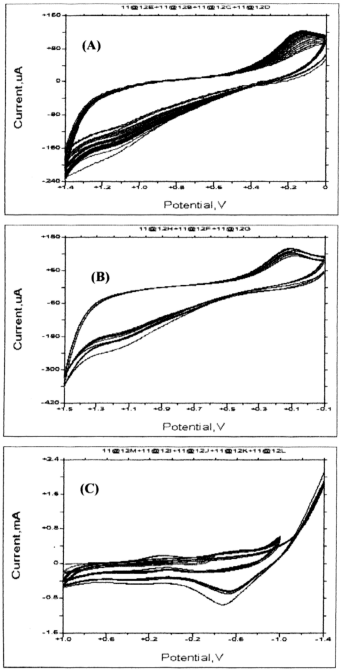

Figure A18. CV for the electropolymerisation of 0.05M pyrrole in 0.01M $NaClO_4$ on Ptti.
(A). +1.4V to 0V 40 sweeps
(B). +1.5V to -0.1V 30 sweeps
(C). +1.0V to -0.1V(10sweeps)
+1.0V to –0.4V(10sweeps)
+1.0V to –1.0V(20sweeps)
+1.0V to –1.4V(10sweeps)

APPENDIX 5

Table A2: Electropolymerization Conditions in film preparations.

Film	Electrode	Current / mA	Time / min	Potential / V	Temperature / °C
1	PT	10	15	0.562	24.2
		50	15	0.797	
		100	10	0.995	
2	PT	80	20	0.972	24.2
3	PT	100	20	1.119	24.2
4	PT	100	20	1.193	24.2
5	PT	100	20	1.090	24.2
6	PT	50	30.0	0.814	25.0
7	PT	50	15.5	1.067	25.3
8	PT	50	8.0	0.813	25.1
		120	5.0	1.235	
		150	7.0	1.385	
9	PT	200	20	2.884	25.2
12	SnO_2	50	15	0.90	25.8
13	SnO_2	50	30	0.81	25.9
14	PT	50	30	0.80	25.6
15	PT	50	30	0.85	25.7
16	PT	50	30	0.85	26.1
17	SnO_2	50	15	-	26.4
6a	Ptti	50	30	0.7	24.6
7a	Ptti	50	15.5	1.6	24.6
9a	Ptti	200	20	1.2	24.8
10a	Ptti	50	15	0.9	25.3
11a	Ptti	50	30	0.8	25.3

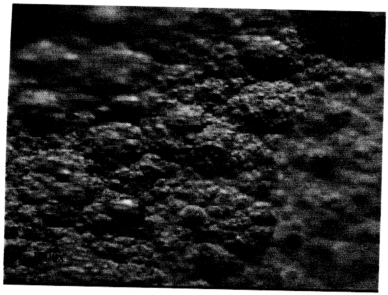

Figure A19. A picture of Ppy-PSS surface growth on electrolyte side. Image by using Leica Q500MC image Processing and Analysis system.
1000X magnification.

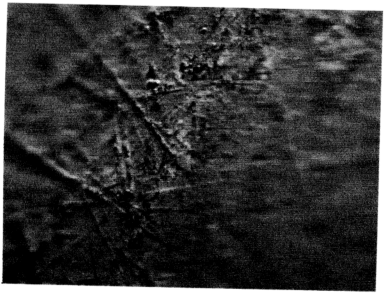

Figure A20. A picture of Ppy-PSS surface which ordinary attached to working electrode.
Image by using Leica Q500MC image Processing and Analysis system.
1000X magnification
Working electrode : Platinised Titanium

APPENDIX 7

Table A3. Data Collected for conductivity of film 9 using "four point-probe" method.

Direction	Current applied I / mA	Potential measured V / mV	Film Resistivity Ohm cm
0°	0.09978	0.265	9.136
	0.14985	0.397	9.114
	0.19936	0.528	9.111
	0.24944	0.660	9.102
	0.29947	0.795	9.132
	0.39953	1.061	9.135
30°	0.09978	0.256	8.826
	0.14985	0.381	8.746
	0.19936	0.508	8.766
	0.24943	0.635	8.758
	0.29946	0.759	8.719
	0.39954	1.013	8.722
60°	0.09979	0.250	8.618
	0.19936	0.502	8.662
	0.24947	0.629	8.674
	0.29947	0.755	8.673
	0.34954	0.882	8.680
	0.39955	1.01	8.696
90°	0.09978	0.251	8.653
	0.19936	0.507	8.748
	0.14986	0.380	8.723
	0.24944	0.635	8.757
	0.29948	0.762	8.753
	0.39954	1.017	8.756
120°	0.09980	0.255	8.790
	0.19937	0.516	8.903
	0.24945	0.648	8.936
	0.29948	0.779	8.948
	0.34948	0.910	8.956
	0.39955	1.040	8.954
150°	0.09980	0.260	8.962
	0.19938	0.521	8.989
	0.24945	0.652	8.991
	0.29948	0.784	9.005
	0.34955	0.914	8.995
	0.39957	1.045	8.997
		Average	**8.863**
		Std. dev.	0.160
		Surface conductivity/ Sm^{-1}	11.28

APPENDIX 8

Calculation for the body conductivity for film No. 14 at 1379 kPa (method of two-pellet)

y	x	y	x	y	x	y	x	y	x	y	x
V/mV	I/A	V/mV	I/A	V/mV	I/A	V/mV	I/A	V/mV	I/A	V/mV	I/A
-49	0.0133	-11	0.00305	27	-0.008	35	-0.0103	-3	0.00054	-41	0.0116
-48	0.013	-10	0.00276	28	-0.0083	34	-0.00996	-4	0.00083	-42	0.0119
-47	0.0127	-9	0.00247	29	-0.0085	33	-0.00966	-5	0.0011	-43	0.0121
-46	0.0125	-8	0.00217	30	-0.0087	32	-0.00936	-6	0.00148	-44	0.0124
-45	0.0122	-7	0.00187	31	-0.009	31	-0.00905	-7	0.00183	-45	0.0127
-44	0.012	-6	0.00158	32	-0.0092	30	-0.00876	-8	0.00205	-46	0.0129
-43	0.0118	-5	0.00129	33	-0.0096	29	-0.00848	-9	0.00234	-47	0.0132
-42	0.0115	-4	0.000995	34	-0.0098	28	-0.00819	-10	0.00263	-48	0.0135
-41	0.0113	-3	0.000708	35	-0.0101	27	-0.0079	-11	0.00283	-49	0.0139
-40	0.011	-2	0.000427	36	-0.0104	26	-0.00759	-12	0.00316	-50	0.0141
-39	0.0106	-1	0.00014	37	-0.0106	25	-0.0073	-13	0.00344		
-38	0.0103	0	-0.000159	38	-0.0109	24	-0.00704	-14	0.00374		
-37	0.0101	1	-0.000458	39	-0.0112	23	-0.00674	-15	0.00405		
-36	0.00975	2	-0.000726	40	-0.0115	22	-0.00656	-16	0.00434		
-35	0.00949	3	-0.00112	41	-0.0118	21	-0.00632	-17	0.00461		
-34	0.00922	4	-0.00137	42	-0.0121	20	-0.00602	-18	0.0049		
-33	0.00895	5	-0.0016	43	-0.0124	19	-0.00573	-19	0.00519		
-32	0.00866	6	-0.00189	44	-0.0127	18	-0.00533	-20	0.00548		
-31	0.00836	7	-0.00211	45	-0.013	17	-0.00494	-21	0.00577		
-30	0.0081	8	-0.00239	46	-0.0133	16	-0.00468	-22	0.00609		
-29	0.00781	9	-0.00272	47	-0.0136	15	-0.00439	-23	0.00638		
-28	0.00759	10	-0.00298	48	-0.0139	14	-0.00417	-24	0.00665		
-27	0.00739	11	-0.00327	49	-0.0143	13	-0.00397	-25	0.00695		
-26	0.0071	12	-0.00356	50	-0.0146	12	-0.00368	-26	0.00715		
-25	0.00687	13	-0.00377	49	-0.014	11	-0.00339	-27	0.0074		
-24	0.00658	14	-0.00407	48	-0.0138	10	-0.00309	-28	0.00769		
-23	0.00629	15	-0.00436	47	-0.0136	9	-0.0028	-29	0.00797		
-22	0.00599	16	-0.00466	46	-0.0134	8	-0.00251	-30	0.00836		
-21	0.0057	17	-0.00497	45	-0.0132	7	-0.00225	-31	0.00872		
-20	0.0054	18	-0.00527	44	-0.0129	6	-0.00196	-32	0.00896		
-19	0.00512	19	-0.00556	43	-0.0125	5	-0.00168	-33	0.00925		
-18	0.00483	20	-0.00585	42	-0.0121	4	-0.00138	-34	0.00949		
-17	0.00459	21	-0.00615	41	-0.0118	3	-0.00109	-35	0.00969		
-16	0.0043	22	-0.00642	40	-0.0116	2	-0.00075	-36	0.01		
-15	0.00401	23	-0.0067	39	-0.0113	1	-0.00046	-37	0.0103		
-14	0.0038	24	-0.007	38	-0.011	0	-0.00023	-38	0.0107		
-13	0.0035	25	-0.00729	37	-0.0109	-1	5.49E-05	-39	0.011		
-12	0.00325	26	-0.00757	36	-0.0106	-2	0.000263	-40	0.0113		

Regression Output:

Constant		-0.818707
Std Err of Y Est		0.39951
R Squared		0.99981
No. of Observations		200
Degrees of Freedom		198
		/ 1000
X Coefficient(s)	-3528.979	-3.529
Std Err of Coef.	3.453426	0.003

Thickness, $l = 24.00 \pm 1.15\ \mu m$

Geometrical Area, $A = (1.316 \pm 0.004) \times 10^{-4}\ m^2$

Slope, $m = 3.529 \pm 0.003$ ohm

Conductivity, $\sigma = (l / A) / m$

$$= \quad 0.05168 \quad S\ m^{-1}$$

$\delta\sigma = (\delta l / l + \delta A / A + \delta m / m) \times \sigma$

$$= \quad 0.00268$$

Conductivity, $\sigma = (5.17 \pm 0.27) \times 10^{-2}\ S\ m^{-1}$