**REPORT**

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The aim of this project is to make conducting glass slides. Which would have better transparency and conductivity along with economic feasibility. Attempts have been made to coat such microscopic glass slides with different samples of ITO available in the lab, and results were have been listed. For this different methods were employed. They are listed as follows:

**Layer by layer technique:** [1, 2, 3]

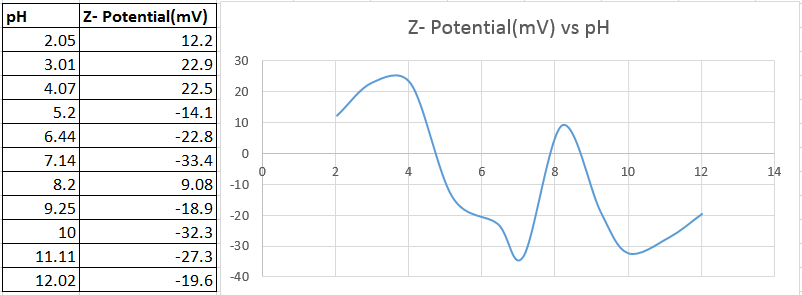
PAH solution was made by dissolving 0.03gm of PAH in 40mL water. PSS solution was made by dissolving 0.5mL PSS in 39.5mL water. 0.0495gm ITO sample (urea at 350/450) was dissolved in 10mL HCl. Glass slide was kept in each of the solution for 15min, in the order of PAH-PSS-ITO. It was dried after each coat. Finally it was kept in oven for drying.

The same technique was also used with all the three solutions at pH 2.5. In all the cases multiple layers of PSS and ITO have also been applied one after another with base layer being PAH.

Observations show that this technique did not show any conductivity. The slide was not transparent. The layer on slide was coarse, ITO particles had agglomerated and formed small clusters all over the slide. The layer was unstable, it easily came off.

**Zeta Potential test**:

Zeta potential was carried out for an ITO sample (600 CD). The following results were obtained.



The results show, there was no single isoelectric point. So this data was not used further.

**Spin Coating:** [4]

For this technique each of the coat was applied on a spinning glass slide. The glass slide was spun at a specific rpm and for a specific time.

For first case, ITO was dissolved in ethanol. The mixture was stirred and sonicated. ITO weight was varied as 0.04 gm and 0.1 gm. RPM was 600, for 60 sec. 20mL of alcohol was taken for each ITO weight. Slides with single and multiple layers of ITO were made. Same was repeated for isopropyl Alcohol. ITO was dispersed better in isopropyl alcohol.

Observations show, the slides did not conduct. Primary reasons are likely to be; the solutions were not viscous enough, the solutions didn’t stay on slide while coating but were rather thrown away from slide. Care was taken to warm up the slides in the oven at 100 deg C after each coat. As far as transparency was concerned, the slides appeared milky and coarse.

For second case, the solutions used in layer by layer coating were coated, in the same order as mentioned in layer by layer coating. RPM was varied from 500 to 800. But no conductivity was observed.

**Particle size analysis:**

Since particle agglomeration for ITO on the glass slides. Particle size analysis was carried out for two ITO samples 550 and 350/450 based on urea fuel. These samples had spherical particles, so they were chosen for analysis.

|  |  |  |
| --- | --- | --- |
| **ITO Sample** | **Centrifuged** | **Not Centrifuged** |
|  | **Particle Size(nm)** | |
| 550 | 3181 | 1208 |
|  | 1213 | 1149 |
|  | 2099 |  |
|  | 488 |  |
| 350/450 | 242 | 348.9 |

We conclude that a centrifuged sample of 350/450 ITO sample has least particle size.

**Sol-gel method:** [5]

Tin nitrate was prepared by dissolving 0.25 gm of pure Tin in 3 mL of HNO3. Indium Nitrate was prepared by dissolving 0.5 gm of Indium in 1.65 mL of HNO3. Tin nitrate solution and Indium nitrate solution were taken in the ratio of 1:9. Four coats of this solution were applied on glass slide, finally heating it at 350 deg C. No conductivity was observed. However a uniform coat was seen with no transparency.

**Drop-Wise deposition:**

Until now, no transparency was seen as well no slide had shown any conductivity. Now, attempts were made to make the glass slide the least to be conducting, transparency was not taken into consideration.

For first case, 0.015 gm of an ITO sample (Citric acid 22nd march) was dissolved in 0.05M HCl and Isopropyl alcohol respectively, it was then stirred and sonicated. So we had two solutions. Each of the solutions was coated on glass slide. Prior to this the glass was heated at 550 deg C for 10 min. On testing the slides, glass slide with 0.05M HCL as solvent gave a current value of 0.02mA. The other slide didn’t show any conducting values.

For second case, same technique was used as the first case, however coating and treating the glass was done at 500 deg C. The results show current value of 0.01mA and voltage value of 1.00mA.

For third case, temperature was varied, along with ITO and HCL concentration. However the results couldn’t be reproduced. The slides gave no conductivity. Now, attempts were made to achieve conductivity with transparency

For fourth case; layer by layer technique was used but it was modified slightly. Instead of dipping the glass slides in each of the solutions, the solutions were deposited on the slide by means of dropper. And each slide was dried in oven. ITO sample (gycine 550 deg C) was used in all cases so far. However better results may be possible if ITO sample (350/450) based on urea fuel is used. The glass was only cleaned, it was not treated at high temperature. So this process is fairly simple. ITO was dissolved in excess of 0.05M HCL and then centrifuged. This gave us transparency along with conductivity.

Eight samples of such slides (and additional slides A, B) have been made to demonstrate the consistency of results. These samples are however synthesized in their own unique way:

Slide 1 to 4: PAH Solution= 0.2gm PAH + 49.8gm water.

PSS Solution=0.5mL PSS + 49.5mL water.

ITO Solution=0.06gm ITO(glycine 550)+0.05MHCl(Excess)

Centrifuge ITO solution for 5 min at 2000 rpm. Slides dried in oven at 96 deg C.

|  |  |  |
| --- | --- | --- |
| **Sample** | **Current(mA)** | **Voltage(mV)** |
| Slide1 | 0.00-0.01 | 2.5-4.0 |
| Slide2 | 0.00 | 0.1-0.3 |
| Slide3 | 0.00 | 0.0-0.5 |
| Slide4 | 0.00-0.02 | 0.0-5.5 |

Slide 5, 6: After each coat slide was dried in furnace between 150-240 deg C. The slide was bought to room temperature and then coated.

|  |  |  |
| --- | --- | --- |
| **Sample** | **Current(mA)** | **Voltage(mV)** |
| Slide 5 | 0.00-0.01 | 0.0-43.1 |
| Slide 6 | 0.00-0.01 | 0.0-100.0 |

Slide 7, 8: Each coat was air dried at room temperature. However PAH layer was air dried in heated in oven to bind the layer.

|  |  |  |
| --- | --- | --- |
| **Sample** | **Current(mA)** | **Voltage(mV)** |
| Slide 7 | 0.00 | 0.2-43.0 |
| Slide 8 | 0.00 | 0.1-24.0 |

Side A,B: These slides were coated same as above, however they were dried in a oven at 96 deg C.

|  |  |  |
| --- | --- | --- |
| Sample | Current (mA) | Voltage (mV) |
| A | 0.01 to 0.03 | 15.1 to 16.0 |
| B | 0.01 | 10.0 to 15.0 |

**Areas to be worked on:**

1. PAH and PSS are pH sensitive. pH needs to be adjusted accordingly.[3]

2. White precipitate forms as soon as PSS is deposited on PAH layer.

3. The entire surface does not conduct. The indicated values are obtained from certain conducting areas. This is probably due to agglomeration of particles of ITO.

4. Volatile solvents need to be used for immediate evaporation.

**Coating currently in progress:**

Since PAH and PSS form precipitate. Attempts are being made to eliminate PSS layer, by coating ITO layer on PAH.

Three slides are being developed with PAH and ITO solution used in acidic and basic form, in variation. Primary observation shows, slides are not so transparent. They appear milky. Conductivity is yet to be tested.

**References:**

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3. LbL Fabricated Poly(Styrene Sulfonate)/TiO2 Multilayer Thin Films for Environmental Applications (D. Neela Priya,†, Jayant M. Modak,‡ and Ashok M. Raichur\*)
4. Wet chemical deposition of ATO and ITO coatings using crystalline nanoparticles redispersable in solutions. (C Goebberta, R Nonningerb, M.A Aegertera, , , H Schmidtb).
5. Preparation of ITO transparent conductive film by sol-gel method.(Zhi-hua LIa, , , Dong-yan RENb).