13. SUMMARY OF THE FINDINGS:

Spray Pyrolysis technique is the most suitable process to deposit uniform large area thin film, where a thin film is deposited by spraying a starting solution on heated surface and then constituents react to form a new solid phase. In Present project, home-made, fully atomized SPD technique has been applied for Fabrication of Dye-Sensitized Solar Cell (DSSC). This technique is particularly useful for the deposition of oxides and has long been production method for applying a transparent conducting tin oxide to glass substrate. Fluorine doped tin oxide (FTO) has been recognized as a very promising material for a number of optoelectronic applications, because it is quite stable for atmospheric conditions, chemically inert, mechanically hard, high-temperature resistant, etc.

Fig. 1 Actual Photograph of Spray Pyrolysis Deposition system

A] FTO preparation: Commercially available soda lime glass (2.5 x 1 cm^2) was used as a substrate material. The temperature was kept 450 ^{0}C constant during deposition.

Step 1] 0.554gm of NH_4F was dissolved into 20 ml of distilled water.

Step 2] 2.256 gm of $SnCl_4$:$2H_2O$ was then added into the solution of step 1

Step 3] after shaking well the prepared mixture, the solution becomes transparent and it is ready to spray.

Step 4] Post annealing was performed at 450 ^{0}C under same conditions for ½ hr. The FTO deposited slides are shown fig. 2

Electrical properties of FTO:

To study the electrical characteristics of FTO thin films the four probe measurement was carried out. Plotting the V Vs I to get a slope becomes 3.453

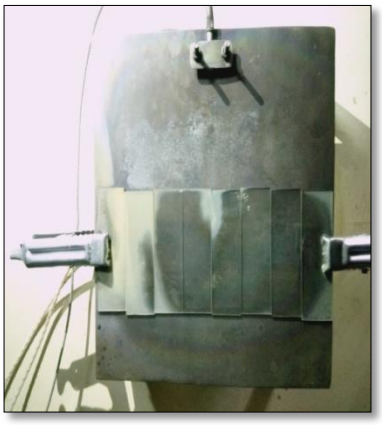

Fig. 2 Actual Photograph FTO thin films

1. Sheet Resistance RS = 4.532 ohm x (3.453) slope = 15.64 Ω

2. Sample resistance R= RS X L/W = 15.64 X 2.5/1 = 39.1 Ω

3. Resistivity ρ = 2πS (spacing between the probe) X slope = 6.28 X 0.2 X 3.453 = 4.3369 Ω-Cm

4. Bulk Resistivity considering the thickness (500 nm) to be uniform ρ =

$$RS \times t = 4.532 \times t = 15.64 \times 500 \times 10^{-9} \text{ m}$$

$$= 7.824 \times 10^{-6} \ \Omega\text{-Cm}$$

5. Conductivity $\sigma = 1/\rho = 1/7.824 \times 10^{-6} = 12.78 \times 10^{4}$ S Cm^{-1}

These values of electrical properties are very impressive for a FTO film on a glass surface for TCO applications, and high values of conductivity reflect the quality of FTO films prepared on soda-lime glass at 450 ^{0}C

B] Preparation of TiO_2:

Titanium dioxide was deposited using Titanium Isopropoxide precursor (97%)

153. Titanium isopropoxide - 1 ml used as a Precursor

ii. Propane 2-ol - 9 ml used as a Solvent

iii. Acetyl Acetone - 0.1 ml used a stabilizer

Total solution of Spray - 20 ml

Deposition Temperature - 450 ^{0}C

Shaking well the above mixture gives transparent solution which was ready to spray. Fig. 3 shows that masking on FTO films for TiO_2 deposition. Masking is necessary to get TCO electrodes. Masking 2mm on three sides and 5mm (for electrode) on one side was done using Al foil.

Fig 3 Masking on FTO for TiO2 deposition

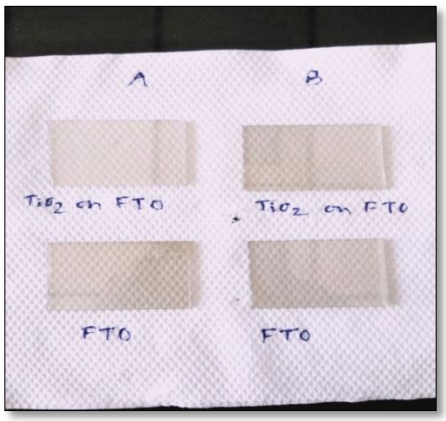

Fig. 4 Cell A and B (upper two slides)

Fig. 4 shows that Cell A & cell B have been deposited by TiO_2 on FTO films which are then ready to dip into dye. Lower two slides are FTO coated which are ready to coat graphite as counter electrode.

C] Dye Preparation:

i. Beet was grinded to get juicy dye as shown in fig 5-a)

ii. Deeping: the top surface (of Upper slides in Fig.4) of Cell A and B were dipped into Beet dye for 30 minutes as shown in fig 5-b).

iii. After 30 minutes the dye coated slides were washed with distilled water twice & then washed with isopropyl alcohol to remove any water contents.

Fig. 5-a Dye preparation using the Beet juice

Fig. 5-b cell A and B are dipped into Beet

D] Dye Preparation:

i. NaI For 10ml solution = 1.4989 gm

ii. I_2 for 10ml solution = 0.2538 gm

$1.4989gm(NaI) + 0.2538gm(I_2) + 10ml$(Acetonitrile) made the Electrolyte solution which was used to insert on porous TiO_2 coated films.

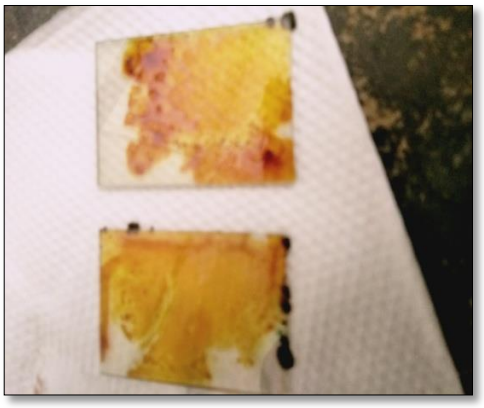

Fig. 6-a Iodide electrolyte solution spread on FTO+TiO2+Dye top surface

Fig. 6-b Graphite layer deposited on FTO

D] Counter Electrode Preparation:

Another slides coated with FTO were used to get counter electrode (lower slides of Fig.4). Counter Electrode was prepared using the flame of candle. Putting the FTO deposited side inside the half flame o candle gives a thin Graphite layer which was used as a counter electrode in this experiment as shown in fig 6-b

D] Building the DSSC:

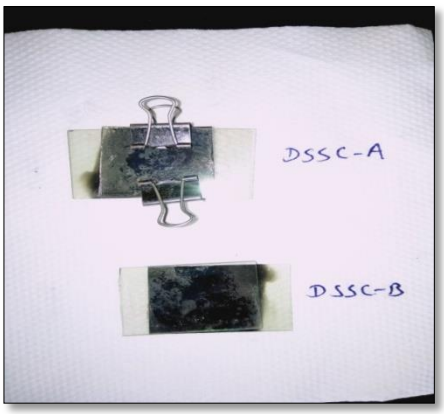

Fig. 6-c Binding Slides in 6-a and 6-b top surfaces

Binding the Slides shown in fig. 6-a and 6-b such that the top surfaces FTO electrodes were kept open to measure the Open Circuit Voltage (Voc) and Short Circuit Current (Isc) of the DSSC as shown in fig 6-c

The prepared DSSCs were characterized for current and voltage in dark and light conditions.

E] Result Summary:

For DSSC, Cell A

	Dark Condition	**Light Condition**
V_{oc}	0.5mV	19.2mV
I_{sc}	0.6µA	52.1µA

For DSSC, Cell B

	Dark Condition	**Light Condition**
V_{oc}	1.3mV	87.5mV
I_{sc}	2.4µA	153.8µA